Attachment 1

Updated GEH Morris CSAR Chapters 1-11

June 2020

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1.0 INTRODUCTION AND DESCRIPTION

1.1 INTRODUCTION

This document contains a consolidation of safety analysis information relating to storage of irradiated nuclear fuel in operations conducted by General Electric Hitachi Nuclear Energy (GEH or the Company) at Morris Operation (MO). Since 1989, the fuel basins at GEH-MO are essentially full, and no further receipts of fuel are planned or anticipated. Fuel shipments are not expected until the DOE repository is opened.

Almost all information in this document has been previously published or otherwise made a part of the public record regarding the Midwest Fuel Recovery Plant (MFRP) or GEH-MO[1]. This document presents information regarding fuel storage operations, disregarding features of the facility not applicable to fuel storage. Not all information in this document describes important to safety structures, systems and components (SSC). Support SSC are also discussed as they apply to fuel storage. Section 8, “Accident Safety Analysis”, and Section 11, “Quality Assurance”, detail SSC important to safety.

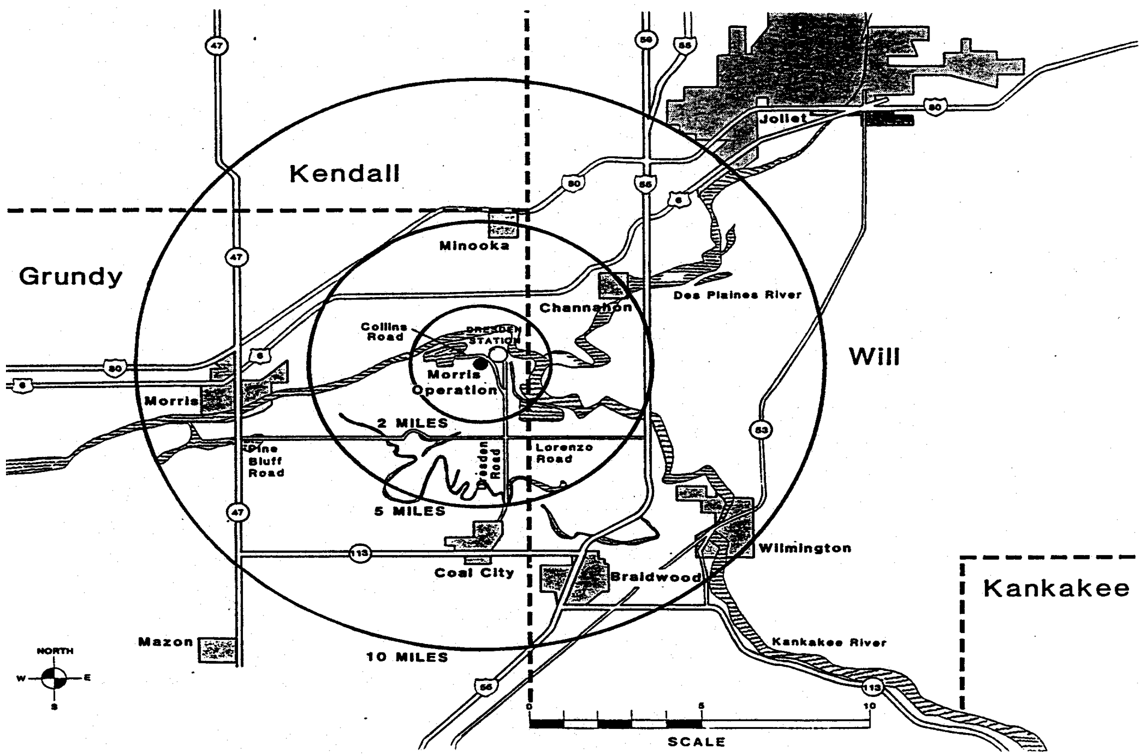
The Company's facility is located near Morris, Illinois, adjacent to the Dresden Nuclear Power Station (DNPS).

The GEH-MO fuel storage facility includes two interconnected water-filled basins with cranes, water treatment system, and other facilities required to store irradiated fuel underwater for an indefinite period. Fuel storage equipment in the basins is designed to protect the integrity of fuel rods during seismic or meteorological events. Special procedures and isolation can be provided for storage of damaged or leaking fuel. Security measures are in effect to protect the facility against unauthorized access. Although intended for interim storage only, based on the storage system environment and aging management, non-replaceable components (concrete basin and basin liner), allow safe storage of the fuel for extended period of time..

In December 1975, GE received a license amendment to increase fuel storage capacity[2] from about 100 TeU to 750 TeU by installation of a fuel storage system of a new design and through appropriate changes in fuel handling and support systems. This modification, designed by GE as Morris Operation-Project I, converted the former high level waste storage basin to a fuel storage basin. The capacity expansion project was completed in 1976.

1.1.1 Corporate Entities, Business, and Experience

Facilities described in this report are owned and operated by General Electric Company, a corporation under the laws of the State of New York with its principal place of business at Boston, MA. The facility is operated through the Company's GE Hitachi Nuclear Energy with headquarters in Wilmington, North Carolina and operations in Morris, Illinois.



GE is a broadly diversified corporation involved in research, design, manufacturing, and marketing products and services in several fields including industrial products, technical systems and materials, and power systems. The latter activity includes nuclear systems, equipment, fuel and services.

The Company's nuclear experience includes research and development of prototype reactors for nuclear submarines, operation of the government's Hanford facilities for more than 17 years and development, design, manufacture, and erection of boiling water reactors currently operating at electric power stations in the United States and throughout the world. The staff of GE Hitachi Nuclear Energy (GEHNE) includes hundreds of scientists, engineers, and technicians, representing one of the largest pools of nuclear knowledge and experience in the world.

1.1.2 Plant Location

GEH-MO facilities are located on the northern end of a rectangular tract of about 327 acres owned by the Company in Gooselake Township, Grundy County, Illinois, near the confluence of the Kankakee and Des Plaines Rivers (Figure 1-1).

The property (Figure 1-2) is about 15 air miles southwest of Joliet and about 50 miles southwest of the Chicago, Illinois - Gary, Indiana area. Morris, Illinois, the county seat of Grundy County is about 7 miles west of the property. The Illinois Waterway and Kankakee River are separated from the property to the north and east by lands owned by the Exelon Company, the site of the Dresden Nuclear Power Station (DNPS) and related facilities, and a privately owned plot of about 50 acres. Goose Lake Prairie State Park is to the west and open land borders the property to the south.

The GEH property consists of undeveloped land, some of which is used for agriculture, the Owner-Controlled Area (OCA), and the parking area.

Note the OCA is a historic designation used at the Morris site and is not equivalent to the controlled area defined in 10CFR20. GEH maintains control of the approximately 327 acres that GEH owns around the OCA. Access to the site is controlled by gates. The property is enclosed by an agricultural fence with posting advising unauthorized persons not to trespass beyond the fence barrier.

No credible acts of nature, man-induced events or accidents have been identified that would result in biologically significant release of radioactive material or direct radiation dose in excess of limits of 10 CFR 72.106 outside the OCA boundary. Therefore, the Emergency Planning Zone (EPZ) for GEH-MO coincides with the OCA boundary. Additionally, the 100 meter minimum distance required by 10 CFR 72.106 is provided by the controlled property boundary surrounding the OCA (as shown in Figure 1-2).

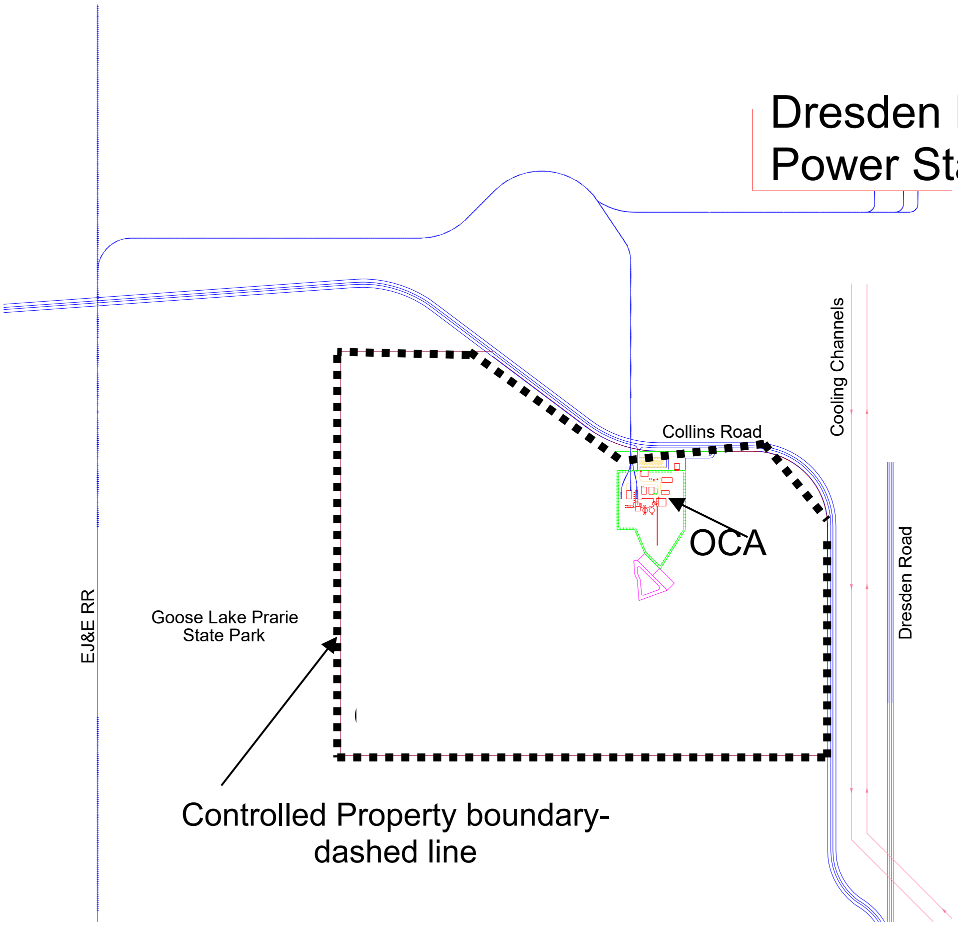


Figure 1-2 GEH Controlled Property & OCA

1.1.3 Existing Facilities

The licensed facilities occupy 15 acres at the north edge of the property (detail Figure 1-3). The principal plant structures, including the ventilation stack, are located within the Owner Controlled Area (15 acres) fenced with chain-link-type fencing topped by multiple strands of concertina wire with an overall height of 8 ft.

Figure 1-3 Principal Activity Facilities – Owner Controlled Area

[redacted]

1.1.4 Fuel Type and Exposure

The design basis fuel stored is UO_2 fuel having had an initial enrichment of 5% U-235 or less, with stainless steel, zirconium or Zircaloy cladding, and in a "bundle of rods" geometry. Design basis fuel was assumed to be irradiated at specific power levels of up to 40 kW/kgU, with exposure to 44,000 MWd/TeU (reactor discharge batch average), and cooled for at least 1 year after reactor shutdown prior to receipt at GEH-MO.

1.1.4.1 Fuel in Storage

Irradiated fuel from PWRs and BWRs has been received and stored at GEH-MO since 1972. These activities have reaffirmed experience elsewhere that fuel can be handled and stored safely with no impact on the environment. There has been no significant fuel leakage (as

determined by measurement of basin water activity), indicating the fuel is a stable, inert material while in the storage basin environment. Effective control of water quality, radioactive material concentration in the water, cask contamination, and airborne radioactive material has been demonstrated.

1.2 GENERAL PLANT DESCRIPTION

The following descriptions are of those aspects of GEH-MO facilities related to irradiated fuel storage.

1.2.1 Site Characteristics

The GEH-MO site is in a developing industrial area. The terrain is typically "rolling prairie," with vestiges of long-abandoned coal strip mines. In general, the land in the area has been farmed for many years, but the GEH-MO site is in an area of rocky outcroppings and thin top soil, unsuited to economical, large-scale farming of crops. Arable portions of the site outside of the OCA have and may continue to be leased to local farmers and have been used and may continue to be used for beef cattle grazing and raising crops. Both road and rail transportation services are available on the site (Figure 1-1). Rail access is via an extension of the DNPS siding from the Elgin, Joliet and Eastern Railway right-of-way to the west of the site. Road access is via county roads which connect with several state highways and provide routes to nearby communities and to interstate highways in the area.

Investigations of site characteristics were made in support of the MFRP construction effort, and Morris Operation-Project I. These studies supplemented extensive information obtained in the course of DNPS development and operation. Factors significant to fuel storage activities are summarized below.

1.2.1.1 Regional and Site Meteorology

The climate of the Morris region of Illinois is typically continental, with cold winters and warm, humid summers. There are frequent short-term fluctuations in temperature, humidity, cloud cover, and wind speed and direction. Storm systems and weather fronts usually move eastward and northeastward through this area. The maximum recorded temperature for the area was 109 ^{o}F, with a minimum temperature of -22 ^{o}F, and an annual mean temperature of about 59 ^{o}F. There is a rather uniform distribution of wind direction, with the most frequent winds from the west and south at an average of 11 to 15 mph.

The most severe weather conditions experienced in the area are tornadoes. Over a 40 year period, there was an average of 4.8 tornadoes per year in Illinois, which is close to the average for all states east of the Rocky Mountains. While tornadoes have been reported near GEH-MO since 1965, no damage to the site has occurred.

1.2.1.2 Geology

Exploration of the site's substructure, as well as actual excavation for facility construction confirmed the rock is sound at all depths with no evidence of active faults. All main building foundations and below-grade vault and basin structures are set in bedrock to ensure high structural integrity for these facilities.

1.2.1.3 Hydrology

Consideration has been given to subsurface water behavior in relation to operation of underground facilities, but because there is no liquid waste discharge, or storage of high activity liquid wastes at the fuel storage site, factors such as drainage patterns to water courses, soil ion-exchange capacity, etc., are not of major significance in ensuring the safety of fuel storage operation[3].

Potential flooding of the site is considered very unlikely. Site elevation at the plant location is 532.5 ft. compared with the maximum historical flood elevation of 506.4 ft. The normal pool elevation of the river as controlled by the Dresden Dam is 505 ft.

1.2.1.4 Seismology

Available references show the GEH-MO site in Zone 1 (zone of minor damage) on the latest seismic probability map. In Richter's Seismic Regionalization map, the site is near the line of demarcation between an area assigned a probable maximum intensity of seven and one with a probable maximum intensity of eight of the Modified Mercalli (MM) scale. To ensure conformance with basin earthquake resistance criteria, design earthquake forces have been taken as those corresponding to a horizontal ground acceleration of 0.1G (MM7) and maximum earthquake forces at a horizontal ground acceleration of 0.2G (MM8).

1.2.1.5 Environs Summary

Distances from the plant stack to GEH controlled property boundaries are 2,265 ft. to the east, 1,646 ft. to the south and 3,100 ft. to the west. The property boundary to the north is about 950 ft. from the stack; however, the DNPS site provides an effective boundary of about 5,950 ft. Studies of population and land usage in surrounding areas were made and reported in the course of DNPS development, during MFRP licensing, and during the GEH-MO capacity expansion. Factors of specific interest are summarized below and discussed further in Chapter 3.

a. <u>Industrial</u>: On the DNPS site there are two operating nuclear power reactors situated about 0.7 miles northeast of the GEH-MO stack. A chemical plant is located about 1.5 miles from

the stack to the northwest. Discontinued clay mines are approximately 1.4 miles south of the stack.

b. Residential: Residential occupancy in the immediate vicinity of GEH-MO is low. There is a cluster of about 30 cottages on the west shore of the Kankakee River, about 0.5 miles from the GEH-MO stack. These are located between Dresden Road and the Kankakee River on a tract of about 50 acres adjacent to the GEH-MO and DNPS sites. Residential development in the immediate vicinity of GEH-MO would be limited to this tract which is now nearing saturation.

There is a similar group of cottages on the Kankakee River east bank greater than 1 mile from the GEH-MO stack. Some homes in this area are permanent residences, although most have been developed for part-time recreational purposes. Surveys by CECo indicate that within 2.5 miles of the DNPS site there are a total of 129 permanent homes and 191 part-time recreational cottages along the Kankakee River. Other residences in the area include several at Dresden Dam about 1.2 miles to the north. There are no major residential centers developing south of the Kankakee and Illinois Rivers in the vicinity of the GE tract.

Within a radius of 5 miles the population is about 20,000, including 13,086 in the village of Channahon, about 4 miles to the northeast.

The population within 5 miles of the site is projected to increase to 21,554 by the year 2050, with most of the growth occurring in the Channahon area to the north[5].

The total population within the 50-mile radius was about 7,114,414 in 2010 and is projected to reach 7,256,549 by 2050 with about 92% of the total beyond the 20-mile radius[6,7].

Studies by CECo's Industrial Development Department indicate that since 1946, 82% of the new industries locating within the CECo's system are located within 25 miles of downtown Chicago. In 1965, 80% of the new industries also located according to this pattern. Current indications are that this industrial growth pattern is slowing but continuing within the 25-mile belt. Thus, the growth adjacent to the GEH-MO-DNPS sites (which are outside of the 25-mile belt) should continue, but at relatively low rates. Joliet and Aurora are the closest areas likely to experience significant population increases.

c. Recreational: In addition to fishing, hunting, and boating activities near the confluence of the Kankakee and Des Plaines Rivers 1 to 2 miles east of the plant, the Goose Lake Prairie State Park has been established adjacent to the GEH-MO property. This natural prairie preserve of about 1,800 acres is west of the tract, with the nearest point being about 0.6 mile from the stack.

1.2.1.6 Property Ownership

The GEH-MO facilities are located on a property of about 327 acres owned by GE. At the time of the previous ISFSI license renewal, GE owned approximately 892 acres. GEH sold four parcels totaling approximately 565 acres at the southern end of the MO site in 2013. Portions of this undeveloped land were leased for agricultural use while under GE ownership. The land continues in agricultural use under the current ownership. A lease agreement permits limited farming and beef cattle grazing on the GEH-owned property outside the OCA.

1.2.2 Facility Descriptions

Site facilities as they exist today are the result of using original buildings, where possible, and rearranging or adding new buildings, where necessary.

1.2.2.1 Main Building

The main building (also known as the process building) is a massive structure of reinforced concrete, about 204 ft. by 78 ft. in plan, and about 88 ft. above grade. The western end of the building houses most of the fuel storage facilities. This portion of the building is of steel frame and insulated metal siding construction, and is attached to the concrete main building.

1.2.2.1.1 Fuel Storage Areas

Fuel storage operation areas include:

a. Cask receiving area
b. Decontamination area
c. Cask unloading basin
d. Fuel storage basins 1 and 2
e. Low level waste evaporator
f. CAS/SAS (was Control Room)
g. Basin water cleanup and cooling

1.2.2.2 Other Structures

Adjacent to the south wall of the main building are the underground Cladding and Low Activity Waste (LAW) vaults, which were originally part of the reprocessing plant waste system, and later part of the fuel storage system waste management facilities. The underground dry chemical vault (DCV), adjacent to the main building east wall, was used during reprocessing system testing. The Clad Vault is empty and is intended for contingency service only. The LAW Vault and the DCV are empty, connecting piping has been removed or capped, and the vaults are laid away. There are no current plans for use of the LAW Vault or DCV.

The sand filter building, a principal part of the plant ventilation system, is east of the main building. All air exhausted from the fuel storage areas and from supporting areas in the main building is passed through the sand filter, sampled, and vented to the atmosphere via the 300 ft. high stack located southeast of the main building. Attached to the sand filter building is the emergency equipment building (EEB). Other prominent structures on the site include a utility and service building; a shop and warehouse building; the administration building; a water tower; and a cask service building.

Operation of the various facilities is described in Section 1.3. The basin areas are diagrammed in Figure 1-4.

1.2.2.3 Building Drawings

Drawings of the main building and the sand filter building are included in Appendix A.14. Elevations in these drawings are based on an arbitrarily selected reference point at 47.5 ft., which is grade elevation at the main building site. The site grade reference is 532.5 ft. above sea level, and the reference "zero" elevation is 485.0 ft. above sea level.

[redacted]

Figure 1-4

Scematic GEH-MO Basin Facilities

[redacted]

1.3 FUEL STORAGE OPERATIONS

1.3.1 Unloading and Storing Spent Fuel

Fuel was normally unloaded using the fuel handling crane - a crane of 5 ton capacity mounted on rails attached to columns below the cask crane rails. The unloading and storage basins are

served by the basin crane - a manual control bridge crane of 7.5 ton capacity. As with other cranes, the basin crane is designed to prevent derailment under seismic conditions. The basin crane has a platform on the north side of the bridge that provides a work station with excellent viewing for the fuel handling crane operator.

1.4 SUPPORT SYSTEMS

The principal support systems are:

a. Radwaste System
b. Ventilation System
c. Basin Water Cleanup and Cooling Systems
d. Sump Monitoring and Pump-out Systems
e. Sewage Systems
f. Utility Systems, including air, water, and electricity
g. Radiation Monitoring Equipment

1.4.1 Radwaste System

The Radwaste System is split into two sub-systems identified as high and low activity. The purpose of this design is to separate highly radioactive basin filter sludge from other plant waste water such as laundry, sump waste and decon solutions. The Radwaste System for liquid waste is shown schematically in Figure 1-5a. Low activity liquid wastes consist primarily of laundry water, sump water, and decon solutions. This waste is processed through an electric evaporator.

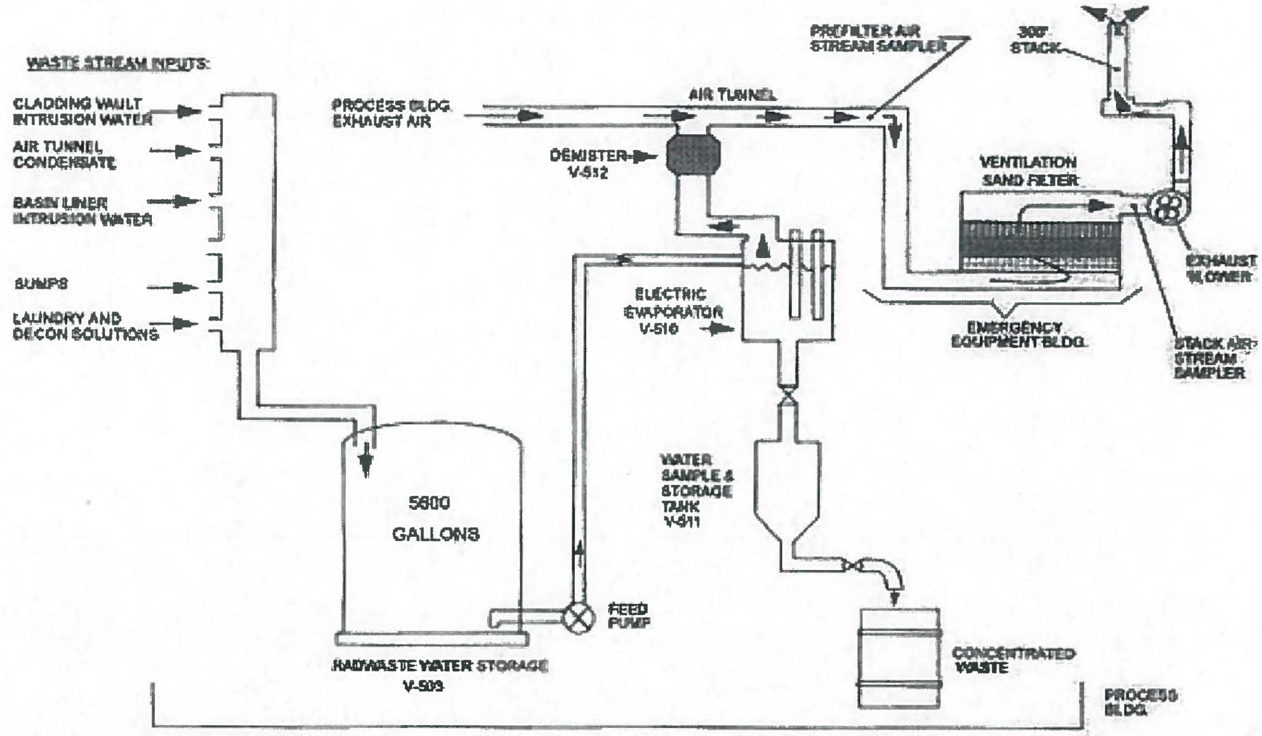


Figure 1-5a. RADWASTE SYSTEM: Low activity radwaste water streams are collected from various sources and piped to the Radwaste Water Storage Tank. Water from this tank is then pumped to an electric evaporator. Evaporator steam is demisted and exhausted via the ventilation system. Evaporator bottoms are put in barrels and shipped off site for processing.

The high activity part of the Radwaste System (Figure 1-5b) dewaters basin filter spent resins and returns the water to the basin. The dewatered filter resins and evaporator bottoms are disposed of as radwaste.

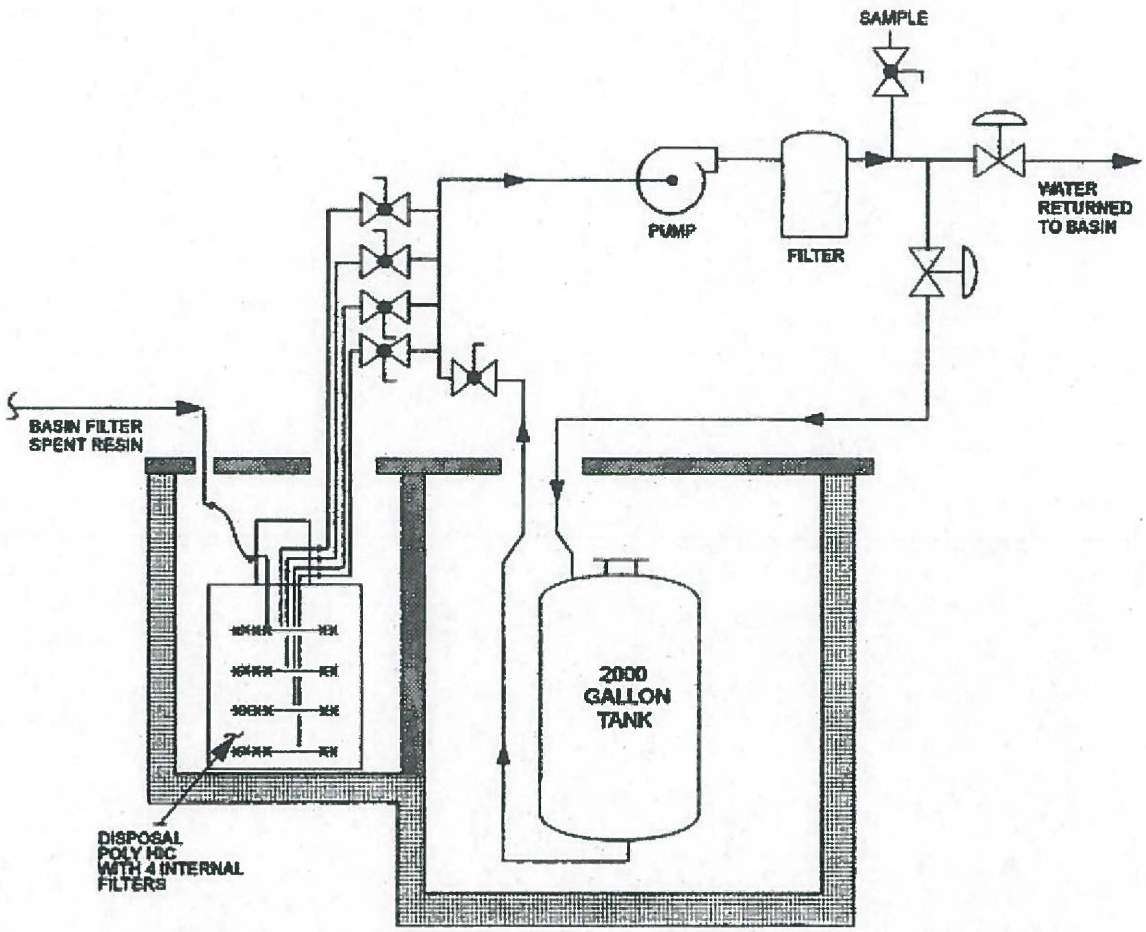


Figure 1-5b. BASIN FILTER SPENT RESIN SYSTEM: Spent resins from the Basin Filter and cask flush solutions are pumped to a shielded Poly High Integrity Container (HIC). Water is removed from the HIC, filtered and then returned to the Fuel Storage Basin. When filled, HICs are dried and shipped off site for burial.

In addition to the Radwaste System, the Cladding Vault is available to receive and hold contaminated water. This reinforced concrete vault is stainless-steel lined. The Cladding Vault is normally empty, but is maintained as a contingency if large volume water storage is required.

1.4.2 Ventilation System

A simplified diagram of the ventilation system is shown in Figure 1-6. Pressure differentials within and among connected areas ensure air flow from areas of low potential radioactive contamination (high air pressure) to areas of higher potential radioactive contamination (low air pressure).

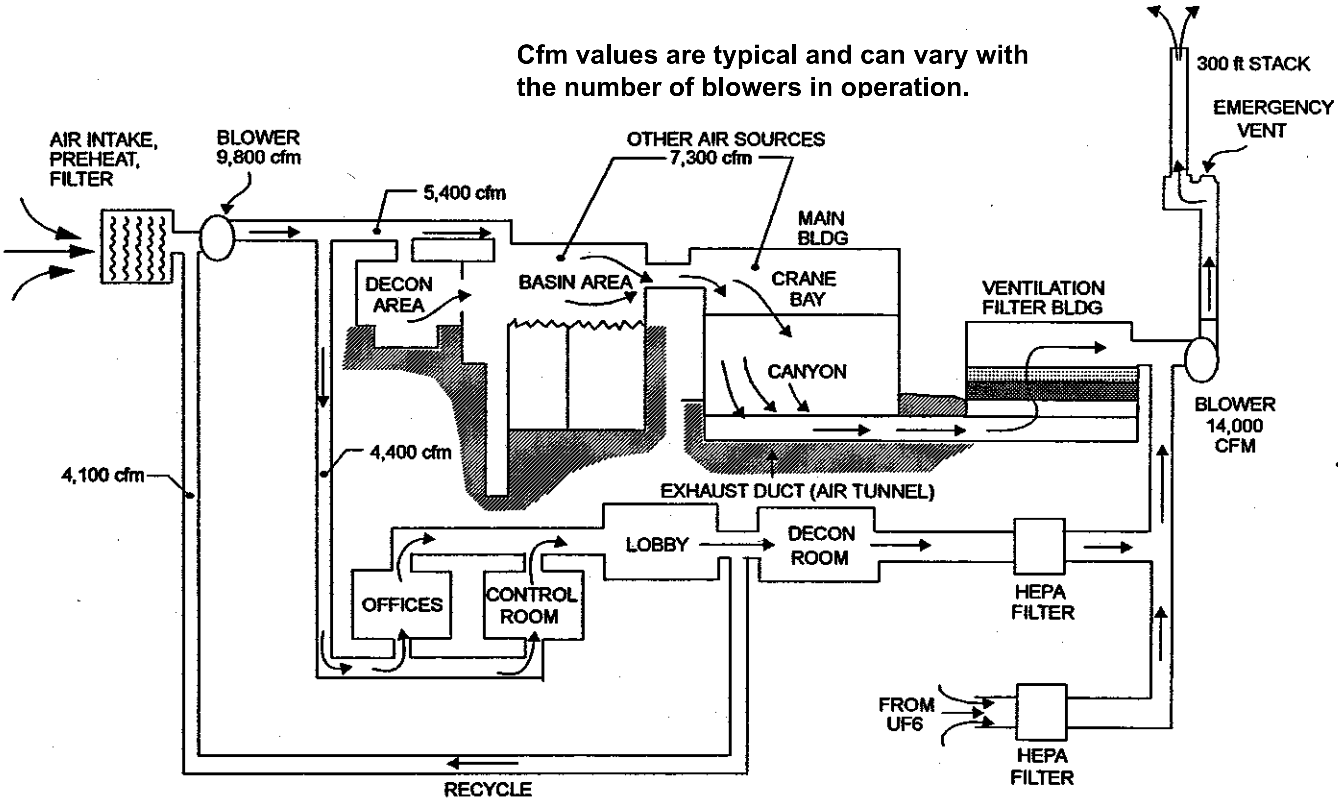


Figure 1-6. Outside air is combined with recycled air from the offices, control room and lobby and then split into two streams. One is a once through stream that passes through controlled areas to the air tunnel, through the sand filter and out the stack. The other stream ventilates the offices and is recycled with fresh incoming air. A small side-stream is diverted from this loop through a decontamination room and a filter to the stack.

Air to be passed through the sand filter flows to the air tunnel in the main building. The air tunnel provides means for draining liquids (such as condensate) to the off-gas cell sump where they are collected and pumped to the Radwaste System (Figure 1-5a and 1-5b).

1.4.3 Basin Water Cleanup and Cooling Systems

Simplified diagrams of the basin water cleanup and cooling systems are shown in Figures 1-7, 1-8, and 1-9. The filter unit is isolated in a shielded and locked room in the basin pump room. The pump room houses two 250 gpm pumps for the basin water chiller system, a 128 gpm pump for the heat pump cooling system, and a 250 gpm filter pump. Piping to the basin skimmers and water return piping is arranged to prohibit siphon action. Filter regeneration is accomplished remotely. Spent resins are pumped to the Radwaste System.

The water chiller system uses a water-to-freon chiller of stainless steel construction and rated at 1.2×10^6 Btu/hr. In addition, a separate heat pump system utilizes the waste heat from spent fuel to aid in heating personnel areas. It has a capacity of 480,000 Btu/hr.

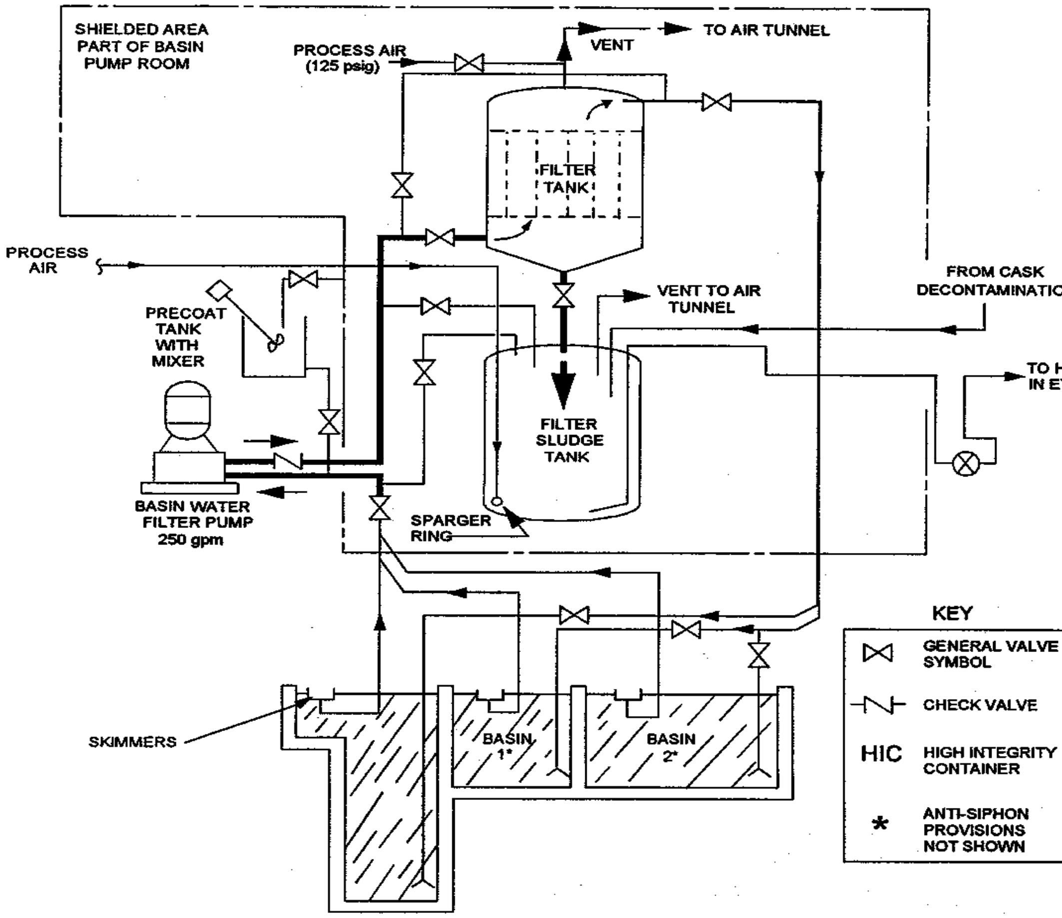


Figure 1-7. BASIN WATER CLEANUP SYSTEM: Water is continually drawn from basin skimmers at about 250 gpm, processed and returned to the basin. Filter sludge and cask decontamination water are collected in the sludge tank, then jetted to Radwaste Processing. Provisions are included for flushing tanks and pre-coating filters.

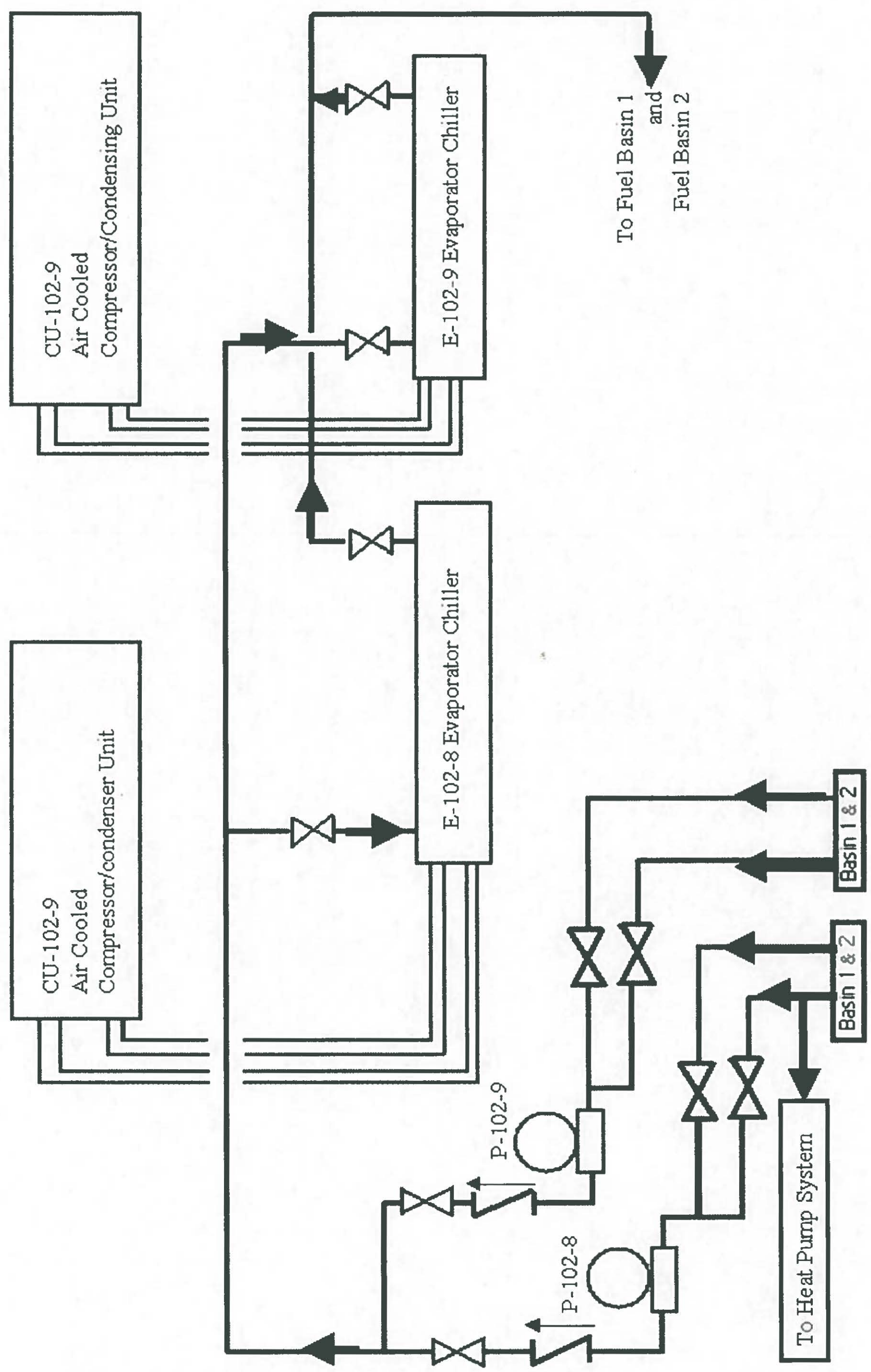


Figure 1-8. <u>BASIN WATER COOLING SYSTEM:</u> Water is pumped from the basins to 2 Evaporator chillers where heat is transferred to a refrigerant system.

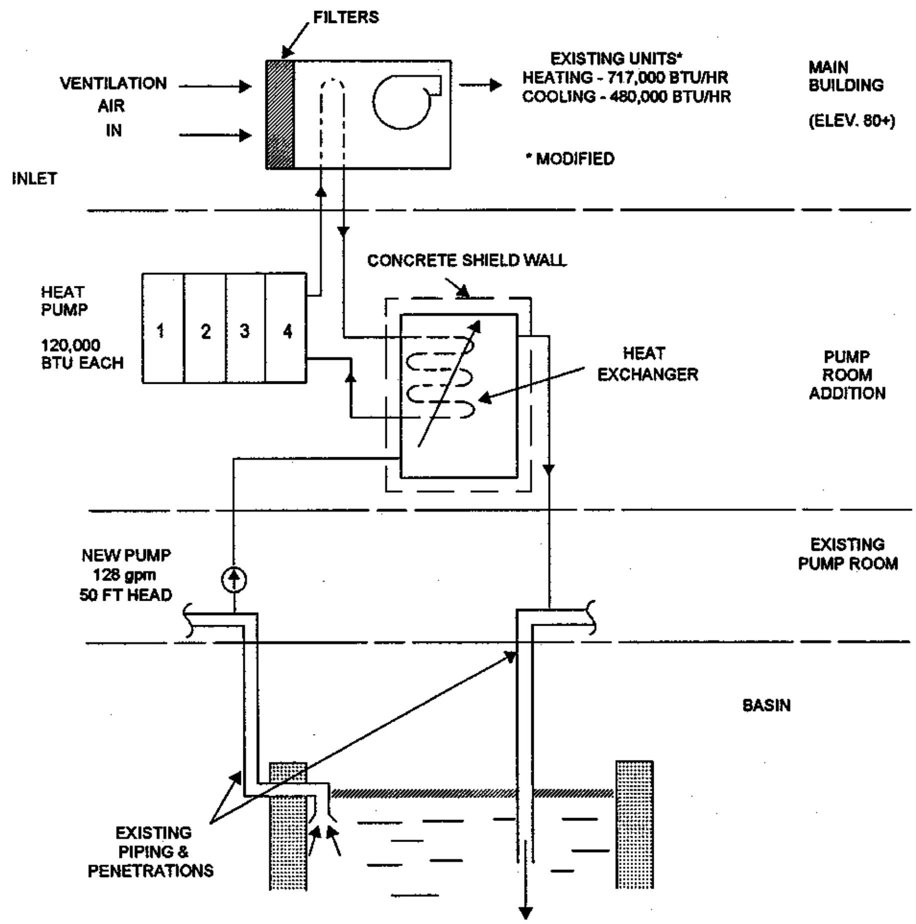


Figure 1-9. Basin Water Heat Pump Cooling System – Simplified Schematic

1.4.4 Leak Detection and Sump systems

Basic to the leak detection system is a sump that accumulates leakage water as well as intrusion water (water entering from surrounding rock). A simplified schematic of the leak detection and empty-out system for the fuel storage basins is shown in Figure 1-10. The sump is emptied using a combination of an air-lift and an air operated diaphragm pump. Provisions are included to sample sump water. All vaults are equipped with similar systems utilizing electric pumps in place of air-lifts.

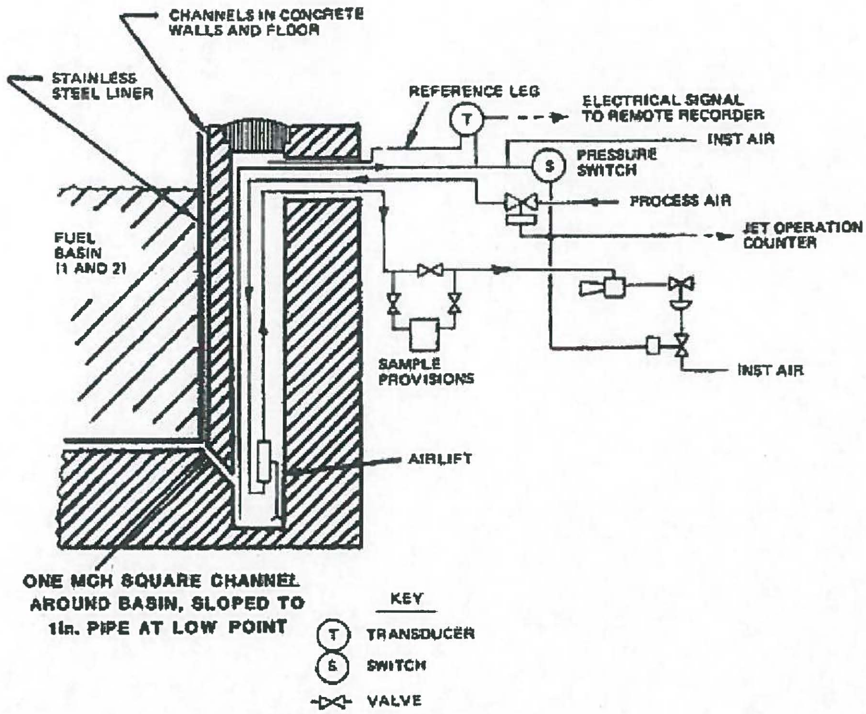


Figure 1-10. LEAK DETECTION, EMPTY-OUT AND SAMPLING SYSTEM: Sumps are provided in several locations to collect leakage or other runoff. Water detection, empty-out and, in some cases, sampling and monitoring facilities are provided. This schematic shows fuel basin liner leak detection and empty-out system in simplified form.

1.4.5 Sewage systems

No sewage is discharged from the GEH controlled property. Sanitary wastes are piped to the sanitary lagoons. A simplified schematic of the sanitary sewage systems is depicted in Figure 1-11.

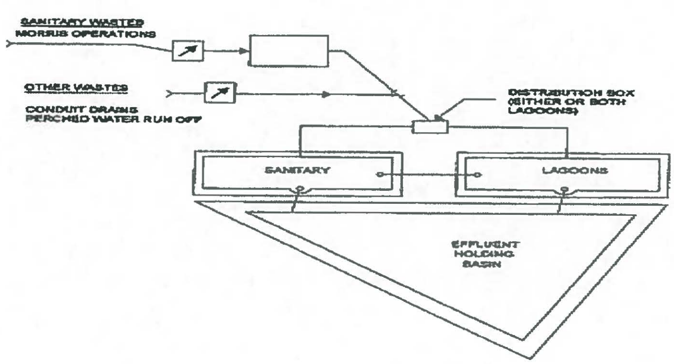


Figure 1-11. SEWAGE SYSTEMS: No liquid effluent is discharged off-site; only rain runoff is drained by open ditch, eventually discharging to the river. Holding basin retains lagoon effluent.

1.4.6 Energy Systems

The one energy source on site is the electrical system.

a. Electrical: Electrical power is furnished by Commonwealth Edison Company (CECo) via two 34,000-volt lines. Distribution facilities are located in and near the utility service building. Principal loads at GEH-MO are crane operation, ventilation system, control and instrumentation, and auxiliary systems and equipment.

   Although interruption of electrical power would not result in unsafe conditions, secondary power sources (originally intended as emergency sources for reprocessing activity) are provided to ensure continuing operation of electrical equipment during power outages.

1.5 RADIOLOGICAL AND OTHER MONITORING

GEH-MO monitors gaseous and liquid (ground water and surface water) effluent from the Morris Operation OCA boundary.

Within the GEH-MO facility, sampling and laboratory analyses supplement the constant air and other monitoring devices to ensure a safe environment for employees and to detect trends or events.

1.6 EMERGENCY PROVISIONS

The GEH-MO Emergency Plan (NEDO 31955) describes actions to be taken during emergency situations. Structures and systems at Morris supporting emergency action such as law enforcement, medical, fire, or other emergency services are identified. Assistance agreements exist with appropriate local agencies.

Access to the GEH controlled property is controlled by gates. The controlled property is enclosed by an agricultural fence with postings advising unauthorized persons not to trespass beyond the fence barrier.

No credible acts of nature, man-induced events or accidents have been identified that would result in biologically significant release of radioactive material or direct radiation dose in excess of limits of 10 CFR 72.106 outside the OCA boundary. Therefore, the Emergency Planning Zone (EPZ) for GEH-MO coincides with the OCA boundary. Additionally, the 100 meter minimum distance required by 10 CFR 72.106 is provided by the controlled property area surrounding the OCA (as shown in Figure 1-2).

1.7 REFERENCES

1. License and docket information and a list of applicable documents are contained in Appendix A.1 and A.2.

2. Storage capacity expressed in terms of metric tons of uranium (TeU) as contained in LWR fuel rods.

3. See Chapter 8.

1.8 Definitions

OCA: Owner Controlled Area encompasses 15 acres that is surrounded by security fence where principle activities occur.

Controlled Property Area: The approximately 327 acres that GEH owns adjacent to the OCA, access to which can be limited by GEH for any reason

Morris Operation: The personnel and processes at the GEH Morris Facility.

3.0 SITE CHARACTERISTICS

3.1 INTRODUCTION

This section provides descriptions of geographical, demographic, meteorological, hydrological, seismological, and geological characteristics of the GEH-MO site and vicinity. This information has been derived from various documents submitted during MFRP licensing activities[1] and site studies performed as part of actual and proposed capacity expansions. Applicable information from the history of experience in receipt, storage and transfer of irradiated nuclear fuel dating back to 1972 is also included.

3.2 GEOGRAPHY AND DEMOGRAPHY OF SITE

This section includes a description of site geography, population and land-use considerations as applicable to the fuel storage facility.

3.2.1 Site Location

GEH-MO facilities are located on a tract of about 327 acres owned by General Electric Company (GE or the Company) in Gooselake Township, Grundy County, Illinois, near the confluence of the Kankakee and Des Plaines Rivers. The tract is located 41°22'53" N latitude, 88°16'32" W longitude; about 15 air-miles southwest of Joliet and about 50 miles southwest of the Chicago, Illinois - Gary, Indiana area. Aurora is located about 25 miles north, and Kankakee is about 25 miles to the southeast. Morris, the county seat of Grundy County, is about 7 miles to the west. Interstate Highway 55 (I-55) is about 4 miles east, and Interstate Highway 80 (I-80) is about 5 miles to the north. Figures 1-1 through 1-3 depict the tract general location, and Figures 3-1 and 3-2 depict general plot arrangement and neighboring structures and activities.

3.2.2 Site Description

Figure 1-3 is a map of the site, showing the site, Owner Controlled Area (OCA), and other details. The GEH-MO site is in a developing industrial area of typically "rolling prairie" terrain. In general, land in the area has been farmed for many years but the GEH-MO buildings are in an area of rocky outcroppings and thin topsoil, unsuited to economical, large-scale farming of crops.

3.2.2.1 GEH-Morris Operation Boundary

GEH-MO boundaries and surrounding lands and waters are shown in Figure 3-1. The tract's northern boundary is formed by E. Collins Road, and the eastern boundary by Dresden Road. The Illinois and Kankakee Rivers are separated from the tract to the north and east by lands of

Exelon Generation Company, LLC's (Exelon's), Dresden Nuclear Power Station (DNPS) and related facilities, and a privately owned plot of about 50 acres. To the south, the tract is bordered by open land that is privately owned. Other lands bordering the GE tract include industrial areas to the northwest, and Goose Lake Prairie State Natural Area adjacent to the GE tract with the closest point about 0.6 miles west of the GEH-MO stack. Road transportation service is available to the site, and portions of rail infrastructure is in place for future use.

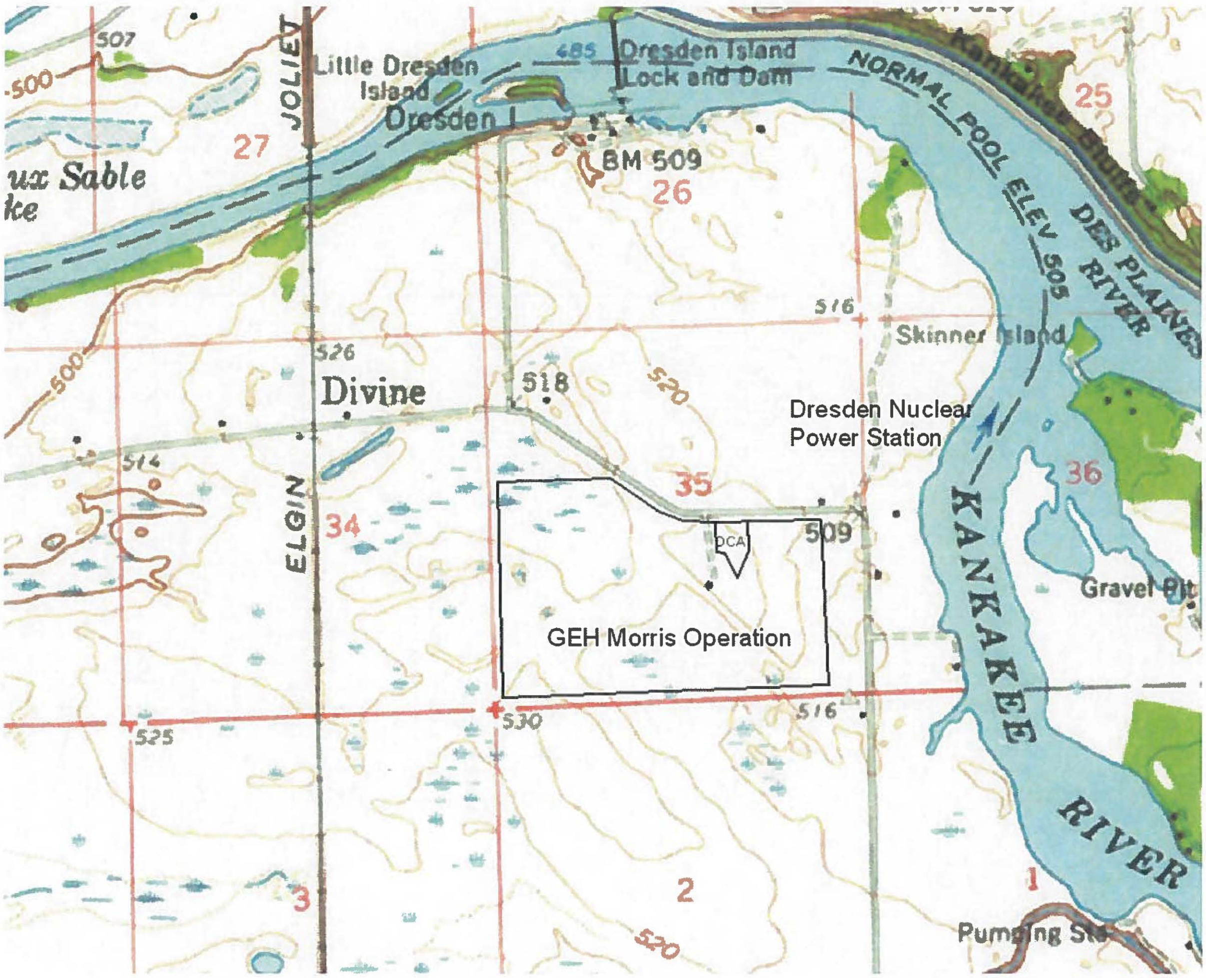


Figure 3-1. <u>TOPOGRAPHIC MAP:</u> GE Tract and Vicinity

[redacted]

Figure 3-2. Contour Map – GEH Morris Operation

3.2.2.2 Property Ownership

GE is the sole owner of the tract, subject to easements, which have been granted for power lines, and natural gas lines, as shown in Figure 1-2. The tract, as originally purchased, totaled about 1,380 acres and included that portion of Section 1, Township 33 North, Range 8 East that is south of the Kankakee River, all of Section 2, Township 33 North, Range 8 East and that portion of Section 35, Township 34 North, Range 8 East that was south of the DNPS site.

Since that time, about 70 acres located in the southwest corner of Section 1, Township 33 North, Range 8 East and about 50 acres in a 400 ft. wide strip along the south edge of Section 2, Township 33 North, Range 8 East were sold to A. P. Green Refractory Company, Illinois Products Division, for use in connection with clay mining and clay products manufacturing activities. Subsequently, the remainder of Section 1, Township 33 North, Range 8 East and a 525 ft. wide strip along the east edge of Section 35, Township 33 North, Range 8 East and extending into Section 2, Township 33 North, Range 8 East for a short distance have been sold to CECo for flume access to and from the DNPS cooling lake. The southern portion of the site with Tax Property Index numbers of 06-02-100-001, 06-02-200-001, 06-02-300-01 and 06-02-400-001 were separated from reference to site with the expectation of sale. In 2013, all four parcels (565 acres) were sold to a private LLC. Currently, GEH referenced property totals approximately 327 acres.

GEH has also leased approximately 15 acres at the northeast corner of the GEH-MO site adjacent to E. Collins Road for development of a solar farm. The solar farm will supply electricity for the MO facility, augmenting its previous source of offsite power. The solar farm will be dedicated to powering MO, so transmission connection with the regional power grid will not be required.

3.2.2.3 Access Control

Access to the GEH-MO tract is controlled. GEH-MO facilities occupy about 52 acres in the north portion of the tract, adjoining the DNPS site. Principal plant structures, including the ventilation stack, are located within an area of about 15 acres, fenced with chain-link-type fencing topped by multiple strands of barbed wire with an overall height of 8 ft. Access to the site is controlled by gates. The remainder of the tract is enclosed by an agricultural fence with posting advising unauthorized persons to keep out. In the conveyance of parcels previously described, provisions have been included to ensure their subsequent use and access will continue to be appropriately controlled. Exelon Generation Company, LLC (Exelon) similarly controls access to the DNPS site and security areas.

A lease agreement permits limited farming and beef cattle grazing on the tract outside the OCA. In addition, GEH has also leased approximately 15 acres at the northeast corner of the GEH-MO site adjacent to E. Collins Road for development of a solar farm.

3.2.2.4 Boundaries for Establishing Effluent Release Limits

The OCA boundary (the tract boundary shown in Figure 1-2) is the boundary for establishing dose equivalents as defined in 10 CFR 72.104 and 72.106.

No credible acts of nature, man-induced events or accidents have been identified that would result in biologically significant release of radioactive material or direct radiation dose in excess of limits of 10 CFR 72.106 outside the OCA boundary. Therefore, the Emergency Planning Zone (EPZ) for GEH-MO coincides with the OCA boundary.

3.2.3 Population, Distribution and Trends

The database for the following sections is founded on information developed by agencies of the U.S Census Bureau, States of Illinois and Indiana, as well as information developed by GE and Exelon [2,3,4].

3.2.3.1 Population 0 and 5 Miles (Figures 3-3 and 3-4)

The population in the immediate vicinity of GEH-MO is very low at 56 (<1 mile). Within a radius of 5 miles the population is about 20,000, including 13,086 in the village of Channahon, about 4 miles to the northeast.

The population within 5 miles of the site is projected to increase to 21,554 by the year 2050, with most of the growth occurring in the Channahon area to the north[5].

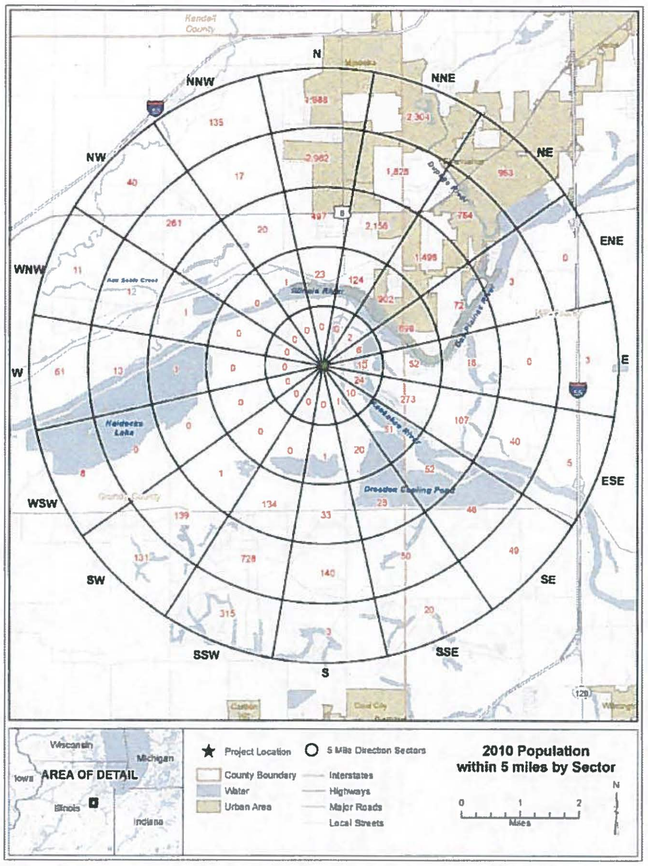


Figure 3-3. Estimated population within a five-mile radius of GEH-MO, 2010

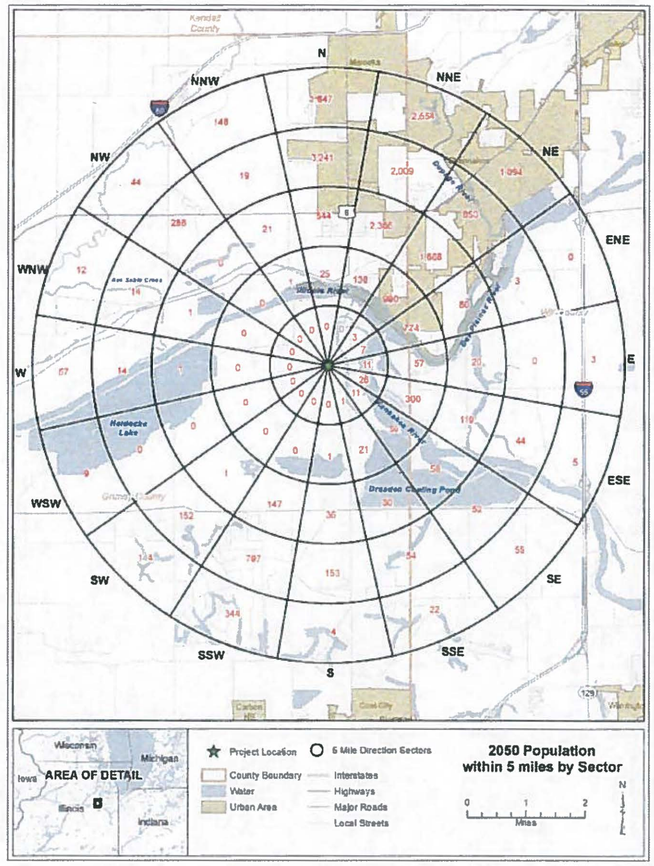


Figure 3-4. Estimated population in a five-mile radius of GEH-MO, 2050

3.2.3.2 Population Within 50 Miles (Figures 3-5 and 3-6)

The total population within the 50-mile radius was about 7,114,414 in 2010 and is projected to reach 7,256,549 by 2050 with about 92% of the total beyond the 20-mile radius[6,7].

Studies by CECo's Industrial Development Department indicate that since 1946, 82% of the new industries locating within the CECo's system are located within 25 miles of downtown Chicago. In 1965, 80% of the new industries also located according to this pattern. Current indications are that this industrial growth pattern is slowing but continuing within the 25-mile belt. Thus, the growth adjacent to the GEH-MO-DNPS sites (which are outside of the 25-mile belt) should continue, but at relatively low rates. Joliet and Aurora are the closest areas likely to experience significant population increases.

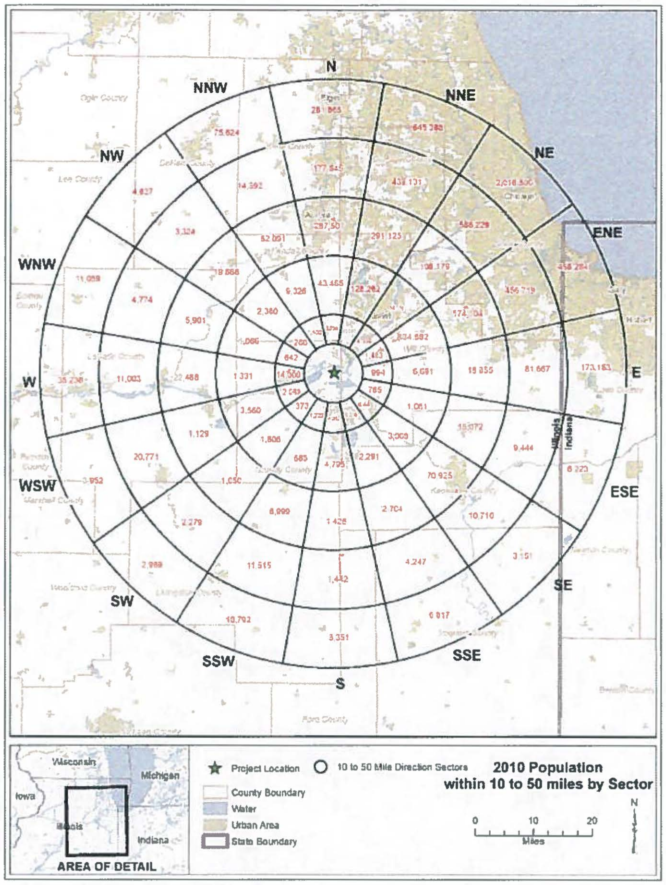


Figure 3-5. Estimated population within a 5-50 mile radius of GEH-MO, 1990

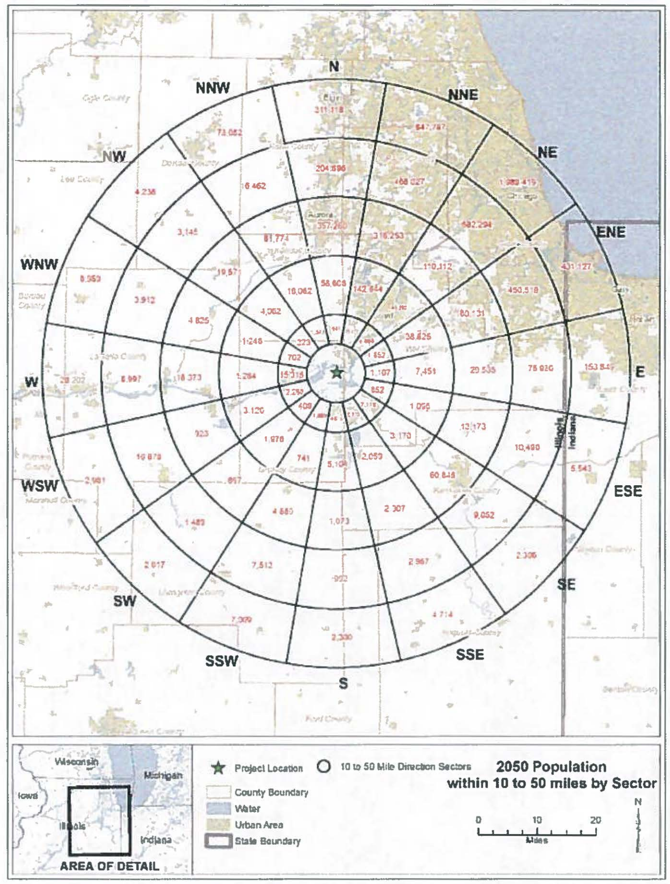


Figure 3-6. Estimated population in a 5-50 mile radius of GEH-MO, 2015.

3.2.3.3 Transient Population

There are small seasonal variations in population in the area farmlands because of harvest personnel requirements. Unlike some farm areas, harvest activities are highly mechanized and relatively few additional workers are required.

Almost all manufacturing and other industrial activity is nonseasonal and draws upon a population base that resides in the same general area, except for DNPS. On a staggered 24-month schedule (for two nuclear units), the DNPS workforce increases by approximately 600 during refueling outages. With the largest part of Chicago's industrial and residential areas within the 50-mile radius, daily movements of people within Chicago and environs result in a

relatively insignificant statistical change from the viewpoint of considerations applicable to the GEH-MO site.

As discussed elsewhere in this Section, recreational uses of lands and water in the area result in small seasonal changes in population in cottages, etc.

3.2.4 Users of Nearby Land and Waters

Immediate GEH-MO neighbors (Figure 3-1) are the DNPS site on the north, open farmland on the south and Goose Lake Prairie State Park to the west. To the east is the Dresden cooling lake and a privately-owned property of about 50 acres, divided into about 30 cottage sites. Collins Station, a former fossil-fired plant to the west-southwest of GEH-MO, was closed and decommissioned in 2004. As mentioned in Section 3.2.2.2, GEH sold four parcels totaling approximately 565 acres at the southern end of the MO site in 2013. The land continues in agricultural use under the current ownership, however there are currently plans for an 1,100 MW (megawatt) natural gas turbine, electric power plant located directly on the south border of the GEH-MO boundary. The facility will occupy about 30 acres of the 80-acre site.

Grundy County developed a Comprehensive Plan including a vision for future land use. The land use surrounding GEH-MO continues as primarily industrial and parks and open space. Residential use occurs along the Kankakee River and in the finger lakes area to the south of the site (Grundy County 2014, p. 90).

Will County prepared a Land Resource Management Plan (last updated in 2011) to guide development in the County over the next 20 years. The Plan identifies the portion of the County west of the GEH-MO and south of the Des Plaines River as rural area. Small neighborhoods and subdivisions along the river make up the Kankakee River Corridor. The Plan's design for the rural area and Kankakee River Corridor is to preserve the land pattern while allowing reasonable opportunities for growth. New development in the river corridor should respect the scale and character of the existing development (small, river-oriented housing areas) and be compatible with the surrounding rural areas. The area north of the Des Plaines River is identified as suburban communities. For the suburban communities land use type, which is identified as the northern half of the County, the Plan also calls for preserving this land use pattern while encouraging and managing mixed residential and commercial growth (Will County 2011, pp. 5-12, 25-26). The Will County line is approximately 1.5 miles east of the GE tract.

3.2.4.1 Industrial

In addition to Exelon's holdings to the east, north, and northwest, another industrial area is located along Interstate Highway 55 (I-55). This highway runs north and south, about 4.5 miles directly east of the tract (Figure 1-1). Two miles east of I-55 is the inactive Joliet Army Ammunition Plant. A large Mobil Oil petroleum refinery is located where I-55 crosses the Des

Plaines River, approximately 5 miles northeast. Just over a mile northwest of MO site are the Reichhold and Aeropres (chemical) manufacturing facilities. Just over 3 miles northwest is a cluster of chemical plants. Just south of those is the Northfield Block Company. Over the last 20 years, some of the industrial sites within a 5-mile radius have changed ownership, however, their locations and footprints are roughly unchanged. Industrial sites are also located on the north bank of the Illinois River.

3.2.4.2 Residential Use and Population Centers

Residential occupancy in the immediate vicinity of GEH-MO is low. There is a cluster of about 30 cottages on the west shore of the Kankakee River, about 0.5 miles from the GEH-MO stack. These are located between Dresden Road and the Kankakee River on a tract of about 50 acres adjacent to the GEH-MO and DNPS sites. Residential development in the immediate vicinity of GEH-MO would be limited to this tract which is now nearing saturation.

There is a similar group of cottages on the Kankakee River east bank greater than 1 mile from the GEH-MO stack. Some homes in this area are permanent residences, although most have been developed for part-time recreational purposes. Surveys by CECo indicate that within 2.5 miles of the DNPS site there are a total of 129 permanent homes and 191 part-time recreational cottages along the Kankakee River. Other residences in the area include several at Dresden Dam about 1.2 miles to the north. There are no major residential centers developing south of the Kankakee and Illinois Rivers in the vicinity of the GE tract.

Cities and towns having populations greater than 1,000 located within 30 miles of GEH-MO are listed in Table 3-1.

Other areas and sites involving intermittent and temporary congregations of persons within 5 miles of area are as follows (data as of January 2020):

a. Schools - Enrollment[8]

Minooka High School	2,725	Channahon School	1,302
Minooka Jr High & Grade School	1,531	Illinois Youth Center[9]	Closed

b. Churches - average attendance of largest service

Minooka Catholic	300	Minooka Methodist	170
Channahon Baptist	250	Channahon Methodist	150
Channahon Catholic	500	Goose Lake Baptist	125
Phelan Acres Bible	65		

c. There are no hospitals within the 5-mile area.

Table 3-1

CITIES GREATER THEN 1,000 POPULATION WITHIN 30 MILES OF GEH-MORRIS OPERATION

Area	Name	Population (2010 Census)
0-5 Miles	Channahon	12,560
5-10 Miles	Braidwood	6,191
	Coal City	5,587
	Morris	13, 636
	Wilmington	5,724
	Minooka	10,924
10-20 Miles	Crest Hill	20,837
	Gardner	1,464
	Joliet	147,433
	Lockport	24,839
	Manhattan	7,051
	Marseilles	4,899
	New Lenox	24,394
	Plainfield	39,581
	Rockdale	1,945
	Seneca	2,268
	Shorewood	15,615
20-30 Miles	Aurora	197,899
	Bolingbrook	73,366
	Bourbonnais	18,631
	Bradley	15,895
	Dwight	4,260
	Frankfort	17,782
	Kankakee	27,537
	Lemont	16,000
	Manteno	9,204
	Matteson	19,009
	Mokena	18,740
	Montgomery	18,438
	Naperville	141,853
	North Aurora	16,760
	Odell	1,046
	Orland Park	56,767
	Oswego	30,355
	Ottawa	18,768
	Peotone	4,142
	Plano	10,856
	Richton Park	13,646
	Romeoville	39,680
	Sandwich	7,421
	Somonauk	1,893
	Sugar Grove	8,997

Tinley Park	56,703
Woodridge	32,971
Yorkville	16,921

3.2.4.3 Agricultural

There is no land suitable for large-scale farming operations within two miles of the GE tract. There are home gardens and some truck farms located near Plainfield and Joliet. Crops from truck farming in this area are generally for local consumption. Most farming operations raise corn, soybeans and grains. There is some farming and beef cattle grazing on the land directly south of the site. There may be some farming and beef cattle grazing permitted on the GEH-MO tract under a lease arrangement. The closest dairy herd is about seven miles south.

3.2.4.4 Recreational

Principal recreational activities in the area include swimming, boating, hunting and fishing. Most activities involve the Kankakee River and the "finger lakes" which have been left from earlier strip-mining operations. Goose Lake Prairie State Natural Area is located to the west of the tract. There is little sport activity, other than boating, on the Illinois and Des Plaines Rivers because of pollution of the Des Plaines River as it flows through the Chicago area.

3.2.4.5 Adjacent Waters

The only waters near the GE tract are the Kankakee and Illinois Rivers, DNPS cooling lake, Collins Station cooling lake, and small "finger Lakes”.

Exelon does not allow access to the Dresden cooling lake for recreational uses. A portion of the Collins Station cooling lake is managed by the Illinois Department of Conservation for fishing and waterfowl hunting. The Illinois Waterway, one of the major inland waterways, is adjacent to the DNPS site.

There are two small "finger lakes" about 2.5 miles south of the GE tract where homes have been built, while other lakes on which houses are being built are located about 3.5 miles southwest. Some houses are solely for recreational purposes.

3.3 NEARBY INDUSTRIAL, TRANSPORTATION AND MILITARY FACILITIES

None of the industrial, military, or transportation activities in the area present a credible hazard to the fuel storage facility nor to the transport of irradiated nuclear fuel. Fuel in storage is located well below ground level in a stainless steel-lined, reinforced concrete water basin, and held in stainless steel baskets latched in a supporting grid. Explosions or fires at "nearby"

industrial facilities would be too far away to have any influence on fuel in storage. Even the explosion of a passing tank truck would not affect the safety of stored fuel. Likewise, the structural characteristics of fuel casks and the nature of nearby activities result in minimum hazard to transportation of spent fuel.

3.3.1 Nearby Nuclear Facilities

The location and identification of nuclear facilities within 50 miles of GEH-MO site are shown in Table 3-2. The closest facilities are the DNPS Units 1, 2 and 3, located about 0.7 miles north of the GEH-MO stack. The combined radiological impacts from GEH-MO and DNPS are within requirements of 10 CFR 72.104 as indicated by calculations and environmental monitoring results. Calculated dose commitments from GEH-MO are a small fraction of the dose commitments from DNPS, even considering design basis accidents evaluated in Section 8.

Table 3-2

NUCLEAR REACTORS WITHIN 50 MILES OF GEH-MORRIS OPERATION

Type	Capacity (MWe)	On Line	Latitude	Longitude	Airline Miles to GE-MO	
BWR	200	1960	41°22’	88°14’	0.7	Dresden 1*
BWR	809	1970	41°22’	88°14’	0.7	Dresden 2
BWR	809	1971	41°22’	88°14’	0.7	Dresden 3
BWR	1,078	1983	41°21’	88°36’	20	LaSalle 1
BWR	1,078	1984	41°21’	88°36’	20	LaSalle 2
PWR	1,100	1986	41°16’	88°13’	10	Braidwood 1
PWR	1,100	1988	41°16’	88°13’	10	Braidwood 2

* Dresden 1 was shut down in 1978

3.3.2 Industrial and Military

The GE tract is near several industrial sites along the Illinois River (Figures 1-1 and 1-2). Most development is north of the Illinois River over 1 mile from GEH-MO. The development of the last few years is slowing as most suitable industrial sites are already occupied and Goose Lake Prairie State Natural Area now occupies most of the remaining land south of the river.

In addition to DNPS immediately to the north, other industry in a 6-mile radius of GEH-MO is listed in Table 3-3.

Table 3-3

INDUSTRIAL, TRANSPORTATION, AND MILITARY ACTIVITIES
(6-mile radius)

Installation	Function	Proximity
EXELON DNPP	Electricity	0.7 NE
Aeropres	Chemicals	1.3 mi NW
Reichold Chemical Plant	Resins and chemicals	1.6 mi NW
Lineage Logistics	Transportation Depot	4.2 mi SE
Alumax Mill Products	Aliminum sheet and coil	5.0 mi NW
Dupont Chemicals	Polystyrene plastic	5.0 mi ESE
Dupont Chemicals	Polystyrene plastic	4.6 mi ENE
Ineos Styrenics	Polystyrene plastic	5.0 mi ENE
ExxonMobil	Oil Refinery	5.3 mi ENE
Air Products & Chemicals	Chemical Gas Products	4.8 mi ENE
Dow Chemical	Chemicals	4.3 mi NE
Equistar Chemicals	Propane	3.5 mi NW
LyondellBasell	Chemical refinery	3.5 mi NW
Nouryon Surface Chemistry	Chemicals	3.6 NW
AkzoNobel	Paints	3.4 mi NW
Exxon-Mobil Oil Refinery	Petroleum Products	4.5 mi NE
Collins Power Station	Electricity generation (fossil-fired)	5.0 mi WSW
Chicago Aerosol	Chemicals	5.6 mi S
Bunge Loders Croklaan	Mfg of Oils & Fats	4 mi WNW

3.3.3 Transportation

One principal factor in the original selection of the GEH-MO site was the ready availability of excellent rail and highway access to all parts of the United States and water transportation that could be developed if required in the future.

Highway access to the tract is via a paved county road, known as Dresden Road, extending south from the DNPS site parallel to the GEH-MO tract and intersecting Pine Bluff Road (Figure 1-2). Pine Bluff Road (named Lorenzo Road in Will Country) runs in an east-west direction approximately 1 mile south of the GE tract boundary and provides access to I-55 approximately 4 miles east of the site, and Illinois 47 to the west. I-55 is a limited access highway between Chicago and St. Louis. Another limited-access highway, Interstate Highway 80, which traverses the State from east to west, is approximately 5 miles north of the GE lands and is accessible either from I-55 or from State Highway 47.

Railroad access to the tract is provided by a spur from the Elgin, Joliet and Eastern (EJ&E) Railway, through the DNPS site. The EJ&E is a belt line which circles Chicago from near Wisconsin on the north to Indiana on the east and connects with every major railroad serving Chicago. Through these connecting lines direct rail services to all parts of the United States are available.

There are no airports within 8 miles of the site and the closest major airports are Chicago O'Hare International Airport and Chicago Midway Airport, situated approximately 50 miles and 40 miles, respectively, to the north and northeast of the site. Commercial flights approach Chicago airports from the southwest, so that most flights pass to the west of the GEH-MO site. Data for aircraft flying the Visual Omni Range (VOR) - Joliet for the 37th busiest day (used for statistical purposes by the Federal Aeronautics Administration (FAA) to represent an above average day) in September 1979 are shown in Table 3-4.

Table 3-4

VOR - JOLIET FLIGHTS[a]
September 1979

Time Periods	Civilian Flights	Air Carriers
0800 - 1600 hrs.	124 (3000 - 9000 ft.)	111 10,000 ft. or above
1600 - 2200 hrs.	85 (same)	96 (same)
2200 - 0800 hrs.[b]	14	21

a. Track is about 3 miles west, 5 miles north of Minooka.
b Data for 2200-0800 hrs. is typical.

3.4 METEOROLOGY

The climate of Illinois is typically continental, with cold winters and warm, humid summers. There are frequent short-period fluctuations in temperature, humidity, cloud cover, wind speed and direction. Winds are controlled primarily by storm systems and weather fronts that move eastward and northeastward through the area. Southeasterly and easterly winds usually bring mild and wet weather. The southerly winds are warm and showery while westerly winds are dry with moderate temperatures. Winds from the northwest and north are usually cool and dry. Except for tornadoes, there are no severe weather extremes in the area[10,11,12].

3.4.1 Regional Climatology

Topography of the area is not significant in affecting regional climatology except for some localized fog situations related to the rivers, strip-mine lakes, and the DNPS cooling lakes. The land is commonly referred to as rolling prairie and is without significant topographical features. Even Lake Michigan, the topographical feature of the area having the most meteorological significance, has only a general effect on the region's climate, and no specific effect on GEH-MO.

3.4.1.1 Temperature and Precipitation

Temperature data for Morris, Illinois, is shown in Table 3-5. Annually, there are usually 28 days with temperatures above 90 °F occurring from May through October and 141 days with temperatures below 32 °F occurring from September through April. Average precipitation, including snowfall, and average snowfall data for Morris and Joliet, Illinois, are shown in Table 3-6[13]. The ANL record for June 1950 to June 1964 shows an annual average precipitation of 31.49 in. with a 24-hr maximum of 6.24 in. A maximum annual snowfall of 100+ in. was recorded during the 1978-79 winter[14].

Table 3-5

LOCAL TEMPERATURE DATA (°F) FOR MORRIS, ILLINOIS

Month	Average	Low	High
January	25.8[a]	-22	68
February	27.5[b]	-22	67
March	37.3	-19	82
April	50.2	17	90
May	61.2	25	103
June	70.8	34	106
July	74.9	41	109
August	73.3	49	107
September	65.9	26	103
October	54.9	14	92
November	40.1	-9	82
December	28.7	-22	64

[a] Record period of 29 years [b] Record period of 28 years

Table 3-6

NORMAL & EXTREME PRECIPITATION[a] & SNOWFALL (IN.) FOR MORRIS & JOLIET, ILLINOIS

Normal Precipitation Amounts

Element	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Precip (in)	1.58	1.64	2.46	3.75	3.87	4.22	4.34	3.92	3.14	2.70	3.00	2.44	36.96

Precipitation Extremes 1948-2001

Month	High (in)	Year	Low (in)	Year	1-Day Max (in)	Date
JAN	3.89	1950	0.05	1981	1.90	01-14-1995
FEB	5.59	1997	0.00	1987	2.75	12-21-1997
MAR	4.84	1954	0.26	1958	2.32	03-25-1954
APR	7.37	1975	0.53	1971	2.20	04-12-1954
MAY	7.62	1975	0.67	1992	2.73	05-10-1990
JUN	11.69	1993	0.38	1988	5.13	06-13-1981
JUL	17.37	1996	0.13	1991	13.60	07-18-1996
AUG	10.05	1972	0.47	1996	4.00	08-15-1958
SEP	13.20	1961	0.04	1979	3.67	09-01-1977
OCT	8.71	1954	0.16	1964	3.75	10-11-1954
NOV	8.18	1985	0.52	1999	2.54	11-18-1990
DEC	7.28	1982	0.27	1995	3.34	12-03-1982

[a] Amounts shown include equivalent inches of water for snowfall

3.4.1.2 Humidity and Fog

Average relative humidity in January is 85% at 8 a.m., 75% at noon and 80% at 8 p.m. (CST). Average relative humidity in July is 77% at 8 a.m., 55% at noon and 62% at 8 p.m. The 1% summer design wet bulb temperature is 78 °F[15].

Fog is more frequent in the region than at continental locations of similar latitude across North America. This is because of the influence of Lake Michigan, local rivers, and the DNPS cooling lake and related systems. The main physical processes causing radiation, advection, orographic and steam (ground) fog are evident in the region[16]. This natural fog occurs most frequently and persists the longest in winter. On the average, dense fog (visibility less than 0.4 km) occurs during less than 15% of the 300 to 450 hours of winter fog. Dense fog is recorded most frequently in the early morning. Winter fog occurs most frequently with temperatures between 14 °F and 40 °F and summer fogs with temperatures between 59 °F and 69 °F. Dense fog in winter occurs almost exclusively with surface saturation deficits of 0.5g per kilogram day air or less[17].

The closest meteorological station that has collected fog data is the Joliet Municipal Airport (about 12 miles NNE). Meteorological observations, representing 99,165 hrs. (about 11 years) indicate that a total of 12,284 hrs. (12.4%) of fog with visibilities of 6 miles or less occurred at the airport. Dense fog having "zero" visibility (less than 330 feet) occurred 0.25% of the time, or about 23 hours per year. These critical cases occurred most often in winter, least in summer (most often in January and least in June) and most often in the early morning hours (0500-0900 CST). The "zero" visibility fogs had a median persistence of up to 3 consecutive hours. However, one occurrence lasted for 12 consecutive hours, with an estimated reoccurrence in 10-20 years[18].

3.4.1.3 Tornadoes

Over a 19-year period (1991 – 2010), there was an average of 54 tornadoes per year in Illinois, which is close to the average for all states east of the Rocky Mountains.

Several tornadoes have been reported near the DNPS site since 1965. On November 12, 1965, a tornado passed 4 miles west of the site while moving toward the east-northeast at approximately 70 mph. Several electrical transmission lines to the site were interrupted and, as a result, DNPS Unit 1 was shut down for about 24 hr. A second tornado, on May 24, 1966, passed near the site resulting in one transmission line being lost. However, the load was carried by other electrical transmission lines, and DNPS Unit 1 operated normally. On July 17, 1972, a tornado passed northwest of the GEH-MO site, and on April 3, 1974, a tornado touched down just north of Morris, Illinois. While tornadoes have been reported near GEH-MO (10 events from 2000 – 2019 in Grundy county), no damage to the site has occurred.

3.4.2 Local Meteorology

Data and sources of data for site temperature, water vapor, precipitation and fog conditions are contained in Section 3.4.1.

3.4.2.1 Wind Data

Annual wind frequencies show a rather uniform distribution of wind direction (Figure 3-8). The most frequent wind directions are from the west and south sectors (based on 22.5 degree sectors). Average wind speed at the 300 ft. level is about 15 mph and at the 125 ft. level is about 11 mph. These observations are based on 1968 data taken from the DNPS meteorological tower. Maximum wind velocity reported in the area of the site is 109 mph, unofficially reported at Joliet on April 3, 1956, and on April 30, 1962, as the fastest gust during heavy thunderstorms and scattered tornadic activity. The fastest windspeed reported at various locations in the site area is 87 mph at Chicago and 75 mph at Peoria[20].

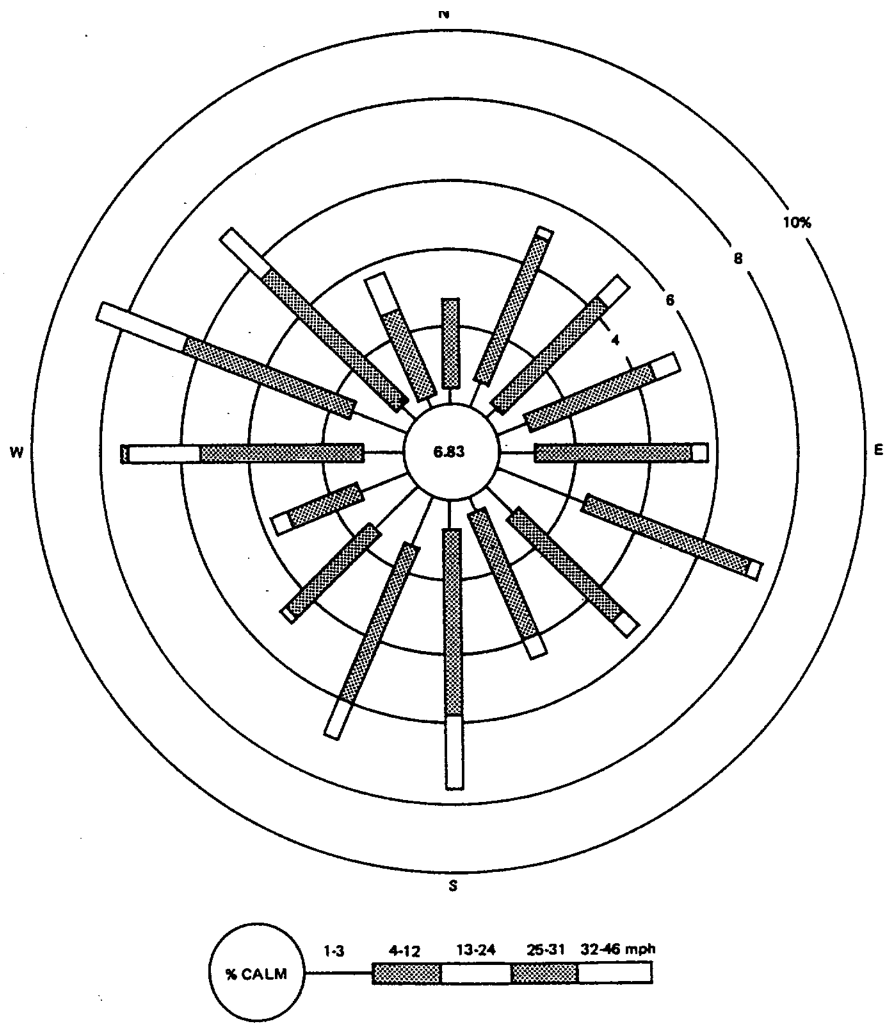


Figure 3-8. Annual Wind Rose at 35 foot Level at DNPS Site.

3.4.2.2 Topography

The only major topographic influence in the area is Lake Michigan, which is 45 miles to the northeast and is considered to have an insignificant effect on site climatology. The only potentially significant topographical features around the site are the Dresden Heights, located on the north side of the Des Plaines River, about 1.5 miles northeast of the site ventilation stack. These bluffs rise to an elevation of 630 ft., compared to the elevation at the site of 530 ft. Since the stack extends 300 ft. above the grade, the perturbation in the flow of the plume over the bluffs located some 1.5 miles away is quite small.

These bluffs are the only significant topographical features near the GEH-MO site or, in fact, in most of northeastern Illinois. The only other topographical disturbances in the area are spoil piles, which remain from abandoned strip mines. These are located farther from the site and are not as high as the bluffs across the river. The highest topographical elevation in Illinois is Charles Mound, elevation 1,241 ft., located on the Illinois-Wisconsin border. The average elevation of the state is 600 ft.

3.4.2.3 Electrical Storms

Thunderstorm activity in the Chicago area for the years 1970 through 1975 is presented in Table 3-7 in terms of thunderstorm days per month. The incidence of thunderstorms over a 33 year period is about 39 per year[21].

Table 3-7

THUNDERSTORM ACTIVITY

			YEAR				33 Year
Month	70	71	72	73	74	75	Average
1	0	0	0	0	0	4	<0.5
2	0	1	0	1	0	1	<0.5
3	2	4	5	4	7	4	3
4	10	3	6	4	7	8	5
5	10	6	5	4	8	9	5
6	9	10	7	10	10	13	7
7	10	9	7	7	6	7	6
8	7	4	8	3	4	9	5
9	11	4	6	6	3	3	4
10	3	2	1	4	1	2	2
11	1	2	0	3	0	3	1
12	1	2	1	1	1	3	1

Total	64	46	46	47	47	66	39

3.4.3 On-Site Meteorological Measurement Program

In late 1967, a 400 ft., fully instrumented meteorological tower was placed in operation at the DNPS site. Actual data collected at levels from 35 ft. above ground to 400 ft. above ground has verified favorable atmospheric diffusion conditions exist at the site. Data obtained from the tower during the first year of operation was correlated hour for hour with atmospheric stability measurements taken at ANL and applied on a preliminary basis to calculations for Dresden reactors. Since ANL is not too distant (27 miles northeast), and located in similar terrain, the two locations are climatologically similar and joint use of data from the two sites is a valid technique.

Meteorological data used to model dispersion characteristics of gaseous emissions from GEH-MO are based on data collected from 1971 through 1993 at the Dresden meteorological tower.

3.4.3.1 Diffusion Climatology

Hourly wind direction variability at the site shows that average direction range (angular change in direction) is 120 degrees in a 1 hr. period, for all wind speed conditions combined. During 0-3 mph wind speeds, the average range in direction is 100 degrees. Approximately 87% of the time when the wind speed is 0-3 mph (or 98.3% of all wind speeds) the wind direction range is 60 degrees or more, which corresponds to a value of the diffusion parameter ($\sigma_\theta u_h$) of 20 degree-mph or 0.16 radian-meter per sec.

Environment surveys of the site and surrounding areas conducted by CECo, ANL, and the State of Illinois show that meteorological diffusion characteristics would cause a dispersion of small amounts of effluent emitted during normal operation to a degree such that these effluents have been undetectable off-site.

3.4.3.2 Wind Speed, Direction and Atmospheric Stability

At the 400 ft. meteorological tower on the adjacent DNPS site, wind speed, direction and persistence are measured at the 35 ft., 150 ft. and 300 ft. levels. In addition, temperature measurements are made at the same levels and dewpoint temperatures are recorded at these levels continuously. A weighing-bucket rain gage is used to measure precipitation. An example of winds at the site is shown in Figure 3-8[22], which is an annual wind rose for the 35 ft. level.

Dresden 1971 through 1974, 150 ft. wind data has been used to estimate dispersion rates and calculate radiation doses from GEH-MO. Table 3-8 shows relative frequency of winds from a given direction by Pasquill stability classes. Variability of the 300 ft. wind direction is determined by computing standard deviation of the most recent 60 wind direction values (one value is reported each minute). The 300 ft. to 35 ft. differential temperature was used to determine the stability class. One year of wind data (1974) was used to prepare the table, with a data recovery rate of 85.0%.

Table 3-9 gives the frequency of each stability class and average wind speed at 150 ft. for that class, based on the 1974 data.

Table 3-8

JOINT FREQUENCY DISTRIBUTION OF PASQUILL

STABILITY CLASS AND WIND DIRECTION, DRESDEN

150-foot level

(percent of total observations)[a]

Class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	TOTAL	Number of Observations
A	0.08	0.01	0.03	0.01	0.04	0.04	0.04	0.05	0.19	0.15	0.24	0.21	0.27	0.09	0.05	0.07		1.58	118
B	0.46	0.20	0.11	0.24	0.50	0.52	0.46	0.60	0.71	0.75	1.38	0.83	0.75	0.48	0.35	0.60	0.08	9.03	673
C	0.56	0.35	0.16	0.27	0.68	0.82	0.64	0.87	0.98	1.48	0.98	0.78	0.60	0.60	0.43	0.38	0.04	10.63	792
D	2.70	2.63	2.54	2.74	3.41	3.05	3.29	4.44	6.27	6.01	4.31	3.76	4.87	5.25	4.20	2.74	0.09	62.30	4641
E	0.21	0.12	0.13	0.16	0.19	0.27	0.20	0.23	0.30	0.36	0.40	0.21	0.31	0.46	0.50	0.27	0.00	4.32	322
F	0.28	0.17	0.26	0.12	0.09	0.21	0.31	0.17	0.26	0.46	0.19	0.27	0.15	0.51	0.36	0.38	0.00	4.19	312
G	0.59	0.62	0.72	0.50	0.36	0.51	0.34	0.35	0.27	0.52	0.48	0.26	0.46	0.82	0.50	0.64	0.01	7.95	592
Total	4.88	4.10	3.95	4.04	5.27	5.42	5.28	6.71	8.98	9.73	7.98	6.32	7.41	8.21	6.39	5.08	0.22	100	7450

[a] 7450 valid observations

Source: Joint wind speeds and frequency reported for the year 1974 at the Dresden Nuclear Power Station meteorological tower.

Table 3-9

STABILITY, FREQUENCY, AND WIND SPEED

Class	Frequency (%)	Wind Speed (mph)
A	1.58	7.7
B	9.03	8.8
C	10.63	9.8
D	62.30	12.8
E	4.32	12.6
F	4.19	13.6
G	7.95	13.4

	As Planned	As Operated
Stack Height	300 ft (91 m)	300 ft (91 m)
Discharge Volume	25,000 cfm	14,000 cfm

3.4.4 Atmospheric Diffusion Characteristics

A general discussion of techniques used in calculating atmospheric diffusion characteristics and the resulting off-site doses from normal operation of GEH-MO is given in Appendix A-3. These same methods and characteristics have been applied to nearby Dresden reactors[23]. Application of these methods for GEH-MO is described below and in Section 7.

Diffusion calculations are based on annual wind direction, frequency, and stability distribution around the stack. Exposures and concentrations are calculated for all areas off-site from the plant based on actual site meteorology, thus ensuring that points with the highest potential exposures and concentrations are identified. These calculations extend to distances of several miles from the site, providing a good profile of the distribution of the dose versus location and distance from the site.

The height of release of effluent is the physical stack height plus effluent rise due to momentum. No credit was taken for possible thermal buoyancy of the plume. The stack and ventilation system design characteristics used in the analysis are listed below.

Meteorological data used in calculating doses and concentrations from radioactive materials released via the stack are a combination of data gathered at the Dresden site and data taken at ANL. Wind speed and direction data taken at the Dresden site were used in the calculation. Atmospheric stability measurements taken at ANL were correlated hour for hour to determine joint wind frequency, stability and velocity distribution at the site.

Data obtained from the GEH-MO/DNPS tower during the first year of operation was correlated and applied on a preliminary basis to calculations for the Dresden reactors. These meteorological data verified the validity of the earlier approach and indicated that application of site data to calculation of maximum effects from releases would reduce calculated effects. Since actual data gathered served to verify the approach which had been taken earlier, calculations were not repeated[24]. In summary, data collected from the meteorological tower at the Dresden site verifies predicted excellent atmospheric diffusion characteristics typical of the northern Illinois site.

3.4.4.1 Meteorological Diffusion Evaluation

Radiological effects of stack releases were evaluated at six points in the atmospheric diffusion spectrum, which should encompass conditions encountered at GEH-MO. These are: (1) poor diffusion conditions caused by inversion (stable), at a wind speed of about 1 m/sec., typical of warm nights; (2) very stable and moderately stable conditions; (3) better diffusion conditions, typical of daytime, represented by neutral and unstable (lapse) diffusion, both at wind speeds of 1 m/sec. and 5 m/sec. Atmospheric diffusion methods reported by Watson and Gamertsfelder[25] and calculations for the site are described in Appendix A.

3.5 SURFACE HYDROLOGY

3.5.1 Surface Features and Drainage Patterns

GEH-MO is located in the Illinois River Drainage basin, just south of the DNPS in eastern Grundy County, Illinois (Figure 1-1). The Kankakee River is 0.5 miles east of the site, flowing north until it meets the Des Plaines River 2 miles northeast of the site.

The two rivers join to form the Illinois River which flows west and south about 270 miles to the Mississippi. The GEH-MO site is on a relatively high area about 30 ft. above normal pool level in the Kankakee River and between the flood plains of the two rivers.

The Illinois River and its tributaries are the primary surface water resources near the site. The Illinois and Des Plaines Rivers form part of the Illinois waterway which is a series of eight navigable pools (with the headwaters above a lock and dam) extending 327.2 miles from its confluence with the Mississippi River at Grafton, Illinois to the Chicago River outlet at Lake Michigan. The Illinois River is the stretch of the waterway from the confluence of the Kankakee

and Des Plaines Rivers to the Mississippi River. The stretch of the Illinois River north of the site is part of the Dresden Island Pool of the waterway and includes the Dresden Island Lock and Dam which is almost due north of the site.

The Illinois River and tributaries drain an area of 32,081 square miles. The river is unique in the sense that during dry weather (low flow) its headwaters are essentially treated liquid wastes from about 5.5 million people and various industries in the metropolitan Chicago area mixed with water diverted from Lake Michigan.

Approximately 1.5 miles southeast of the GEH-MO site, Exelon constructed a 1,275-acre cooling lake for DNPS. The intake/discharge flumes are located along the east boundary of the GE tract. The lake is confined by an encircling earth dam (or berm) with the top of the dam at an elevation of 527 ft. The elevation of the cooling lake is approximately 522 ft. No recreational use of this lake is planned.

A series of small marshes and ponds, primarily located in the Goose Lake Prairie Preserve, comprise the remaining surface water of the area. The ponds are approximately 1.5 miles southwest of the GEH-MO boundary.

3.5.1.1 Stream Flows

Stream flows on the Illinois Waterway fluctuate significantly due to seasonal effects and water flow regulation by means of Lake Michigan diversion and the lock-and-dam system. For example, on September 20, 1971, flows in the Dresden Pool dropped to 2,400 cfs from about 17,000 cfs on the preceding day. Average flow rate over the period 1921 to 1945 measured at Marseilles (20 miles downstream of the Dresden Pool) was 12,050 cfs (5,400,000 gpm). A 7 day 10 year low flow of 3,300 cfs was determined from data collected from 1940 to 1965 at Marseilles. A maximum flow of 93,900 cfs occurred at Marseilles in April of 1957. The flow of the Illinois River at Marseilles is greater than 3,000 cfs 98% of the time. The average flow of the Illinois River (1920-1963) at Dresden Island Lock and Dam was approximately 10,900 cfs.

The normal pool elevation in the Illinois River, controlled at the Dresden Island Lock and Dam, is 505 ft., with a maximum historical flood elevation of 506.4 ft. (1957). The estimated maximum flood elevation is 520 ft.; the GE-MO site elevation is higher than 532 ft. Spillway capacity at the Dresden Island Lock and Dam is well in excess of the estimated maximum instantaneous flow of the Illinois River (1,000,000 cfs, based on the assumption that maximum flows for all contributory streams occur simultaneously). The site elevation is well above the valley storage upstream from the dam.

Compared to the Illinois River, the Kankakee River is a relatively small river, with an average flow rate of 3,810 cfs (1,710,000 gpm), a minimum of 204 cfs (91,600 gpm), and a maximum of 75,900 cfs (measured at Wilmington, Illinois).

3.5.2 Site Flood Potential

The highest flood of record in the region occurred in 1957 and involved flows of less than 100,000 cfs, and created far below the 532 ft. minimum elevation of the GEH-MO site as referenced to mean sea level. A study has been performed to develop rating curves for discharges of up to 600,000 cfs where the water level would rise to less than 520 ft. or more than 10 ft. below the GEH-MO site. This study is summarized in Appendix A.6.

There are no other credible flood situations affecting GEH-MO.

3.5.3 Surface Water Quality

Agricultural activity, boat traffic, and dredging have increased the Illinois River silt load over the past years and keep it in a continuously turbid condition. Water quality data collected at Morris, Illinois, including temperature and dissolved oxygen values, are presented in Table 3-10.

The Kankakee is usually several degrees cooler than the Illinois (see Table 3-11) and is not disturbed by barge traffic or dredging, as is the Illinois. These are probably the major factors for the existence of a more diverse fish population in the Kankakee than in the Illinois. Water quality of the Kankakee is not spectacularly better than that of the Illinois, however, and in some aspects is even poorer (compare Table 3-10 and Table 3-11) based on data from the sampling station on the Kankakee I-55 bridge.

Table 3-10

CHARACTERISTICS OF THE ILLINOIS RIVER AT MORRIS, ILLINOIS[a]

PARAMETER	1957 - 1971 Range	Average	1990 - 1993 Range	Average
Water Temperature (°C)	1.1 - 29.4	15.6	0.7 - 26.9	13.3
Turbidity (mg/l)	16 - 330	67	0.3 - 150.0	24.6
Dissolved Oxygen (mg/l)	N/A	N/A	6.1 - 14.2	10.0
Alkalinity (mg/l)	96 - 208	174	104 - 206	160
Hardness (mg/l)	144 - 388	283	201 - 347	273
Total Suspended Solids (mg/l)	N/A	N/A	412 - 580	447.5
Chloride (mg/l)	23 - 162	58	42 - 110	67
Sulfate (mg/l)	11 - 125	48	51 - 125	75
Nitrite & Nitrate (mg/l) as NO_3	0 - 35	6	2.60 - 7.80	4.64
Ammonia (mg/l) as N	0 - 11	3.9	0.05 - 0.80	0.31
Total P (mg/l) as PO_4	0.1 - 37.0	3.8	0.22 - 0.57	0.35
pH	7.2 - 8.2	7.6	6.1 - 13.7	7.60
Fluoride (mg/l)	0.4 - 2.1	0.9	0.22 - 0.54	0.33
Dissolved Iron (μg/l)	0 - 500	100	23 - 5K	61
Specific Conductivity (μmhos)	410 - 1050	700	540 - 933	729
Fecal Coliform/100 ml	10 - 2000	977	60 - 4900	1094
Totals Dissolved Solids (mg/l)	250 - 670	448	332 - 927	448

[a] Compiled from Water Quality Network, 1971 and 1993, Illinois EPA

Table 3-11

CHARACTERISTICS OF THE KANKAKEE RIVER AT WILMINGTON, ILLINOIS[a]

PARAMETER	**1957 - 1971**		**1990 - 1993**	
	Range	**Average**	**Range**	**Average**
Water Temperature (°C)	0.6 - 30	13.9	0.7 - 26.0	13.1
Turbidity (mg/l)	1 - 400	58	2.5 - 210.0	29.0
Dissolved Oxygen (mg/l)	5.4 - 14.6	10.1	5.0 - 13.0	9.4
Alkalinity (mg/l)	116 - 220	178	104 - 228	184
Hardness (mg/l)	116 - 576	308	208 - 382	307
Total Suspended Solids (mg/l)	N/A	N/A	7 - 188	42.0
Chloride (mg/l)	9 - 56	21	17 - 33	24.3
Sulfate (mg/l)	20 - 152	78	35 - 123	82.3
Nitrite & Nitrate (mg/l) as NO_3	0 - 24	6	0.5 - 8.4	4.80
Ammonia (mg/l) as N	0 - 10.1	1.0	0.01 - 0.20	0.07
Total P (mg/l) as PO_4	0.0 - 10.0	1.1	0.04 - 0.39	0.12
pH	7.1 - 8.8	7.9	6.9 - 9.1	7.80
Fluoride (mg/l)	0.0 - 0.4	0.2	0.11 - 0.23	0.18
Dissolved Iron (μg/l)	0.0 - 12.0	1.1	5 - 5K	56.6
Specific Conductivity (μmhos)	N/A	N/A	432 - 773	615
Fecal Coliform/100 ml	10 - 800,000	31,848	10 - 2,750	136.6
Totals Dissolved Solids (mg/l)	170 - 530	362	N/A	N/A

[a] Compiled from Water Quality Network, 1971 and 1993, Illinois Environmental Protection Agency

3.6 SUBSURFACE HYDROLOGY

3.6.1 Regional and Area Characteristics

Groundwater in northeastern Illinois is drawn from four aquifer systems:

a. Sand and gravel deposits in the glacial drift;

b. Shallow dolomite formations mainly of the Silurian age;

c. Cambrian-Ordovician aquifers of which the Ironton-Galesville dolomite and the Galena-St. Peter sandstones are the most productive formations; and

d. The Mt. Simon aquifer consisting of the sandstone of the Mt. Simon and lower Eau Claire formations of the Cambrian age.

In the vicinity of GEH-MO, glacial drift thickness ranges from none, with outcropping bedrock, to at most a few feet of drift. There is no evidence of the Silurian dolomite. As a result, groundwater in the vicinity of the site is drawn from the Cambrian-Ordovician aquifer which is used almost exclusively as the groundwater supply for municipal and industrial use in the area.

Glacial drift in the area is underlain by the Pennsylvanian-Spoon formation sandstone, or the Ordovician-Fort Atkinson limestone, or both. Beneath these formations and directly over the Cambrian-Ordovician aquifers is a layer of Ordovician-Maquoketa shale approximately 65 ft. thick. The top of the Cambrian-Ordovician aquifers at the site is approximately 100 to 150 ft. beneath the surface and the piezometric surface of the Cambrian-Ordovician aquifers is about 100 ft. further down. The major source of near-surface groundwater in the area is from rainfall, which seeps down through the alluvial overburden and upper strata of weathered and fractured rock to collect over relatively impermeable areas (clay seams, underlying shale).

3.6.1.1 Water Quality

Water from the glacial drift and Silurian dolomite aquifers ranges in hardness from 100 to 1,000 ppm, although the majority of samples analyzed for hardness ranged from 100 to 450 ppm. Temperatures range from 46 °F to 54 °F (Suter, et al., 1959). Hardness of water from the Cambrian-Ordovician aquifers ranges from 260 to 880 ppm. Both hardness and temperature increase eastward, and water quality noticeably deteriorates south of the Illinois River (Suter, et al., 1959). Mt. Simon waters are of poor quality in this region because of their brackish nature. This characteristic increases rapidly eastward across northeastern Illinois.

3.6.2 Site Characteristics

Geological structure under the GEH-MO site is typical of the region, presenting no anomaly significant in hydrological considerations. In general, the upper 10 to 20 ft. of Fort Atkinson Limestone has high but variable permeabilities with permeabilities decreasing to less than 100 ft. per year near the base of the formation.

Water-level measurements from piezometers installed in the Fort Atkinson, Scales, and Galena formations indicate that the Scales Shale acts as an effective aquitard between the Fort Atkinson Limestone and the dolomite of the Galena group.

The historical record of groundwater variations within the Galena Dolomite (the upper unit in the Cambrian-Ordovician aquifer) shows a cone of depression has developed near Joliet and that the piezometric surface has dropped over 100 ft. from 1915 to 1958 to an elevation of about 400 ft. above mean sea level.

While the regional piezometric surface of the Galena at the present time is unknown, the number of wells, which penetrate this aquifer has increased since 1958 and it is probable the surface has further dropped. During drilling of the water supple well on the GE-MO site in 1968, the static water level within the Galena Dolomite was at about 370 ft. while the static water level of the Cambrian-Ordovician aquifer as a unit was at about 395 ft. The piezometric level in the Fort Atkinson Limestone parallels the ground surface, is 3 to 5 ft. deep and reacts rapidly to precipitation. The piezometric level in the Scales Shale is also near the ground surface but reacts slowly to precipitation.

During LAW Vault construction, serious groundwater intrusion problems were encountered. The results of the investigation[26] indicated a complex groundwater system with several potential sources:

a. direct percolation from rainfall and runoff;

b. lateral seepage and flow from perched or confining zones in response to percolation from rainfall; and

c. lateral flow along joints, faults or fractured rocks.

3.6.2.1 On-Site Well

There is a single deep well on site into the Cambrian-Ordovician aquifer and is equipped with a 100 gpm submersible vertical turbine pump. Principal use of water from this source is potable, sanitary and basin makeup water. Well water could also be used for firefighting. Characteristics of water from this well are contained in Table 3-12 & 3-13.

There is no release of liquids from GEH-MO to potable ground water since site structures do not penetrate any principal aquifers. Even a major rupture of concrete basin walls could impact only on local on-site sample wells and would not penetrate to the Cambrian-Ordovician strata. (See Sec 8 and B.12, Ground Water Investigations by Dames & Moore, dated August 1977.)

3.6.3 Groundwater Investigation - 1977

As a part of a study of potential expansion of GEH-MO facilities, a groundwater investigation was conducted in the spring and summer of 1977 by Dames and Moore[27]. The study included:

a. A review of previous site investigations
b. A review of literature
c. Evaluation of site boring data, groundwater level data, and pressure testing results
d. Evaluation of groundwater regime in the site area
e. Evaluation of groundwater movement and use at the site and in the region

Conclusions from this study (August 1977) are consistent with past studies, showing good availability of water for plant operations with negligible impact on aquifer performance. The more detailed analysis of permeabilities performed under this study further emphasize the suitability of the site for basin storage of irradiated fuel.

Table 3-12

WATER ANALYSIS - MORRIS OPERATION WELL

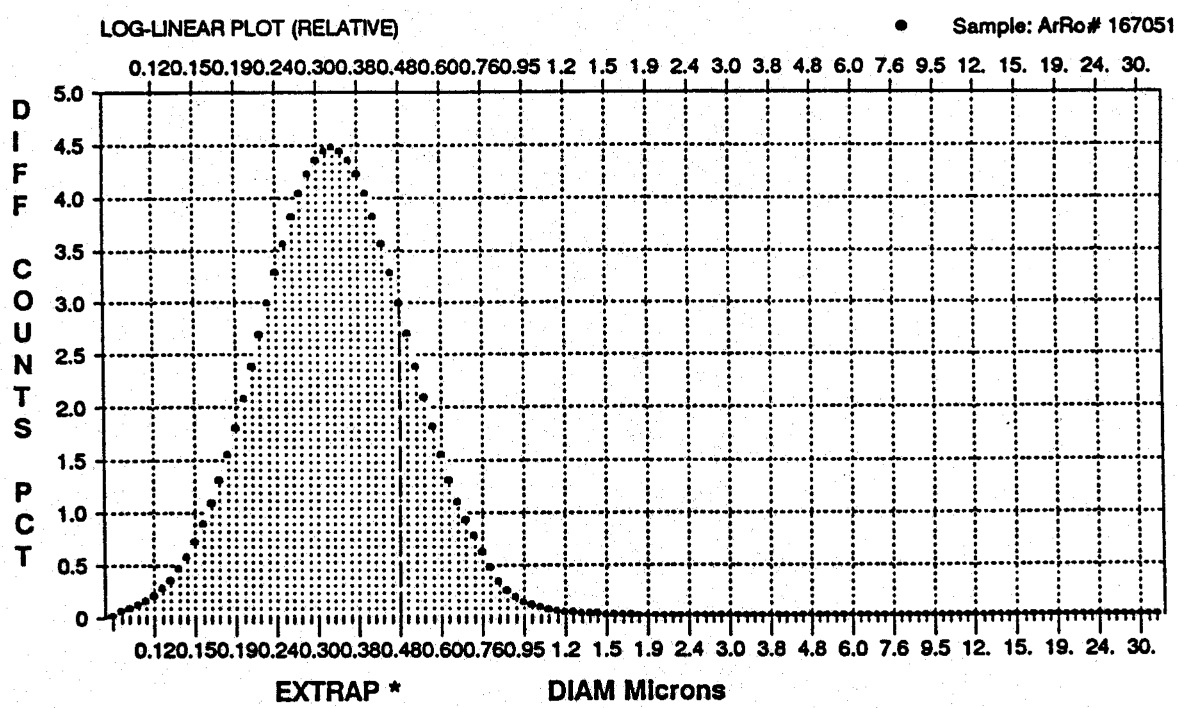
Material	**Parts per Million**
Chloride	100 ± 10
Nitrate	4.2
Iron	< 0.4
Silica (as Silicon)	5
Sulfate	225
Calcium	58
Magnesium	25
Sodium	159
Phosphate	None Detected
Manganese	< 0.1
Sulfide	None Detected[a]
Bicarbonate	295
Potassium	16
Tin	3
CO_2	11.6
pH	8.0
Conductivity	1.1 x 10^4 mhos/cm
Dissolved Solids	706
Total Suspended Solids	5
Turbidity	0.3[b]
Total Organic Carbon	2.8

[a] As much as 2.2 ppm H_2S (expressed as $CaCO_3$ equivalents) was present in 1968.

[b] NTU Units

Table 3-13

MICROSCOPIC PARTICLE SIZE DISTRIBUTION – MORRIS OPERATION WELL WATER



Geometric Mean Size:	0.333 um
Geom. Std Deviation:	1.517 um
Geom. Skewness:	0.002
Geom. Coeff Variation:	455.6
Arithmetic Mean Size:	0.364 um
Median Size:	0.324 um
Mode Size:	0.330 um
Kurtosis:	24.791
Arith Std Deviation	0.176 um

-- PERCENTILES --

0.100% Counts above 1.745 um
1.000% Counts above 0.907 um
6.000% Counts above 0.633 um
22.00% Counts above 0.456 um
50.00% Counts above 0.331 um
78.00% Counts above 0.241 um
94.00% Counts above 0.175 um
99.00% Counts above 0.130 um
99.90% Counts above 0.104 um

Source: Analysis by ARRO Laboratories, Inc., Joliet, Illinois.

3.7 GEOLOGY AND SEISMOLOGY

3.7.1 Geologic Studies

Geologic studies of the site have been performed by Dames & Moore. Studies were also performed by these consultants for DNPS and for the MFRP facilities. These studies are listed in Table 3-14. Reports of recent investigations, unique to fuel storage at GEH-MO, are noted in Table 3-14 and are contained in the microfiche packet (Appendix B).

Table 3-14
MORRIS OPERATION SITE INVESTIGATIONS

M Report, Site Evaluation Study, Phase I - Part 1, Proposed Dresden Unit 2, Grundy County, Illinois, For General Electric Company Dated: April 13, 1965

M Report of Foundation Investigation, Proposed FRO Plant Project, Near Morris, Grundy County, Illinois, For General Electric Company Dated: December 13, 1967

Report, Subsurface Water Investigation, FRO Plant Project, Morris, Illinois, Fluor P.O. 4204-0-014, For General Electric Company Dated: February 25, 1970

Report of Drainage Well Pumping Tests, FRO Plant Project, Midwest Fuel Recovery Plant, Near Morris, Illinois, For General Electric Company Dated: January 11, 1971

M Report, Fault Investigation, Midwest Fuel Reprocessing Plant, Near Morris, Illinois, For General Electric Company Dated: October 1, 1974

M Report, Geological and Ground Water Investigation, Proposed Spent Fuel Storage Facility, Near Morris, Illinois, For General Electric Company Dated: September 3, 1975

M Letter Report, Evaluation of Foundation Recommendations, Project IV - Fuel Storage Capacity Expansion, Near Morris, Illinois, For General Electric Company Dated: May 12, 1977

M Report, Geophysical Investigations, Project IV - Fuel Storage Capacity Expansion, Near Morris, Illinois, For General Electric Company Dated: June 10. 1977

M Report, Ground Water Investigations, Project IV - Fuel Storage Capacity Expansion, Near Morris, Illinois, For General Electric Company Dated: June 17, 1977

Report, "Proposed Approach for Evaluate the Adequacy of Ground Water Monitoring System at Nuclear Spent Fuel Storage Plant - Morris, Illinois, Grundy County for General Electric Company" Dated: February 10, 1993

Report, "Groundwater Modeling and Specifications for Monitoring Wells at Morris, Illinois Operation for General Electric Company" Dated: August 18, 1993

Report, "Preliminary Estimates of Evaporation From Fuel Storage Basin at Morris, Illinois Facility for General Electric Company" Dated: September 29, 1993

Report, "Transport Modeling for Accidentally Released Water from Spent Fuel Storage Basin at Morris, Illinois Facility of General Electric Company" Dated: October 26, 1993

Report, "Groundwater Monitoring Well Network Summary and Installation Report – Morris, Illinois Facility for General Electric Company" Dated: January 28, 1994

Report, "Well No. DM-8, Groundwater Monitoring Well Network Installation Report, Morris, IL Facility, General Electric Company" Dated: January 4, 1995

M – Microfiche in Appendix B
Source : Dames & Moore, Consultants – Environmental and Earth Sciences, Park Ridge, Illinois

3.7.2 Regional and Tract Geology

The GE tract is situated in the Morris Basin, a relatively low area of slight topographic relief. Elevations range from 532 ft. on the site to about 500 ft. at the Illinois River bottom. The general appearance varies from flat to very gently rolling with slopes greater than 3% being rare. Surface topography is characterized by very shallow topsoil, with frequent outcroppings of bedrock. Dresden Heights is the dominant topographical feature and is located on the north side of the Des Plaines River about 1.5 miles northeast of the tract. Elevation of these bluffs is 630 ft. There are vestiges of abandoned strip mines in many parts of the area.

Regional structures in north and northeastern Illinois trend northwesterly and are characterized by asymmetrical folds with steep southwestern limbs and by vertical faults and joints that trend northwesterly. Fracture sets trending northeasterly also occur. Major regional geologic structures around the tract are shown in Figure 3-9.

A major structural zone of the underlying Illinois Basin is the LaSalle Anticlinal Belt, a north-northwesterly trending band of en echelon folds. Within the northern two-thirds of the basin this folded zone separates the shallow eastern shelf of the basin from the larger and deeper western shelf. The rocks of the eastern shelf - the area of the GE tract - are nearly flat-lying. Initial deformation along the LaSalle Anticlinal Belt began in the northern end during the post-Mississippian, pre-Pennsylvanian period, and migrated southward with time[28].

Cambrian and Lower Ordovician rocks are exposed along the trend of the Ashton Arch, an anticline that merges with the northern portion of the LaSalle Anticlinal Belt. Uplift along the Ashton Arch was at least post-Silurian, probably occurring in the same period as along the LaSalle Anticlinal Belt[29].

The Ashton Arch is bounded to the north by the Sandwich Fault Zone, trending west-northwest across northern Illinois to within 6 miles of the Morris site. It is mapped on the surface and

subsurface for nearly 90 miles. The fault zone is essentially vertical, with the northeastern block downthrown a maximum of 900 ft. by the main fault, with numerous associated short faults near the northwestern end. The throw decreases toward the southeastern end of the zone and a scissors effect causes the southwestern block along a subsidiary fault to be downthrown more than 100 ft.[30]. Movements along the Sandwich Fault Zone are dated as post-Silurian, pre-Pleistocene, but major movements along the fault may have occurred when the LaSalle Anticlinal Belt was uplifted in post-Mississippian, pre-Pennsylvanian time[31].

The attitude of folds and faults in the region indicate that compressive forces acted along northeast-southwest lines during deformation in the Paleozoic Era. Extension fractures from parallel to maximum compression and shear fractures are symmetrically inclined (angles less than 45 degrees) about the compressive force axis. Such fracturing has been mapped at the DNPS site by the Illinois State Geological Survey[32].

The locations of these faults and others between the LaSalle Anticlinal Belt and the Sandwich Fault provide strong evidence of direct relationship between faults mapped adjacent to the Morris site and regional structures[33].

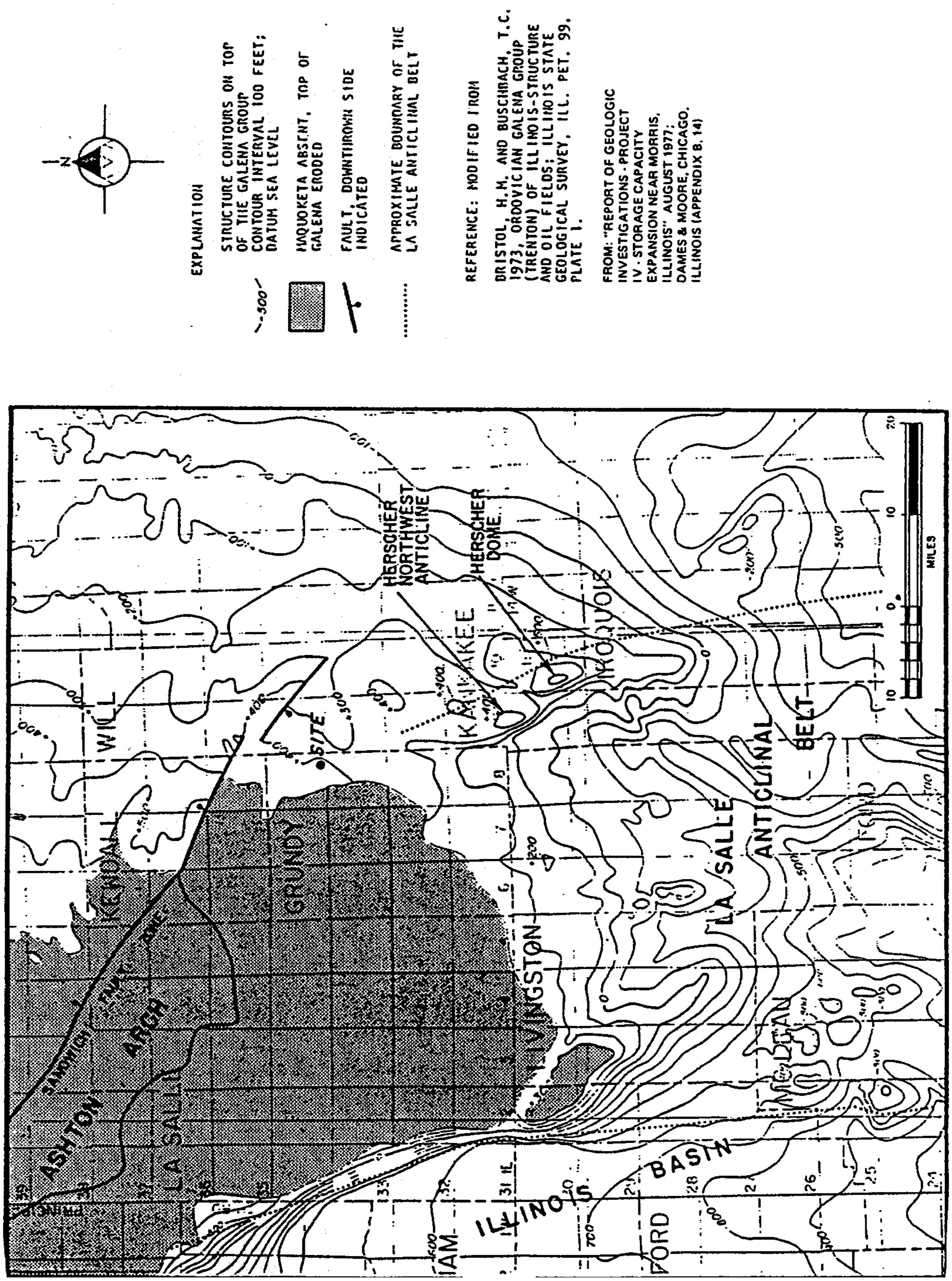


Figure 3-9. Major Regional Geologic Structures

3.7.2.1 Site Geology

Stratigraphy was determined by test borings and trenching performed during several geologic studies[34] of the area, with the most recent study completed in August 1977. The spatial relationships found at the site are complex, but can be explained in terms of glacial erosion, deposition, and post-glacial erosion. The generalized stratigraphic column for GEH-MO (Figure 3-10) consists of an upper layer Spoon Formation sandstone of varying thicknesses, underlain by Fort Atkinson Limestone about 46 ft. thick. Scales formation shale is beneath the limestone. The site is overlain with a thin topsoil. The Ordovician system has a thickness of about 1,000 ft., overlaying the Cambrian system. Brecciated rock is found in some cross sections, indicating ancient faulting.

Surface drainage is rather poor since the bedrock surface is undulating and entraps surface water. A perched water condition exists because of relatively impermeable limestone and shale underlying the site. This condition is encountered only a few feet below the surface (4 or 5 ft.). True groundwater occurs in the Cambrian-Ordovician aquifers at depths of about 120 ft. at GEH-MO. Maximum frost penetration is about 4 ft. Clay is the known mineral deposit of value at the site, and this is limited to the shallow overburden.

3.7.3 Investigation of Faults

A northwest-trending fault passing southwest of the main building was originally identified by Dames & Moore from borings made for a foundation investigation in 1967. Another northwest-trending fault was inferred in 1971 during investigation of effectiveness of drainage wells but could not be otherwise confirmed.

The northwest-trending fault was studied by Dames & Moore in 1974, in more detail in 1975, and again in 1977.

The 1974 study identified the fault, showing it to have an offset of 35 to 40 ft. with the southwest side dropped in relation to the northeast side. It was concluded at the end of the 1974 study that the most probable time of faulting occurred between the late Ordovician and early Pennsylvanian periods. The 1975 study included a seismic refraction survey of the site and a site stratigraphic survey through use of test borings and trenching. Conclusions from the 1975 study placed the major movement of the fault contemporaneous or pre-contemporaneous with major development of the northern portion of the LaSalle Anticlinal Belt, which is generally accepted to be about 300,000 to 400,000 years ago.

3.7.3.1 1977 Fault Study

A geological investigation was conducted in the spring and summer of 1977 to determine structural and stratigraphic relationships of the northwest-trending fault zone and to substantiate age of faulting at the site.

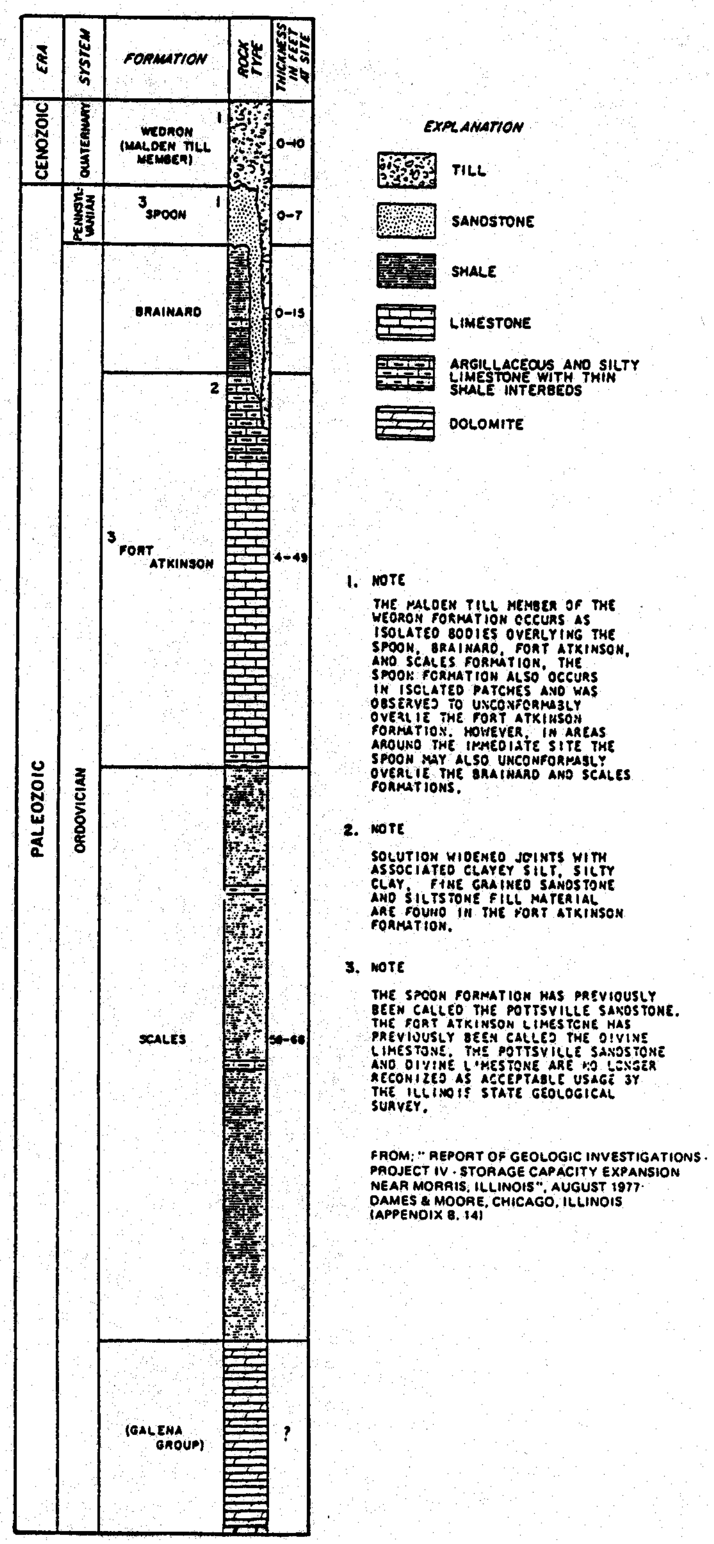


Figure 3-10. Generalized Stratigraphic Column for the GEH Morris Operation Site

Field investigations included soil and rock core drilling, borehole water pressure testing, piezometer installation, geophysical surveys, trenching across the fault zone, and geological mapping of the trenches.

The investigation showed multiple northwest-trending faults are present in an en echelon pattern instead of a single fault as previously interpreted. Furthermore, it was interpreted that cross faults trend northeasterly and also occur in an en echelon pattern.

Relative movement of the northwest-trending fault zone is down-to-the southwest. Several faults exposed in trenches have downward displacement to the northeast, however. Most individual faults also are displaced down-to-the-southwest. The faults probably converge with depth creating step-like extensional blocks that have variable displacements relative to adjacent blocks as well as rotational displacements. The variability of displacements of fault blocks is characteristic of en echelon gravity faults produced by antithetic tensional forces. The excavations provided comprehensive information regarding detailed structural relationships of the fault zone including displacement of faults, orientation of faults and joints, and continuity of fault blocks. Faults mapped within the trenches correlated well with fracture zones measured in the angle borings (Figure 3-11; note shaded areas).

3.7.3.2 Conclusions - 1977 Study

Evidence of the Spoon Formation sandstone directly overlying a fault and fault block of Fort Atkinson Limestone conclusively dates the fault as having occurred no later than pre-early or early Desmoisian. Presence of clay-limestone rubble as a colluvial wedge-shaped deposit along the fault block supports a probable post-Chesterian age of faulting. Age of faulting (post-Chesterian/early-Desmoisian) at the site is supported further by the regional geologic history. Initial deformation along the LaSalle Anticlinal Belt and major movements of the Sandwich Fault occurrence during post-Mississippian/pre-Pennsylvanian time[35] is equivalent to the age of site deformation.

Continued uplift within the area occurred after Pennsylvanian time but this renewed activity was of less magnitude[36] and may be partially responsible for warping or increased inclination of bedding planes within the Spoon Formation during its unlithified, unconsolidated state. No displacement of offset is found within beds of the Spoon Formation at the site.

Criteria for faulting, as defined at 10 CFR 100, Appendix A, require that a fault has not moved in the last 35,000 years or has no history of recurrent movement in the last 500,000 years. The stratigraphic evidence found throughout the site, both in this and previous investigations, indicates a pre-Spoon deposition age for faulting. Relationships observed in Trench CT-7 (Appendix B.14) provide substantiated evidence that faulting occurred in post-Chesterian to early Desmoisian time (approximately 280 million years before the present). Therefore, faulting at the site is not capable.

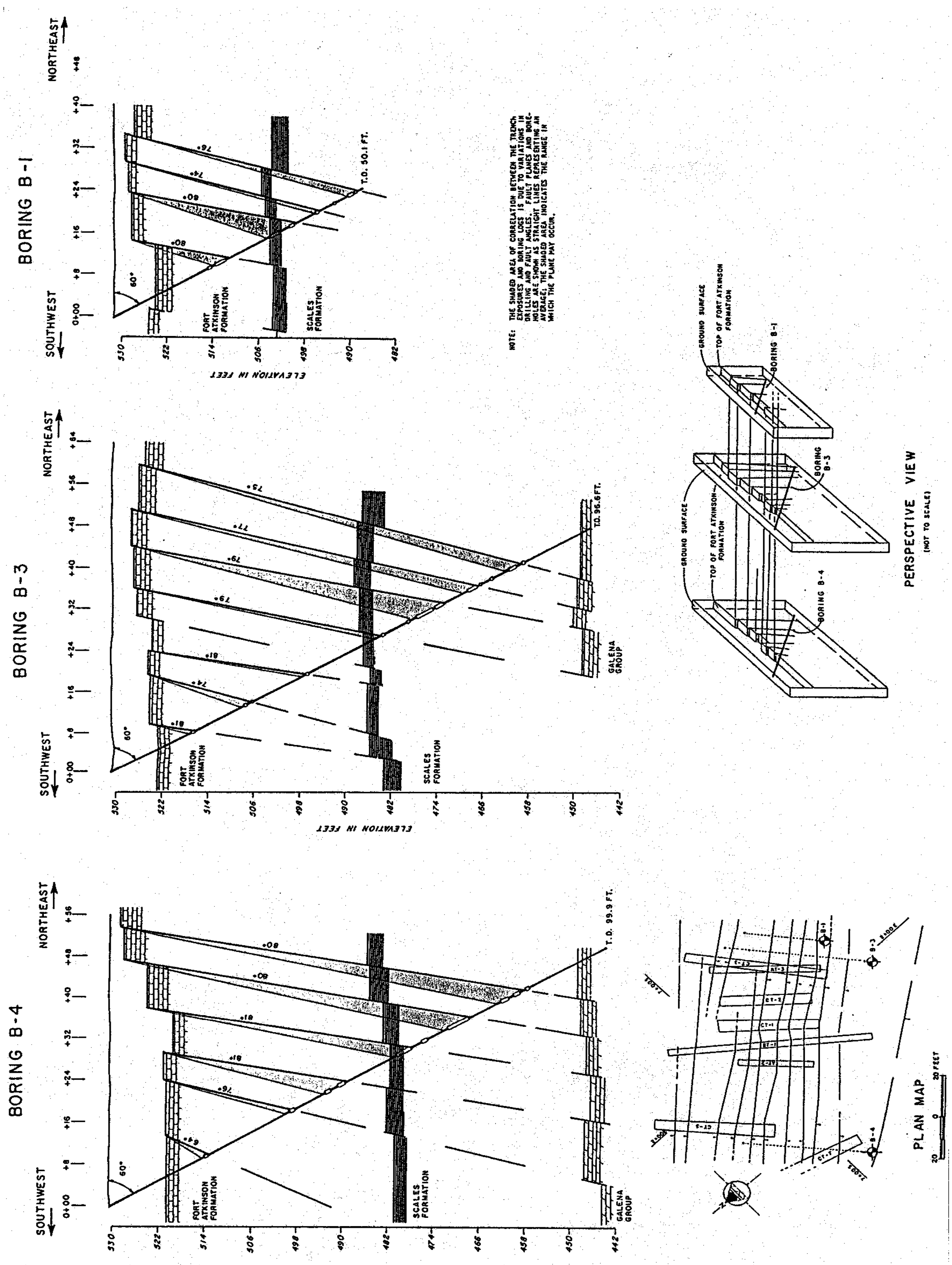


Figure 3-11. Correlation of Angle Boring and Trench Data.

3.7.4 Earthquake and Seismicity

Historical data shows seismic events in the vicinity of the site are relatively infrequent and are characterized by fairly low intensities and magnitudes.

3.7.4.1 Engineering Properties of Materials Underlying the Site

Static and dynamic properties of materials underlying the site have been summarized in a report of a foundation investigation[37]. In general, underlying materials have been found very suitable for heavy facility construction.

3.7.4.2 Seismic History

Several earthquakes of intensity MM V (Modified Mercalli (MM) scale) or higher have been listed as having epicenters in Illinois, including four of intensity MM VII. Only one significant earthquake has been centered within 50 miles of the site (intensity MM V or greater). It occurred on January 2, 1912 and was centered about 15 miles northwest of the site. It is described in "Earthquake History of the United States" (1973) as having an intensity of MM VI at Aurora, Freeport, Morris and Yorkville, and of V at Chicago. The shock was felt at Milwaukee and Madison, Wisconsin, and in Iowa, Indiana, and Fulton County, Kentucky. An intensity of MM VI was probably felt in the vicinity of the site as a result of this earthquake.

On September 15, 1972, an earthquake of epicentral intensity MM VI was centered about 55 miles northwest of the site. Press reports indicate the shock caused cracked plaster at Morris and Ottawa and a broken window at Rockton.

Only one earthquake of intensity MM VII has been centered within 100 miles of the site area. It occurred on May 26, 1909, about 88 miles NW of the site and according to "Earthquake History of the U.S.," it was felt from Missouri to Michigan and Minnesota to Indiana. A shock of intensity MM VII was noted over a considerable area from Bloomington, Illinois, to Platteville, Wisconsin[38].

The maximum intensity X-XII (MM) New Madrid, Missouri, earthquakes of 1811-1812 whose epicenters were approximately 350 miles to the south probably resulted in an intensity no greater than MM VI in the site area[39].

Another distant shock felt over a large area during historical times was the Charleston, South Carolina, earthquake of August 31, 1886. This shock may have been felt with about intensity MM III in the site area though it was reportedly not felt at Joliet and Kankakee.

The seismic risk map (Figure 3-12) of the conterminous United States was prepared by a group of research geophysicists headed by Dr. S. F. Algermissen of the United States Coast and

Geodetic Survey and issued in January 1969. The site area lies well within zone 1 where minor earthquake damage can be expected. According to this map, zone 1 corresponds to intensities V and VI on the modified Mercalli (MM) scale.

MM VI seems to be the greatest intensity experienced historically in the site area. This was the result of the 1912 earthquake which was centered approximately 15 miles from the site and may also have been the result of the 1811-1812 New Madrid, Missouri, earthquakes. MM VI, with its corresponding acceleration (according to Newmann's curve) of 0.01 G may be reasonably expected to occur again within the lifetime of the facility.

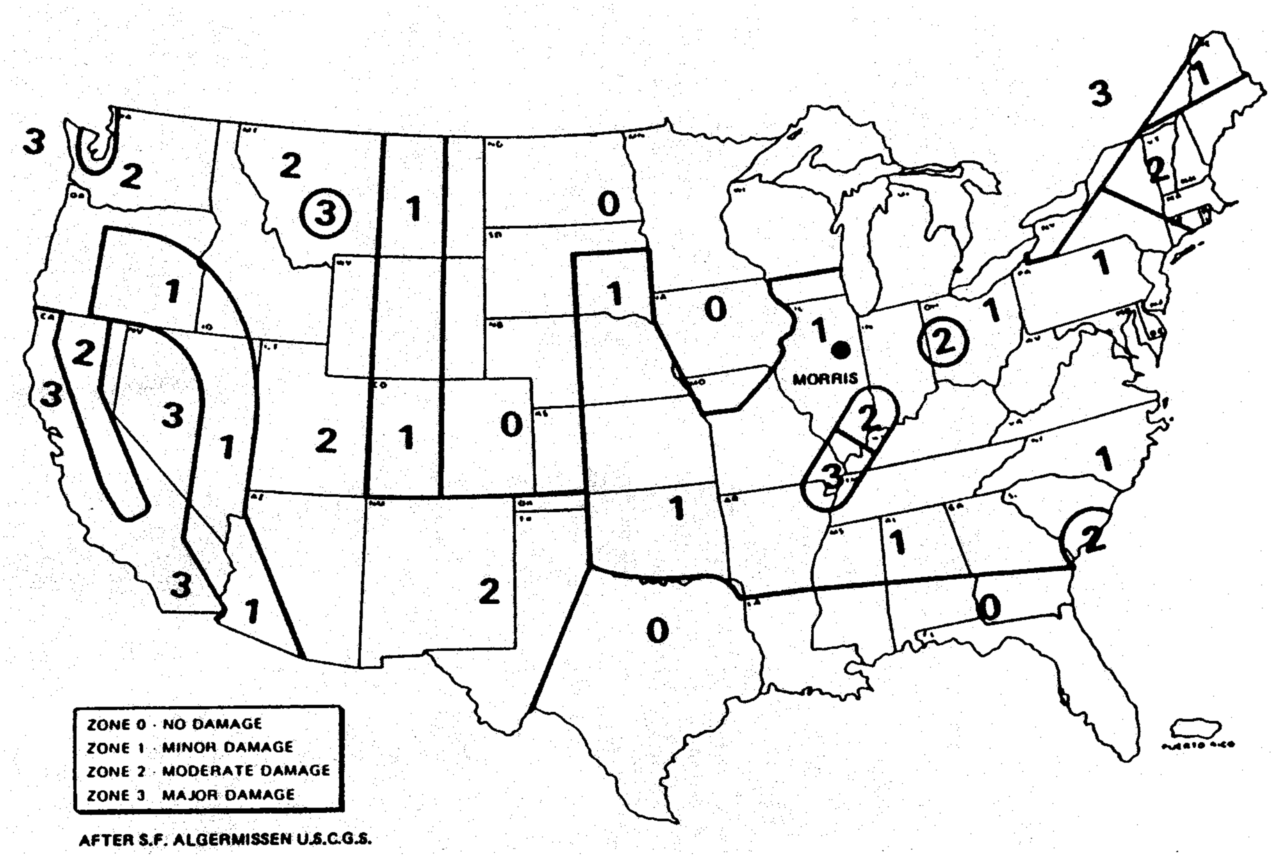


Figure 3-12. Map of the U.S. Showing Zones of Approximate Equal Seismic Probability.

3.7.5 Earthquake Design Basis

The design earthquake basis for the basin was a horizontal ground motion of 0.1 G. The basin structure and fuel storage system are designed to withstand the design basis earthquake without damage to structures or components essential to the integrity of stored fuel or fuel being moved in the normal process of storing or shipping fuel. The design earthquake is defined as a seismic event that has a reasonable probability of occurrence during the life of the facility, based

on studies of seismic history and geology. A maximum earthquake with ground accelerations of 0.2 G is also considered in the seismic analyses. The design bases are discussed in Section 4.

3.8 TRANSPORTATION OF IRRADIATED FUEL

Irradiated fuel was received by truck or rail at GEH-MO in casks certified to comply with applicable U.S. Nuclear Regulatory Commission (NRC) regulations[40].

As of the end of 1989, 737 shipments of fuel had been completed, moving about 750 tonnes - heavy metal in 3,450 fuel bundles. Shipments to GEH-MO have been completed without highway or rail accidents over about 744,300 miles.

Environmental impact of these transportation operations has been negligible, thus supporting conclusions of various studies and analyses[41,42].

Non-radiological and radiological impacts of transportation are analyzed in the literature[43]. Environmental impact assessments of GEH-MO by the NRC staff have also found no significant environmental impact from spent fuel transport[44,45].

3.9 SUMMARY OF SITE CONDITIONS AFFECTING FACILITY OPERATING REQUIREMENTS

Irradiated fuel storage operations have been conducted at GE-MO since January 1972 when the first shipment of irradiated fuel was received under Materials License No. SNM-1265, Docket 70-1308, issued December 1971. Throughout this period of operating experience and during on-going environmental studies and monitoring programs, no condition has been found to detract from the desirability of this site as a fuel storage location. Factors significant in selection of design bases for GE-MO follow.

3.9.1 Meteorology

The climate at the site offers no severe extremes except tornadoes. Analysis of tornado activity, including official and unofficial records, indicates a frequency close to the average for all states east of the Rocky Mountains.

Site topography introduces little perturbation in diffusion calculations; only the 630 ft. elevation of Dresden Heights, about 1.5 miles north of the GEH-MO stack is of concern in selecting stack design bases. Local fog conditions are involved in dispersion considerations. Diffusion climatology and characteristics have been firmly established and confirmed by the meteorological measurement program.

3.9.2 Hydrology

Site surface hydrology offers no characteristics significant to selection of design bases (except for usual consideration of natural drainage pathways, etc.). Subsurface hydrology shows excellent separation between upper strata and deeper aquifers that provide water for municipal and industrial use.

Intrusion of groundwater was of concern during construction. These flows indicate a complex near-surface groundwater system that becomes significant because of localized fracturing induced during construction.

3.9.3 Geology and Seismology

The site is located in a stable area which has experienced historically low seismic activity. The existing construction is founded on bedrock of Ordovician (Paleozoic) age. Design of the facility and its fuel storage equipment for horizontal ground motion of 0.10 G is considered conservative.

3.10 REFERENCES

1. See Appendix A.1 for document list.

2. State of Illinois, Bureau of the Budget, Illinois Population Projections (Revised 1977), Springfield, September 1977.

3. State of Indiana, State Board of Health, Indiana County Population-Projections, Indianapolis, 1978.

4. Northeastern Illinois Planning Commission, Regional Data Report, Chicago, June 1978.

5. Supplement to GEH Morris Operation Environmental Report, Dec 2019

6. The USNRC staff reported an adjusted estimated 1980 population for the area within the 50 mile radius of about 9,169,337 (Environmental Impact Appraisal, Docket 70-1308m NR-FM-002).

7. During research for these data, differences were noted between (for example) the Northeastern Illinois Planning Commission data and Federal census figures. In general, however, the data appear mutually supportive, particularly at the county level.

8. Within 5 miles of the site the total school population is about 5000.

9. Correctional institution (juvenile) at Channahon, 3 miles WNW. (Closed)

10. Climatography of the United States, No. 60-11, revised and reprinted June 1969.

11. H. E. Landsberg, "Climates of North America," World Survey of Climatology, Vol. 11, edited by Bryson, et al., Elsevier Scientific Publication Co. (1974)

12. S. S. Visher, Climatic Atlas of the United States, Harvard University Press, Cambridge (1966).

13. U.S. Department of Commerce, Climatography of the United States No. 86-9, "Decennial Census of United States Climate," for Illinois, Washington, D.C. (1964).

14. "Final Environmental Statement related to operation of the Midwest Fuel Recovery Plant by the General Electric Co.," Doc. 50-268, USAEC (December 1972).

15. Fluor Cooling Products Company, "Evaluated Weather Data for Cooling Equipment Design," Addendum No. 1, Winter and Summer Data, Santa Rose, CA (1964).

16. D. W. Phillips, et al., "The Climate of the Great Lakes Basin," Climatological Studies Number 20, Environment Canada, Toronto (1972).

17. J.L. Vogel, et al., "Fog Effects Resulting from Power Plant Cooling Lakes," Journal of Applied Meteorology. Vol. 14 (August 1975).

18. Final Environmental Statement related to the operation of Dresden Nuclear Power Station Units 2 and 3 by the Commonwealth Edison Co., Docket No. 50-237 and 50-249, AEC (November 1973).

19. Applicants Environmental Statement, Dresden Nuclear Power Station Unit 3, Commonwealth Edison Co., Docket No. 50-249 (July 1970).

20. Thom suggests an annual extreme-mile (fastest mile) wind speed of 82 mph for 30 ft. above ground and for a 100 yr. mean recurrence interval. Thom, H.C.S., "New Distributions of Extreme Winds in the United States, "Journal of the Structural Division,, Proc. ASCE, Vol. 94 No. St. 7 (1968) Applicants Environmental Report, Midwest Fuel Recovery Plant Morris, Illinois, June 1971.

21. Murray and Trettel, Inc. Consulting Meteorologist, Chicago, IL. Letter, Literski (M&T) to Eger (GE), September 23, 1976.

22. From Braidwood Station Environmental Report, Commonwealth Edison Co., Chicago, IL. Year of record: July 1971 - June 1972.

23. The application of these methods to the Dresden reactors and the description of the techniques used there can be found in Appendix A of the Final Safety Analysis Report for Dresden 2 and 3, Docket 50-237.

24. The description of the first year's data taken at the site can be found in Amendment No. 13, Question B-11, to the Dresden Unit No. 2 Final Safety Analysis Report, Docket 50-237.

25. E. C. Watson and C. C. Gamertsfelder, "Environmental Radioactive Contamination as a Factor in Nuclear Plant Siting Criteria," February 14, 1963, HW-SA-2809.

26. NEDO 10178-1, Water Intrusion Consideration, July 1971.

27. Dames & Moore report, "Ground-Water Investigations," (Appendix B.12).

28. Payne, 1940, page 7; and Eardley, 1962, page 45.

29. Willman and Templeton, 1951, page 123.

30. Bristol and Buschbach, 1973, Plate 1.

31. Willman and Templeton, 1952; also Bristol and Buschbach, 1971, Figure 3.

32. Ekblau, 1956; Dames & Moore, 1965.

33. Kempton, 1975.

34. See Table 3-14 for studies referenced in this section.

35. Payne, 1940; Willman and Templeton, 1951.

36. Willman and Templeton, 1951.

37. Dames & Moore, report dated December 1967 (Appendix B.2).

38. J. A. Udden prepared a report describing observations of this earthquake. He presents an isoseismal map for this earthquake and, according to his map, the site was in the area which experienced Rossi-Forel intensity VI (about V-VI on the modified Mercalli scale).

39. This intensity is based on an isoseismal map prepared by O. W. Nuttli and presented in the Bull. Seis. Soc. Am., Vol. 63, No. 1, 1973.

40. K. Eger, Operating Experience Report - Irradiated Fuel Storage at Morris Operation - January 1972 to December 1982, General Electric Company, (NEDO-20969B).

41. 10 CFR 51, Summary Table S-4, "Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water Cooled Nuclear Power Reactor," U.S. Nuclear Regulatory Commission, especially Note 4, "Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site."

42. Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, U.S. Atomic Energy Commission, December 1972 (WASH-1238); and U.S. Nuclear Regulatory Commission, April 1975 (Supplement 1, NUREG-75/038).

43. Final Environmental Statement of the Transportation of Radioactive Material by Air and Other Modes, U.S. Nuclear Regulatory Commission, December 1977 (NUREG-0170).

44. Environmental Impact Appraisal by the Division of Fuel Cycle and Material Safety Related to License Amendment for Materials License Amendment for Materials License No. SNM-1265 Morris Operation Facility - Grundy County, Illinois for General Electric Company - Docket No. 70-1308, Nuclear Regulatory Commission, December 1975 (NR-FM-002), especially Section 6.

45. Environmental Impact Appraisal related to the Renewal of Materials License No. SNM-1265 for the Receipt, Storage and Transfer of Spent Fuel at Morris Operation - General Electric Company - Docket No. 70-1308, U.S. Nuclear Regulatory Commission, June 1980, especially Sections 7.5 and 8.2.

4.0 DESIGN CRITERIA AND COMPLIANCE

4.1 INTRODUCTION

A general description of GEH-MO and a summary of operational functions are contained in Section 1. Original design criteria for GEH-MO facilities were developed and established as part of the design for a fuel reprocessing plant - the Midwest Fuel Recovery Plant (MFRP). Criteria herein are those applicable to the use of those facilities for spent fuel storage.

4.1.1 Material Stored

The material stored at GEH-MO is irradiated light water UO_2 fuel with initial enrichment of 5% U-235 or less, stainless steel, or Zircaloy cladding and in a "bundle of rods" geometry. The calculated fission product activity contents of fuel irradiated at 40 kW/kgU, exposed at 24,000 MWd/TeU and 44,000 MWd/TeU, and cooled 1 year are presented in Table 4-1.

Fuel stored at GEH-MO has exposures from 177.9 MWd/TeU to 36,712.9 MWd/TeU. The average burn-up of the fuel bundles is 17,740.1 MWd/TeU and the median burn-up is 19327.8 MWd/TeU. The cooling periods range from 33 to 50 years with as of April 2020.

Included in the fuel stored, GEH-MO currently stores four fuel bundles from San Onofre Unit 1 that exhibited high radionuclide transfer rates, and 753 bundles from Dresden Unit 2 that are warranty returns.

The four San Onofre fuel bundles (numbers C-21, C-28, C-46 and C-47) are stored in basket P-117, located in Fuel Basin II, grid B-13. These fuel bundles exhibited higher than normal radionuclide transfer rates during sipping testing at San Onofre in May 1976. Further testing provided evidence that the fuel bundles were within regulatory limits for shipping. The radionuclide transfer rate decreased with time in storage, and storage of these fuel bundles has not had an unacceptable effect on the Morris fuel basin. The bundles were received during February and March of 1978. The bundles are 14 x14 Stainless Steel clad PWR bundles discharged on June 2, 1973. Burn-up on these bundles range from 30,946 to 32,804 MWd/TeU.

The 753 fuel bundles stored at Morris from Dresden Unit 2 are GE 7 x 7 BWR bundles with Zircaloy cladding and discharge dates from July 15, 1970 to April 13, 1972. The burn-up on the Dresden fuel bundles ranges from 178 to 5,708 MWd/TeU. Analysis on several fuel pins from this batch showed evidence of cladding hydriding.

Sipping and visual inspections of fuel were performed in the early 1980s to verify the radionuclide transfer rates and the physical integrity of the fuel stored at Morris Operation.

The quality of the water in the GEH-MO basin is strictly maintained to inhibit corrosion of Zircaloy and Stainless Steel cladding and components. Perforations in fuel cladding expose the

Uranium oxide pellets to water. Uranium oxide pellets have been observed to be highly stable when in contact with pool water (IAEA 1012 pg. 55). Basin radiochemistry is routinely monitored, and an appreciable change in the radionuclide transfer rate of fuel bundles in storage would be evident.

Realistic exposures based on fuel in storage have been used in some analyses, as appropriate. Table 4-2 contains a list of analyses, fuel exposures and cooling times on which each is based.

Heat load calculations for basin water temperature and evaporation rates, basin water cooler design, and ventilation air cooling design are based on heat loads from fuel currently in storage and that expected to be stored.

4.1.2 Storage Conditions

Normal storage conditions at GEH-MO impose much less stress on fuel than does the normal operational environment within a reactor. Maintaining basin chemistry and the integrity of fuel rods provides protection against uncontrolled release of radioactive material from fuel in storage. Instrumentation and other equipment are provided to warn of unsafe conditions or the approach of unsafe conditions. However, the approach of unsafe conditions is relatively slow in all cases, so rapid response and prompt, automatic initiation of corrective action - as in a reprocessing plant or reactor in non-storage conditions - is not required.

The parameters presented in Tables 4-1 and 4-2 were used for bounding analyses and do not represent the current state of the fuel stored at GEH-MO. Given the long cooling times of the fuel presently located at GEH-MO, several of the isotopes are either no longer present or their inventories have been significantly reduced. Therefore, the conservative values presented in the tables below remain applicable to this safety demonstration.

Table 4-1
SPENT FUEL FISSION PRODUCT ACTIVITY
(Ci/TeU)
Specific Power = 40 kW/kgU
Cooling Time = 1 Year

CLASS	ISOTOPE	HALF LIFE	24,000 MWd/TeU	44,000 MWd/TeU
Noble Gases	Kr-85	10.701y	7,620	12,000
Halogens	I-129	1.57×10^7y	.021	.044
Tritium	H-3	12.346y	416	766
Transuranics	Am-241	432y	99	250
	Am-243	7370y	2.6	32

	Cm-242	162.76d	1,350	9,160
	Cm-244	18.099y	169	5,090
Total			1,621	14,532
All Remaining Fission Products	Rb-86	18.82d	.000693	-
	Sr-89	50.55d	9,410	7,140
	Sr-90	28.82y	64,700	103,000
	Y-90	64.06h	64,800	103,000

CLASS	ISOTOPE	HALF LIFE	24,000 MWd/TeU	44,000 MWd/TeU
	Y-91	58.51d	20,800	16,500
	Zr-93	1.53×10^6y	2.3	3.9
	Zr-95	63.98d	41,500	38,300
	Nb-95m	86.6hd	527	487
	Nb-95	34.97d	87,800	81,800
	Tc-99	2.14×10^5y	10.8	18.9
	Ru-103	39.35d	2,680	3,280
	Rh-103m	56.116m	2,680	3,290
	Ru-106	366.5d	172,000	344,000
	Rh-106	29.8s	172,000	344,000
	Ag-110m	26.42d	12,300	51,700
	Ag-110	24s	160	672
	Cd-113m	14.6y	15	42.8
	Cd-115m	44.8d	3.5	4.9
	Sn-119m	250d	26.4	40.2
	Sn-123	129d	6113	801
	Sb-124	60.2d	3.2	8.1
	Sb-125	2.71y	4,840	10,100
	Te-125m	58d	1,180	2,470
All Remaining Fission Products	Sn-119m	250d	26.4	40.2
	Sn-123	129d	6113	801
	Sb-124	60.2d	3.2	8.1
	Sb-125	2.71y	4,840	10,100
	Te-125m	58d	1,180	2,470
	Te-127m	109d	1,320	1,870
	Te-127	9.35h	1,300	1,830
	Te-129m	33.52d	43.1	52.7
	Te-129	69.5m	27.4	33.5

CLASS	ISOTOPE	HALF LIFE	24,000 MWd/TeU	44,000 MWd/TeU
	Cs-134	2.062y	88,900	283,000
	Cs-137	30.174y	77.900	142,000
	Ba-137m	2.5513m	73,700	134,000
	Ce-141	32.55d	800	772
	Ce-144	284.5d	530,000	594,000
	Pr-144	17.3m	530,000	594,000
	Pr-144m	7.2m	6,360	7,130
	Pm-147	2.62344y	104,000	91,400
	Pm-148m	41.29d	94.5	88.0
	Pm-148	5.37d	6.5	6.07
	Sm-151	87y	936	1,350
	Eu-152	13.2y	6.9	8.0
	Eu-154	8.5y	4,390	16,000
	Eu-155	4.96y	1,020	3,100
	Gd-153	241.6d	3.9	21.0
	Tb-160	72.1y	16.6	63.3
Total of All Remaining Fission Products			2.08×10^6	2.98×10^6

Table 4-2
ANALYSES, FUEL EXPOSURES, AND COOLING TIMES USED

Section	Type of Analysis	Exposure and Cooling Time Used MWd/TeU	Months
5.4.4.3	Storage Basket Heat Transfer	44,000	4
7.3.1	Radiation Sources	24,000	12
7.3.2	Fission Gases Released	24,000	12
7.4.2	Direct Radiation from Fuel	24,000	12
7.7.2	Maximum Off-site Exposures	24,000	12
8.6	Fuel Drop Accidents	44,000	12
8.7	Missile Impact Accidents	24,000	12

4.2 STRUCTURAL AND MECHANICAL SAFETY CRITERIA

Structures, systems and components (SSCs) contributing to prevention of accidents (or to mitigation of consequences of accidents) which could affect public health and safety have been

designed, fabricated, erected, operated, and maintained in compliance with established performance and quality standards. Under these standards, GEH-MO will withstand, without loss of important protection capability, all credible operating and accident stresses, including forces that might be imposed by natural phenomena such as earthquakes, tornadoes, or flooding conditions.

Standards for ensuring SSCs will adequately perform required safety functions for their intended service life with a low probability of failure have been based on temperatures, corrosion rates and other stress conditions derived from comprehensive analyses, including consideration of:

a. accessibility for in-service surveillance, monitoring and repair (or replacement);

b. potential for short-term exposure to abnormal operating or accident conditions;

c. consequences of component failure - no single component failure or multiple failures caused by a single initiating event shall result in significant radiation exposure to the public;

d. accessibility for emergency services, including ambulance attendants, fire and police services, and other emergency activity.

4.2.1 Wind and Tornado Loadings

4.2.1.1 Criteria

Final structures and components essential for safety shall be designed to withstand effects of short-term wind velocities of 300 mph with pressure differentials of up to 3 psi without damage to fuel in storage to an extent endangering public health and safety. The site is located in USNRC Tornado Intensity Region I, as defined in Regulatory Guide 1.76.

4.2.1.2 Compliance

The fuel basin structure (enclosure) was analyzed with calculated wind loads applied as uniform static loads on vertical or horizontal projected areas of the walls and roof. Only dead load was considered as resisting uplift. Horizontal wind loads are distributed by the walls to the floor and roof systems, which transfer loads to the lateral load-carrying elements of the structures.

Plant structures and components were designed to withstand sustained wind velocities of 110 mph without loss of functions. At higher velocities, enclosure covering may fail or blow away.

These analyses included consideration of a drop in atmospheric pressure of 3 psi in 3 seconds. This condition would damage the basin enclosure, probably damage or even remove much of the roof and wall sheathing from the basin enclosure, but would cause no off-site radiological effect.

4.2.2 Tornado Missile Protection

4.2.2.1 Criteria

Plant SSCs essential for safety shall be designed to withstand effects of windborne missiles without damage to fuel in storage to an extent endangering public health and safety.

4.2.2.2 Compliance

Analyses in Appendix A.15 indicate the public health and safety would not be endangered as a result of tornado missiles impacting fuel storage structures or components.

4.2.3 Water Level (Flood) Design

4.2.3.1 Criteria

Structural integrity of fuel storage buildings and components shall not be endangered by flooding.

4.2.3.2 Compliance

Analysis has shown the maximum water level of a hypothetical flood greater than the maximum recorded flood at the site is below the site elevation (Appendix A.6).

4.2.4 Seismic Design

4.2.4.1 Criteria

Fuel storage structures and components essential to integrity of stored fuel, or fuel in the process of being transferred from shipping cask to the storage basin, shall be constructed to withstand a seismic event which, based on studies of area seismic history and geology, has a predicted recurrence of once per 1,000 years.

4.2.4.2 Compliance

The main building, including all portions of the structure now used for irradiated fuel storage, was originally constructed to seismic criteria based on a design earthquake and a maximum earthquake. The design earthquake was defined as a seismic event that has a reasonable probability of occurrence during the life of the facility, based on studies of historical seismically and structural geology. The design earthquake has a horizontal ground acceleration of 0.1 G.

The maximum earthquake is rated at twice the acceleration of the design earthquake, or 0.2-G. The design basis earthquake (DBE) can be sustained by these structures without exceeding allowable stresses. The maximum earthquake (ME) can be sustained without exceeding yield stress limits of the structure.

The 1940 El Centro, California earthquake has been thoroughly studied and well documented and provided most of the seismic data for time-history analyses available at the time of MFRP design. Illinois is not noted for earthquakes and no equally well studied seismic data base was available for Illinois.

Comparisons have been made between the El Centro earthquake spectrum and the spectrum in Regulatory Guide (RG) 1.60 for both Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) conditions. Results are shown in Figures 4-1 and 4-2. In generating spectra for the El Centro earthquake, damping values of 2% for DBE and 5% for ME were used. These damping values are consistent with those used in design of the basin structure. Sampling values for the RG 1.60 spectrum are 4% for OBE and 7% for SSE conditions, per RG 1.61. Differences between these spectra are insignificant.

A new fuel storage system was completed in 1976 to replace the original MFRP storage system. Since the new system is fabricated and installed as a separate entity in relation to the civil structures, it was designed to criteria in accordance with 10 CFR 100, Appendix A, and Regulatory Guide 1.60.

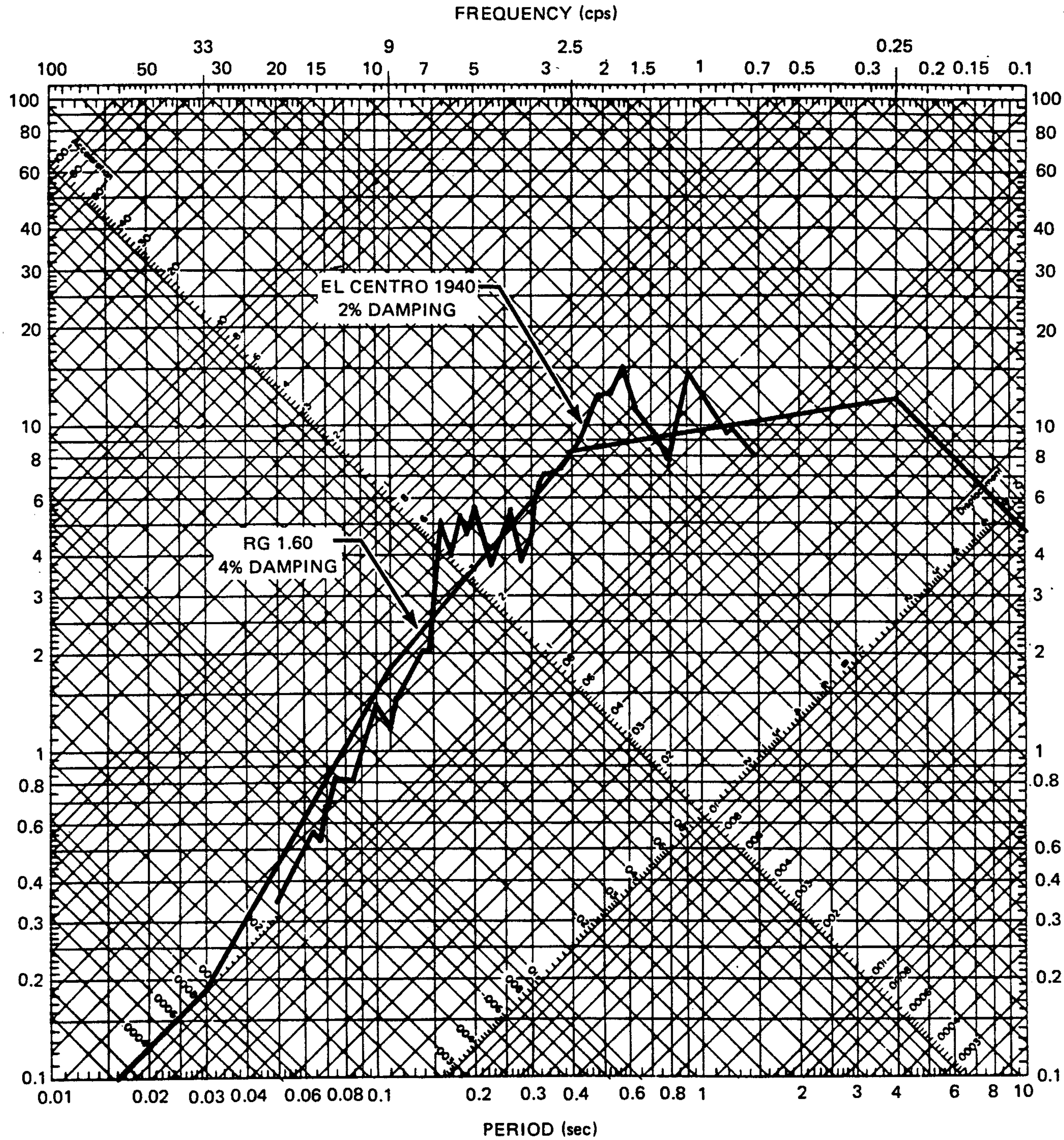


Figure 4-1. Spectra Comparison – 0,10G Ground Acceleration – RG 1.60 vs. El Centro 1940 N-S

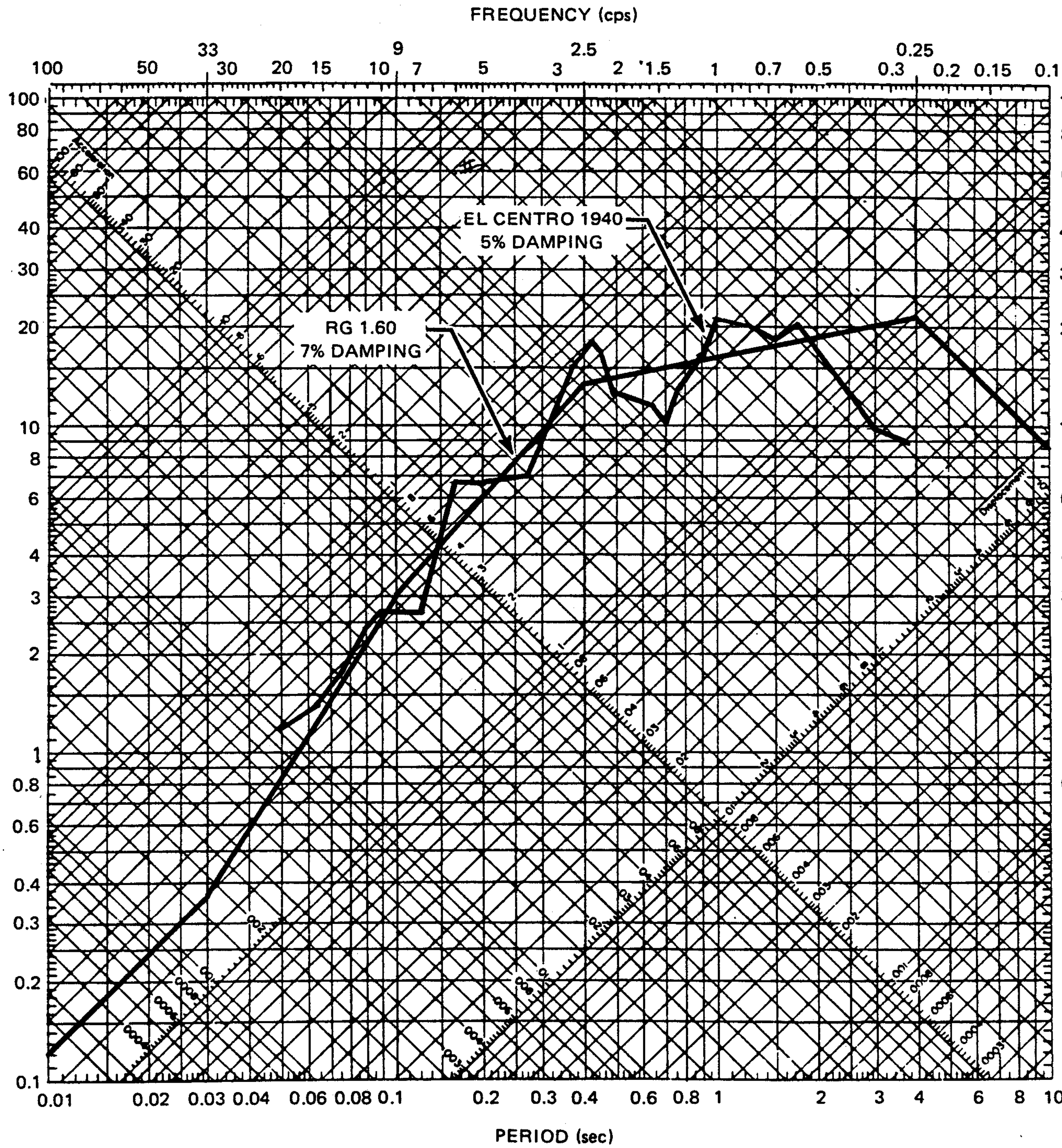


Figure 4-2. Spectra Comparison – 0.20G Ground Acceleration – RG 1.60 vs. El Centro 1940 N-S

4.2.4.2.1 Seismic Accelerations - Basins and Related Structures

a. Design Response Spectra

Structural (and equipment supported at grade) accelerations resulting from the DBE are defined by design response spectra. Design of fuel unloading and storage basins and underground vaults was based on north-south components of the 1940 El Centro earthquake normalized to 0.1G and 0.2G for the maximum earthquake case. The El Centro accelerogram is shown in Figure 4-3. The time used for the floor-level (main building) spectra was 6 seconds. Comparison of ground motion spectra for the 30 second period shows no measurable differences in the range provided.

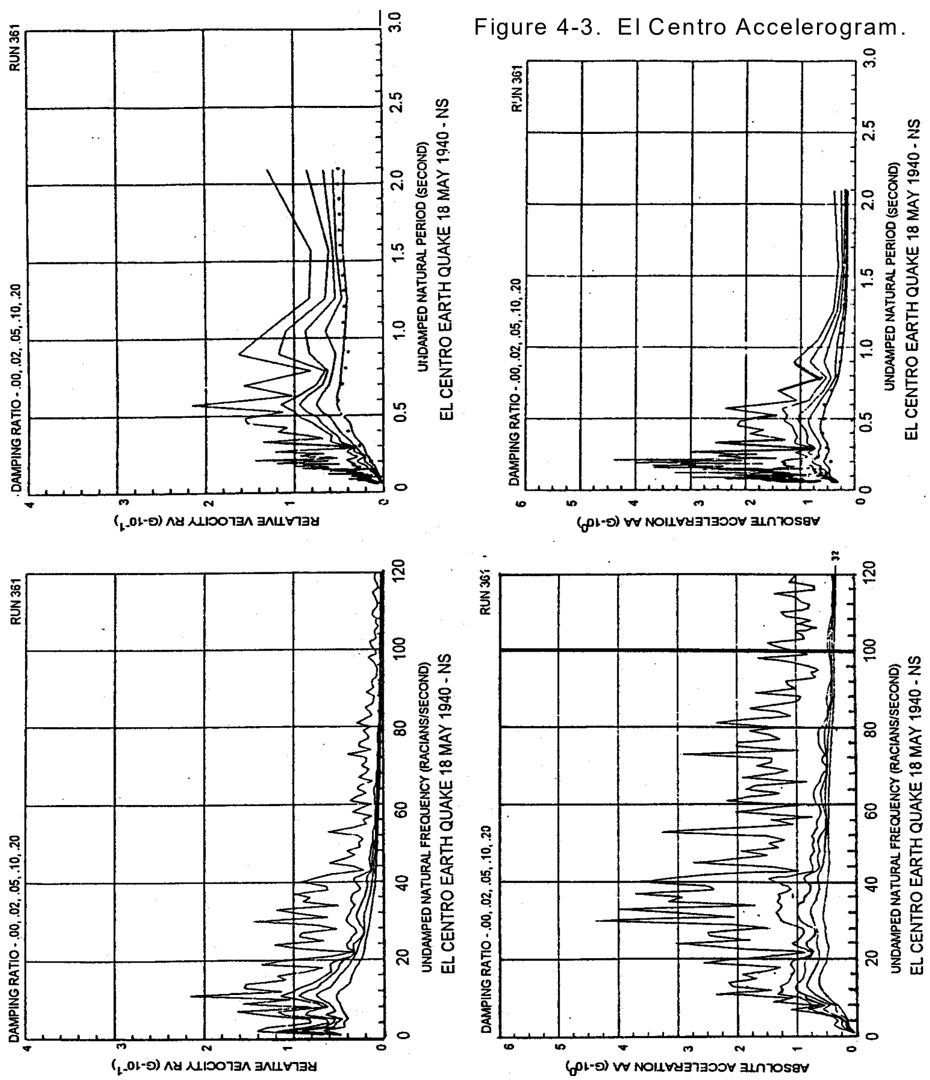


Figure 4-3. El Centro Accelerogram.

b. Design Response Spectra Derivation

Absolute acceleration response spectra for ground motion are shown in Figures 4-4, 4-5 and 4-6 for damping ratio values of 0.005, 0.010, and 0.020, respectively. These spectra result from a time-history analysis of the 1940 El Centro earthquake.

c. Damping values used for both design and maximum earthquake dynamic analyses of basin and vault structures, excluding basket and grid system, are:

ITEM	% CRITICAL DAMPING
Reinforced concrete structures	5.0
Steel frame structures	2.0
Welded assemblies	1.0
Bolted and riveted assemblies	2.0
Piping systems containing radioactive material	0.5
Underground vaults and basins containing radioactive material	0.5

d. Bases for Site-Dependent Analysis

A site-dependent analysis was not used. Section 3 describes the basis for specifying vibratory ground motion for design use.

e. Soil-supported Structures

Structures important for safety are founded on existing rock material exposed by excavation. The foundation support materials will withstand pressures imposed by appropriate loading combinations without failure (Appendix B.2).

4.2.4.2.2 Seismic System Analysis - Basins and Related Structures

Seismic system analyses applicable to basins, vaults, and related structures are discussed in the following paragraphs and Appendix B.4.

a. Seismic Analysis Methods

Hydrodynamic effects were a main consideration in analysis of vaults and tanks; specifically, cladding vault, fuel unloading basin, and fuel storage basins. Because the mathematically precise procedure for analysis is very complex, a simplified approach based on References 5 through 8 was used.

When a tank containing fluid of weight W is accelerated in a horizontal direction, a certain portion of the fluid behaves similarly to a solid mass in rigid contact with the wall. This mass

exerts a maximum horizontal force directly proportional to the maximum acceleration of the tank bottom. Acceleration also causes another portion of the fluid to respond as

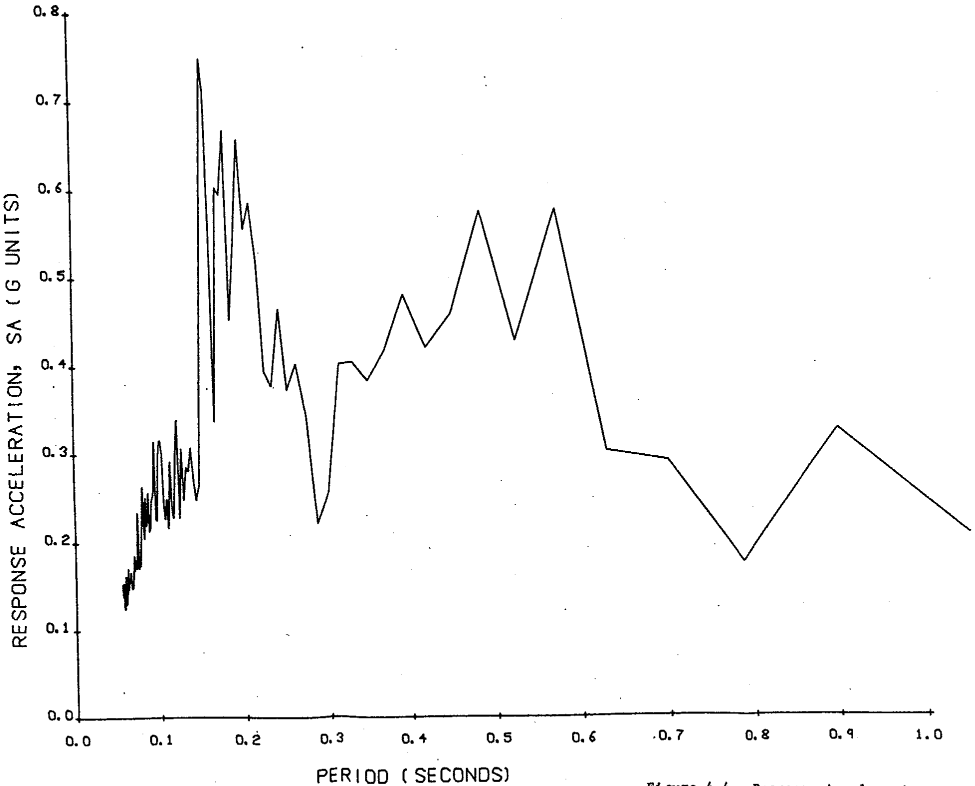


Figure 4-4. Response Acceleration Spectrum – Morris Operation – Main Building, Ground Motion, Damping Ratio – 0.005

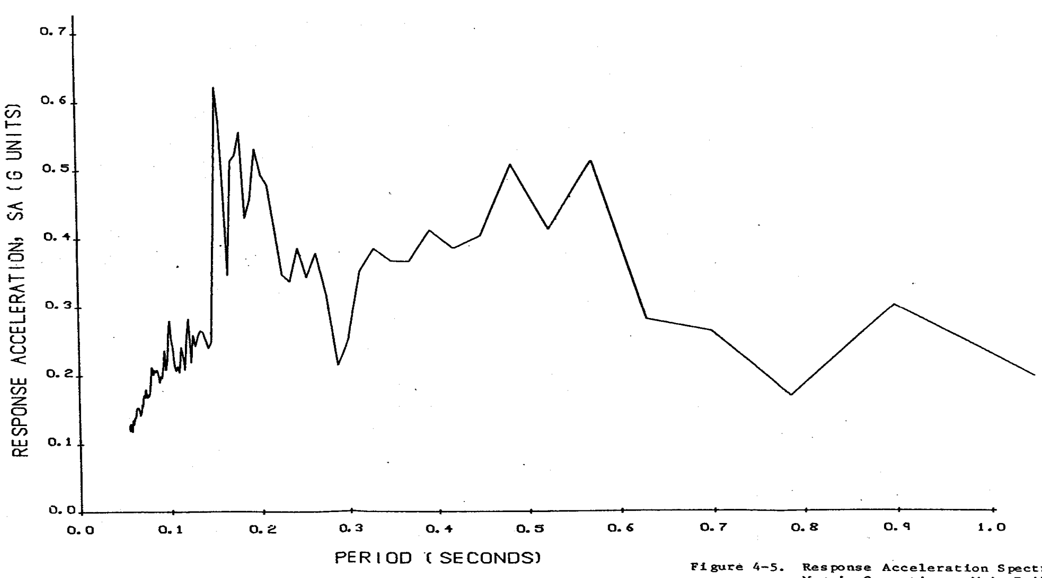


Figure 4-5. Response Acceleration Spectrum – Morris Operation – Main Building, Ground Motion, Damping Ratio – 0.010

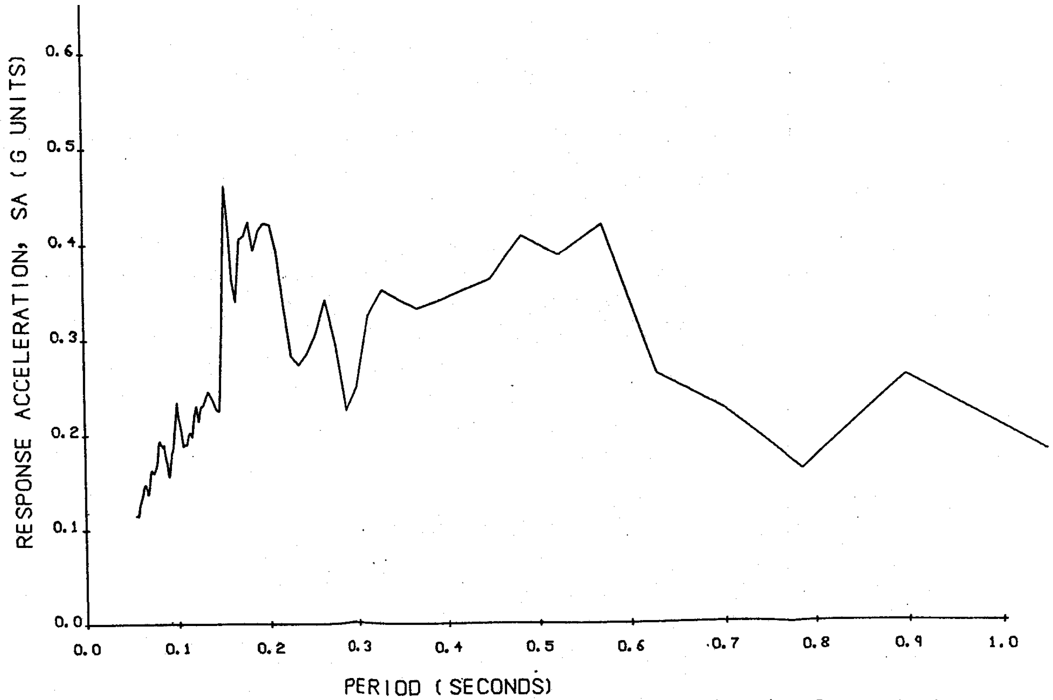


Figure 4-6. Response Acceleration Spectrum - Morris Operation - Main Building, Ground Motion, Damping Ratio - 0.02

though it were a solid oscillating mass flexibly connected to the walls. The maximum amplitude of the mass relative to the walls determines both maximum vertical displacement of the water surface (slosh height) and horizontal force exerted on the walls.

Figure 4-7 provides dynamic constants (aspect ratios) used in determining period and magnitude of sloshing. In this figure, alpha is the ratio of twice the height to average width of the tank.

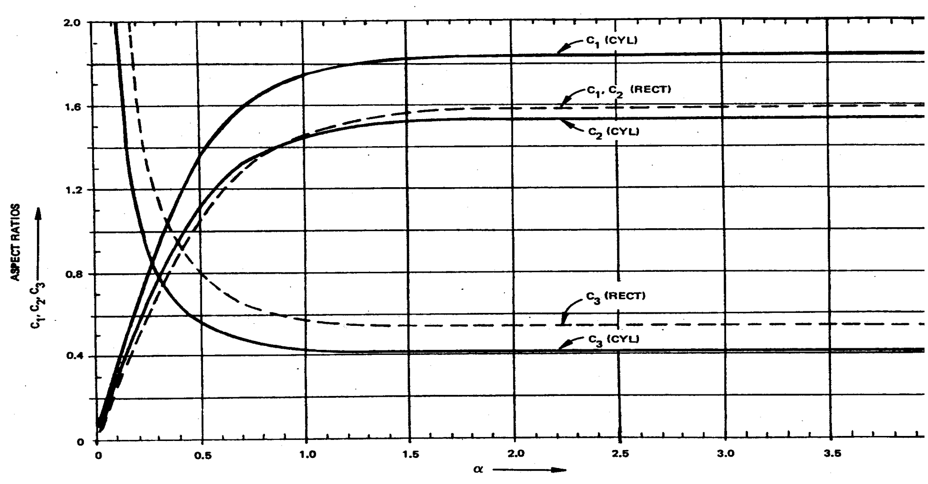


Figure 4-7. Hydrodynamic Constants for Rectangular and Cylindrical Tanks

b. Rocking and Translational Response Summary

Because underground vaults and tanks are embedded in sound rock, lateral soil pressures on these elements are negligible. An evaluation of vaults and tanks (section a. above) was made on the basis of a shearing stress of 330 psi in the rock. Resulting deformations in the rock and concrete were used to calculate stresses. Special attention was given to points of stress concentration caused by cavities behind the concrete and to localized deformations at corners. Distortion was considered, caused by the discontinuity of rock at cavity sides and bottom of the cavities, and stresses in the vaults were calculated on the basis of resulting deformations.

Stresses were most severe at corners of thick walls of short span and where interior walls are formed into outer walls. Stresses in concrete walls were found to be less than allowable stresses in concrete or steel.

Periods of sloshing for vessels and tanks are given below.

Element	Period of Sloshing (Seconds)
Cladding Vault	3.7
Fuel Unloading Pit	2.2
Fuel Storage Basin I	3.5
Fuel Storage Basin II	3.9

Rocking and translational loads in the basket and grid system are transferred through the grid to walls of the fuel storage basin. An analysis was performed to determine if basin walls and liner can safely sustain maximum load combinations of the basket and grid system and water mass in the basin. The following stresses in the basin walls were found to be less than allowable stresses of concrete or steel:

(1) Bearing stresses at the base of the wall due to the support mechanism of the fuel storage system.

(2) Peripheral or punching shear at the base of the wall due to the support mechanism of the fuel storage system.

(3) Shear-friction of concrete in the wall; a crack is assumed to occur along the shear path. Relative displacement can be resisted by friction maintained by shear-friction reinforcement available across the potential crack.

(4) Stress due to skin-friction of the bearing plate (wedge) on the basin liner.

c. Methods Used to Couple Soil with Seismic System Structures

Cladding vault, cask unloading basin, and fuel storage basins are deeply embedded in rock. Consequently, they are assumed to be rigid and move with the rock.

d. Development of Floor Response Spectra

Floor response spectra are the same as those discussed in Section 4.2.4.2.1.

e. Differential Seismic Movement of Interconnected Components

Allowable stresses for extreme loads are 90% of yield strength. (In design of the fuel storage system, allowable stresses of 1.5 times AISC allowable stresses were used.)

f. Use of Constant Vertical Load Factors

No constant vertical load factors are used for structures, systems and components. The method of analysis used for both vertical and horizontal directions is the response spectrum method. Induced forces, moments and stresses due to motions in vertical and two horizontal directions are combined by the square root of the sum of the squares technique.

g. Seismic Restraint of Overhead Cranes

Overhead cranes that could potentially fall into the fuel unloading basin or fuel storage basins have seismic retainer attachments, or are designed otherwise to prevent dislodging during a seismic event.

4.2.4.2.3 Seismic Acceleration and Response Spectra - Fuel Storage System

a. Response spectra for the fuel storage basket and grid system were derived as follows:

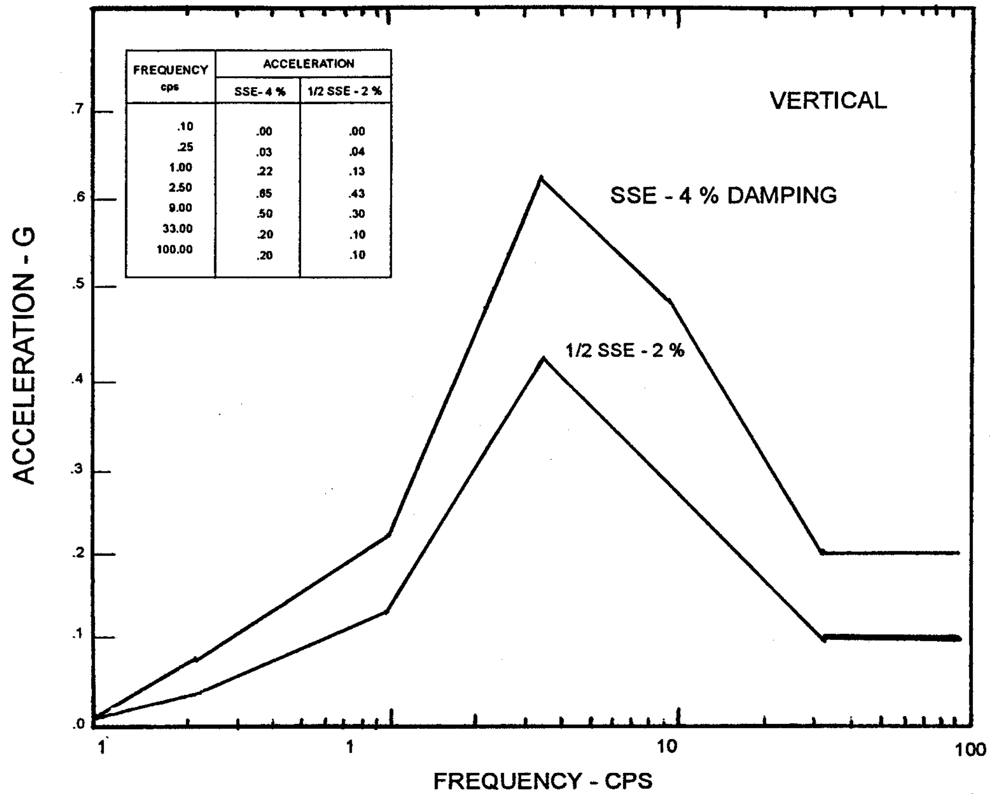
(1) Horizontal and vertical component design response spectra are scaled to a maximum horizontal ground acceleration of 0.20 G for SSE at 4% damping as specified in Regulatory Guides 1.60 and 1.61.

(2) Horizontal and vertical component design response spectra are scaled to a maximum horizontal ground acceleration of 0.10 G for 1/2 SSE at 2% damping as specified in Regulatory Guides 1.60 and 1.61.

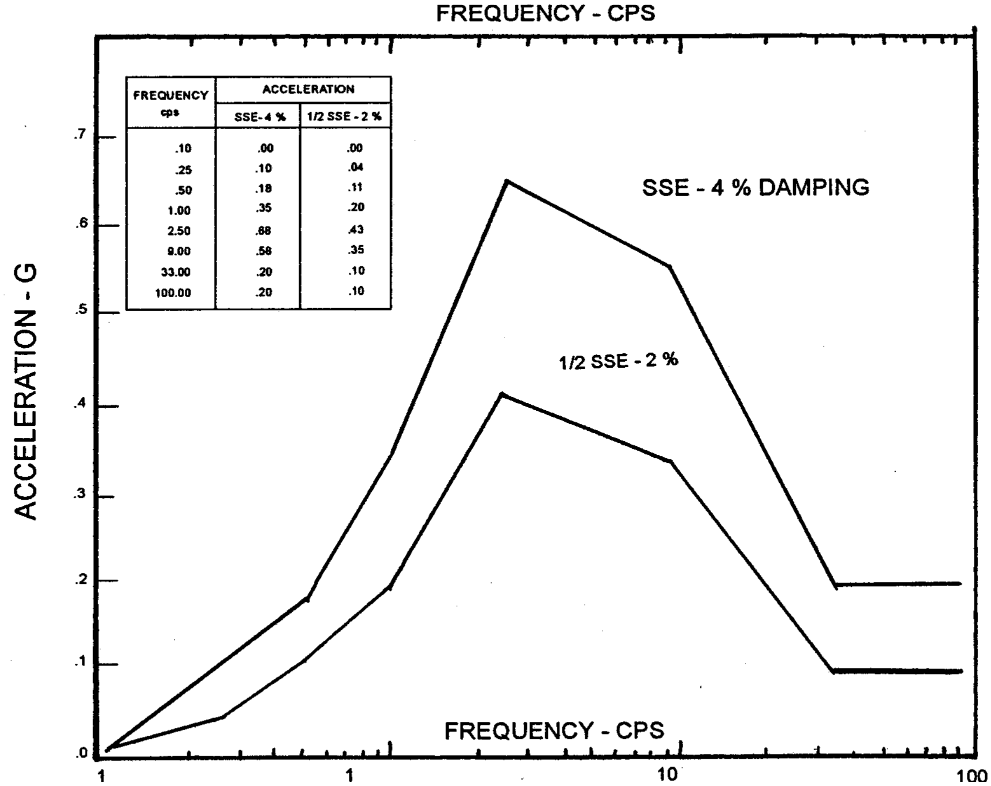
A plot of these spectra is shown in Figure 4-8.

b. Peak vertical acceleration of the response spectra for the basket and grid system occurs at a frequency of 3.5 cps. The fundamental frequency is 0.68 cps.

c. Damping values used for design and maximum earthquake dynamic analyses of the basket and grid design shall be (from Regulatory Guide 1.61) 2% (1/2 SSE) and 4% (SSE) for welded steel structures.



FREQUENCY cps	ACCELERATION	
	SSE- 4 %	1/2 SSE - 2 %
.10	.00	.00
.25	.03	.04
1.00	.22	.13
2.50	.65	.43
9.00	.50	.30
33.00	.20	.10
100.00	.20	.10



FREQUENCY cps	ACCELERATION	
	SSE- 4 %	1/2 SSE - 2 %
.10	.00	.00
.25	.10	.04
.50	.18	.11
1.00	.35	.20
2.50	.68	.43
9.00	.58	.35
33.00	.20	.10
100.00	.20	.10

Figure 4-8. Vertical and Horizontal Design Response Spectra for Nuclear Power Plants

4.2.4.2.4 Seismic System Analysis - Fuel Storage System

a. Seismic Analysis Methods

In the seismic analysis a detailed mathematical model of the fuel storage baskets and support grid was subjected to horizontal and vertical design response spectra by the use of a computer system (SAP IV). The same mathematical model was used for both static and dynamic analyses.

The analysis used to obtain seismic response of the mathematical model is based on standard equations of motion for damped linear systems. Matrix equations were used to find the lowest natural frequencies, corresponding mode shapes of the system and response spectrum.

The SAP IV program calculates maximum responses in each of the lowest modes based on the spectra (accelerations) in the x, y and z directions. Total response for displacements and stress resultants is calculated as the square root of the sum of the squares of the modal maximum responses.

Seismic responses were obtained for N-S, E-W and vertical directions of storage baskets and grid. Degrees-of-freedom at the tops of the basket were "slaved" to six "master" baskets by partitioning 270 baskets into six groups. Seismic response of the lowest six modes was considered. Primary participation was derived from the first two modes.

Analyses used to obtain vertical dead load stresses and displacements were based on the same model as described above, except static loads were applied. The model was also subjected to two sets of static loads at 1.0G corresponding to N-S and E-W directions. A fourth load condition approximated a static equivalent analysis of the response spectra by applying horizontal loads at 0.6G and vertical loads at 0.2G.

b. Natural Frequencies and Response Loads

Frequencies and periods of vibration of basket modules and bottom holding grid are listed below for the first six modes.

MODE	FREQUENCY (HERTZ)	PERIOD (SEC)
1	5.99	0.167
2	7.59	0.132
3	8.71	0.115
4	9.97	0.100
5	10.05	0.100

6	10.32	0.097

c. Procedures Used to Lump Masses

Spent fuel storage baskets and grid were idealized as a finite element model consisting of over 1,300 nodal points and over 4,000 flexural beam-column elements. The grid was assumed to be on rollers on the basin floor and in axial contact with the wall at two adjacent sides of the basin. Basket modules were modeled as an equivalent cantilever beam connected to the grid by four artificial beam-type elements representing the holddown device. A segment of mathematical model used in the analysis is shown in Appendix B.

Material and section properties for 12 basic elements were determined. In most elements these properties were extracted directly from the American Institute of Steel Construction (AISC) tables on steel sections. In other cases these properties were derived from combined shapes, built-up sections or castings. (See Appendix B.)

4.2.4.2.5 Seismic Subsystem Analysis

a. Determination of Number of Earthquake Cycles

Structures and equipment are designed on the basis of ground motion response spectra defined previously. Design of such structures and equipment is not controlled by fatigue because most stresses and strains occur only a small number of times. Full design strains from earthquakes and accidents occur too infrequently and with too few cycles to require a fatigue design basis for these structures.

b. Root Mean Square Basis

The total maximum value of any response quantity Q (shear, moment, deflection stress and acceleration) is based on the absolute sum, or on probability considerations, by the square root of the sum of the squares procedure according to the following equation:

$$Qmax = [(Q_1 \max)^2 + (Q_2 \max)^2 + (Q_3 \max)^2 + \ldots + (Q_n \max)^2]^{1/2}$$

4.2.5 Combined Loads

4.2.5.1 Criteria

Stress levels for structures and equipment shall be limited to allowable stresses set forth in applicable codes, without allowance for short-term loading. Stresses arising from seismic motion in both vertical and horizontal directions shall be added to stresses arising from other applicable loadings. No significant concrete cracking shall occur as a result of design loading

conditions. For maximum seismic ground motion or tornado wind conditions, combined stresses may approach but shall not exceed yield stresses.

4.2.5.2 Compliance

In general, concrete sections are designed so that failure would occur by yielding of the reinforcement rather than by crushing of the concrete. Where calculations indicated that a structure or component would be stressed beyond the yield point an analysis was made to determine its energy absorption capacity to ensure it exceeds the energy input from the initiating condition. In addition, such designs were reviewed to ensure any resulting deflections or distortions would not prevent performance of functions essential to continued confinement of radioactive materials and would not impair proper functioning of other structures and components from a safety point of view.

4.2.5.2.1 Loads - Definitions of Terms and Nomenclature

a. Normal Loads

Normal loads are those encountered during normal facility operation. They include:

D = Deadloads, or related internal moments and forces, including any permanent equipment loads.

L = Live loads, or related internal moments and forces, including any movable equipment loads and other loads which vary with intensity and occurrence, such as soil pressure.

T_o = Thermal effects and loads during normal operating conditions based on the most critical transient or steady state condition.

b. Severe Environmental Loads

Severe environmental loads are those that could be encountered infrequently during the life of the facility. Included in this category are:

E = loads resulting from the design earthquake

W = loads resulting from the specified design wind.

c. Extreme Environmental Load

Extreme environmental load is the load that is credible but highly improbable. It is:

W_t = loads resulting from design tornado, including wind velocity pressures, pressure differential and tornado-generated missiles, where applicable.

d. Abnormal Loads

Abnormal loads are those generated by a postulated accident, e.g., cask drop. They include:

T_a = Thermal loads resulting from an accident condition; specifically, this shall include design of fuel storage basins for thermal loads resulting from boiling basin water (212 °F), which could occur under certain conditions due to loss of basin cooling.

P_a = Pressure loadings resulting from an accident condition.

e. Other Definitions

u = section strength for concrete structures that is required to resist design loads and based on methods described by the American Concrete Institute in ACI 318.

s = section strength for structural steel based on elastic design methods, and allowable stresses against which calculated actual stresses are compared, are to be taken as 35/36 times allowable stresses defined by AISC Steel Construction Manual, Seventh Edition, Appendix A for 36,000 psi yield strength steel.

The yield strength for 304 stainless steel is used as 35,000 psi at 0.2% offset and a modulus of elasticity of 2.9×10^7. Allowable stresses for elements directly in the lifting load train are based on a safety factor of 5/1 on yield.

Y = section strength for structural steel required to resist design loads taken as 90% of yield strength. Allowable stresses of 1.5 times AISC allowable stresses are used, which are equal to or less than 90% of yield strength.

4.2.5.2.2 Load Combination and Acceptance Criteria for Concrete Structures

a. Load combinations used for normal operating conditions are:

(1) $u = 0.9D + 1.9E$

(2) $u = 0.75\ (1.4D + 1.7L + 1.7T_o)$

(3) $u = 0.75\ (1.4D + 1.7L + 1.9E + 1.7T_o)$

(4) $u = 0.9D + 0.75\ (1.9E + 1.7T_o)$

(5) $u = 1.4D + 1.7L + 1.9E$

b. Load combinations used for factored load conditions are:

(1) $u = D + L + T_o + W_t$

(2) $u = D + L + T_a$

4.2.5.2.3 Load Combinations and Acceptance Criteria for Steel Structures

a. Load combinations used for normal operating conditions are:

(1) $s = D + L$

(2) $s = D + L + 0.5E$

(3) $s = D + L + W$

(4) $1.5s = D + L + T_o$

(5) $1.5s = D + L + T_o + 0.5E$

(6) $1.5s = D + L + T_o + W$

b. Load combinations used for factored load conditions are:

(1) $Y = D + L + T_o + E$

(2) $Y = D + L + T_o + Wt$

(3) $Y = D + L + T_a$

(4) $Y + D + L + T_o + 1.5 P_a$

c. Local yielding or buckling due to tornado winds and missile loadings is allowed unless this results in excessive release of radioactive materials to the environs.

4.2.6 Subsurface Hydrostatic Loadings

4.2.6.1 Criteria

Subsurface hydrostatic loading shall be considered in analysis of below-grade structures.

4.2.6.2 Compliance

Subsurface water is present at the interface between below-grade structures and surrounding rock, at least at the points of intersection with identified perched water zones. Lateral flow rates through rock are rather slow but are sufficient for hydraulic pressure head to accumulate outside below-grade structures. Magnitude of the pressure head varies with time and seasonal changes but only within the range of upper perched water zone level variations. This hydrostatic load is combined with other loads described in Section 4.2.5.

4.2.7 Basin Water Cooling

4.2.7.1 Criteria

Means shall be provided to maintain water temperature less than 200 °F (93.3 °C).

4.2.7.2 Compliance

Basin water is cooled by a system described in Section 5.5.3.

4.3 SAFETY PROTECTION SYSTEMS

4.3.1 General

There are no site-related factors sufficiently unusual to require protection systems or special design considerations beyond those normally required for a facility of this type. Operations take into account DNPS proximity to ensure cumulative effects of these operations do not constitute an unreasonable risk to public health and safety.

4.3.2 Protection by Multiple Confinement Barriers and Systems

The total confinement system consists of one or more individual confinement barriers and systems that successively minimize potential for release of radioactive material to the environment. These features also protect fuel in storage by protecting the fuel from damage and providing a favorable environment.

4.3.2.1 Criteria

Equipment and systems containing radioactive or potentially contaminated materials shall provide a continuous boundary against escape of such material and be designed to have a low probability of gross failure or significant uncontrolled leakage during the design lifetime.

Secondary confinement barriers such as vaults, ventilation system, etc., shall be designed and constructed to contain results of primary system failure, under conditions that may have initiated such failure, without loss of required integrity and to continue operation for the maximum anticipated period of stress.

Storage vaults and basins shall be designed and constructed for low probability of gross failure or uncontrolled leakage, with means provided to monitor leakage and preclude transport of radioactive materials to underlying aquifers. For lined structures containing radioactive or potentially contaminated liquids, leak detection and empty-out means shall be provided between liner and structure so that release of radioactive material to the environs can be avoided by pumping leakage back into storage, effecting repairs where leaks can be located and are accessible, or installing additional facilities in the event repair is not feasible. Water systems shall be designed to prevent accidental removal of water from basins by any means to less than a safe level. Basin water level shall be indicated and alarmed (low water alarm) in the CAS/SAS.

4.3.2.2 Compliance

All criteria described above have been satisfied; refer to Section 5.

4.3.3 Building Ventilation

4.3.3.1 Criteria

Radioactive material in building ventilation exhaust shall be reduced to levels **A**s **L**ow **A**s **R**easonably **A**chievable (**ALARA**) before being released to the environs. Special venting lines and enclosures shall be employed when necessary, to confine airborne radioactive particulate materials.

4.3.3.2 Compliance

Principal methods used to meet these criteria include:

a. Generation: Airborne radioactive material may originate from; preparation of contaminated equipment for disposal; and from operation of low-activity liquid waste treatment systems. Other than these principal sources and minor H-3 and Kr-85 leakage from fuel in storage, no other significant source exists[1]. These activities (other than fuel storage) can be suspended on short notice whenever higher than prescribed levels of radioactive materials are detected in the ventilation air exhaust stream. The waste evaporator system is designed to limit radioactive material in its effluent.

b. Confinement: The building ventilation system utilizes pressure differentials to maintain air flow paths to exhaust all ventilation air through the filter system and discharge stack.

Special venting systems and special enclosures may be employed to confine airborne particulates from cask venting, decontamination activities, or similar sources to the filter - discharge stack system. The ventilation system is designed for all credible normal or anticipated off-normal conditions.

c. Release: Most of ventilation air is passed through a sand filter of demonstrated capability for removing particulate matter, and released through a 300 foot high discharge stack. Two streams are filtered through HEPA filters before release to the stack.

4.3.4 Protection by Equipment and Instrumentation

4.3.4.1 Criteria

Equipment and instrumentation shall be provided to monitor radiation and other parameters of operation, and to perform related control functions in accordance with the following:

a. Equipment and systems shall be set and adjusted to alarm and/or initiate action such that specified limits are not exceeded as a result of normal or abnormal occurrences.

b. Redundancy and independence shall be provided to a degree sufficient to ensure that no single failure of an instrument or equipment item can result in loss of control functions.

c. Equipment shall be designed to permit inspection, testing, and maintenance.

d. Monitoring of important systems and functions during normal operations and under anticipated off-normal or accident conditions is performed.

4.3.4.2 Compliance

Equipment is designed to permit inspection, maintenance, and periodic testing of functions to specified parameters. Temporary removal of single items of equipment from service has no safety significance.

Instrumentation is provided to ensure proper operation or notification of the failure of systems. Instrumentation is designed or specified to standards of known reliability.

Alarms that indicate a set point has been exceeded are annunciated in the CAS/SAS. Alarms with safety significance sound locally as well as in the CAS/SAS.

4.3.5 Nuclear Criticality Safety

4.3.5.1 Criteria

Every reasonable precaution is taken to ensure a criticality incident does not occur. Design controls are utilized and complemented by administrative control.

4.3.5.2 Compliance

The design of the spent fuel storage system includes the following controls to preclude a criticality incident:

a. Initial analyses were made in sufficient detail to demonstrate that criticality control concepts considered (e.g., control of geometry) were feasible under all credible conditions. Additional detailed nuclear criticality safety evaluations of the final design were made by qualified experts in the field to ensure final dimensions and other factors safety margins were adequate to prevent a criticality incident. Additional detailed analyses required to confirm the final design are included in Appendices A.10, B.5 and B.15.

b. In the derivation of subcritical limits, the k_{eff} permitted for the most reactive credible conditions was specified as 0.95 at a 95 percent confidence level[2].

Operation of the spent fuel storage facility includes the following administrative controls to preclude a criticality incident:

a. Safety evaluation, review and approval of operating procedures related to design control parameters.

b. Verification of nuclear fuel parameters for fuel scheduled to be stored at GEH-MO.

c. Verification of fuel identity for fuel received at GEH-MO for storage.

d. Maintenance of fuel storage location records.

e. Specific fuel and cask handling procedures when these tasks are performed.

f. Personnel training.

Independent reviews and audits are utilized to determine adequacy of nuclear safety control provisions and effectiveness of implementing activities.

4.3.6 Radiological Protection

4.3.6.1 Criteria

Radiation and radioactive contamination conditions at GEH-MO are controlled to provide protection of personnel health and safety at all times. Emphasis is placed on minimizing both individual exposures and total exposure (man-Rem) to **A**s **L**ow **A**s **R**easonably **A**chievable (**ALARA**).

During normal operations, including anticipated occurrences, the annual dose equivalent to any person located beyond the OCA boundary does not exceed 25 mRem to the whole body, 75 mRem to the thyroid and 25 mRem to any other organ as a result of either planned discharges or direct radiation from the facility.

Any person located at or beyond the nearest boundary of the OCA will not receive a dose greater than 5 Rem to the whole body or any organ from a design basis accident.

4.3.6.2 Compliance

Criteria are satisfied through the following design features and operational practices:

a. Confining radioactive materials to prescribed locations.

b. Clearly defining areas in which significant radiation or contamination levels exist.

c. Applying special provisions and appropriate procedures to assure personnel safety.

d. Applying rigorous surveillance, housekeeping, and clean-up practices.

e. Providing comprehensive personnel training in radiological safety.

Dosimeters are provided for ensuring accurate detection and assessment of personnel exposure to ionizing radiation in accordance with applicable procedures. Thermoluminescent dosimeters (TLDs) are positioned throughout the site to assess trends in background dose rates so that increases may be detected and corrective plans initiated.

4.3.6.2.1 Access Control (Controlled Areas)

Provisions have been established for controlling personnel access to areas in which radioactive material is present and are maintained to keep potential for contamination spread and exposure to radiation **ALARA**. This is accomplished by maintaining a series of access control barriers with increasingly restrictive occupancy constraints and access authorization requirements. These access controls were designed as follows:

a. General Electric Tract: Agricultural fencing with appropriate posting encloses the tract. Routine surveillance by operating and security personnel is utilized to ensure that unauthorized occupancy for significant periods of time is prevented.

b. OCA: A double 8 ft. high chain link fence topped with razor wire surrounds the OCA in which GEH-MO storage facilities are located. Personnel and vehicle access gates are locked or guarded by security personnel at all times. Vehicles, materials and equipment are checked into and out of the area following procedures that require potentially contaminated or radioactive items to be monitored and cleared before entry or exit is authorized.

c. Radiologically Controlled Area (RCA): Personnel access to RCAs in which radioactive material is stored is controlled by limiting entrance such that occupancy authorization requirements can be strictly enforced. Access to various areas is controlled by structural compartmentalization and by authorization procedures commensurate with conditions existing in the particular areas. Access to all potentially contaminated areas is limited to specific routes in accordance with prescribed procedures and clothing and monitoring requirements which are varied according to conditions. Exit from RCAs, except under emergency conditions, is by the same controlled routes through necessary clothing change stations and monitoring facilities. Routine radiation surveys of the area are performed and TLDs are posted. Equipment requiring access (e.g., basin coolers) can be decontaminated to permit maintenance.

   Materials and equipment required for operation and maintenance will be checked into the areas and will be monitored before leaving the areas in accordance with prescribed control procedures. Access for transfer of such items is limited to specific points which are provided with means for precluding unauthorized usage.

   Additional requirements are utilized to limit access into areas of known or potential of high radiation levels or contamination levels. High Radiation Areas will be locked or guarded continuously.

4.3.6.2.2 Shielding

Radiation shielding is provided to control personnel exposure to **ALARA** levels.

4.3.6.2.3 Radiation Alarm Systems

Sampling and detection systems are provided that have sufficient sensitivity and scope of coverage to ensure any radiation or contamination condition of potential safety significance is accurately and promptly assessed.

Area radiation monitors (ARMs) meet the following requirements:

a. Monitors will detect gamma radiation within the range of 0.1 to 1,000 mRem/hr.

b. The high level alarm is audible locally.

c. The criticality accident alarm system meets the following requirements:

   (1) The system has gamma-sensitive monitors that meet sensitivity requirements of 10 CFR 70.24(a)(1).

   (2) The system produces a unique audible alarm.

   (3) Two detectors are provided in the storage basin area, but are not underwater.

   (4) The system is continuously functional.

   (5) The high level alarm circuits for the system are arranged in parallel so that either alarm will energize all criticality alarms.

   (6) The alarm circuit that energizes the criticality horns is designed to stay on until a manual reset in the SAS is employed to silence the horns (assuming radiation level is below trip point).

4.3.6.2.4 Effluent Monitoring

Sampling and monitoring systems and associated procedures are provided to measure radionuclides in ventilation effluent and in sample wells. Documentation and procedures for assessment of dose to the public from GEH-MO effluents is contained in the GEH-MO Off-site Dose Calculation Manual (ODCM).

4.3.7 Fire and Explosion Protection

4.3.7.1 Criterion

Structures, systems and components directly involved in storage of fuel shall be protected so that performance of their functions is not impaired when exposed to credible fire and explosion conditions.

4.3.7.2 Compliance

This criterion is met by using noncombustible and heat-resistant materials whenever practical throughout the facility, particularly in locations vital to functioning of confinement barriers and

systems such as the basin areas and pump room. Fire detection, alarm, and suppression systems are installed in warehouse areas, and certain areas of the main building where deemed necessary. Fire extinguishers are strategically located throughout the facility. Fire training is furnished to all personnel. Fire alarms are audible in the CAS/SAS.

4.3.8 Fuel Handling and Storage

4.3.8.1 Criterion

Cask and fuel handling systems shall provide safe, reliable and efficient handling of casks and fuel.

4.3.8.2 Compliance

GE Hitachi Morris Operation (GEH-MO) is capable of receiving irradiated fuel bundles in shielded casks mounted on trucks or railroad cars. All major equipment such as cranes located above basin areas containing fuel are designed to ensure that components will not fall into the basin. The cask handling system has been designed to preclude a cask from being moved over fuel storage basins. Means are provided to preclude lifting a fuel bundle or a fuel storage basket to an elevation within a basin such that the shield provided by basin water is reduced to less than the prescribed depth.

Cask drop analyses have determined that energy absorption provisions in the fuel unloading basin are adequate.

Treatment of the storage basin water is adequate to minimize corrosion and prevent undue exposure of personnel.

4.3.9 Radioactive Waste Treatment

4.3.9.1 Criteria

Radioactive waste shall be stored in a manner that does not preclude retrieval and transfer off-site. Provisions shall be made for inspection and sampling of the material. No liquid radioactive waste shall be discharged from the site to the environs. Solid radioactive waste shall be disposed of in accordance with current regulations.

4.3.9.2 Compliance

Radioactive liquid waste is processed using the GEH-MO or vendor radwaste system and is periodically concentrated by evaporation to reduce volume. Solid waste is disposed of via a licensed contractor.

4.3.10 Utility Systems

4.3.10.1 Criterion

Utility systems shall maintain the capability to perform safety related functions assuming a single failure.

4.3.10.2 Compliance

See Section 5.7.1.

4.4 CLASSIFICATION OF STRUCTURES, SYSTEMS AND COMPONENTS

The objective of GEH-MO is to prevent conditions that could result in undue risk to public health and safety by providing quality structures and reliable systems and components.

The degree of reliability that must be provided for various structures, components, and systems is determined primarily by consequences of failure of that unit. Failure of some structures, systems, or components could - if uncorrected - expose people to ionizing radiation (See Section 8). However, in a passive facility such as a fuel storage basin, repair or replacement of the failed structure, system or component can usually be accomplished long before consequences pose undue risk to public or employee health and safety. Failure of other structures, systems or components could result in an unacceptable loss of operating efficiency, but would pose no significant long or short-range risk to employees or the public.

Quality Assurance history and a list of safety related structures, systems and components are in Section 11. The quality assurance plan is NEDE-31559, "GEH-MO Quality Assurance Plan".

4.4.1 Intensity of Natural Phenomena

Monitoring of natural remarkable events is provided by local, state, and federal agencies. These events are self-evident and appropriate response is documented in the GEH-MO Emergency Plan.

4.5 DECOMMISSIONING

4.5.1 Criterion

The GEH-MO facility shall effect decontamination and decommissioning activities to an extent consistent with existing regulatory requirements.

4.5.2 Compliance

GEH-MO design provides a stainless-steel-lined basin that includes cleaning, volume-reducing waste management facilities and a ventilation sand filter that will facilitate decontamination and decommissioning operations.

Codes, guides, and standards applicable to the GEH-MO facility, as noted in this report, are listed in Table 4-3.

4.6 REFERENCES

1. K. J. Eger, Operating Experience - Irradiated Fuel Storage at Morris Operation, General Electric Company, January 1972 through December 1982 (NEDO-209969B).

2. See ANSI N18,2A-1975, Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants.

Table 4-3
CODES, GUIDES, AND STANDARDS

Item	Section Where Referenced
Uniform Building Code	5.3.1
ASTM C150 (Cement)	5.5.1.2
ASTM A15 (Rebar)	5.5.1.2
ASTM 262 (Stainless Steel Liner)	5.5.1.3
Regulatory Guide 1.76	4.2.1.1
Regulatory Guide 1.60	4.2.4.2
Regulatory Guide 1.61	4.2.4.2
AISC Steel Construction Manual 7th Edition, Appendix	4.2.4.2.4[a]
ACI 318	4.2.5.2.1
ANSI-N18.2A 1975	4.3.5.2
ASTM A514 (Stainless Steel)	Appendix A.8
ASTM A285 (Stainless Steel)	Appendix A.13
ASTM A240 (Stainless Steel)	Appendix A.13
AWS-ASTM (welding rod)	Appendix A.13

[a] Other references, also.

5.0 FACILITY DESIGN AND DESCRIPTION

5.1 INTRODUCTION

This section contains descriptive information on buildings and other features of GEH-MO used for storage of irradiated fuel. Facilities associated with fuel reprocessing are discussed only as they relate to irradiated fuel storage activities.

This information has been consolidated from documents previously submitted and are part of the public record. The majority of descriptive material is based on the “Midwest Fuel Recovery Plant Final Safety Analysis Report” (MFRP FSAR) (NEDO-10178) with amendments and supplements and “The Safety Evaluation Report for Morris Operation Fuel Storage Expansion” (NEDO-20825).

Reproductions of maps and other illustrations in Sections 1 and 3 (especially Figures 1-1, 1-2, 3-1, and 3-2) provide geographical information about the GEH-MO tract and show boundaries of property and general arrangement of buildings and other site features. (See Section 1 for use of terms "tract" and "site.") A detailed layout and contour map of the site and environs is shown in Figure 5-1.

Radioactive material handling activities related to fuel storage are located within the Owner Controlled Area (OCA). There are no scheduled radioactive liquid effluent releases to the environs and no burial of radioactive or contaminated material on the tract. The only radioactive materials leaving the site are the gaseous effluents discharged through the ventilation stack or solid low-level radioactive wastes shipped for off-site burial. Off-site shipments are made in accordance with applicable United States Nuclear Regulatory Commission (NRC), United States Department of Transportation (USDOT), and other State and Federal regulations.

The entire GE tract (Figure 1-3) is enclosed by agricultural fencing with appropriate posting and forms the site boundary as defined in 10 CFR 20.1003 and described in Section 3.

5.2 CONTROLLED, RESTRICTED AND PROPERTY PROTECTION

5.2.1 Restricted and Owner-Controlled Areas

Restricted areas, as defined in 10 CFR 20.1003, are within a 15-acre Owner Controlled Area (OCA) on the northern side of the tract (Figure 5-1), enclosed by a chain link fence topped with multiple strands of barbed wire for a total fence height of 8 ft. Facilities located within the OCA include the main building, adjacent ventilation sand filter and emergency equipment building (EEB), ventilation exhaust stack, cask service facility (CSF), utilities and service building, shop warehouse building, administration building, general warehouse, and water system well and elevated water tank. Liquid (nonradioactive) waste discharge lines are routed from the OCA to

the sanitary treatment lagoons located south of the protected area. The sanitary lagoons are fenced to control access.

[redacted]

Figure 5-1. Site Plan showing Principal Facilities.

5.2.2 Gates

Entrance to the OCA is from the east-west county road (Collins Road), which bounds the tract on the north side. Entrances for personnel, road and rail traffic are at the northwest corner of the OCA. Entry is controlled from a guard station in the foyer of the administration building that includes the personnel entrance and is adjacent to the road and rail gates. A parking area for employees and visitors is provided north of the OCA.

5.3 PRINCIPAL STRUCTURE

The principal structure at GEH-MO is the main or process building. This building was constructed to contain mechanical and chemical operations and processes for recovery of uranium and plutonium from spent nuclear fuel.

This Safety Analysis Report is concerned only with use of this structure for fuel storage. Consequently, only those portions of the main building and other facilities associated with fuel storage activities are discussed in detail.

5.3.1 Main Building Design Basis

Design, materials and construction of the process building is in accordance with the Uniform Building Code and meets requirements of governing ordinances and authorities having jurisdiction (circa 1967). Facilities necessary for normal plant operation and confinement of radioactive materials were designed to resist earthquake and tornado conditions.

Section 4 describes significant criteria selected for design of the main building and other principal structures and describes principal means of satisfying these criteria.

5.3.2 Fuel Storage Facility Layout

Fuel storage facilities at GEH-MO utilize the following portions of the process building:

a. cask receiving and decontamination areas;

b. fuel unloading pit;

c. fuel storage basins[1];

d. basin support systems (basin water cooling and filtration, etc.);

e. control room.

5.3.2.1 Process Building Plan and Sections

Appendix A.14 contains plan and section drawings of those portions of the process building associated with fuel storage. Drawings of other structures associated with fuel storage are included.

5.3.2.2 Confinement Features

The principal means of confinement of radioactive materials in a fuel storage facility is inherent in the fuel itself. Radioactive fuel pellets are contained within fuel rods; these stainless steel or zirconium alloy tubes are hermetically sealed when manufactured which prevents release of radioactive materials including gases that evolve from fuel during irradiation. Any potential escaping gas from defective fuel rods would be filtered and then vented via the 300 ft. stack. Any such release would be a small fraction of 10 CFR 20 limits (Section 7). The fuel storage environment is benign relative to fuel cladding design conditions. Consequently, low temperatures and favorable water chemistry of the storage environment are not perceived to promote clad deterioration.

Irradiated nuclear fuel was received at GEH-MO in shielded shipping casks, which were designed, loaded, and transported in accordance with NRC and DOT regulatory requirements. Prior to shipment to GEH-MO, fuel was inspected for defects; known defective fuel was not normally accepted for storage by GEH-MO. Prior to unloading fuel for storage, cask flush water may be sampled to detect fuel damaged in transit. Fuel bundles were unloaded maintaining a minimum of 9 ft of water shielding for operating personnel. Cask unloading equipment and facilities are designed to minimize the effect of dropping or tipping over a cask.

Fuel bundles are stored in stainless steel basket assemblies designed to protect fuel from physical damage and to maintain fuel in a subcritical configuration. Baskets are locked into grids in the fuel basins to provide seismic restraint.

The basins are constructed below ground with stainless steel lined, reinforced concrete walls about 2 ft. thick poured in contact with the sides of a bedrock excavation. The south wall of the basin is about 4 ft. thick, because it was intended to stand independent of the surrounding rock to facilitate possible future expansion. Geophysical characteristics of the rock foundation would result in low permeability in the unlikely event of a major basin leak. A leak detection system and pump-out facilities are provided for the space between concrete walls and floor and the stainless-steel liner.

A ventilation system is provided for the basins and other areas. It is designed so that air passes sequentially from areas of low contamination potential to areas of higher potential.

Basin water is circulated through a system that reduces radioactive contamination by ion exchange and filtration. A suction system is provided to vacuum basin floors and floating debris is removed by skimmer intakes. Radioactive materials collected by these systems are processed in the Radwaste System.

Irradiated fuel from light water reactors has been received and stored at GEH-MO since 1972. These activities have reaffirmed irradiated fuel can be handled and stored safely with no impact on the environment[2]. There has been no detectable deterioration of fuel in storage (as determined by measurement of basin water activity) indicating the fuel is stable while in the storage basin environment.

5.4 FUEL STORAGE SYSTEMS

Following paragraphs describe fuel storage systems. The functional sequence of fuel storage operations is described and illustrated in Section 1.

5.4.1 Cask Handling Crane, and Handling Equipment

A two-motion, radio-controlled crane of 125-ton capacity is mounted on overhead rails that are parallel to and centered on the rail spur that serves the CRA. Lift height of the crane is approximately 34 ft. above grade. The horizontal travel area of the crane extends from the CRA over the BDP and finally over the cask unloading basin. The cask-handling crane does not extend over any part of the storage basins.

The crane is equipped with rail keepers ("up-kick lug") to prevent the crane from derailing and falling into the CRA, BDP, or cask unloading basin.

Handling equipment will be used in conjunction with the cask crane to lift the cask from the transport vehicle and to move the loaded or empty cask.

5.4.2 Basin Decontamination Pad (BDP)

The Basin Decontamination Pad (BDP) (Figure 1-4) is used for incoming cask preparation and outgoing decontamination of fuel shipping casks. These operations include tightening or loosening cask head closures, incoming cask wash down, and sampling of cask coolant. The area is used for other activities involving decontamination.

5.4.2.1 Area Description

The BDP, about 27 ft. by 20 ft. in plan, is located inside the process building. The floor is a reinforced concrete pit, 3.5 ft. below grade, sloped to a sump located near the southwest corner of the pit. A stainless-steel platform is centered on the north-south axis of the pit, welded to horizontal rails set in concrete. The platform is about 21 ft. by 8 ft. by 0.375 in. thick. The

slightly raised platform allows for liquid runoff during cask wash and decontamination activities. The above-grade structure enclosing the decontamination facilities is of steel frame and insulated siding construction adequately airtight to maintain ventilation control. The roof is approximately 50 ft. above grade and is of steel deck, rigid insulation and built-up roofing construction. The cask entry doors below the craneway are vertical dual doors about 30 ft. high and 11 ft. wide. A separate lift-type door is provided for the craneway.

Equipment, such as yokes, fixtures, and special tools required to receive and process casks, is moved into the BDP as required. Work platforms are provided for access to the upper parts of casks. A pump system is provided to flush casks internally. The BDP pit sump contents are pumped to the Radwaste System. Radiation shielding is provided for fixed lines carrying cask flush water.

5.4.2.2 Low-Level Solid Waste

Solid radioactive waste generated at GEH-MO is collected and periodically packaged for shipment to a commercial low-level contaminated waste disposal site. This waste consists primarily of disposable protective clothing, shoe covers, cleaning wipes, rags, rubber gloves, and similar materials used in various cask preparation and handling operations. Shipment of low-level waste off-site to approved disposal facilities for incineration of combustible materials and re-melt of metals are preferred methods for treatment and disposal.

Contaminated resins are transferred to High Integrity Containers (HICs) and dewatered for subsequent disposal at an approved site. Low-level waste packages are transported in shielded or unshielded trucks or semi-trailers dedicated to transfer of this type of waste[3].

5.4.2.3 Low-Level Liquid Waste

See Appendix Section B.23 for description.

5.4.3 Cask Unloading Pit

The cask unloading pit (Figure 1-5) is a two-level, water-filled basin adjacent to the BDP and connected to the fuel storage basins.

5.4.3.1 Description

The cask unloading pit is a reinforced concrete structure[4], poured against bedrock, with a stainless-steel inner liner. General dimensions are shown in Figure 1-5. The cask unloading basin and other basin areas are filled with demineralized water to a reference level of 50 ft., or 2.5 ft. above grade, to provide cooling of stored fuel and radiation shielding during fuel unloading, transfer, and storage operations. The cask unloading pit is serviced by all three facility cranes: the cask handling crane, the fuel handling crane, and the basin crane.

Floors of the shelf and the cask unloading pit are provided with devices to dissipate impact loads from the maximum cask-drop accident. The set off shelf is provided with a fabricated, stainless steel crushable pad and a 2 in. steel plate on top of the stainless-steel liner. The floor of the cask unloading pit is covered with a 1.75 in. thick steel plate, under the 0.25 in. thick stainless-steel liner.

5.4.3.2 Basket Positions

Three fuel basket positions are provided along the south wall of the cask unloading pit (fuel storage system components are described in Section 5.4.4). Empty baskets may be positioned in the basin before or after the cask is lowered to the floor. Using the fuel handling crane (Section 5.4.3.6), the crane operator engages a bundle with the fuel grapple, withdraws a bundle from the cask, and places the bundle in a predetermined position in a designated fuel basket. Basket designation and bundle position are determined by administrative procedures.

5.4.3.3 Doorway Guard

The only location throughout the facility where fuel basket contents could be discharged as a result of a postulated basket drop is at the cask unloading pit entrance to the fuel storage basin. During all other basket movements, the bottom of the basket is no more than 3 ft. above the basin floor (about 12 in. above the grid or about 27 in. above the floor). Under these conditions, a basket drop would not generate forces sufficient to eject fuel bundles from the baskets. Length of the basket assembly and height of the mounting grid prevent a base-up position with sufficient elevation to allow fuel ejection from the basket (Also, see Section 8.6.2). However, if a basket were dropped in the doorway just inside Basin 1, the basket might tip toward the cask unloading pit and eject fuel bundles which could fall to the floor. Although consequences of this postulated accident do not present a serious safety hazard to either public or employees, a doorway guard is installed at the entrance to the fuel storage basin.

The doorway guard consists of a frame made of stainless-steel pipe (Figure 5-5). It is supported in the doorway on the cask unloading pit side by hinges on the bottom attached to door brackets, and cables on the top. Each of the two cable assemblies includes a rod 0.25 in. diameter and 8.75 ft. long. Keepers are provided to ensure the cables stay on the pulleys. Underwater pulleys are attached to brackets on the cask unloading pit wall.

Before fuel is loaded in a storage basket the guard is in the retracted or vertical position. The guard is lowered to the basket transfer (or angled) position prior to movement of a basket through the doorway. The basket-lifting tool is lowered through the guard and attached to the basket located directly below the guard. The basket is then lifted through the guard and moved laterally into the fuel storage basin. Baskets must be moved to the eastward fuel basket position before being lifted to the doorway.

The doorway guard is designed to function as an energy absorbing device. Energy imparted to the guard by a basket falling against it, is absorbed by stretching the two stainless steel rods (up to 40% elongation).

The fixed length of the basket lifting tool (grapple) prevents a basket from being lifted over the guard. A basket must be lifted through the guard and then moved laterally into the fuel storage basin. In this way, if a basket is dropped and it tilts toward the cask unloading pit, the guard will prevent it from tilting past a horizontal position.

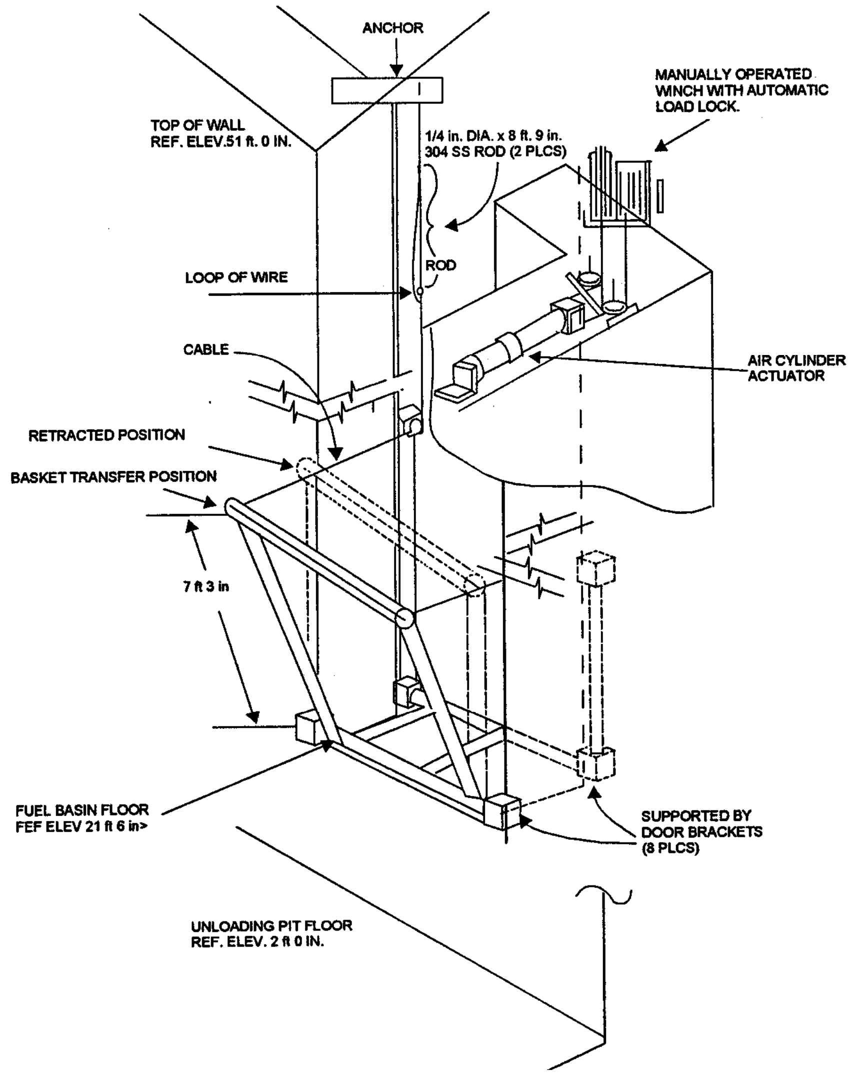


Figure 5-5. Unloading Pit Doorway Guard

5.4.3.4 Fuel Grapples

Fuel grapples are designed to transfer fuel bundles between a cask and storage baskets. The 5-ton capacity fuel-handling crane is used to move the grapple to engage the fuel bundle. Grapples are fabricated to meet requirements of specific fuels. Typical BWR and PWR grapples are discussed in following paragraphs.

The BWR fuel grapple is constructed of two 20.5 ft. tubular sections joined lengthwise with a lifting bail and latching control mechanism at the top and a means of latching the fuel at the bottom. The grapple can be positively engaged through design features depicted in Figure 5-6. It can be disengaged only when the weight of the fuel bundle is not applied. The control mechanism for the grapple's hook is a manually operated handle connected to the latch by a cable running down the center of the grapple. An emergency release feature is incorporated into the design for use if the release cable fails.

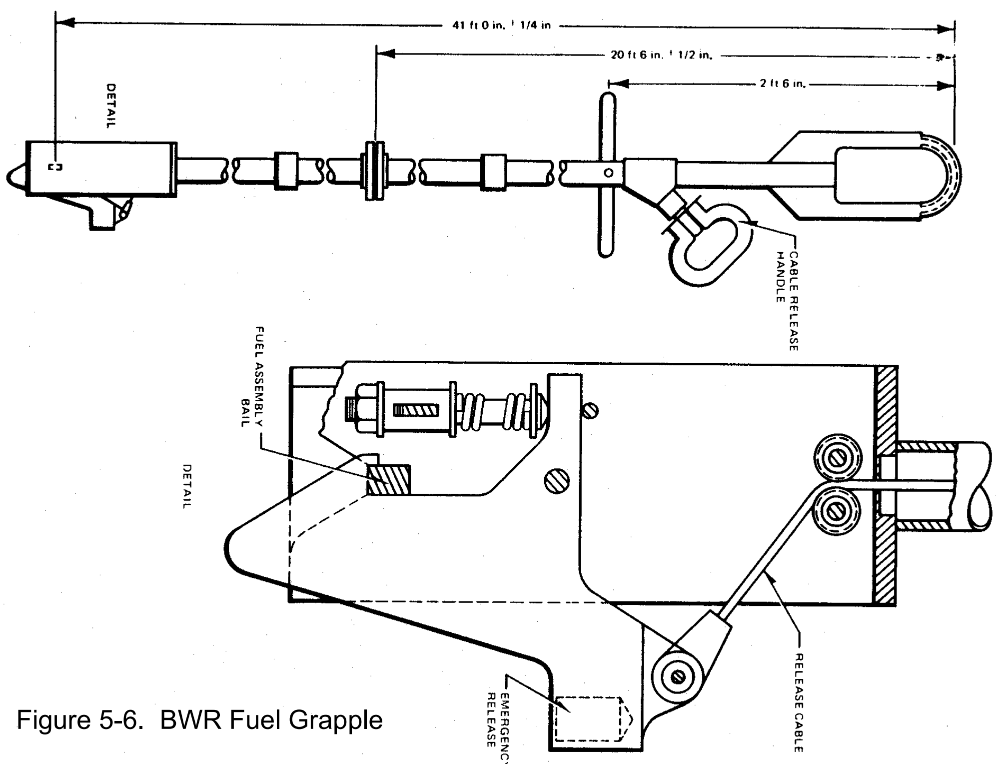


Figure 5-6. BWR Fuel Grapple

The PWR grapple (Figure 5-7) is 50 ft. long and constructed of stainless steel. At the top is a lifting bail and operating mechanism. At the bottom is the latching mechanism designed for the specific type of fuel bundles to be handled. The PWR fuel bundle has a "picture frame" upper plate. When the grapple is lowered onto the bundle, two guide pins on the grapple fit into holes in opposite corners of the picture frame, thus aligning the grapple. After the grapple is lowered

to touch the upper plate of the fuel bundle, the four evenly spaced grapple fingers are forced outward by manual rotation of the handle of the locking mechanism. This operation forces a cylinder down among the pivoted fingers, positively locking them in place. Once the bundle is locked in position on the grapple, it is ready for transfer to the storage basket.

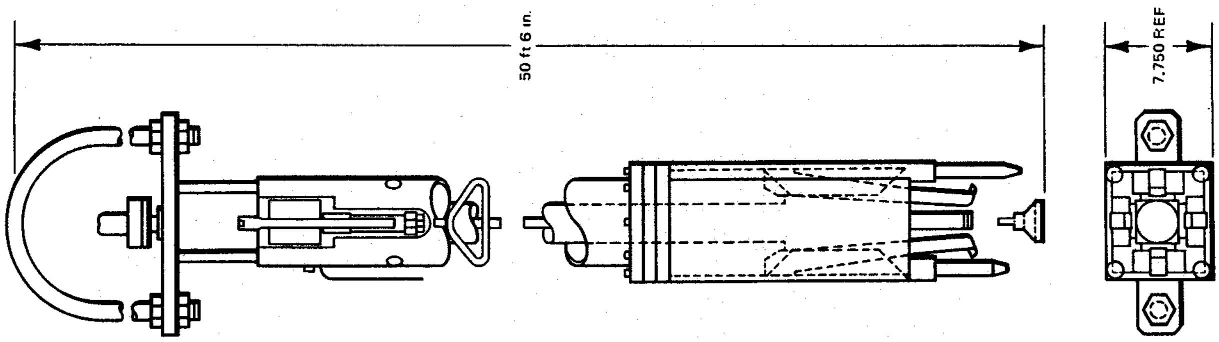


Figure 5-7. PWR Fuel Grapple

5.4.3.5 Basin Crane

The (fuel storage) basin crane is a manual control bridge crane of 7.5-ton capacity. Lift travel is limited by use of a long shank hook extension to prevent lifting of fuel baskets to within 9 ft. of the water surface. Travel limits of this crane extend from the cask unloading basin to the south end of the fuel storage basins. A platform on the south side of the crane bridge near water level facilitates operation of the basin crane. The fuel-handling crane is operated from a platform on the north side of the basin crane. Bridge wheels and retainers are designed to maintain the basin crane in position under earthquake conditions. Derailment, if it occurs, would not result in either bridge or trolley falling into the basin. Repositioning on the rails can be accomplished manually with the use of hoists and jacks. Interruption of service of this crane has no safety connotation.

5.4.3.6 Fuel Handling Crane

The fuel-handling crane (also referred to as basin auxiliary crane) is used to handle fuel bundles in the cask unloading basin. This crane has a 5-ton capacity with stepless speed control and is supported from rails attached to the underside of the cask crane support members. Provisions for meeting seismic conditions are similar to those for the basin crane including restraints (rail keepers) to prevent the crane from derailing and falling into the basin. The bridge is of the underslung monorail type, and the trolley is a rigid, one-piece weldment capable of withstanding vertical, lateral, or torsional strains. Bumpers for both bridge and trolley prevent over-travel. Interruption of service of this crane has no safety connotation.

5.4.4 Fuel Storage System

Fuel is transferred between cask and storage baskets the cask unloading pit. Loaded baskets are moved into the storage basin by use of the basin crane (Section 5.4.3.5). Fuel baskets are latched into a supporting grid structure on the basin floor that provides seismic restraint.

The original intent for fuel storage at GEH-MO was to provide short-term storage for fuel to be reprocessed. Thirty-two fuel baskets of relatively low storage density were provided to contain fuel bundles in the basin[5]. The unit storage densities[6] originally provided were approximately 0.2 TeU/ft^2 for BWR fuel and 0.1 TeU/ft^2 for PWR fuel in baskets and approximately 0.5 TeU/ft^2 for PWR fuel in storage racks. The present design provides more effective use of the total basin area for long-term storage by permitting unit storage densities of approximately 0.35 TeU/ft^2 for either BWR or PWR fuel. This modification was authorized by amendment to Materials License No. SNM-1265, dated December 1975.

5.4.4.1 Fuel Integrity In Storage

Regulations for safe storage of irradiated nuclear fuel require structural integrity to be maintained under severe accident conditions or catastrophic natural phenomena to prevent failure of fuel rods or a criticality excursion and to effectively control contamination levels in basin water. Integrity of fuel cladding is the primary barrier to release of radioactive material from fuel pellets.

Based on current experience and assessment of relevant literature, storage of spent nuclear fuel in storage basins for periods greater than 20 years is considered reasonable[7,8,9,22]. Fuel cladding is designed to withstand a far more severe environment in a reactor than that encountered in a storage basin.

Considerations include:

a. Zircaloy-clad fuel has been stored satisfactorily in basins since 1964 and stainless-steel clad fuel has been stored since 1970. There are no indications of clad deterioration from the basin environment.

b. Low temperature and favorable water chemistry are not likely to promote cladding deterioration.

c. There are no obvious degradation mechanisms which operate on cladding under basin conditions at rates that would cause failures in the time frame of interim storage.

Literature[7,8,9,22] shows no significant effects of pool storage on fuel rods. Questions have been raised regarding long-term storage (20 to 100 years) because of possibilities of corrosive effects from inside the cladding and from effects at the external crud-cladding junction. However, tests

at Windscale on 9-year storage fuel do not show such attacks. It should be noted that the effect of small cladding defects in individual fuel rods is relatively minor due to chemical inertness of fuel pellets in water and cleanup capabilities of the filtration and ion exchange systems provided to control basin water contamination.

5.4.4.2 Equipment Description

The GEH-MO fuel storage system utilizes uniformly spaced baskets (26 in. square baskets on 27 in. centers). A schematic drawing of arrangement of PWR and BWR baskets is shown in Figure 5-8 and engineering drawings are located in Appendix A.14. Baskets for storage of BWR fuel bundles consist of either nine 8.5 in. stainless steel round tubes, or nine 6.25 in. stainless steel square tubes, while those for PWR fuel bundles consist of four 12 in. schedule 5S stainless steel pipes. The bottom of each basket is closed while holes in the basket wall permit convection flow through the basket. The closed-bottom area traps material that may fall from a fuel bundle, such as corrosion material on surfaces of the fuel bundle. The square tube BWR baskets have flow holes in the bottom and the wall to promote convective water flow through the basket.

Stainless steel baskets reduce neutron interaction between adjacent fuel bundles, permitting more efficient use of space. The resultant combination of separation and stainless-steel neutron absorption ensures that the effective multiplication factor (k_{eff}) for an array of baskets will be < 0.95 at the 95% confidence level.

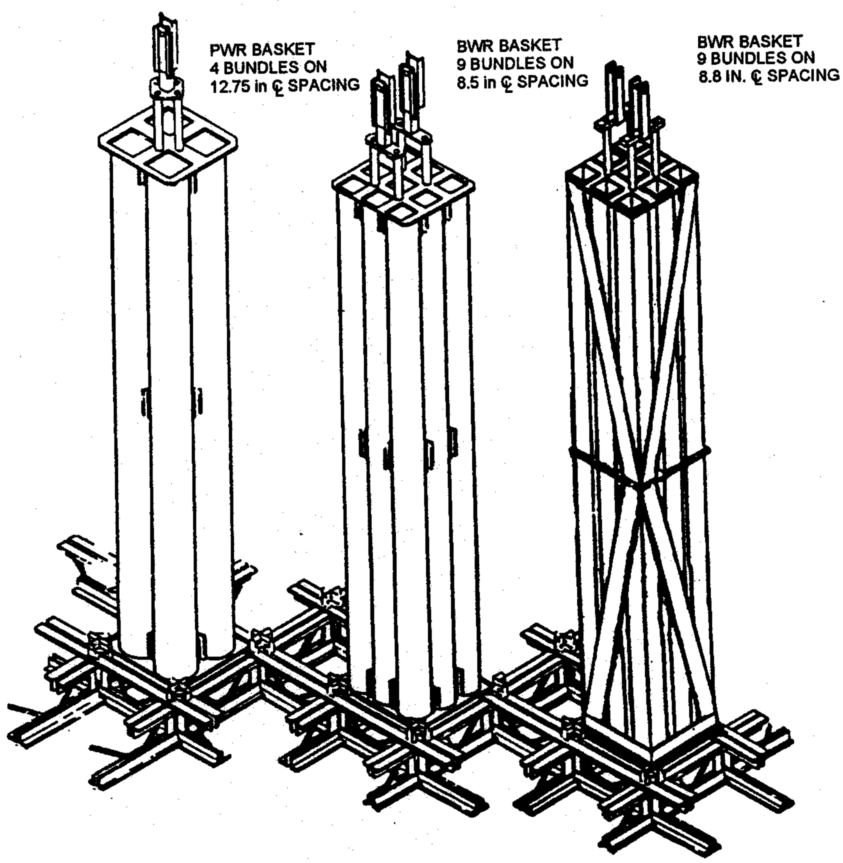


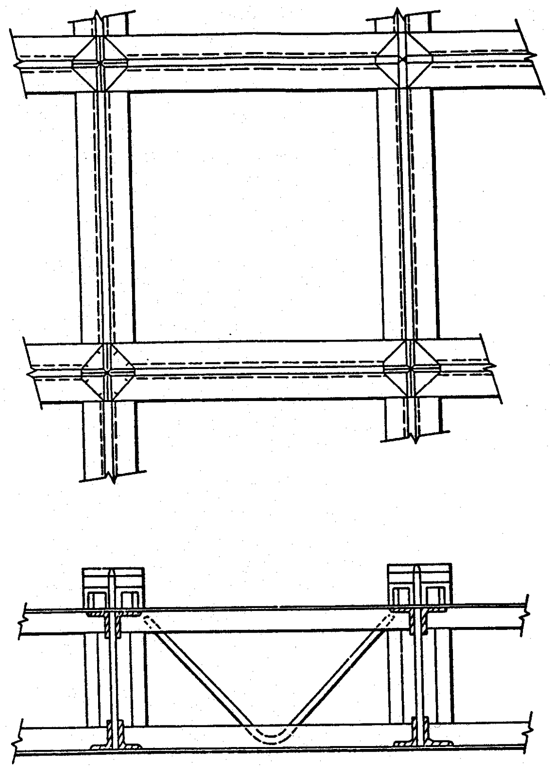
Figure 5-8. Morris Fuel Storage System. Constructed of stainless steel, the system provides a secure, flexible system for storage of LWR fuels. The three types of baskets mount interchangeably in the support grid.

Pipes or tubes are attached firmly together and supported by a substructure, forming an independently movable basket. To lift the basket, special hooks are used to engage lifting rods that protrude above the basket. Outside substructure dimensions of PWR and BWR baskets are identical; therefore, each will fit interchangeably into a standard supporting structure.

Baskets are locked in position on a mounting grid of stainless-steel members on the basin floor. A three-basket mount is installed in the cask unloading pit and a similar mount may be installed in the transfer corridor so baskets can be temporarily placed in the cask unloading pit or in the corridor in a manner equivalent in safety to that used in the main basin area. These mounts are called basket retainer frames and are equivalent to the mounting grid used in the fuel basins.

Figures 1-13, 5-8 and 5-9 show views of the grid. Grids are installed in the basins in large modules (typically 4 by 14 basket units per module), which are limited to the size that can be moved and installed safely and conveniently in the fuel storage area. Grids are braced against

the walls using wedges. An analysis of load effects on basin walls and liner indicates basin walls will withstand seismic and thermal loads transmitted by the support grid. As a result of the analysis, a solid film lubricant (Electrofilm)[10] was used on wedges to reduce the coefficient of



friction between grid and wall to accommodate thermal and seismic movement.

Grids are fabricated from stainless steel structural material. Basket weight is supported by the stainless-steel angle structure of the grid. At each intersection of cross members, a locking block is attached to the top of the grid structure, secure to the baskets in place.

Each basket has four cam-activated latches (Figure 5-10). Latches extend from each corner of the basket base and engage locking blocks on the grid when the latches are activated by linkage to the four lifting rods at the top of the basket assembly. When the weight of the basket (full or empty) is supported by the lifting rods, the cam-operated latch assemblies are retracted and will not engage the locking blocks. When the basket is set in place on the grid and lifting rods are released (tension removed), the weight of the lifting rod assemblies cause latch assemblies to engage locking blocks.

Design criteria basis and safety analysis of the fuel basket system, including criticality analysis, are contained in Appendices A and B. The grid-basket system has been subjected to seismic

Figure 5-9. Typical Grid Assembly

testing to design criteria. Appendix A.14 includes engineering drawings of baskets and support grids. The fuel storage system has a minimum design life of 40 years but because of the nonaggressive service environment, a much longer useful life is indicated.

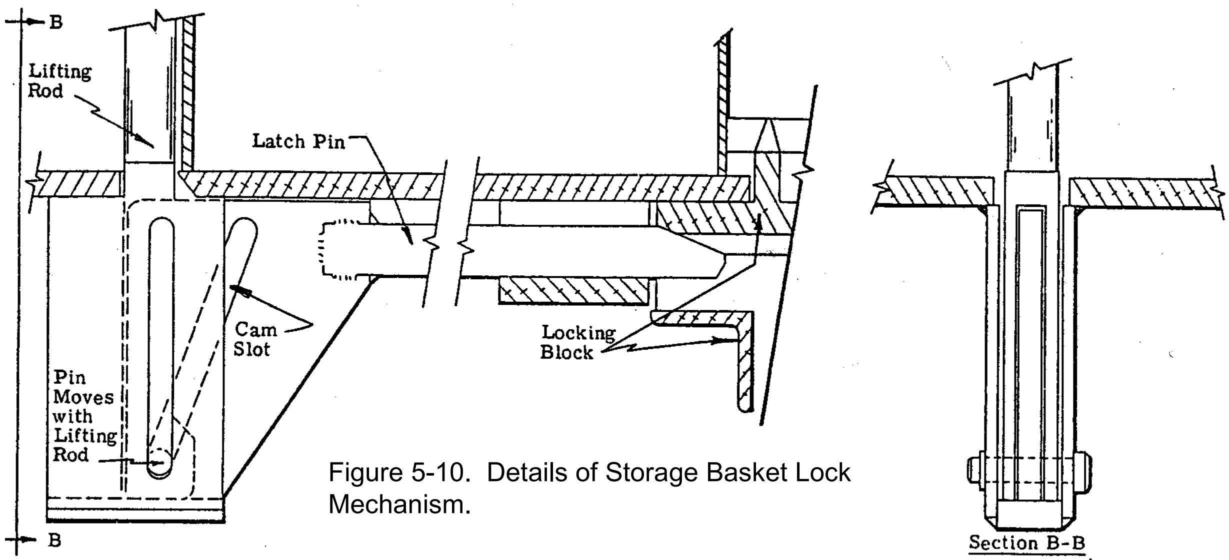


Figure 5-10. Details of Storage Basket Lock Mechanism.

5.4.4.3 Heat Transfer from Stored Fuel

Heat transfer from stored fuel has been calculated for both BWR and PWR fuels and differential temperatures from fuel to basin water determined (Appendix A). Calculations included determining hole sizes in the basket wall that allow adequate water flow. Final basket assembly design is such that, even with some hole plugging (not considered a credible event), fuel temperatures remain satisfactory. Even with basin water-cooling systems inoperative, maximum water temperature would be 123 °F[23]. See Appendix A.9.

5.4.4.4 Basket Lifting Tools

The BWR and PWR basket lifting tools (or basket yokes) are identical in function. However, the BWR yoke has two lifting hooks and the PWR yoke has one hook in order to match respective basket lifting bails.

Both lifting tools are constructed of stainless steel. Each tool is approximately 14 ft. long, a feature that precludes inadvertently lifting fuel closer than 9 ft. to the surface of basin water.

5.5 FUEL STORAGE BASINS AND SYSTEMS

This section describes fuel storage basins (Basins 1 and 2) and includes information about concrete and construction techniques employed when basins, main building, and other related facilities were built. Information regarding reinforced concrete construction is referenced in other sections of this report. General configuration and size of the water-filled fuel storage basins are shown in Figure 1-5.

5.5.1 Storage Basin Description

Basin 1 has an area of about 900 square ft.; Basin 2 has an area of about 1,500 square ft. There are a total of 414 fuel basket positions: 150 in Basin 1 and 264 in Basin 2.

Fuel storage basins and the cask unloading pit are constructed of reinforced concrete poured on bedrock with a welded stainless-steel liner. Fuel storage basins are filled with demineralized water to a nominal depth of 28.5 ft. Water level may be lowered 2 ft. for maintenance or other purposes but at least 9 ft. of water is normally maintained above the top of stored fuel. If the water level falls more than 2 ft., pump suction inlets will be exposed. There is no means of accidentally draining the basin, nor can any basin water systems inadvertently drain the basin (i.e., the water systems are designed with nonreversible pumps, no drainage system, etc.). Basin water level is indicated in the CAS/SAS. The system includes an audible low-level alarm.

Cask handling, cask loading, and fuel storage areas are constructed of concrete, steel, and other materials which are either nonflammable or fire-retardant No significant amount of flammable materials is used in these areas, and other potential fire dangers (bottled gases, etc.) are introduced only under stringent administrative control. No fire detection or automatic fire suppression systems are required in these areas or in the basin pump room and its extension. Fire extinguishers are strategically located, and plant personnel are trained for fire surveillance. Further protection is provided by surveillance patrols.

Reinforced concrete in basin walls and floors were designed and constructed in accordance with the applicable national standards and meet conditions consistent with longevity as described in NUREG-1801, “Generic Aging Lessons Learned Table A5.1-e and Appendix A-8. The GE-MO basin water chemistry provides an excellent media for SS materials consistent with IAEA-TEDOC-1012 [22] and Appendix A-8.

5.5.1.1 Foundation and Excavation

The basins are founded on shale bedrock (Figure 5-11). Samples of the shale have been tested at ultimate compressive strengths ranging from 6,000 to 11,000 psi. Appendix B contains a site survey and foundation report prepared for MFRP construction[12]. The excavation site was over excavated and back-filled to the south of Basin 2 to facilitate possible expansion of storage

capacity at some later date. All loose and disturbed rock was removed prior to concrete construction. Backfill consisted of controlled and compacted granular soils. Concrete mud mats were poured to fill any area excavated more than 4 in. deeper than required (except for the south wall of Basin 2). The basin wall structure is designed to resist pressures from backfill and soil water where over excavations were made (south of fuel basin and vaults, Figure 5-11).

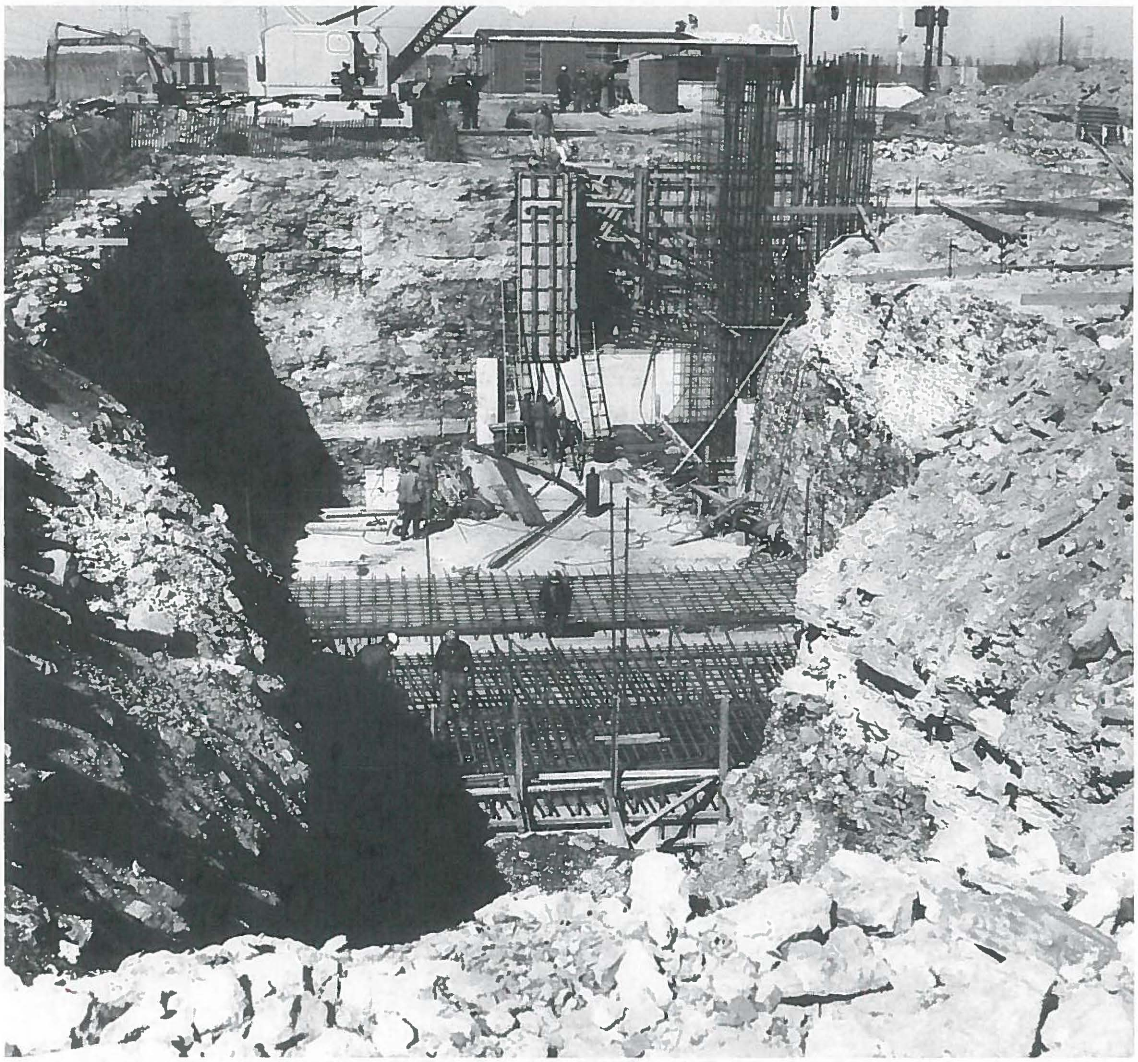


Figure 5-11. Excavation and Foundation Construction.

5.5.1.2 Concrete Structure

Storage basin floors were poured on bedrock and range in thickness from 30 to 54 inches. Basin walls extend 3.5 ft. above grade.

Materials used for basin concrete construction are typical of other concrete construction at GEH-MO. Materials used for reinforced concrete structures were:

- Cement conforming to ASTM C150 type 2
- Washed sand
- Washed and graded aggregate
- Reinforcing steel per ASTM A15, intermediate grade

Concrete pours had slump tests and laboratory samples taken, usually at the truck discharge, but at times at the point of placement - particularly on canyon containment walls. Concrete samples were taken for every pour of 100 yards or less, whenever a pour composition changed and one per 100 yards for pours greater than 100 yards. A full-time concrete inspection program was in effect during construction.

Reinforcing steel used in the basins is intermediate strength with 40,000 psi minimum yield strength. Structural welds that carry loads from one element or reinforcing bar to another were not used. Where required, loads were transferred from bar to bar by conventional reinforcement bar laps secured in assemblies by steel tie wires. In special cases, U-bolts were used. The only welding permitted was tack-welding reinforcing steel to brace assemblies away from forms or to secure embedded items in position during the concrete pour. In most cases, assembly bracing or embed securing was done by use of additional reinforcing steel or structural steel tack welded to the reinforcing steel assembly. Embeds were either welded or clamped to this steel. Tack welds were made no larger than necessary to produce sound, crack-free welds.

5.5.1.3 Basin Liner

The unloading and storage basin complex is completely lined with 304L stainless steel sheets placed flush against concrete walls and floors and welded to a gridwork of stainless steel back-up members embedded in the concrete (Figure 5-13). The cask unloading pit floor liner is 0.25 in. thick and is placed over a 1.75 in. thick steel plate provided for distributing impact loads over the underlying concrete structure. Additional energy absorbing means, as may be required by cask drop accident considerations, will be installed for receipt of larger-sized casks.

The set off shelf liner, also 0.25 in. thick, is placed directly on the concrete structure with an energy absorbing assembly placed on top of the liner (seen in Figure 1-13).

For the remainder of the storage basin complex, the floor liner is 0.187 in. thick. Walls of the cask unloading pit, including shelf area are lined with 11-gauge sheet steel. For the fuel storage

basin walls, the liner is 11-gauge sheet steel from floor level to approximately 16 ft. up the wall and 16-gauge sheet steel from there to the top of the basin.

Large liner sheets (generally on the order of 6 ft. by 16 ft.) were welded continuously along each edge to the grid-work of back-up bars and also were slot welded to embedded plates at intermediate locations so the liner is held against the concrete wall to reduce potential for puncture damage. To facilitate fit-up and ensure high integrity, liner sheets were welded to embedded stainless steel angles at wall-to-wall and floor-to-wall joints. The liner terminates on a stainless-steel angle at the top of the basin. Specifications for liner installation include approved joint design welding procedures and welder qualification requirements. All welds were visually inspected and vacuum box tested to ensure leak tightness[13]. Final verification of liner integrity was provided during basin filling.

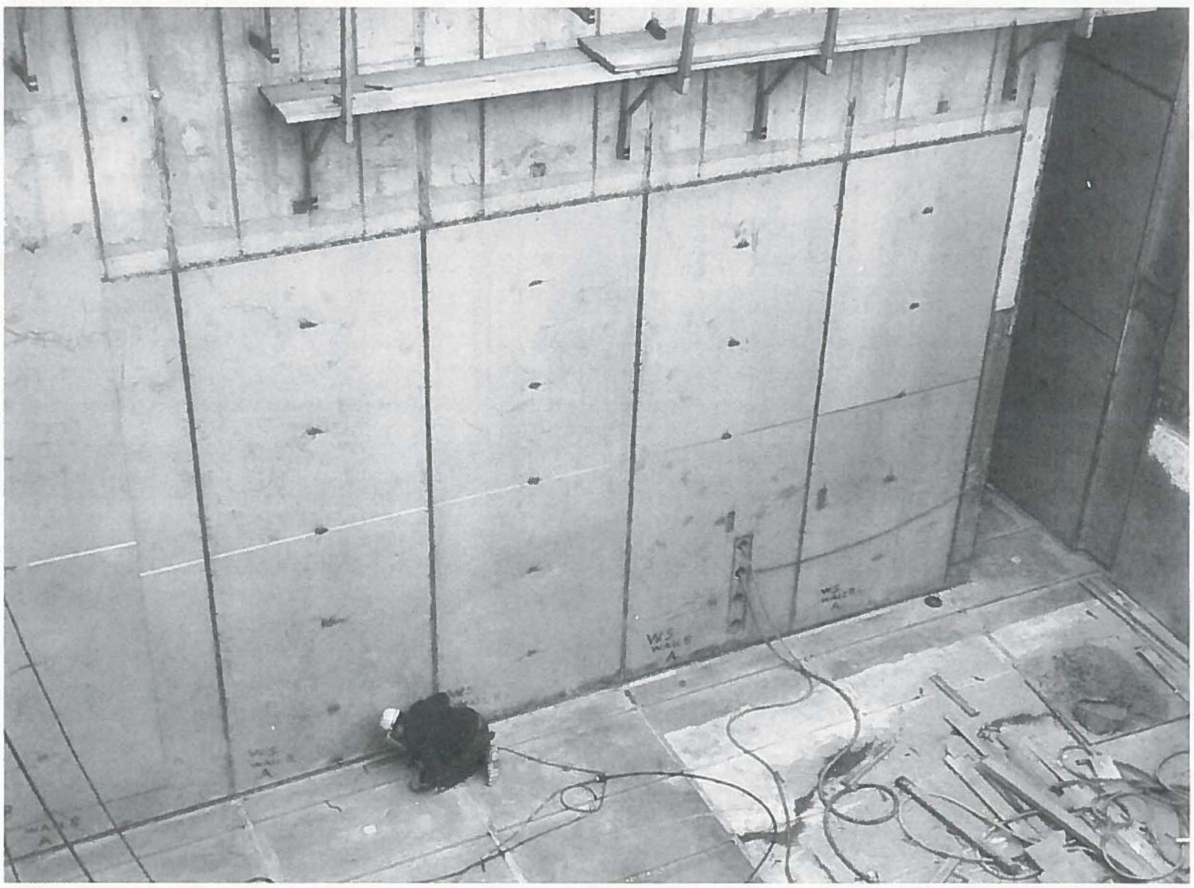


Figure 5-12. Stainless Steel Basin Liner. Both storage basins and the unloading basin are completely lined with stainless steel sheets (304L) placed flush against the concrete walls and floor, welded to a grid of stainless steel embedments.

Because of the nonaggressive basin liner service environment, corrosion testing of 304L liner sheet steel was not required. However, a substantial quantity of 304L sheet steel material was subjected to corrosion tests, with few lots exceeding the 0.003 in. per month in Huey Tests as specified in ASTM A262, Practice C. Many rates were lower than 0.001 in. per month with no evidence of pitting or cracking.

The specified Huey Test is based on exposure to 65% HNO_3 at boiling temperatures whereas actual service is in neutral demineralized water at about 80 °F average temperature (maximum of 120 °F). In demineralized water at the lower temperatures, it is estimated that corrosion rates are significantly lower than those measured in the accelerated tests. The data measured on the Morris basin liner shows a depth of penetration of 0.4 mils over a 20-year period. Using this corrosion rate, for the thinnest (upper basin wall) liner, a 50% reduction in thickness from "one-side" corrosion at such a rate would require 18,000 months.

Basin liner corrosion, to the extent that it occurs, is expected to be a general attack with essentially no effects from galvanic corrosion. System pH is controlled, and metal ions present in the system are minimized by use of demineralized water. Water purity is maintained by circulating basin water through a filtration and ion-exchange cleanup system.

5.5.1.4 Basin Liner Leakage Control

To facilitate drainage of water from between the concrete structure and the stainless-steel liner (water that may seep in through the concrete as well as any liner leakage), 0.5 in. square drain slots on approximately 3 ft. centers are provided in concrete basin walls and floors behind the liner. These lead to a 1 in. square collection header located behind the floor-to-wall joint at the basin perimeter, which drains to a single sump at the bottom of the cask unloading pit. The sump consists of a 6 in. diameter vertical pipe embedded in the west (exterior) wall of the unloading pit, extending above water level to a point approximately 1 ft. below floor level and connecting to the perimeter collection header.

The sump contains a liquid level detector line and necessary piping for a removal system. Auxiliaries for the level detection and removal system are located in the basin pump room. The removal system employs an airlift working in conjunction with an air operated pump. Operation of sump equipment has met design requirements.

5.5.1.5 Earthquake and Tornado Analyses

The basins were designed for earthquake and tornado conditions in accordance with criteria presented in Section 4. Earthquake, tornado and missile analyses are contained in Appendix B. Although much of the building is unused and not relevant to fuel storage, the structure does form a portion of the basin area east wall, as well as containing the ventilation tunnel, control room (SAS), and other support functions.

5.5.2 Basin Water Clean-Up System

The interconnected basins are supplied with demineralized water from the on-site well and water treatment facilities. These facilities include pre-filters to control organic material in incoming water. The basin water clean-up system includes a suction system for underwater "vacuum cleaning" and a resin pre-coat filter system with associated equipment.

The purpose of the basin water treatment system is to maintain water clarity and quality, minimizing concentration of radioactive materials in the water. Basin water clarity is maintained such that objects at the bottom of the storage basin are visible from the pool surface with or without optical devices at the surface[14]. Radioactive material in basin water originating from fuel element surfaces and leakage from defective fuel rods is controlled to ensure that radiation and contamination levels are **ALARA**. Basin water quality is controlled to prevent potential corrosion attack and stress corrosion cracking of system components.

5.5.2.1 Water Quality and Characteristics

Water added to the basin has a maximum conductivity of 1.35 μmho/cm. a conductivity of less than 1.35 μmho/cm yields a pH from 5.5 – 8 in demineralized water. Based on the operating experience of various reactors, and storage pools, conductivity and pH are the most important water quality indicators and are the only indicators of water quality commonly measured at such facilities. Basin water chemical characteristics are selected to maintain a benign environment for fuel and equipment stored in the basin water.

Based on operating experience, factors of turbidity and organic material are not considered to be as important as conductivity and pH. Turbidity would present a temporarily inconvenient operating condition that would be remedied by adjusting filter media or procedures. Control of organic material by pre-filters is considered adequate to maintain this contamination below acceptable limits.

5.5.2.2 Radioactive Materials in Basin Water

Principal radioactive contaminants in the GEH-MO storage basin water include the fission product Cesium-137 and the activation product Cobalt-60 with typical concentrations as of April 2020 of 7.3×10^{-4} μCi/ml and 2.1×10^{-6}, respectively. A maximum concentration of 5×10^{-3} μCi/ml was measured at the end of a 3-week period during which the filter was purposely not operated. Similar levels of contamination have occurred in recent years.

Since removal mechanisms and relative proportions of the two principal contaminants differ, operational controls for the basin are based on exposure levels. Technical Specifications include a limit on concentration of radioactive material in basin water for which special corrective

action is required. If the gross β concentration reaches 0.02 μCi/ml a cleanup campaign will be initiated.

5.5.2.3 Basin Water Filter System

The filter system maintains water clarity and removes dissolved materials. A 250 gpm pump delivers water from the skimmers or vacuum hoses to the coated tube filter (a 115 square-foot DeLaval unit, about 2.5 ft. in diameter by 6 ft.) and back to the basin. The filter is pre-coated with Solka Floc, a cellulose filter base. This base can be overlain with diatomaceous earth, Powdex resins, or Zeolon as desired. Sludge from the filter is collected in a small tank (approximately 600 gal.) and ultimately transferred to the Radwaste System.

The basin clean-up filter is housed in a heavily shielded, restricted access room with electric lock entry control. A Special Work Permit (SWP) is required for entry. The filter is changed remotely by a programmed controller (Figure 5-15), which flushes filter media from the filter septums into the sludge tank. Therefore, personnel are not routinely exposed to radioactivity accumulated in the unit.

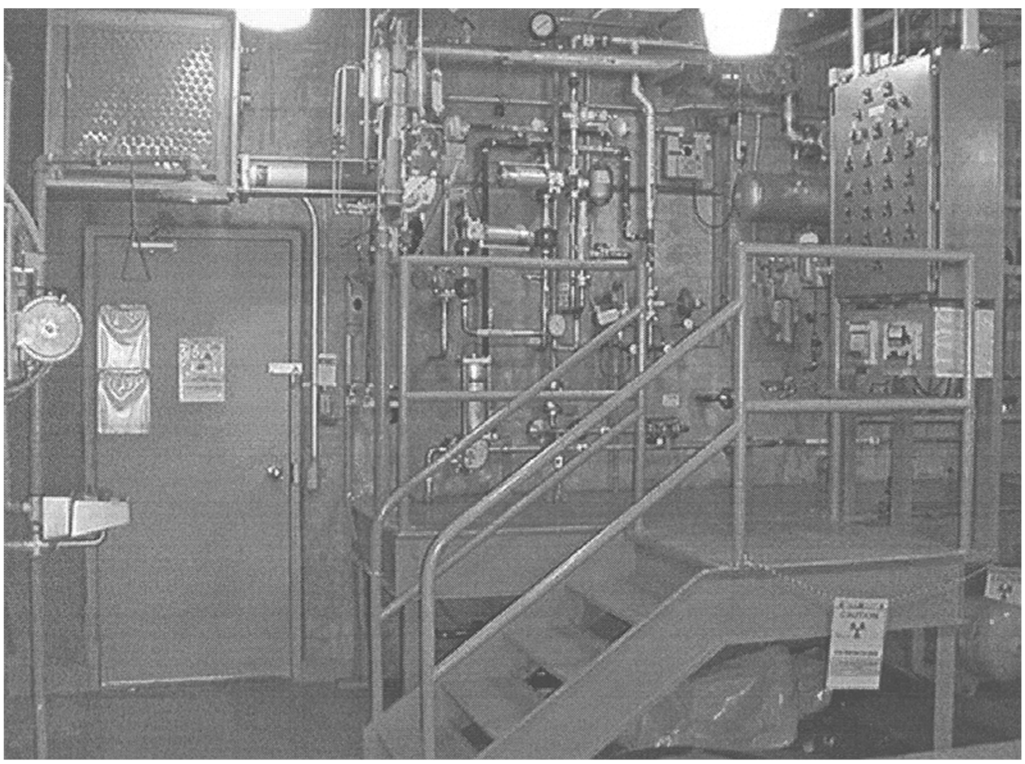


Figure 5-15. Basin Filter Controls: View shows basin filter programmed controller and associated instruments and piping. Filter is housed in shielded room behind locked door to the left.

An inherent advantage of the Powdex system is the ability to accommodate a variety of water purifiers. For example, a quantity of Zeolon[15], a synthetic alumino-silicate molecular sieve having a high affinity for cesium, may be added to the normal recharge used for the Powdex system. In practice, two kilograms of Zeolon-100 are added with the mixed cation-anion Powdex resins during filter make-up. The zeolite acts as a true ion exchanger and, under clean basin water conditions, partitions radiocesium so that about 90% is absorbed by Zeolon and 10% remains in the water. This partitioning ratio remains constant irrespective of the radiocesium transfer rate (from fuel to basin water) since chemical concentration levels in the water do not measurably exhaust the chemical exchange capacity of the ion exchanger[16].

5.5.2.4 Safety Evaluation

Failure of the basin water treatment system is not critical to safety of the fuel storage system. Redundant or spare filters are not required. The system has been out of service for several weeks without marked deterioration of basin water quality. Typical basin water isotope concentration levels are shown in Table 5-1. Isotope concentrations vary, depending upon rate of addition of fuel to the basin and method of operation of the basin filter.

Data in Table 5-1 indicate that the activity levels in basin water do not contribute significantly to personnel exposure. There is little accumulation of contamination on the basin liner at waterline.

Table 5-1
TYPICAL ISOTOPE CONCENTRATIONS IN BASIN WATER as of April 2020

Isotope	Typical Concentration[a] (μCi/ml)
Cs-137	7.3×10^{-4}
Co-60	2.1×10^{-6}
H-3	2.5×10^{-5}

[a] The concentration of other radionuclides which are low-energy beta emitters is less than the total radiocesium and cobalt. In terms of radiotoxicity they are insignificant compared with cesium and cobalt.

5.5.3 Basin Water Cooling System[17]

The heat load as of October 1996 is about 1×10^6 BTU/hr. At this point in the fuel and fission product decay cycle, the heat load should decrease about ten per cent each two years.

5.5.3.1 Equipment Description

Basin water heat dissipation is accomplished through the use of 2 parallel heat pumps and heat exchangers each forming a closed loop. Typically, one unit has the capacity to maintain the basin water temperature and the second unit will function as a back-up. Historically, basin water temperature has been maintained under 40 °C with typical temperatures less than 35 °C.

5.5.3.2 Safety Evaluation

Failure of the basin cooling system is not critical to safety of the fuel storage system. In the event that both heat exchanger units should fail, there is enough time to supply make-up water to the basin while the cooling system is repaired or replaced. With both heat exchanger units inoperative and the current fuel load, the temperature of the basin water will slowly rise (<2 °F/day) and approach an equilibrium temperature of about 123 °F. See Appendix A.9.

Potential leaks in the cooling system that could occur as a result of an accident have been analyzed and results are given in Section 8. It was concluded that the consequence of a leak in the system is insignificant[18]. Coolers are periodically inspected for leaks. Accumulation of radioactive contaminants in the cooling system components is monitored, and the system decontaminated when required (Section 7.3.2.3).

5.5.4 Ventilation Exhaust System

Facilities provided for filtration, monitoring, and release of effluent air are described in following sections (Figure 1-22 and Appendix A.14). Discussion of radioactive contaminants in effluent air is contained in Section 7.

5.5.4.1 Air Tunnel

A below-grade reinforced concrete tunnel runs the east-west length of the main building along its north wall. The tunnel was originally intended to collect all building ventilation exhaust air (via ducts from various cells, hoods, etc.) for routing to the ventilation exhaust filter. The rectangular cross section of the tunnel is on the order of 20 square feet, increasing in area toward its outlet at the sand filter. A 3 in. deep stainless-steel floor pan is provided for collection of condensate. The floor slopes toward a collection point (41.5 ft. elevation) from which a drain line is routed to the off-gas cell sump. Instrument ports are located near the tunnel outlet for radiation off-gas monitors. Provisions are made for future extension of the tunnel to an additional sand filter, if ever required. Air from the basin area is drawn into the air tunnel via the canyon area.

5.5.4.2 Ventilation Exhaust Filter

A reinforced concrete structure, 75 ft. by 80 ft. in plan and 15 ft. in height, houses the low-velocity, upward flow sand filter through which effluent air is drawn before discharge from the stack. It is located immediately east of the main building and is connected to it by an underground extension of the ventilation air tunnel. The tunnel extension leads to a central air distribution duct at floor level (about 40 ft. reference elevation) of the filter structure.

The filter bed is about 8 ft. deep and is comprised of layers of graded gravel and sand. Openings are provided in the central duct to distribute incoming air laterally through the gravel bed which forms the bottom layer of the filter. The floor is sloped for positive drainage back through the air tunnel to the off-gas cell sump. Outlet from the upper, open portion of the filter structure is through ports in the west wall leading to an adjacent reinforced concrete structure (the equipment building) 24 ft. by 80 ft. in plan, housing exhaust blowers as well as a diesel-electric generator and associated switchgear, effluent air sampling system and two air compressors. This arrangement places all equipment and auxiliaries essential to exhaust system operation within reinforced concrete structures for protection against earthquake and tornado conditions.

5.5.4.3 Emergency Equipment Building (EEB)

The EEB is divided into three rooms:

a. Fan Room: Exhaust blowers are located in an area, 19 ft. by 35 ft. in plan, with a grade level concrete slab floor. Inlet ducting for the blowers connects directly to openings in the filter enclosure wall. Each blower unit consists of an electric motor and fan capable of providing 13,000 cfm of flow at 6 in. of water pressure differential. Normal system configuration is one unit operating with the second available for back up use. Other equipment in the fan room includes the system for continuous sampling of air entering the sand filter from the main building, and a sampling system for air being routed to the stack.

b. Compressor Room and Compressed Air System: Two air-compressors, the primary air receiver and the dual bed air dryer are located in this area of the equipment building. Failure of the compressed air system is not critical to safety of the fuel storage system. The system is discussed here, because it does perform some auxiliary non-safety related function involved with fuel storage and are located in the emergency equipment building.

   Instrument air is supplied from the receiver to drying equipment in the equipment building from which it is delivered to an instrument air receiver in the main building. The air is used for instruments and air operated valves. The instrument air system is served preferentially upon loss of compressor air supplies to the main receiver; low pressure in the main receiver automatically valves off the process air system.

c. Generator Room[19]: (Not essential to fuel storage activities and discussed here because it is located in the emergency equipment building.) The remaining area of the filter building is

21 ft. by 23 ft. in plan and houses the diesel generator and auxiliaries. The diesel-driven 400 kVA unit is designed for automatic startup upon total loss of commercial power and is provided with both battery and air-pressure starting systems. Battery racks, with continuous charger, and two air bottles for the starting systems are located in the generator room as is all switchgear required for the secondary power supply system. A 1,000-gal diesel fuel tank is located adjacent to the generator room and both electrically driven and manual pumps are provided for transferring fuel from the storage tank to the 33-gallon day-tank located in the generator room. The radiator for the diesel engine is mounted in a wall opening and is provided with a heavy grill for protection against wind borne missiles. This opening is in the west wall of the equipment enclosure and faces the main building, the east wall of which is about 30 ft. away, so that some additional protection against damage from wind borne missiles is provided.

5.5.4.4 Effluent Air Release

A 4 ft. diameter reinforced concrete pipe is provided for routing air from exhaust blowers to the main stack which is located approximately 350 ft. south of the sand filter and equipment building. The pipe is essentially at grade level and has a protective earth covering. It is equipped with a covered instrument enclosure to house monitoring equipment and a bolted-cover manhole to provide an alternative release point in the event flow through the stack is blocked due to stack failure. A stainless-steel drain line is provided for routing condensate to the stack condensate collection system. The main stack is an all-welded steel unit, which reaches a height of about 300 ft. (91.4 m.) above grade and is supported on a reinforced concrete foundation by external cable guys. It is provided with an inner stainless-steel liner.

5.5.4.5 Earthquake and Tornado Protection

Provisions of earthquake and tornado protection for sand filter, exhaust duct, and stack are in accordance with design criteria and requirements stated in Section 4; also see Appendix B.

Earthquake and wind analysis of the main stack defines design wind velocity at 110 mph. This value is in accordance with Uniform Building Code recommendations and established engineering practice. Based on this velocity, the stack is capable of withstanding wind impressed loads and forces. Within the context of stack design the term "extreme conditions" is defined as conditions greater than design wind velocities. The stack is located sufficiently distant from other facilities so that structural failure would not result in damage to any fuel storage systems or structures. The earth-covered duct between exhaust fan enclosure and stack is provided with a port that can be opened to permit grade-level release of ventilation air in the unlikely event that structural failure resulted in severe restriction of stack flow.

5.5.5 Main (Process) Building Facilities

The main building contains certain facilities other than fuel basin areas that are directly or indirectly involved in fuel storage. Some of these have been discussed in preceding sections, such as the ventilation tunnel which extends almost the length of the building, passing underground to the ventilation filter building and servicing the Radwaste System. See illustrations, Appendix A.14.

5.5.5.1 Building Entrance Area

The main building entrance door, vestibule and lobby are located near the midpoint of the south service area, essentially at grade level. Between the gallery exterior wall and corridor, which parallels the south canyon wall at this point are rest rooms, change room, shower room, and decontamination room required for control of personnel access to and exit from potentially contaminated areas of the main building. The corridor, which services the change room complex leads to the mechanical cell operating gallery and fuel storage basin.

5.5.5.2 Gallery Area

Adjacent to the process canyon and structurally attached thereto are multi-level galleries, which allow personnel access to the main building. The galleries extend the full length of the process canyon on the north and part way on the south sides and are connected by transverse corridors at the east end of the building. The gallery structure is of steel frame with reinforced concrete floors, walls and roof areas, as was required for protection of equipment and functions under extreme conditions including tornado-generated missiles. Access to limited occupancy zones is provided by locked doors. Air locks are provided at major access points as required to maintain differential air pressure control during movement between ventilation zones.

5.5.5.4 Control Room, or Secondary Alarm Station (SAS)

The Control Room (or SAS) is located in the south gallery area intermediate level (65 ft. floor elevation). The room is about 75 ft. by 21 ft. in plan, with direct stairway access to the building lobby and secondary access to the unused computer room. Principal items of control room equipment include the main process control panel across one side of the room, and various monitoring equipment. Fuel storage functions monitored in the control room are listed in Table 5-2. Although some functions are normally controlled only from the control room (e.g., basin fill system, ventilation supply and exhaust fans), the noncritical nature of all control systems permits replacing controls with local control. The control room (SAS) is one of two Alarm Stations (other is in the Administration Building (CAS)). At least one (CAS or SAS) is continually staffed.

Table 5-2

CENTRAL ALARM STATION MONITORING OF FUEL STORAGE FUNCTIONS

The following functions are monitored in either the Control Room (SAS) or CAS:

BASIN SYSTEMS

- Filter System
  Sludge Tank Level Indicator and Alarm
  Filter Differential Pressure
- Water Chillers
  Basin Cooling Unit CU102-8 Shutdown
  Basin Cooling Unit CU102-9 Shutdown
- Basin Water
  Water Temperature
  Water Level Alarms
  Leak Detection and Alarm
  Water Addition Control and Measurement*

COMMUNICATIONS

- Radio Off, On Site
- Telephone
- Intercom - Public Address

*Control Room Operation - Local Lockout Capability

SECURITY SYSTEMS

- Closed Circuit TV Systems
  Main Gate Monitor
  Basin Entry and Exit Monitors
  Basin Area Monitors

VENTILATION SYSTEM

- Intake Plenum
  Pressure, Temperature Indicators and Alarm
  Controls and Indicators*

- Exhaust Plenum

Controls and Indicators*

- Stack
  Air Flow
  Sampler Indicators and Alarms

STORAGE VAULTS

- Cladding Vault
  Leak Detection Indication and Alarm

- Low Activity Waste (LAW) Vault
  Intrusion System Indication and Alarm

- Dry Chemical Vault (DCV)
  Intrusion Detection and Alarm

UTILITY SYSTEMS

- Air Systems
  Pressure Indication and Alarms

- Water Systems
  Demineralized Water Indicator and Alarm

*Control Room Operation - Local Lockout Capability

ELECTRICAL SYSTEMS

- Diesel Generator
  Instrumentation, Indicators and Alarms

- Power Bus
  Indicators and Alarms
  Ground Faults and Malfunctions

HEAT PUMP SYSTEM

- Temperature, Flow, Condition Alarms and Indicators

SUMPS

- Basin Pump Room and Addition Alarms
- Hydraulic Equipment Room Alarms
- Canyon Areas
  Indicators for Decon Cell, Off Gas Cell and Mechanical Cell sumps.

RADWASTE SYSTEM

- Evaporator Malfunction Alarm
- Tank Level Alarms
- High Filter Differential Pressure Alarms

MISCELLANEOUS

- Protected Area Door Controls and Indicators
- Evacuation, Take Cover Alarm Controls
- Fire Alarm Panel and Smoke Detectors
- Area Radiation Monitor (ARM) Indicators and Annunciators
- Criticality Alarm Indicators, Annunciator and Controls

*Control Room Operation - Local Lockout Capability

5.5.5.5 Off-Gas Cell

Process off-gas treatment facilities are located in the off-gas cell. It is roughly “L” shaped, occupying the south side of the canyon opposite the anion exchange cell and spanning the full width of the canyon (19 ft.) at its east end. The cell floor is lined with stainless steel, which extends up the cell walls to 3 ft. above the floor level. The lined sump is equipped for pumping collected liquids to the Radwaste System.

A vertical ventilation panel is provided near the canyon centerline to span the opening between the northside cell cover (42 ft. above the cell floor) and the southside cover (10 ft. lower). There are three equipment positions in the 19 ft. south wall of the cell.

5.5.5.6 Radwaste System Evaporator

The new Radwaste System Evaporator is electrically heated. It is accessed through the PuNp Load Out Area on the 48’ elevation in the Process Building. Evaporator bottoms are periodically transferred to steel barrels and stored in the Evaporator Bottoms Room or Canyon for subsequent shipment for treatment and subsequent burial. Steam vapor from the evaporator is demisted and routed to the air tunnel, then through the sand filter to the stack.

5.5.5.7 Ventilation Supply Room

Blowers and associated equipment to supply main building ventilation air are located in a room, 39 ft. x 21 ft. in plan, on the top floor of the south gallery area of the main building (81 ft. reference elevation). Personnel access is from the Control Room by way of the Computer Room and emergency power room with additional access from the Instrument Gallery. Two hooded air intake openings are provided in the reinforced concrete roof (elevation approximately 93 ft.). Air conditioning system coolers also are located on the south gallery roof.

5.5.5.8 Basin Pump Room Addition (BPRA)

In 1980 an addition was made to the original basin pump room (BPR) as shown in Figure 1-4 to house chemical decontamination equipment for basin water cooling system decontamination, and equipment to utilize heat from basin water as an energy source to heat the Main Building, including the fuel storage area. Because of its isolation from main building areas, the BPR and BPRA are cooled by a separate air conditioner.

a. Basin Pump Room Addition (BPRA) Building: The BRPA is located near the west wall of the existing pump room (BPR). The addition is a prefabricated steel building built on a concrete slab with outside dimensions of about 20 ft. by 30 ft. in plan. A space of about 4 feet separates the BPRA from the BPR wall except for an enclosed walkway connecting the BPR to the BPRA. A concrete pad extends along the north wall of the BPRA and a double door is located in the center of this wall. An air conditioner compressor mounting pad is located outside the north side of the BPRA.

   An above grade reinforced concrete vault housing a basin water-to-freon heat exchanger is located in the southwest corner of the BPRA. The vault drains to a sump which may be emptied by pumping collected water to the Radwaste System. Piping between the BPR and BPRA is routed overhead, passing through the enclosed walkway and connecting to existing piping systems in the BPR.

b. Systems and Equipment: A new pump was installed in the existing BPR to circulate basin water though the heat exchanger located in the heat exchanger vault. Four GE heat pumps are mounted on a steel rack adjacent to the heat exchanger vault. Freon is circulated from the heat exchanger and heat pumps to existing heating and cooling units located in the ventilation room of the Main Building. These units were modified to adapt to the new system. The heat pump system is reversible to provide either heating or cooling of fresh air entering the Main Building ventilation system.

   A 600-gallon stainless steel tank is located in the BPRA and serves as the collection point for basin area low-level radwaste streams. A pump, adjacent to the tank, transfers liquid from this vessel to the low-level radwaste evaporator system.

The BPRA and existing BPR are air cooled by a system located in the addition. The compressor for this system is mounted outdoors on the pad at the west end of the BPRA.

5.5.5.9 Basin Chiller Room

In 2000 an addition was made to the basin pump room addition (BPRA) as shown in Figure 1-4 to house heat exchangers for the basin water cooling system.

a. Basin Chiller Room (BCR) Building: The BCR is attached to the west wall of the existing pump room addition (BPRA). The room is a prefabricated steel building built on a concrete slab with outside dimensions of about 18 ft. by 20 ft. in plan. The access door to the chiller room is in the west wall of the BPRA.

   An above grade reinforced concrete vault housing 2 basin water-to-freon heat exchangers is located in the northeast corner of the BWCR. The vault drains to a sump, which may be emptied by pumping collected water to the Radwaste System. Piping between the basin and the chiller heat exchanger is routed overhead, passing through the BPR and BPRA, connecting to existing piping systems in the BPR.

b. Systems and Equipment: Two new pumps were installed in the existing BPR to circulate basin water though the heat exchangers located in the heat exchanger vault. Two 100-ton air cooled heat pumps are mounted outside, on concrete piers to the west of the chiller room. One of these is enough to maintain basin water temperature. The second unit is a back-up. Freon is circulated from the heat pumps to the heat exchangers to chill the basin water.

   The BCR is air cooled by a system located in the BPRA.

5.6 WASTE VAULTS

Three below-grade vaults were constructed as part of the MFRP:

a. Low Activity Waste (LAW) Vault - originally provided for on-site interim storage of low-level wastes from aqueous processes.

   As of July 1994, all additions to the LAW Vault were terminated. Waste streams are now processed by the new radwaste system (see Appendix B.23). As of October 1996, the LAW Vault is empty and dry, but still contains radioactive material as contamination adhering to the vault walls and floor. The LAW Vault connecting piping has been removed or capped, and the vault is laid away. There are no current plans for use of the LAW Vault.

b. Cladding Vault - originally provided for interim storage of compacted, leached hulls and other contaminated metal scrap from fuel reprocessing operations. This vault has been

emptied and cleaned. CRA and CSF drains, which previously went to the Cladding Vault have been capped. Stack drain has been routed to the stack condensate system. This vault is not being used but is being held available on a contingency basis.

c. Dry Chemical Vault (DCV) - provided for interim storage of contaminated dry process chemicals of low activity level[21]. This vault was emptied in 1993. The DCV connecting piping has been removed or capped, and the vault is laid away. There are no current plans for use of the DCV.

Local hydrology (e.g., drainage patterns to water courses and soil ion exchange capacity) is not of major significance in ensuring safety of fuel storage operations.

Subsurface water conditions encountered during MFRP construction were more severe than expected. Therefore, concrete density and monitoring and control equipment were designed to handle these conditions. No significant difficulties with this equipment have occurred.

Storage vaults were designed and constructed to provide high integrity confinement of contained materials and include systems for detecting leakage into or out of these tanks. The systems permit detection of radioactive material in highly diluted samples (caused by water intrusions) and provide pump-out capability to collect and dispose of intrusion water as well as any leakage from stored material.

5.6.1 Cladding Vault

A below-grade cylindrical vault, 45 ft. in diameter and 72 ft. deep was provided for underwater storage of leached cladding hulls and other metallic scrap.

5.6.2.1 Cladding Vault Construction

The cladding vault is constructed of reinforced concrete about 2 feet thick and is lined with stainless steel. The top of its 2.5 ft. thick reinforced concrete cover is at 41.5 ft. elevation. The vault is located adjacent to the LAW vault on the south side of the main building (Figure 1-4). It is connected to the mechanical cell in the canyon by a reinforced concrete waste disposal cart tunnel (top about at grade level) which extends across the top of the vault to a 235 sq. ft. cart equipment pit. The pit roof has two access openings with shield plugs. The vault is equipped with leak detection and sampling systems similar to those for the fuel storage basins, with level recorder and unit alarm in the control room (SAS) and local control in the mechanical cell operating area.

Intrusion water around the vault is pumped to the Radwaste System.

5.6.2.2 Cladding Vault Description

a. Elevation: The circular floor of the cladding vault is 80.5 ft. below grade level and the interior height of the structure is 72 ft. The floor of the waste disposal cart tunnel which connects the cladding vault and the mechanical cell in the main building canyon area is approximately at the same level as the underside of the vault roof (8.5 ft. below grade) which is about 1 ft. above the maximum liquid level in the vault. The floor of the equipment pit located adjacent to the vault is 14 ft. below grade level. The top of the cladding cart tunnel and equipment pit roof is 0.75 ft. above grade and that of the vault proper is 6 ft. below grade.

b. Construction: The cylindrical vault structure is reinforced concrete lined with stainless steel. Excavation extended roughly 82 ft. into the underlying bedrock, which was sufficiently sound to provide clean vertical surfaces for 2 ft. thick concrete walls to be poured against, using conventional interior forming. The reinforced concrete floor is approximately 4 ft. thick. The equipment pit and the cart tunnel also are of reinforced concrete and tied to the vault structure. The roof of the cart tunnel, which extends across the vault and the cover of the equipment pit is approximately 4 ft. thick. The remainder of the vault top cover is 2.5 ft. thick reinforced concrete.

c. Vault Liner: The cylindrical vault structure is completely lined with 0.125 in. thick (11 gauge) 304L stainless steel sheets placed flush against the concrete walls and floor. As in the storage basins, the sheets are welded continuously along each edge to a gridwork of stainless-steel angles and plates embedded in the concrete. At the floor-to-wall joint, the sheets are welded to a stainless-steel angle. Quality control and verification procedures parallel those applied to the storage basins.

d. Leak Collection, Monitoring and Pump-Out Provisions: Drain slots are provided in the concrete walls and floor, between the liner and concrete. These lead to a perimeter collection header behind the floor-to-wall junction. The perimeter header is sloped to a low point, which is connected to a single leak collection sump. The sump consists of a 6 in. diameter vertical stainless-steel pipe embedded in the vault wall, which extends from the top of the vault to approximately 1 foot below the vault floor level. It contains a liquid level detector line and necessary piping for a 5 gpm (nominal) pump-out system. Auxiliaries for the level detection and pump out systems, including a monitoring sample station, are located in the mechanical cell gallery of the main building. Water from the pump-out system is routed to the Radwaste System.

5.7 SUPPORT FACILITIES

Support facilities are described in the following sections. As in previous sections, those functions related exclusively to fuel reprocessing are omitted or discussed only briefly.

5.7.1 Utility and Service Building

On the north side of the main building is located the single-story high-bay utility and service building (Figure 1-4). It is 71 ft. by 50 ft. in plan and is of conventional steel frame, insulated siding and roof construction on a grade level concrete foundation. The building is divided into a utility section which houses the demineralized water system; primary electrical switchgear, training room, operations ready room, and first aid area; and a personnel section containing change room, lunchroom, and office areas. The arrangement takes into account the normal industrial safety requirements for major electrical equipment. Consideration also is given to isolation of normal industrial functions and equipment from all potential sources of radioactive contamination. Utility services are not critical to safety of fuel storage operations. Interruption of these services for short periods of time, up to several months, would have no off-site impact as long as basin water level is maintained. Principal features are described in the following paragraphs.

5.7.1.1 Utility Section

The 1,700 sq. ft. utility section of the building is divided into two major rooms, the larger of which houses water demineralization and three smaller room partitions for training, an operations ready room, and a first aid area. The demineralizer system consists of ion exchange resin provided by a contract service. It is capable of treating 25 gpm continuously. The pump required for operation and distribution is located nearby.

A separate 300 sq. ft. room in the utility section houses the primary electrical distribution switchgear for the plant. Incoming power from the CECo distribution system is reduced to 480 volts prior to entry into the utility building.

5.7.1.2 Outside Facilities

The following facilities are directly associated with utility system operations (Figure 1-4):

a. A chain link fence surrounds a rectangular area 62 ft. by 30 ft. in size located on the east side of the building and encloses the terminal structure of two 34,000 volt incoming overhead transmission lines and two CECo owned 1,500 kVA transformers which reduce the incoming supply to 480V. The fenced area is locked to preclude accidental access to high voltage equipment.

5.8 UTILITY SYSTEMS

Water, electric service, and sewage systems are described in the following sections.

5.8.1 Water Supply

Water to meet potable, utility and fire-fighting requirements is obtained principally from a 788 ft. deep, 12 in. diameter well located within the OCA, southeast of the administration building (Figure 1-4). A submersible, 100 gpm vertical turbine pump is provided, capable of developing 100 ft. of head. This pump is connected to the emergency power distribution system. The pump discharges through filters to a 50,000-gallon elevated water sphere, located near the well. Tests have confirmed a continuous pumping rate of 250 gpm from this well.

An electric water heater in the well house is used to prevent freezing of water in the sphere.

Water is rendered potable by filtration and chlorination before delivery via underground lines to various personnel occupancy areas. Process-related requirements are supplied from the utility water system.

5.8.1.1 Utility Water Supply

Underground piping is provided to distribute utility water from the elevated storage tank to the utility building for supplying the demineralizer system, and to various points in the main building for uses not requiring demineralized or potable water.

5.8.1.2 Demineralized Water Supply

Demineralized water is used for fuel storage basin supply. This water is supplied from the series cation-anion demineralizer located in the utility building, which is capable of treating 25 gpm continuously from the utility water supply system. Distribution to points of use is via a pump-pressurized header system. There is a 1 in. line to the basin to furnish make-up water. Basin water level is maintained under manual control of the basin operator, who would normally add water when basin water level dropped 2 in., which is low enough to affect basin cleanup system operation. A back-up-low-level alarm in the CAS/SAS activates if basin water level drops 6 in. below normal.

5.8.1.3 Fire-Fighting Water Supply

Potable and utility water usage is limited by location of outlet piping to the topmost 8,000 gal. of water sphere capacity, with the remaining 42,000 gallons reserved for fire protection. Distribution is via a standard underground piping system located beneath historical frost penetration in accordance with underwriter and building codes.

5.8.1.4 Backup Water Supplies

Parallel fuel storage basin pumps and heat exchangers reduce the likelihood of complete loss of basin cooling capability. In the highly unlikely event that cooling system capability could not be restored within 50 days[23] (or more, depending on circumstances), makeup can be provided from demineralized or utility water storage or from other emergency sources, including water pumped from the DNPS cooling lake, or even from the river[21]. Emergency pumping equipment could be brought to the site and placed in operation within the 50-day period with no impact on public health or safety from stored fuel.

5.8.2 Electrical Supply

GEH-MO fuel storage activities require an electrical peak load capacity of 725 kW, with an average load requirement of 500 kW. Principal load requirements come from crane operation, ventilation system requirements, control and instrumentation requirements, and operation of auxiliary systems (e.g., air, and water).

Although interruption of any of these functions would not result in an unsafe condition, secondary power sources (originally intended for fuel reprocessing requirements) are provided, which ensure continuing operation of equipment and services, including security systems, important to plant operation.

5.8.2.1 Normal Electrical Power Source

The normal source of electric power for GEH-MO is the CECo distribution system. Supply is via two separate 34,000V pole-mounted lines from the DNPS Switchyard to GEH-MO power terminal facilities located adjacent to the utility building. Each of these lines serves one of two CECo owned 1,500 kVA transformers. A current limiting bus connects the 480V power terminals of each transformer to a bus system in the load center switchgear located in the utility building.

The substation type load center consists of metal-enclosed, high current capacity, manually and electrically operated air circuit breakers and bus bar systems for distribution of power to seven motor control centers and an essential services load center which feeds two motor control centers.

Bus sections and associated circuit breakers are provided with protective relays, which de-energize appropriate portions (or all) of the system in the event of overload or short circuit conditions.

5.8.2.2 Essential Services Power Facilities

The loss of electrical power, even for many hours, would not result in a situation presenting a hazard to employees or the public because of stored irradiated fuel. However, a diesel generator is available. All electrical loads, which contribute directly to plant capability under abnormal conditions are supplied from an essential services distribution system. This system consists of metal-enclosed, high current capacity load center type switchgear through which 480V, three phase power is supplied to one motor control center in the EEB and one motor control center located in the main building. The 400kVA diesel driven standby generator located in the EEB generator room is provided with appropriate controls so it can automatically supply power to the essential services load center in the event both utility incoming power sources are lost. Interlocks are provided within the load center switchgear that prevent the diesel driven generator from being connected in parallel with the incoming utility power system.

Special electrical subsystems are provided to meet particular power needs such as those for instrument operation and system control functions. Control power of 24 VDC is supplied from two rectifiers. The demand is such that one rectifier can carry normal plant load as well as keep batteries charged. Rectifiers convert 480 VAC power from the essential services power distribution system and are located in the same room as the rectifiers. Power is routed from the subsystem location in the gallery area electrical equipment room to a distribution network within the main building control panel and to control relay cabinets located directly behind the main control panel, in the BPR, in the utility building and in the EEB.

5.8.2.3 Distribution System

Industrial type motor control centers provide power to each individual use point. These control units utilize local or remotely operated magnetic contactors sized for the particular load requirements being served. Distribution systems throughout the plant utilize commercial electrical cabling of specified capability. Routing between buildings is via underground concrete-encased conduit. Power distribution cables are routed in standard electrical cable trays and conduit. Within the main building, the bulk of power supply cabling and wiring for instrumentation and control functions are carried in separate wiring trays with appropriate protection against unwanted interactions, fire damage, etc.

5.8.2.4 Operating Characteristics

Electrical power required for normal fuel storage operations can be supplied by either of two incoming power lines from the CECo distribution system. Upon loss of either line, a manual, two-of-three circuit breaker system can be actuated to switch load to the single operating line. The bus-tie breaker cannot be actuated unless one incoming line breaker is open. To restore normal operation after the supply outage, the bus-tie breaker is opened, and incoming line circuit breakers are closed. Some distribution system circuit breakers as well as control system lockout switches and relays must be manually reset.

The essential services power distribution system is normally fed from the No. 1 bus bar. If power to this bus bar section is lost, the power supply for the essential services power distribution system automatically transfers to the No. 2 bus.

In the unlikely event that power from both incoming supply lines is disrupted, the following sequence of automatic operations will take place:

a. The standby diesel generator will start.

b. The essential services load center will separate from the normal supply source.

c. For load shedding purposes, some circuit breakers in the two essential services motor control centers will open.

d. After the diesel-driven generator is up to speed, the circuit breaker connecting the generator to the essential service power distribution system will close and restore power to some lighting systems, basin cooling water pump(s) and other important loads.

e. With power available to the essential service power distribution system, preselected loads will be automatically and sequentially restarted (e.g., one air compressor to maintain instrument and process air, supply and one ventilation exhaust fan to maintain minimum air pressure differentials).

   An ammeter in the CAS/SAS indicates output of the diesel driven generator. Lights on the main control panel indicate status of the two utility power sources. Separate annunciators on the main control panel are provided to alert the SAS/CAS operator to a malfunction in the diesel generator system, 24 VDC system and utility supply system.

5.8.3 Site Natural Gas Supply

All use of natural gas was discontinued in 2002 and natural gas service is no longer available on site.

5.8.4 Sewer Systems

At GEH-MO, industrial and sanitary sewage system are combined and discharged to sanitary lagoons and a holding basin with no direct discharge of any process or sanitary liquid effluent to local waterways. The systems meet requirements of the State of Illinois, and appropriate permits for operation have been issued.

5.8.5 Rail Transportation Facilities

Rail service to the site is provided by a spur track from the DNPS siding, approximately 0.5 mile north of the plant site, which connects to the Canadian National right-of-way serving the general area. The spur track is designed to carry heavy cask carloads at low speed (ASCE 100 lb. rails, appropriately limited curves and grades). After crossing the county road, the track is divided into three spurs and enters the OCA. All tracks have been cut and sections removed to prevent any rail movement.

The eastern spur enters the cask receiving area in the main building, terminating in a car bumper set in a heavy concrete block to protect the decontamination and basin areas from involvement in a rail accident. The spur is sloped to the north, and a manual derail is located north of the receiving area to stop a runaway car. The center spur serves the cask service facility. The western spur is a storage track, terminating in a standard car bumper, with capacity to store four cars.

5.9 ITEMS REQUIRING FURTHER DEVELOPMENT

GEH-MO fuel storage activities have been underway since January 1972, and, except for a continuing program of improvements based on operating experience, no specific equipment or facility item is now known to require further development.

5.10 REFERENCES

1. Fuel storage basins are designated Basin 1 and Basin 2. Basin 2 was originally the high-level waste storage basin, converted to fuel storage under Materials License No. SNM-1265, Docket 70-1308, December 1975.

2. K. J. Eger, Operating Experience - Irradiated Fuel Storage - Morris Operation, Morris, Illinois, General Electric Company, NEDO-20969B.

3. Non-contaminated waste is accumulated in dumpsters, which are mechanically emptied into a commercial garbage truck for disposal at a licensed land fill site. Trash is monitored before leaving the site to assure no radioactive material is included in uncontaminated waste.

4. Refer to Section 5.5 for discussion of reinforced concrete design bases common the main building and associated structures, including the cask unloading basin.

5. When the fuel storage basin was almost full, storage racks were installed in the high activity waste basin - now Basin 2 - on an interim basis (see letter dated April 6, 1973, requesting amendment to License No. SNM-1265).

6. Densities expressed in metric tons of uranium and abbreviated TeU.

7. B. F. Warner, the Storage in Water of Irradiated Oxide Fuel Elements, British Nuclear Fuels, Ltd.

8. A. B. Johnson, Jr., Behavior of Spent Nuclear Fuel in Water Pool Storage, Battelle Pacific Northwest Laboratories, September 1977 (BNWL-2256).

9. P. R. C. Winter, Battelle Pacific Northwest Laboratories, telex to H. A. Klepfer, General Electric, September 28, 1977.

10. Electrofilm, Inc., North Hollywood, California, 91605.

11. The heat transfer calculations have not been changed from the old basis. It is doubtful that boiling would ever occur under credible conditions.

12. Site survey and foundation report by Dames & Moore, Park Ridge, Illinois, see Appendix A.

13. This method was selected as an alternative to dye-penetrate checking.

14. Process photographs of actual operations (typical Figure 1-13) were made through up to 50 ft. of basin water.

15. Proprietary product of Norton Co.

16. L. L. Denio, D. E. Knowlton, and E. E. Voiland, Control of Nuclear Fuel Storage Basin Water Quality by Use of Powdered Ion Exchange Resins and Zeolites, June 1977, (ASME 77-JPGC-NE-15).

17. The capacities shown for the cooling systems are based on basin water at 120 °F, ambient air at 95 °F.

18. Also referred to as "emergency generator," a term originating from the original design as a reprocessing facility. Loss of electric power at the fuel storage facility would not constitute an emergency.

19. Except LAW vault intrusion water; piped to process water.

20. This vault contained natural or depleted uranium, fluoride salts, and other materials used during MFRP testing. This vault is currently empty.

21. Loss of cooling is discussed in Chapter 8, "Accident Analysis."

22. "Durability of Spent Nuclear Fuels and Facility Components in Wet Storage," International Atomic Energy Agency Report IAEA-TECDOC-1012

23. "Fuel Basin Water Evaluation: Conductivity Change and Evaporation Rate," T. D. Maikoff, August 2004.

6.0 WASTE MANAGEMENT

Waste management practices at GEH-MO have included underground vault storage, metal melt, burial and incineration by contracted services and on-site volume-reduction by evaporation of liquid waste. Also included is disposal of basin water filter media via HIC disposal.

6.1 UNDERGROUND WASTE VAULTS

6.1.1 Dry Chemical (DCV) Vault

As of October 1993, the DCV is empty, containing only residual radioactivity in the form of radioactive contamination on the walls and floor. The DCV vault connecting piping has been removed or capped, and the vault is laid away, with no current plans for use.

6.1.2 Low Activity Waste (LAW) Vault

As of October 1996, the LAW Vault is empty, containing only residual radioactivity in the form of radioactive contamination on the walls and floor. The LAW vault connecting piping has been removed or capped, and the vault is laid away with no current plans for use.

6.1.3 Cladding Vault

As of October 1996, the Cladding Vault is empty and is held available on a contingency basis.

6.2 RADWASTE SYSTEM

Concurrent with the decision to eliminate use of the LAW Vault was an immediate need for an alternate means to treat and reduce the volume of low-level liquid waste. In 1993, a system was designed, installed and is in operation. See Appendix B.23 for details of operation.

6.3 SOLID RADIOACTIVE WASTE

Accumulated low-level radioactive waste is disposed of by metal melt, incineration and/or burial. On-site storage of radioactive LSA waste is an option, but is not favored or planned.

6.4 NONRADIOACTIVE WASTE

Nonradioactive, conventional solid wastes (trash) are disposed of via commercial trash pickup. No other effluents of consequence are released to the environment.

7.0 RADIATION PROTECTION

7.1 INTRODUCTION

This section describes the GEH-MO radiation protection program and provides estimated and actual occupational radiation exposures to operating personnel during fuel storage operations. Information is provided on facility and equipment design, planning and procedures, programs, and techniques and practices employed in meeting requirements for protection against radiation as specified in 10 CFR Part 20.

7.2 MAINTAINING OCCUPATIONAL RADIATION EXPOSURES AS LOW AS REASONABLY ACHIEVABLE (ALARA)

GEH-MO requires exposure of personnel to ionizing radiation be kept **A**s **L**ow **A**s **R**easonably **A**chievable (ALARA). This is a requirement of, and is implemented through the health physics program described in this section.

7.3 RADIATION SOURCES

This section describes sources of radiation that are bases for radiation protection design and which are used as input to shield design calculations.

7.3.1 Irradiated Fuel

General characteristics of irradiated fuel are given in Section 4. However, for purposes of estimating dose rates, calculations are based on parameters that more realistically reflect fuel in storage. Although most fuel currently in storage has cooled much longer than a year (33 to 50 years as of April 2020), and has an average exposure of under 20,000 MWd/TeU, it is conservatively assumed that all fuel in the basin has the following characteristics for radiation protection calculations under normal operation:

a. Exposure - 24,000 MWd/TeU
b. Specific power - 40 kW/kgU
c. Cooling time - 12 months

For calculation purposes, fission product activity in fuel with assumed conservative characteristics is given in Table 7-1 and resulting gamma spectrum is given in Table 7-2. Assumptions for the basin radiation source calculations include:

a. The radiation source is approximated by a uniformly distributed source within a volume of 21,000 cu. ft. (1,500 sq. ft. floor area x 14 ft. length of fuel).

b. The source volume is 14.5 ft. below the pool surface (approximate depth to top of fuel bundles in storage).

c. Credit is taken for self-shielding in the source volume, assuming that the source medium is water only (i.e., no credit taken for shielding from fuel or stainless steel, etc.).

Calculations are performed in Section 7.4.2.1.

7.3.2 Storage Basin Water

The radioactive material concentration in the storage basin water results from a balance between the addition rate from stored fuel and the basin cleanup system removal rate. Operating experience gained in storage of irradiated fuel at GEH-MO since early 1972 demonstrates that radioactive material concentration in the basin water can be reliably maintained at personnel exposures that are ALARA.

The values presented in Table 7-1 and 7-2 are conservative relative to the current cooling times of the actual fuel stored at GEH-MO and are still applicable for radiation protection calculations.

Table 7-1
FISSION PRODUCT ACTIVITY
(24,000 MWd/TeU, 40 kW/kgU)

			Activity (Ci/TeU)			
Isotope	Half-Life		1 Year	5 Years	10 Years	20 Years
Kr-85	10.701	y	7.62E+03	5.88E+03	4.25E+03	2.22E+03
Rb-86	18.82	d	6.93E-04	0	0	0
Sr-89	50.55	d	9.41E+03	1.88E-05	0	0
Sr-90	28.82	y	6.47E+04	5.88E+04	5.21E+04	4.10E+04
Y-90	64.06	h	6.48E+04	5.87E-04	5.21E+04	4.10E+04
Y-91	59	d	2.08E+04	6.33E-04	2.54E-13	0
Zr-93	1.53E+06	y	2.31	2.31	2.31	2.31
Zr-95	63.98	d	4.15E+04	5.55E-03	1.42E-11	0
Nb-95m	86.6	h	5.27E+02	0	0	0
Nb-95	34.97	d	8.78E+04	2.33E-08	0	0
Ru-103	39.35	d	2.68E+03	1.78E-08	0	0
Ru-106	366.5	d	1.72E+05	1.09E+04	3.43E+02	3.45E-01
Rh-103m	56.116	m	2.68E+03	0	0	0
Rh-106	29.8	s	1.72E+05	1.09E+04	3.43E+02	3.45E-01

Ag-110m	252.2	d	1.23E+04	2.22E+02	1.47	6.48E-05
Ag-111	7.5	d	8.53E-11	0	0	0
Cd-115m	44.8	d	3.49	5.32E-10	0	0
Sn-119m	250	d	2.64E+01	4.60E-01	2.91E-03	1.17E-07
Sn-121m	55	y	9.12E-02	8.67E-02	8.14E-02	7.18E-02
Sn-123	129	d	6.13E+02	2.39E-02	1.31E-05	0
Sn-125	9.625	d	3.93E-08	0	0	0
Sb-124	60.2	d	3.23	1.61E-07	0	0
Sb-125	2.71	y	4.84E+03	1.74E+03	4.84E+02	3.75E+01
Sb-126	12.4	d	4.74E-02	0	0	0
Te-125m	58	d	1.18E+03	3.08E+05	1.02E-14	0
Te-127m	109	d	1.32E+03	1.22E-01	1.10E-06	0
Te-127	9.35	h	1.30E+03	0	0	0
Te-129m	33.52	d	4.31E+01	3.00E-12	0	0
Te-129	69.5	m	2.74E+01	1.90E-12	0	0
I-129	1.57E+07	y	2.10E-02	2.10E-02	2.10E-02	2.10E-02
I-131	8.04	d	2.37E-08	0	0	0
Xe-131m	11.77	d	1.59E-05	0	0	0
Xe-133	5.245	d	4.71E-15	0	0	0
Cs-134	2.062	y	8.89E+04	2.32E+04	4.32E+03	1.50E+02
Cs-136	13	d	1.48E-04	0	0	0
Cs-137	30.174	y	7.79E+04	7.11E+04	6.34E+04	5.04E+04
Ba-137m	2.5513	m	7.34E+04	6.72E+04	6.00E+04	4.78E+04
Ba-140	12.789	d	5.13E-03	0	0	0
La-140	40.27	h	5.90E-03	0	0	0
Ce-141	32.55	d	8.00E+02	2.46E-11	0	0
Ce-144	284.5	d	5.30E+05	1.51E+04	1.76E+02	2.42E-02
Pr-143	13.59	d	1.56E-02	0	0	0
Pr-144	17.3	m	5.30E+05	1.51E+04	1.76E+02	2.42E-02
Nd-147	10.98	d	7.69E-05	0	0	0
Pm-147	2.62344	y	1.04E+05	3.61E+04	9.65E+03	6.88E+02
Pm-148m	41.29	d	9.45E+01	2.11E-09	0	0
Pm-148	5.37	d	6.51	1.48E-10	0	0
Sm-151	87	y	9.36E+02	9.07E+02	8.71E+02	8.04E+02
Eu-154	8.59	y	4.39E+03	3.17E+03	2.11E+03	9.42E+02
Eu-155	4.96	y	1.02E+03	5.83E+02	2.90E+02	7.17E+01
Eu-156	15.11	d	6.64E-03	0	0	0

Tb-160	72.1	d	1.66E+01	1.32E-05	3.13E-13	0
All Remaining Fission Products			1.18E+01	1.17E+01	1.16E+01	1.14E+01

Table 7-2

GAMMA ENERGY SPECTRUM (E) FOR FUEL IN STORAGE - VOLUMETRIC SOURCE (S_v)
(24,000 MWd/TeU, 40 kW/kgU, 12 mo. Cooling)

Energy Group	E (MeV)	S_v (MeV/cm^3 sec)
1	1.75 to 2.25	2.2156×10^8
2	1.25 to 1.75	1.342×10^8
3	0.75 to 1.25	1.1078×10^{10}
4	0.25 to 0.75	2.1151×10^9

Because of passive storage conditions, if any defects occur during storage, they would likely be minor perforations (or "pin holes") in the fuel cladding rather than gross cladding failure.

Radioactive material in basin water consists of corrosion product surface contamination and fission product nuclides escaping through minor perforations in the clad. A reported value of the escape rate coefficient of 10^{-13} per second indicates diffusion rates within fuel are so low that major releases from the fuel matrix will not occur[1].

7.3.2.1 History of Radioactive Material Concentration

The history of radioactive material concentration in basin water is shown graphically in Figure 7-1[2]. The general trend is a gradual increase in concentration with increasing fuel loading and time, culminating in plateaus and abrupt decreases. Plateaus may be caused by a reduction in the source or establishment of a steady-state condition between radioactive material addition and removal. Decreases are due to accelerated removal of radiocesium and radiocobalt by use of filtration, a special ion exchange material in the basin water filter, and radioactive decay.

7.3.2.2 Contaminants

The principal dissolved radioactive contaminant in basin water is Cesium-137 with concentrations (typically now 7.3×10^{-4} µCi/ml) ranging up to 2.1×10^{-3} µCi/ml. A means of cesium removal has been found that makes reduction and control of this contaminant relatively simple. For example, over a 10-week period in 1974, radiocesium concentration was reduced to one-third of that at the beginning of the period. The basin water inventory was correspondingly reduced from about 29 Ci to 11 Ci. In 1975, during a 4-week period, the radiocesium concentration was reduced by a factor of six and the basin water inventory reduced from 14 Ci to 2.3 Ci. At the end of the latter period, the radiocesium concentration was 9×10^{-4} µCi/ml.

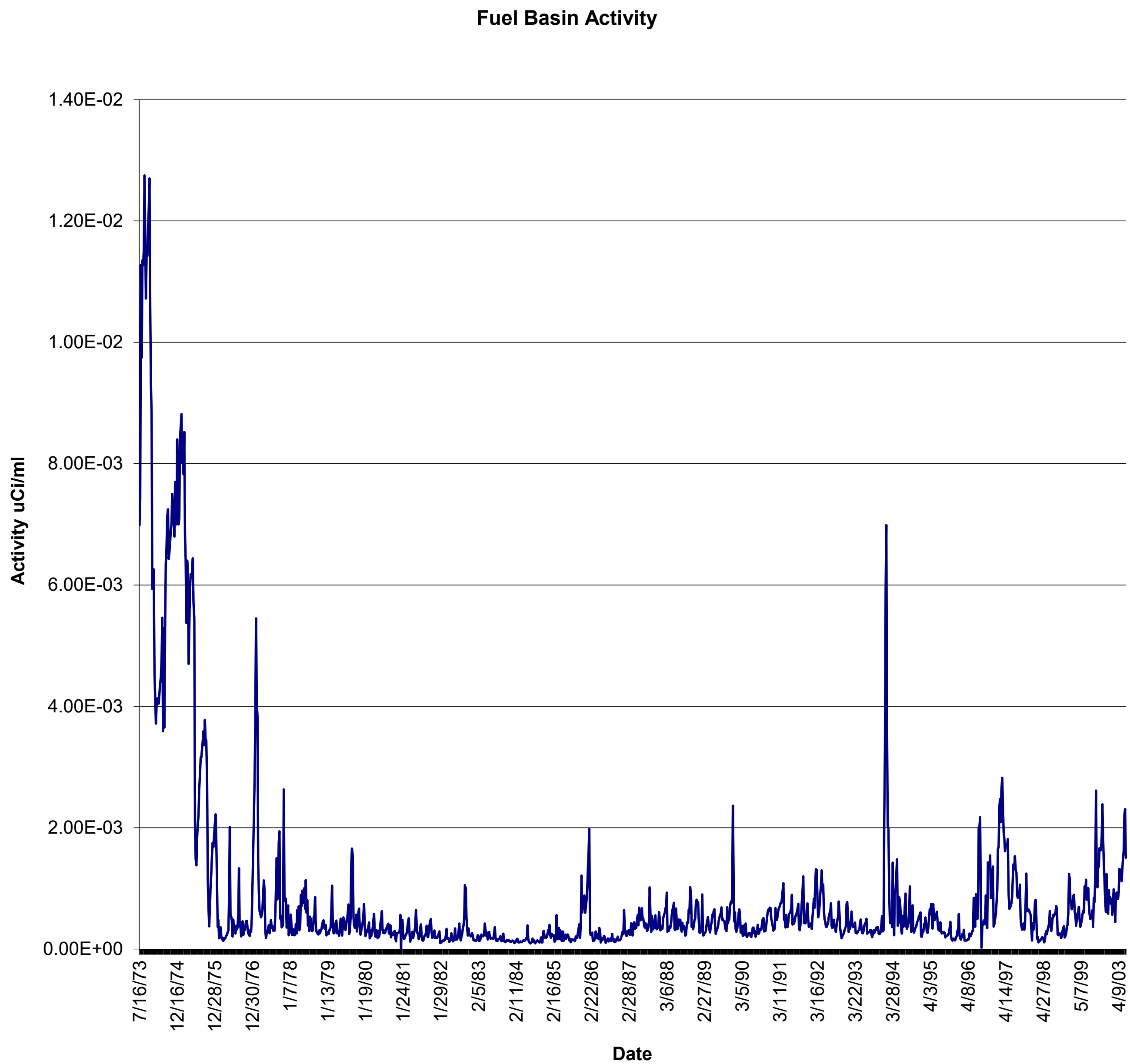


Figure 7-1. History of Morris Operation Basin Water Activity.

An inorganic molecular sieve medium, Zeolon[3], is used to selectively remove cesium. Tests demonstrate that Zeolon-100 removes about two-thirds of the radiocesium per Powdex charge. By routinely using Zeolon and adjusting Powdex replacement frequency, concentrations are effectively controlled.

In addition to radiocesium, the radionuclide contributing most significantly to basin water contamination is cobalt-60. Concentrations in basin water (typically now 2.1 x 10^{-6} µCi/ml) are attributed to corrosion products on fuel bundle surfaces released to water. Normal filtration and ion exchange reduce cobalt concentrations without special effort.

Fuel in the basins is currently about 714 TeU (1/99). While the basin is near capacity (98%), the radiocesium source term has not significantly increased (about one curie per week as measured in fourth quarter of 1993)[4]. Ability to control basin water radionuclide content ALARA is not compromised.

7.3.2.3 Basin Chiller Decontamination

After a period of operation, contaminants accumulate on the inner surfaces of chiller piping, tubes, and headers. A peroxide chemical decontamination process was installed to reduce exposure rates around the chiller heat exchangers acceptable levels.

7.3.3 Airborne Radioactive Material Sources

Four potential sources could release radioactive material to ventilation air. Most of this material would be captured by the sand filter and some fraction would be exhausted to the stack. These potential sources are:

a. Effluent from the Radwaste System evaporator

b. Off-gas from defective fuel rods in the basin

c. Decontamination activities

d. Uranium used in MFRP testing

Although release of radioactive material in the demisted effluent from the evaporator is possible, such occurrences would be rare and the amount released would be very small. In more than 40 years of fuel storage experience, there has been no apparent leaking of gases from stored fuel. Incidental airborne contamination from decontamination activities could occur. Use of special enclosures ("greenhouses") and other techniques limit such releases to very small amounts, and these activities are infrequent. Natural uranium was used in MFRP testing and some contamination is present within the canyon that could become dislodged and subsequently exhausted via the air tunnel.

Actual measurements of particulate radioactive materials in air exhausted via the stack are made routinely at GEH-MO. In 2019, 2.34 x 10^{-6} Ci of beta emitting nuclides were released. The resulting dose to the public was 1.3 x 10^{-6} mRem.

There has been no measurable stack release of a noble gas. Average concentrations of airborne beta activity within fuel storage areas are a small fraction of DAC values.

Annual basin air samples indicate fuel basin Kr-85 source term is about 0.8 Ci per year[5].

7.4 RADIATION PROTECTION DESIGN FEATURES

7.4.1 Facility Design Features

Layout and arrangement drawings of the fuel storage facility, showing locations of all radiation sources (fuel storage areas) described in Section 7.3, are contained in Appendix A-14. Design features related to radiation protection include basin leak detection, collection and control systems, water make-up capabilities, fuel and basket lifting tools that preclude raising fuel too close to the pool surface, water clean-up capability, and other features as discussed in this section.

GEH-MO has provisions for controlling personnel access to areas of the plant having actual or potential levels of radiation or radioactive contamination that exceed levels specified in plant procedures. There is little potential for high radiation dose rates or contamination levels in most areas.

Radiation measurement equipment is provided at various locations throughout the fuel storage area. This equipment includes area radiation monitoring, criticality monitoring, portable survey meters, and portable and fixed air sampler-monitors.

Basic procedures and criteria for controlling personnel exposures are specified in the GEH-Morris Operation Instructions (MOI's) and Special Procedures (MOSP's). Programs adopted for controlling radiation exposure are the result of previous experience at other installations. The program uses modern equipment and techniques proven effective for control of exposures. Such an approach has effectively maintained exposures well below 10 CFR 20 limits.

7.4.2 Shielding

The main building design, originally intended for fuel reprocessing, has maintained personnel exposure to well within 10 CFR 20 limits.

Direct radiation from fuel in storage is shielded by basin water. Concrete shields are used where appropriate, such as for the basin filter.

7.4.2.1 Direct Radiation from Fuel in Storage

The direct radiation dose rate from fuel in storage is from actual measurements of dose rates obtained in July 2004. A dose rate of 3 mRem/hr was found to be constant with depth when measured below the surface of the pool to within 7 ft. of the top of the fuel bundle upper tie plate. The 3 mRem/hr dose rate is due to radioactive contamination in the pool water. Underwater, about 4 ft. above fuel bundles, dose rates were 12 mRem/hr to 290 mRem/hr.

Routine dose rate measurements are taken throughout the storage basin area. For example, during the year 2016, the average dose rate on the basin crane was about 1.0 mRem/hr as measured by OSL.

7.4.3 Ventilation

The main building ventilation system (Figure 1-17) performs the functions of fresh air supply, personnel comfort control and radioactive contamination control within the plant. To accomplish these functions, a single inlet-single exhaust system is provided in which incoming air is filtered and heated for cleanliness and personnel comfort and then distributed to various main building zones at pressures controlled to assure air flow is always from zones of slight (or no) contamination towards zones of potentially higher contamination. Exhaust air is collected in the air tunnel and drawn through the sand filter or HEPA filters and discharged through the stack.

7.4.3.1 Primary Safety Considerations

a. If airborne radioactive materials escape from waste treatment systems, the material is confined within the main building ventilation system under all credible operating conditions.

b. Spread of airborne radioactive material from contaminated areas is prevented under normal and abnormal operating conditions.

c. Radioactive material released from the plant must be held ALARA.

7.4.3.2 Principal Mechanisms for Ensuring Safety

a. Confinement of mobile radioactive material is ensured by:

    (1) Providing high integrity ventilation exhaust ducts, filters, fans and auxiliary equipment required for system operation, with protection against earthquake and tornado effects.

    (2) Using the building structure to provide secondary confinement barriers of structural strength and leaktightness appropriate to potential contamination, potential internal pressures, and exterior forces that could exist.

b. Protection against spread of airborne radioactive material within the building is ensured by:

   (1) Maintaining ventilation air-flow in series patterns from zones of low (or no) contamination potential towards those of successively higher potential levels.

   (2) Providing a single ventilation exhaust path and means for automatic pressure balancing to prevent cross-flow between ventilation subsystems.

   (3) Locating the ventilation air intake point to minimize potential to recycle stack effluents.

c. Discharge of radioactive material from the plant stack is held ALARA by:

   (1) Providing effective demisting of vapor from the Radwaste System.

   (2) Passing all potentially contaminated ventilation air and Radwaste System evaporator gaseous effluent through the sand filter.

7.4.4 Airborne Effluent Monitoring Instrumentation

7.4.4.1 Functional Description

Multiple samplers collect samples of air discharged from the plant. Sufficient detailed information is obtained to calculate the integrated total quantity of radioactive material released from the stack to the atmosphere.

7.4.4.2 Major Components and Operating Characteristics

a. Sand Filter Inlet Sampler: A sample of the air stream entering the sand filter is passed through a particulate filter that is analyzed weekly for alpha and beta-gamma activities.

b. Ventilation Exhaust Sampling: Provisions are made for taking parallel samples of the ventilation exhaust air stream, downstream of exhaust fans, for continuous sampling of stack effluent release. Sample streams are filtered to collect particulates for periodic counting. Parallel sample streams are combined downstream of their individual blowers.

7.4.4.3 Sampling Considerations

Effluent samples withdrawn for monitoring and analysis must be representative of sampled streams, unbiased and sufficiently sensitive to ensure radionuclides released to the environs are adequately assessed.

a. Representative air sampling is ensured by:

   (1) Utilizing dual stack sampling points designed to provide an accurate cross section of effluent radioactive materials.

   (2) Collecting samples by means of isokinetic probes designed so that particulate concentrations collected are representative of the air stream sampled.

   (3) Calibrating sampler equipment to establish sample volume relationships to requisite accuracies.

   (4) Providing sample lines as short and straight as possible, with no abrupt turns, to minimize line effects.

   (5) Providing sample line heating to prevent condensation in lines.

b. Continuous sampling of effluent is ensured by:

   (1) Providing two redundant sampling systems to determine alpha and beta-gamma particulate. I-131 monitoring is provided in the remarkable event of a criticality incident in the basin.

   (2) Employing sample pumps of high reliability.

   (3) Controlling air-flow through sampling systems equipped with low flow alarms to indicate pump failure or filter blockage.

   (4) An effective system maintenance program.

7.4.5 Radiation Monitors

7.4.5.1 Functional Description

A number of different radiation monitoring systems are provided throughout the fuel storage areas to detect radiation associated with normal operations, and to detect and warn personnel of abnormal levels.

7.4.5.2 Major Components and Operating Characteristics

a. Area Radiation Monitors (ARMs): ARMs are located in various occupancy zones to provide continuous indication of gamma radiation levels. These monitors employ Geiger-Müeller tube sensor-converters equipped with auxiliary units to provide local indication of radiation

levels as well as local audible and visual alarms. Output from the basin area units (criticality monitors) is routed to an indicator-alarm-trip unit and to the Site Instrument Monitoring System (SIMS) in the CAS/SAS. ARMs have a range of 0.1 to 1000 mR/hr, with the criticality monitors, specifically, having a range of 0.1 – 10,000 mR/hr.

Each monitor is equipped with two adjustable set-point trip units - one to alarm on high readings and the other to warn of instrument malfunctions as evidenced by abnormally low readings.

b. Air Sampling and Monitoring: A combination of portable air samplers and fixed air monitoring stations are utilized to determine concentration of airborne radioactive material in fuel storage areas and to provide warning of approach to levels requiring corrective action. A sampler consists of an electrically powered vacuum pump, flow control system and filter. After an appropriate sampling period, the filter is removed for counting. Air monitors, consisting of sampling systems equipped to detect buildup of activity on filters, are provided in areas of personnel occupancy in which airborne concentrations may exceed 10 CFR 20 limits.

c. Criticality Monitors: A detection system (two ARMs) is provided in the fuel storage pool enclosure to warn personnel in the highly unlikely event of a criticality incident and to initiate evacuation to staging areas. Detectors are set at a trip point high enough to lessen potential for false alarms. Two detectors ensure monitoring continuity. Criticality alarms are unique, intermittent klaxons so situated that they can be heard throughout the main building, auxiliary buildings, and in outside areas.

d. General: Portable survey instruments and hand-foot counters are in use. Optically stimulated luminescent dosimeters (OSL's) are posted throughout the site. An ionization chamber is mounted in the basin water treatment filter cell to provide information regarding filter radiation level.

7.4.5.3 Radiation Monitor Considerations

Typical locations of basin area radiation monitors are depicted in Figure 7-2. ARMs are designed to be fail-safe in that they alarm both audibly and visually in the event of an upscale reading. On a downscale reading a warning light will signify instrument malfunction.

[redacted]

Figure 7-2. Radiation monitor typical locations.

a. Adequacy of protection system coverage is ensured by:

(1) Providing gamma radiation monitors in selected personnel access areas.

(2) Locating air samplers to provide measurements representative of breathing zone concentrations.

(3) Use of portable instruments to monitor specific activities.

b. Assurance of clear indications of abnormal conditions is provided by:

(1) Equipping monitors with local alarms to assure adequate warning of personnel in the vicinity of the monitor.

(2) Providing distinctive alarm signals designed to be clearly heard over background noise levels and readily recognized as to meaning.

(3) Including signal recognition and interpretation in operating training requirements and in operating procedures and instructions.

(4) Providing alarm monitoring in the CAS/SAS for the basin criticality monitors.

c. Reliability of personnel protection system functions is assured by:

(1) Providing capability for checking operability and accuracy of all monitors with calibrated radioactive sources.

(2) Providing redundant power supply systems.

(3) Utilizing system components of demonstrated capability and proven reliability

(4) Source check portable instruments before use

(5) Use of self-reading pencils

(6) Use of Optically Stimulated Luminescent dosimetry (OSL) badges

(7) An effective system maintenance program

Calibration of ARMs, air monitors, and other radiation detection equipment is checked periodically. In addition to these requirements, all radiation monitors are calibrated periodically.

7.5 PERSONNEL EXPOSURE ASSESSMENT

Radiation levels at GEH-MO are controlled ALARA. Personnel exposures are determined primarily by background radiation levels and are a function of the total man-hours of occupancy in the basin area and activities under way during an exposure occurrence period.

Management controls include operating limits for radioactive material concentration in basin water requiring special corrective actions. The gross β concentration value is 0.02 μCi/ml. If the rate is exceeded, a cleanup campaign is initiated.

7.6 HEALTH PHYSICS PROGRAM

The primary purpose of the health physics program is minimization of occupational exposure. Personnel protection is accomplished through use of monitoring equipment (described in Section 7.4.5) and by monitoring the radiological status of hazardous areas within the facility. Trained personnel make frequent surveys to appraise conditions and specify protective measures needed for work. Personnel also monitor or inspect activities to keep plant personnel informed of area radiation and contamination status.

Daily exposures during routine operation are maintained ALARA. The personnel monitoring program includes OSL badges and self-indicating pencil dosimeters.

Workers who require access to contamination control areas participate in the bioassay program on an annual basis and at other times as determined by the RSO or Safety Committee. Internal exposures are estimated through reviews of air sample data, and whole body counting. Urinalysis is performed as deemed appropriate by the Radiation Safety Officer[8].

The radiation safety program is conducted according to MOI's and MOSP's. Plant operations are conducted under procedures consistent with site instructions. Operations and maintenance procedures, which have safety significance, are reviewed by the Safety Committee.

7.7 ESTIMATED MAN-REM OFF-SITE DOSE ASSESSMENT

GEH-MO fuel storage activity produces no significant radioactive effluent. The environmental monitoring program is one of effluent sampling and radiation monitoring.

7.7.1 Effluent and Environmental Monitoring Program

Environmental radiation monitoring near the GEH-MO site has been performed since1958.

Monitoring program results from 1968 to 1994 confirm the absence of detectable off-site radioactive contamination. Off-site exposure resulting from fuel storage is a very small fraction of regulatory limits. In addition, Illinois Department of Public Health measured radiation dose rates in populated areas around the DNPS/GEH-MO sites and in 13 central Illinois counties from 1971 to 1976 indicate no significant difference in radiation exposure between the two areas even though the joint site consists of two reactors and a fuel storage facility[9].

Specifications for the current environs monitoring program are depicted in Table 7-3 and locations of sampling points are documented in Figures 7-3 through 7-5. Samples are collected at points on the GEH-MO property boundaries. Reference samples provide a background, which enable GEH-MO to distinguish significant radioactive material introduced into the

environment by GEH-MO operation from that introduced by nuclear weapons testing and other sources.

Particulate radioactive material in air consists of residual radioactive fallout from weapons testing and other man-made events plus cosmic and natural sources. Cosmic and background sources result in a dose rate of 2 to 3 mRem/week. River water concentrations show a natural background of about $1x10^{-8}$ µCi/ml due to natural radium, uranium and radiopotassium.

The program meets USNRC requirements.

Table 7-3
MORRIS OPERATION RADIOLOGICAL MONITORING PROGRAM

Particulates in Air

No routine particulate environmental air samples are collected due to operation of the GEH-MO. Air samples are collected at the site boundary in the event one of the following occurs:

1. The stack air monitoring system and back-up system fails or is out of service for a time period greater than 24 hours.
2. License specification 4.1.1 "Effluent Air" gross beta activity exceeds $4x10^{-8}$ µCi/ml.
3. An airborne activity release alert is declared as defined by the GEH-MO Emergency Plan.

SAMPLE MEDIUM	COLLECTION SITE	ANALYSIS	FREQUENCY
Exposure by OSL	Duplicate OSL's are placed at the 15-acre site boundary in positions approximately corresponding to eight points of the compass.	Gamma radiation analysis	Quarterly
Water	a. Sanitary Lagoons	Gross β H-3	Monthly
	b. North Drainage Ditch (If water in ditch)	Gross β H-3	Monthly
	c. Eight site monitoring wells	Gross β H-3	Quarterly

[redacted]

Figure 7-3. OSL Sampling Locations

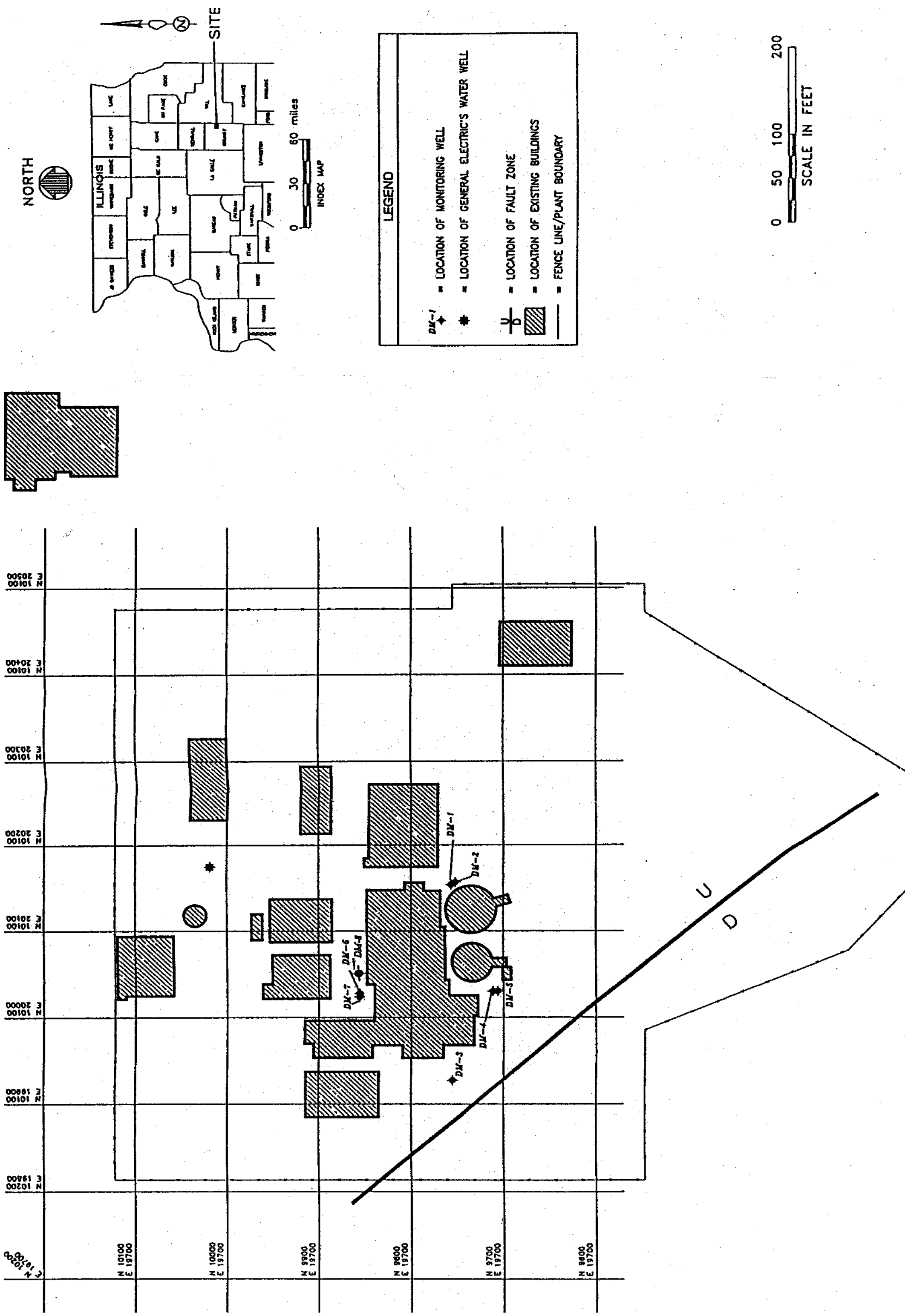


Figure 7-4. Monitoring Well Locations

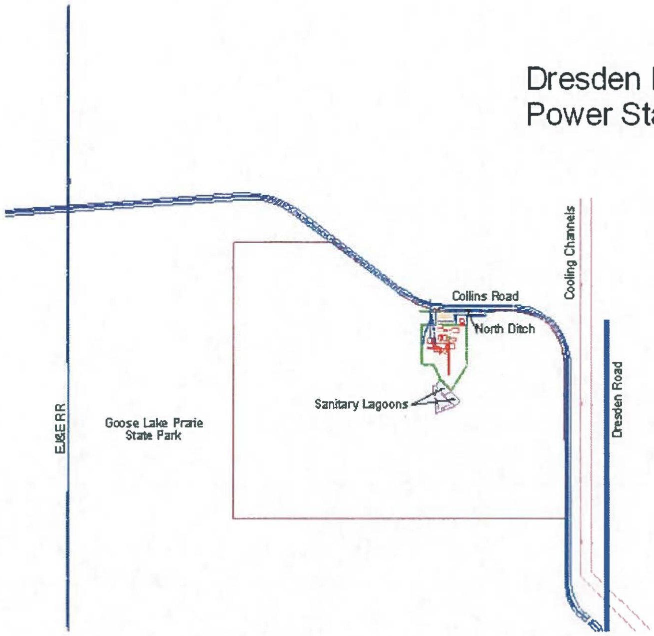


Figure 7-5. Environmental Water Sample Locations at the sanitary lagoons and north ditch

7.7.2 Estimated Exposures

Exposure from radioactive material released in stack effluents is estimated using COMPLY (an EPA software program approved by the NRC). Atmospheric diffusion characteristics, including joint stability-frequency and wind speed data, method and conditions used in calculations of ground-level radiation doses, are discussed in Section 3. Population distribution around the plant is included.

7.7.2.1 External Exposure

Calculations have been made of external exposure from gamma emitters in the stack plume, beta exposure from immersion in the plume and from ground deposition of gamma-emitting particulate activity. Immersion in the plume, and gamma dose from the overhead plume are the only significant contributors. Kr-85 contributes essentially all the exposure from immersion since it is the only radioactive noble gas present after decay of other short half-life noble gases. Kr-85 is a beta emitter with a gamma photon abundance of only 0.4%. Therefore, exposure to Kr-85 results in primarily a beta dose to exposed skin and is of less radiological significance than penetrating whole-body exposure. Shielding provided by clothing will eliminate most skin dose from exposure to β radiation.

For purposes of this analysis, conditions described in Section 7.3.2 were used, with equations and conversion factors for skin doses taken from DOE/EH 0070[10]. Skin dose calculations indicate a maximum off-site dose (about 800 meters from the main stack) of about 0.0045 mRem/yr.

7.7.2.2 Internal Exposure from Inhalation

GEH Morris Operation recognizes the constraint of 10 mRem per year to the general public as suggested by Regulatory Guide 4.20, “Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other than Power Reactors”, December 1996. Adoption of Reg. Guide 4.20 requires that GEH-MO modify the calculation methodology formerly used. GEH-MO uses “COMPLY” (EPA software program) at screening level 4 to demonstrate compliance and to derive the air emission dose to the public.

7.7.2.3 Man-Rem Calculations

Man-Rem calculations were estimated for annual whole-body exposure due to inhalation of released beta emitters and skin dose due to release of Kr-85. Averages of exposures were calculated for concentric circles with radii of multiples of 10 miles. These average values were multiplied by the population within each area which gives an average annual whole-body man-Rem. The sum of these values for each area out to a radius of 50 miles gives a total of less than 2 x 10^{-6} man-Rem/yr whole body and less than 0.12 man-Rem skin dose for the period

from 1970 to the year 2100.For comparison, the population exposure from normal background radiation (taken at 100 mRem/yr) in the same area is approximately 665,000 man-Rem for 1970, to 750,000 man-Rem for the year 2000. Therefore, the radiological impact from the GEH-MO fuel storage operations is relatively insignificant.

7.7.3 Liquid Releases

There are no planned releases of liquid wastes from the site boundaries.

7.8 REFERENCES

1. RESSAR-41 Reference Safety Analysis Report, Vol. 6, Westinghouse, December 1973 and Amendments.

2. K. J. Eger, Operating Experience - Irradiated Fuel Storage - Morris Operation, Morris, Illinois, General Electric Company (NEDO-20969B).

3. A proprietary product of the Norton Co.

4. See "Annual Report" to Region III, USNRC dated February 14, 1994.

5. See NEDG-249122-1, "In-Plant Test Measurements For Spent fuel Storage At Morris Operation,, " May 1981.

6. T. Rockwell, Reactor Shielding Design Manual, VanNostrand, 1956.

7. M. J. Bell, Origen - The ORNL Generation and Depletion Code, ORNL-4628.

8. Teledyne Isotope, Northbrook, IL. Provides environmental sampling and analysis (especially for radionuclides) and bioassay services.

9. State of Illinois, Department of Public health, Monitoring and Regulation of Nuclear Facilities in Illinois, Springfield, Illinois (1977). The report shows slightly higher radiation levels in the control counties.

10. DOE/EH 0070, "External Dose Rate Conversion Factors from Calculation of Dose to the Public", July, 1988.

11. DOE/EH 0071, "Internal Dose Rate Conversion Factors for Calculation of Dose to the Public", July 1988.

8.0 ACCIDENT SAFETY ANALYSIS

8.1 INTRODUCTION

This section contains an analysis of postulated accidents in terms of the causes of such events, the consequences, and the ability of the GEH-Morris Operation (GEH-MO) organization to cope with each situation.

The function of GEH-MO is to store and ship irradiated nuclear fuel. A primary requirement of these operations is to protect the public and employees from excessive exposure to ionizing radiation, as specified by the requirements of 10 CFR 72.106. Specifically, any individual at or beyond the controlled area boundary shall not receive a dose greater than 5 Rem to the whole body or any organ from any design basis accident (i.e., those accidents described in this section).

8.1.1 Release Pathways

Exposure of the public and employees might result from postulated accidents, by direct radiation from the fuel, by airborne release of radioactive material, or by release of radioactive material to groundwater. These postulated events are discussed in this section. None of these potential releases have off-site impacts, which exceed the limitations of 10 CFR 72.104.

8.1.1.1 Direct Radiation

Exposure of the public and employees could be postulated to result from direct radiation from fuel in storage or by release of radioactive material to the environs. Direct radiation from the fuel would occur only if the water level in the storage basin became too low to provide adequate shielding. This would pose a hazard to persons only if they were in relatively close proximity to the basin. Loss of water could result from postulated drainage or evaporation of the basin water, but only when basin make-up water supply quantity or rate is not sufficient to keep up with the water loss. Sudden draining of water from the basin is not credible.

8.1.1.2 Airborne Release

Airborne release of radioactive material could result from fuel being mechanically damaged sufficiently to release fission gases from the plena of fuel rods. Of the gases released, only Kr-85 and I-129 would be of concern.

No mechanism exists in the fuel storage environment to cause an airborne release of particulate radioactive material in quantities sufficient to result in exposures approaching limits specified in 10 CFR 72.104. During certain cask operations (e.g., decontamination and venting) particulate releases might occur but in very small quantities, even under the most severe conditions that can be postulated. These quantities would be much too small for an off-site impact. A criticality

incident could result from the dropping of a basket in such a way that all the fuel falls out of the basket and comes to rest in a critical array, or by the deformation of fuel baskets into a critical array by a tornado-generated missile. In reality, however, the above events have an extremely low probability of occurring and the impact of either would be substantially less than the limits of Part 72.104.

8.1.1.3 Waterborne Release

Vault intrusion water is normally disposed of in the sanitary lagoons, so that an off-site release would not be likely even in the unlikely event the water is contaminated.

Water from the storage basins can be released due to a leak in the basin structure, permitting water to escape to the surrounding rock.

8.1.2 Accident Description/Discussion

The following sections contain discussion of various postulated accidents and estimates of the quantity of radioactive material release and projected consequences. A summary of events resulting in postulated radiation exposures to the public is shown in Figure 8-1. No combination of normal and credible accident events has been developed that would result in an off-site release or direct radiation exposure that would exceed the regulatory limits for an accident (10 CFR 72.106).

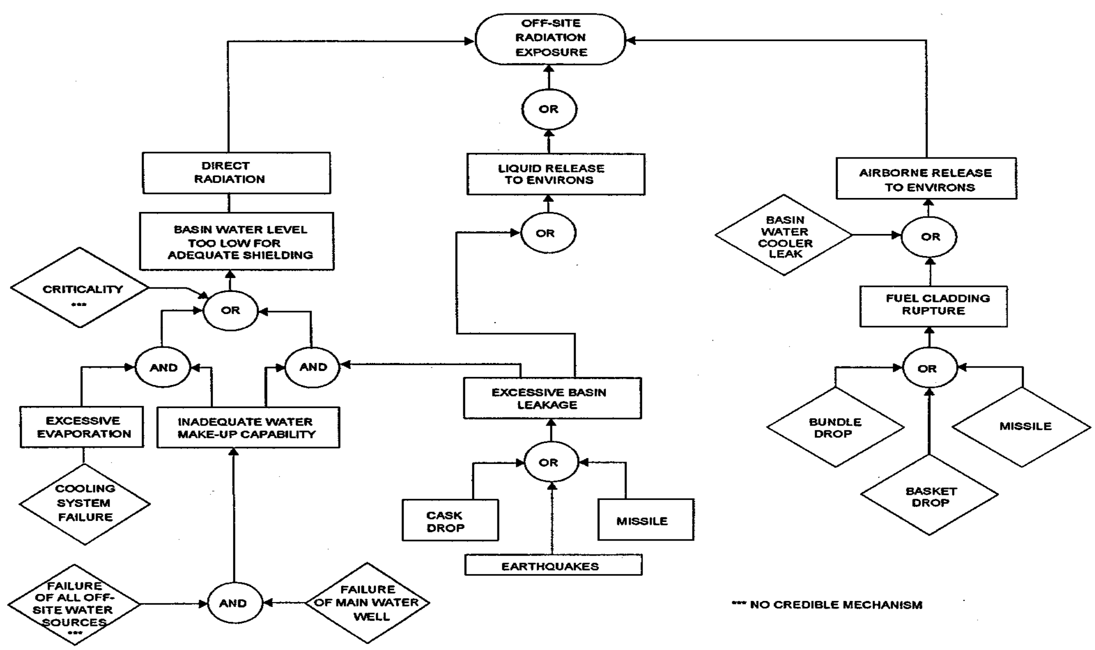


Figure 8-1. Event Diagram of Postulated Accidents

A release of noble gases and halogens from DNPS, similar to or greater than at TMI-2, would not affect fuel storage safety at Morris. The location and construction of the GEH-MO control room, the availability of respiratory protective masks and systems, the availability of protective clothing, and other radiological emergency preparations at Morris would minimize the impact on GEH-MO of any release from DNPS[1]. Even if it should become necessary to temporarily evacuate GEH-MO, the slow loss of basin water by evaporation and the ease of replacement negates possible detrimental effects, and protects the public health and safety.

8.1.3 Exposure Paths

Of the possible exposure paths, only whole body exposure from external radiation and internal exposure through inhalation are considered credible at any off-site location. No mechanism has been identified that will cause radioactive contamination of farmlands, feed lots, or other sensitive areas, that could result in an ingestion dose greater than a small fraction of regulatory limits.

8.2 LOSS OF FUEL BASIN COOLING

The basin cooling system is not critical to safety. When the cooling system is not in service, the water make-up system can be used to replace water lost by evaporation. Even if the water make-up system is out of service, there is adequate time to repair or replace both cooling and make-up systems or to provide make-up water from alternate on-site or off-site sources. (The water make-up system includes the water well and all equipment related to the normal make-up water supply to the basin.)

The time available to provide make-up water if the cooling and water make-up systems are out of service has been determined by measurement of evaporative losses with the fuel in storage as of June 2004. Based on actual measurement of basin heat-up rate, the time available to provide make-up water before reaching the technical specification (Section 10.3.1) limit of 9 feet of water above the top of the fuel bundle upper tie plate is more than 60 days.

8.2.1 Basin Water Temperature

Maximum basin water temperature as measured in June 2004 after 60 days of operation with no cooling or makeup water was 123º F and more than 319,263 gallons of water would have to evaporate before the top of the fuel bundles upper tie plate would be exposed. This would require approximately 150 days.

The probability of excessively high radiation dose rates resulting from loss of fuel basin cooling is clearly quite small given ample time for repairs and water replacement.

8.3 DRAINAGE OF FUEL BASINS

There are no piping penetrations, which could drain the fuel storage basins, and there are no paths for siphoning water from the basin. Therefore, to inadvertently drain water from the basin, the basin structure must be penetrated. Since the basin structure is below grade and given low permeability of surrounding rock (except for the overburden) and high level of upper strata groundwater, leakage (even if it were undetected) would not uncover the fuel (Appendix A.13).

8.3.1 Basin Liner rupture Experience

An accident occurred in June 1972 that resulted in the rupture of the basin liner and demonstrated the ability of GE-MO to withstand and recover from such an incident. No measurable exposure to ionizing radiation was experienced by site personnel or the general public as a result of the incident, and no groundwater contamination above background levels was detected.

8.4 CASK DROP INTO THE CASK UNLOADING BASIN

A postulated means of damaging the basin floor structure is dropping a shipping cask on either the cask unloading pit set off shelf or the floor.

The cask unloading pit set off shelf is protected by an energy absorbing pad designed to accommodate the impact of a cask. Detailed design analysis of the pad is given in Appendix A. Included in that appendix is an analysis of an impact on the corner of the shelf and an impact on the floor of the cask unloading pit. In each case, it is shown the integrity of the structure is not breached and in neither case is basin water released to the environs. Rapid recovery from a breach in the liner caused by a cask incident is discussed in Section 8.3.1.

8.5 FUEL DROP ACCIDENTS

Accidents could occur during fuel handling that might result in mechanical damage to the fuel and subsequent release of fission gases. Such accidents could happen during transfer of fuel from a storage basket to a cask, or during transfer of storage basket from basin to unloading pit. In any case, the postulated accident is assumed to occur in the fuel unloading pit since the fuel is lifted to greater height than in the storage basins.

During cask handling operations, there is no movement of a cask over fuel. The design of the fuel storage facility is such that a cask cannot be moved over the fuel storage basins. Further, administrative controls prevent cask movement when fuel is present in the unloading pit.

The following discussion addresses the fission gas inventory in the fuel, water decontamination factors, and assumptions that pertain to both fuel drop and basket drop analyses.

a. Fission Gas Inventory in the Fuel

Fission gas inventory in the fuel is dependent primarily on the total fuel exposure. Of the radioisotopes present in the fission gas inventory, Kr-85 and I-129 represent the greatest curie inventory in fuel that has cooled 1 year or more. Figure 8-2 depicts the Kr-85 inventory as a function of cooling times for different fuel exposure levels. Amounts of I-129 in the fuel range from about 0.008 Ci/TeU for 8,000 MWd/TeU exposure to 0.04 Ci/TeU for exposure of 44,000 MWd/TeU and remain essentially constant with time.

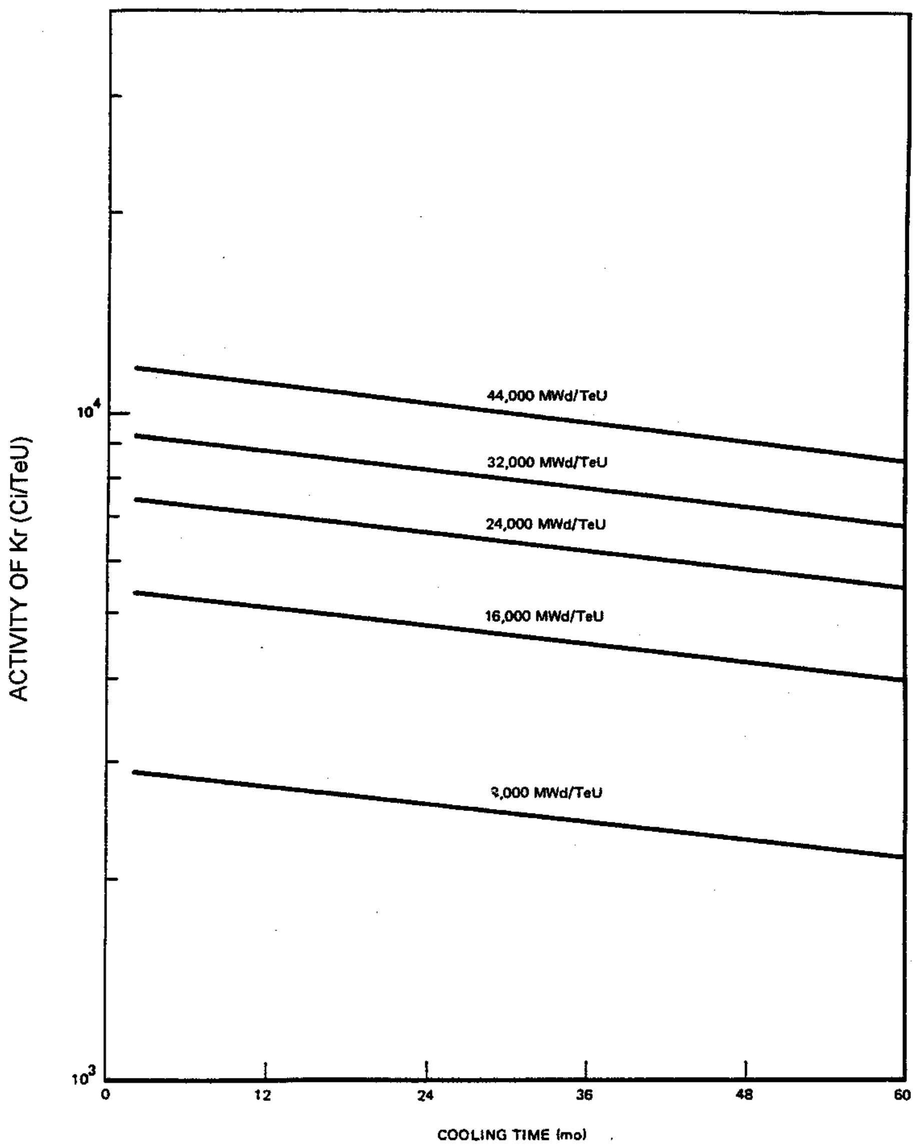


Figure 8-2. Kr-85 Activity as function of cooling time for different fuel exposures. (Total inventory in fuel rod.)

Other fission gases, including I-131, Xe-131m and Xe-133, decay relatively quickly. After one year cooling time, all three are decayed to insignificant levels as shown in Figure 8-3. The total fission gas inventory for a 1 year cooling time is given in Table 4-1, Section 4.

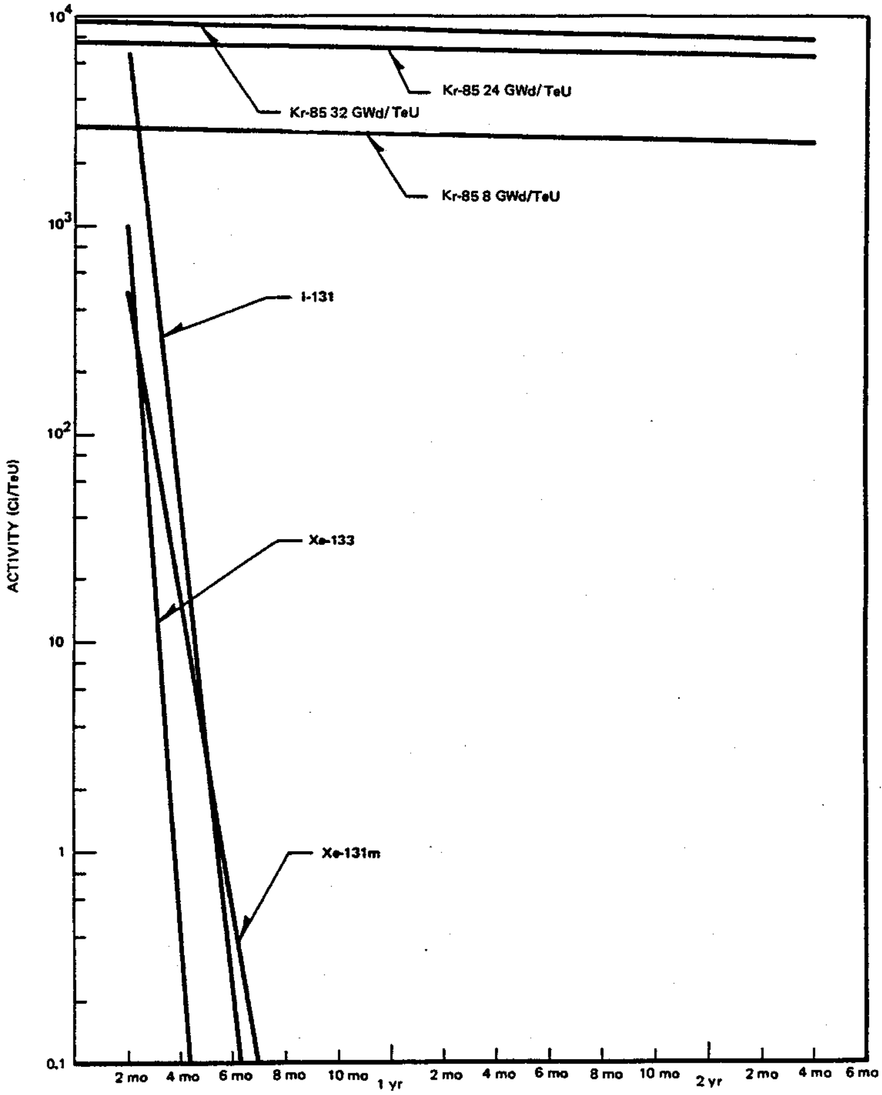


Figure 8-3. Iodine, Krypton and Xenon Decay

The amount of fission gas released from UO2 fuel and accumulated in the plenum of each rod is dependent on the specific power (fuel temperature) during operation. At higher specific power, a greater fraction of gas will be released to the plenum. Calculations of fission gas inventory result in a release fraction that ranges from 20% to 45% depending on the irradiation history of the fuel rods. For example, a Westinghouse safety analysis report

states that approximately 2.5% of Xe and approximately 3% of iodine are found in the gas plenum (Docket 50-295, "Zion Nuclear Power Station," Commonwealth Edison Co.).

GEH uses plenum percentages for radioisotopes that are based on fission product release data from defective fuel experiments[2]. A comparison of these values with the NRC Regulatory Guide and the values used in the fuel drop analysis for GEH-MO is shown below:

	GEH Fuel Drop Analyses for Reactors	NRC Regulatory Guide	GEH Fuel Drop Analyses For Morris Op
	PERCENT OF RADIOISOTOPES(S) IN PLENUM		
Radioiodine			
I-131	1.2	10	2
Kr-85	30	30	30
All other noble gases		10	
Xe-131m	3.9		
Xe-133	2.5		

These values are considered realistic values based on the analytical and experimental data contained in the references cited above. The value for radioiodine is also recommended by Appendix VIII, WASH-1400. The Kr value agrees with that in Regulatory Guide (RG) 1.25.

b. Water Decontamination Factor

Not all iodine released from a fuel rod would be released from the basin water. Being highly soluble, much of the iodine would dissolve and remain in the water. RG 1.25 recommends a factor of 100 for pool decontamination of iodine.

In analysis of a fuel handling accident, Westinghouse based decontamination factors on iodine tests conducted to determine the mass transfer from the gas phase to surrounding liquid[3]. That work resulted in the formulation of a mathematical expression for the iodine decontamination factor in terms of bubble size and bubble rise time. The equation is:

$$\text{Decontamination Factor} = (7.3) \exp [0.313\ t/d]$$

where t = rise time, and
d = effective bubble diameter.

Evaluating the decontamination factor for iodine released from a fuel bundle, a minimum factor of 760 is calculated for a water depth of 26 ft. However, for their "conservative analysis" the factor was reduced to 500.

For a fuel bundle drop at GEH-MO, the worst-case accident occurs in the cask unloading pit. Minimum water depth in that pit is about 32 feet. Therefore, a decontamination factor of 500 is sufficiently conservative.

c. Assumptions

The following assumptions are made for the safety analysis:

1. The fuel bundle or basket drop occurs in the fuel unloading pit.

2. Because of the negligible particulate activity available for release from the fuel plena, none of the solid fission products are released.

3. The overall effective decontamination factor for iodine is 500. Because water has a negligible effect on removal of the noble gases, the decontamination factor is 1.

4. Ventilation air flow exhaust rate from the basin areas is 7,600 scfm via the air tunnel, sand filter and the main stack. Duration of release is 2 hours.

5. Worst case $\overline{X}/Q$ is 2.8 x 10^{-5} sec/m^3. (See Appendix A.5, Section A.5.1b, Short-Term (Accident) Diffusion Estimates.)

6. Fuel characteristics are 44,000 MWd/TeU exposure, 1-year cooling.

7. Dose conversion factors are:

Species	Whole Body $\frac{\text{mRem}}{\mu\text{Ci}} - \frac{m^3}{\text{sec}}$	Thyroid $\frac{\text{mRem}}{\mu\text{Ci}} - \frac{m^3}{\text{sec}}$
Noble Gas	4.75 x 10^{-7}	-
Halogen	8.72 x 10^{-5}	4.472 x 10^{-1}

8.5.1 Fuel Bundle Drop Accident

a. It is highly unlikely fuel rods would be ruptured in a fuel drop accident. However, to establish an upper boundary in the consequence analysis, it is assumed all rods in the bundle have ruptured releasing all fission gases present in the plena to the basin. The following release is calculated:

	Amounts Released (Ci)	
Species	BWR	PWR
Noble Gases	684	1530
Iodine	3.3E-7	0.48E-7

It is assumed that all of the fission gases are expelled from the basin and passed through the sand filter and released from the main stack.

Using the assumed values for atmospheric diffusion and dose conversion factors, the maximum off-site dose rates are:

	Maximum Dose Rate (mRem/hr)	
Body Organ	BWR	PWR
Whole Body	4.5E-3	1.0E-2
Thyroid	1.8E-6	4.0E-6

If an individual off-site were exposed at the maximum dose rate for the duration of the accident (2 hr.), the maximum doses are estimated to be about 0.02 mRem whole body and 8.0 x 10^{-6} mRem thyroid. Such doses are clearly insignificant and well below the Part 72 guideline of 5 Rem for whole body or any organ.

If this accident were to occur with the ventilation system inoperable, the basin enclosure would contain the fission product gasses and act as a radiation source. Using Microshield v5.05 a Grove Engineering software program for estimating exposure from gamma radiation, the exposure from this source would be (mR/hr):

	BWR	PWR
Off-Site dose	.12	.26
Dose at Basin enclosure boundary	14.2	31.7

b. Actual Bundle Drop Experience

In actual fuel drops, some fuel bundles suffered minor damage, but in all cases, no major deformation of the fuel bundles occurred. For example, during the winter of 1973-1974 the Pilgrim Nuclear Power Station was down for a scheduled refueling and maintenance outage. During transfer of irradiated fuel from the core, a fuel bundle was accidentally dropped from the fuel grapple to the fuel pool floor. The bundle was carefully inspected. There was no indication of major fuel rod failure or distortion nor was there a measurable release of airborne activity as a result of this drop.

In the fall of 1974 during a scheduled outage of the Millstone Nuclear Power Station, an irradiated fuel bundle was dropped to the floor while being transferred from the fuel preparation machine to the fuel storage rack. Consequences of that drop included fracture of all the tie rods, separation at the upper tie plate, and minor permanent deformation at the upper tieplate. Although the fuel bundle appeared to be slightly bent and twisted, no major dislocation of rods, rod segments, or fuel pellets was indicated.

Early in the operation of the Garigliano reactor in Italy, a fuel drop occurred during transfer of fuel to the operating floor. A fuel rack containing five unirradiated fuel bundles dropped on a concrete floor, a distance of about 70 ft. in air. As a result, the rack was badly bent and twisted. Approximately 20% of the 36 fuel rods in each bundle split. Although some fuel pellets were expelled, most of the pellets remained within the fractured rods. Damage to each fuel bundle was confined to the lower one-third of the rods, the lower tieplates and spacers. The upper portion of the bundles remained intact with no apparent damage.

In another case, a fuel bundle was dropped more than 15 ft. and landed on a fuel rack. Consequences of that accident were damage to the nosepiece of the lower tieplate and a slight twist of the assembly. No deformation of the fuel rods or other bundle components was found.

8.5.2 Fuel Basket Drop Accident

After the cask is unloaded and the fuel placed in a storage basket, the basket is transferred to a fuel storage basin (Basin 1 or 2). During this transfer, the basket is less than 3 ft. above the basin floor. When in the cask unloading pit, the maximum height is about 22.5 ft. (equivalent drop height in air is about 12.6 ft.) above the cask unloading pit floor.

In the unlikely event that a basket is dropped in the cask unloading pit, there could be damage to the basin liner, the basket, and the fuel it contains. Damage to the basin liner would be less extensive than that analyzed for a cask drop accident. (See Section 8.4). The criticality aspect of a postulated basket drop accident is discussed in Section 8.9.

The fuel rods within a fuel bundle most likely would not break in a postulated basket drop accident. It has been concluded that fuel bundles in a shipping cask retain their integrity in a 30 ft. cask drop[4]. Since the pipe construction of the fuel basket offers support and protection for the fuel, the postulated drop should cause minor, if any, damage to the fuel.

Comparing actual fuel drops (see discussion in Section 8.6.1) with a postulated basket drop accident at GEH-MO, conditions in the actual cases discussed were more severe in that drop heights were greater than the maximum drop height in the GEH-MO cask unloading pit (12.6 ft. equivalent in air). Many of the actual drops involved fuel bundles that were unsupported and not as well contained as fuel would be in the GEH-MO fuel storage basket.

A structure is installed in front of the entrance of the fuel storage basin (Figure 1-15) to restrain a basket in the event it is somehow dropped at the entrance and the top of the basket tips toward the cask unloading pit. The restraint prevents the basket from tipping in such a way as to disgorge the fuel it may contain.

To transfer a basket from the cask unloading pit, the basket is moved directly under the cask unloading pit doorway guard (Section 5.4.3.3) and lifted through the bottom of the structure. Then the basket is moved laterally into the fuel storage basin. Therefore, the orientation of the basket involved in a postulated drop accident is vertical (i.e., a side drop is not possible and is not analyzed).

8.5.2.1 Accident Analysis

In addition to the assumptions listed in Section 8.6.c, it is assumed the storage basket is full of fuel at the time the accident is postulated. It is unlikely any of the fuel rods would be damaged in such a drop. However, to conservatively evaluate consequences, all the rods in all the bundles are assumed to have ruptured and all the plenum fission gases are assumed to be released to the basin water.

a. The amount of fission gases released to the basin area is calculated to be:

	Amount Released to Basin Area (Ci)	
Species	BWR	PWR
Noble Gases	6156	6120
Iodine	3.01E-6	2.99E-6

b. The maximum off-site dose rates for 2 hr. release duration were calculated to be:

	Maximum Dose Rate (mRem/hr)	
Body Organ	BWR	PWR
Whole Body	4.05E-2	4.0E-2
Thyroid	1.62E-5	1.6E-5

An individual off-site who received the maximum exposure for the 2-hour period would receive less than 0.08 mRem to the whole body and 3.25E-5 mRem to the thyroid. Such an exposure is insignificant compared to the Part 72 guideline value of 5 Rem to the whole body or any organ.

If this accident were to occur with the ventilation system inoperable, the basin enclosure would contain the fission product gasses and act as a radiation source. Using Microshield v5.05 a Grove Engineering software program for estimating exposure from gamma radiation, the exposure from this source would be (mR/hr):

	BWR	PWR
Off-Site dose	1.05	1.04
Dose at Basin enclosure boundary	127.5	126.8

8.5.3 Recovery Practice

Specific procedures for recovering from a basket or bundle accident cannot be described because of the many variables involved (arrangement of bundles on the unloading pit floor, etc.). In general, however, recovery would involve picking up each bundle using appropriate grapples and inspecting each bundle for damage before inserting into a basket. Damaged bundles would be handled (canned or as otherwise appropriate) in much the same manner as for damaged incoming fuel.

8.6 TORNADO-GENERATED MISSILE ACCIDENT

An accident is postulated in which a tornado-generated missile is hurled into the fuel storage basin. Because the building covering the basins is not designed to withstand the forces of a tornado, it is assumed that the building has been blown away, leaving the fuel basins exposed.

The impact of a missile could cause damage to the basin liner or fuel, but not both concurrently. As indicated in the discussion of potential missiles in Appendix A-15, a missile would not have sufficient energy to damage both fuel and basin liner after striking one or the other.

Criticality aspects of this accident are discussed in Section 8.9. The analysis below concerns the consequences of a missile damaging the fuel. In the missile analysis given in Appendix A-15, two missiles were analyzed. One was a 12 in. diameter by 20 ft. long section of a telephone pole weighing 630 lb. The other missile was a small automobile, 5 ft. by 5 ft. by 8 ft. in dimensions and weighing 1,800 lb. The spectrum of missiles has been expanded to include those listed in Table 8-1. The impact velocity given in the table is defined as that when the missile enters the water of the storage basin.

8.6.1 Accident Analysis

Each missile that was analyzed is listed in Table 8-1. The approximate velocities and kinetic energies at depths of 14 ft. and 21 ft. are given in Table 8-2. These values are those the missile could have if it entered the storage basin water in a vertical orientation. If the missiles entered the water in a horizontal orientation the drag force is greater in many cases and its velocity and kinetic energy would be less. Therefore, the values shown in Table 8-2 are "worst-case" values.

Postulated missile damage depends principally on the cross-sectional (or impact) area, its weight, and the amount of energy it could transfer to the fuel bundle. As indicated in Table 8-2, Missile F has the greatest amount of energy at a depth of 14 ft, which is the depth to the top of the fuel storage baskets. Because of its weight and frontal area (approximately 143 sq. in.), it

could potentially cause the most damage. Yet, there is a limit to the number of fuel bundles such a missile could damage.

If the missile entered vertically into the pool, it could potentially strike as many as six BWR bundles or four PWR bundles. The storage basket would move under the impact and the pipes that make up the basket would probably break free. This action would likely absorb all the energy delivered by the missile.

Other missiles, mostly various sizes of pipe, could cause fuel rupture. However, the damage would be confined to one or two fuel bundles, except for Missile E, the 12 in. diameter pipe. This missile could potentially damage as many as six BWR or four PWR fuel bundles, which is comparable to that estimated for the utility pole, Missile F.

Table 8-1
LIST OF TORNADO-GENERATED MISSILES

Missile	Dimensions	Weight (lb)	Impact Velocity as Fraction of Tornado Velocity*
A-Wood Plank	4 in. x 12 in. 12 ft.	200	0.8
B-Steel Pipe	3 in. diam, 10 ft. long, Sched 40	78	0.4
C-Steel Rod	1 in. diam x 3 ft. long	8	0.6
D-Steel Pipe	6 in. diam, 15 ft. long, Sched 40	285	0.4
E-Steel Pipe	12 in. diam, 15 ft. long, Sched 40	743	0.4
F-Utility Pole	13.5 in. diam x 35 ft. long	1,490	0.4
G-Automobile	20 $ft.^2$ frontal area	4,000	0.2

- Defined as rotational plus translational velocity.

•

Table 8-2

VELOCITIES AND KINETIC ENERGIES OF MISSILES IN WATER WHEN ENTERING FUEL POOL IN A VERTICAL POSITION

Missile	14 ft. Depth Velocity (ft./sec.)	Kinetic Energy (ft.-lb.)	21 ft. Depth Velocity (ft./sec.)	Kinetic Energy (ft.-lb.)
A	196	1.2×10^5	124	4.8×10^4
B	195	4.6×10^4	188	4.3×10^4
C	236	7.0×10^3	202	5.0×10^3
D	200	2.0×10^5	196	1.8×10^5
E	200	4.6×10^5	195	4.4×10^5
F	159	6.0×10^5	136	4.3×10^5
G	13	1×10^4	13	1×10^4

Missile G, the automobile, reaches a terminal velocity of about 13 ft./sec. within a depth of about 7 ft. It would then settle to the top of the fuel or to the floor. If it hit the fuel, the energy (one of the least of all the missiles) that it could transfer to the fuel is distributed over a 20 sq. ft. area. No fuel is expected to fail as a result of impact from this missile.

8.6.2 Assumptions

Assumptions used in the safety analysis include the following

a. All the fuel rods in six BWR bundles or four PWR bundles are ruptured. The impact of only one basket is considered.

b. The accident takes place in the fuel storage basin.

c. An average of 30% of the total Kr-85 and 2% of the I-129 activity is in the fuel rod plena and available for release.

d. No solid fission products are released (negligible particulate radioactive material is present in the fuel plena).

e. The overall effective decontamination factor is assumed to be 1 (the accident is assumed to occur in the fuel storage basin).

f. Fuel characteristics are 24,000 MWd/TeU exposure, specific power of 40 kW/kgU and one year cooling.

g. The storage basin is open (i.e., the sheet-metal building over the basin is assumed to have been blown away by the postulated tornado).

h. A maximum X/Q value is 4.0 x 10^{-4} sec/m^3 is taken from Appendix A.5, Section A.5.1 for a short-term ground level release.

8.6.3 Dose Rate Calculations

Using the above assumptions, the amount of fission gases released was calculated to be:

	Amount Released (Ci)	
Species	BWR	PWR
Noble Gas	2.5E+3	3.7E+3
Iodine	1.2E-6	1.8E-6

Assuming an individual was present during the entire period during which the cloud passed, his maximum exposure is calculated to be approximately:

	Dose (mRem)	
Body Organ	BWR	PWR
Whole Body	0.5	0.8
Thyroid	2.3E-4	2.4E-4

Comparing these values with the Part 72 guideline values of 5 Rem to the whole body or any organ, they are clearly insignificant.

8.7 CHILLER SYSTEM LEAK

A water to freon heat exchanger system replaced the fin-fan coolers in 2000, and basin water no longer is piped outside the building to the original fin-fan coolers. The release of radioactive material into the atmosphere because of a leak in the basin chiller system - specifically, a leak in a water-to-freon heat exchanger is not possible. The operating pressure of the freon is greater than the basin water, so freon would leak into the basin water and not the reverse.

If the leakage occurred in the heat exchanger structure, the water would be channeled to a sump and automatically pumped to the Rad Waste System.

8.8 CRITICALITY ACCIDENT

The safety margin against an accidental criticality could potentially be reduced by receiving fuel that is more reactive than assumed in the design analyses or by mechanical damage to the storage basket or fuel sufficient to cause the stored fuel bundles to be forced into a critical configuration.

8.8.1 Fuel Handling Procedures

Nuclear safety in the cask unloading pit is maintained, in part, by handling one fuel bundle or one fuel basket at a time in accordance with approved procedures. However, fuel baskets are not limited to one fuel bundle when being transferred to storage: each basket can hold as many as four PWR fuel bundles or nine BWR fuel bundles.

The baskets are designed to rest in a grid installed in the fuel storage basins. A single grid section is installed in the cask unloading pit to hold a maximum of three baskets in line.

Fuel bundles are transferred, one at a time, from the shipping cask to the storage baskets. (See Section 1.) The baskets are removed from the cask unloading pit, one basket at a time, and placed in the fuel storage basin. Prior to moving the cask, all fuel must be removed from the cask unloading pit; either moved to storage in Basins 1 or 2, or loaded into the cask for transfer.

8.8.2 Reactivity Calculations

KENO calculations were performed by BNWL for a square array of four PWR bundles having 3/16 inch stainless steel plate between the bundles and around the array. For fuel having an enrichment of 1.575% U-235 and a K_∞ of 1.1996 the k_{eff} values for the array were as follows:

Bundle Pitch (in.)	k_{eff}
8.675	0.930 ± 0.004
9.250	0.923 ± 0.004
9.732	0.890 ± 0.005

The results calculated with the GE codes are about 5% more conservative than those calculated with the KENO code. Fuel characteristics for these calculations were as follows:

Rod Pitch:	0.604 in.
Rod o.d.:	0.448 in.
Pellet diameter	0.400 in.
Cladding Material	Zirconium
Rod Array:	14 x 14

PWR fuel having an initial k_∞ of 1.35 (2.8% U-235) and having undergone one cycle of irradiation (10,000 MWd/TeU) would have a post-irradiation k_∞ based on BNWL calculations using the LEOPARD code, of approximately 1.19. Calculations of uniform arrays of PWR fuel were made by GE personnel using proprietary reactor design codes, to describe the relationships between k_∞ spacing and K_{eff}. These calculations did not include the poisoning effect of the stainless steel in the baskets, which BNWL calculations indicated would reduce k_{eff} by 2.5%. Figure 8-4 depicts the relationship between k_∞ and K_{eff} for PWR fuel bundle arrays with 2 in. separation. A 2.5% reduction in k_{eff} is included for the effect of stainless steel. The data shows that k_∞ would have to exceed 1.21 for the array to be critical.

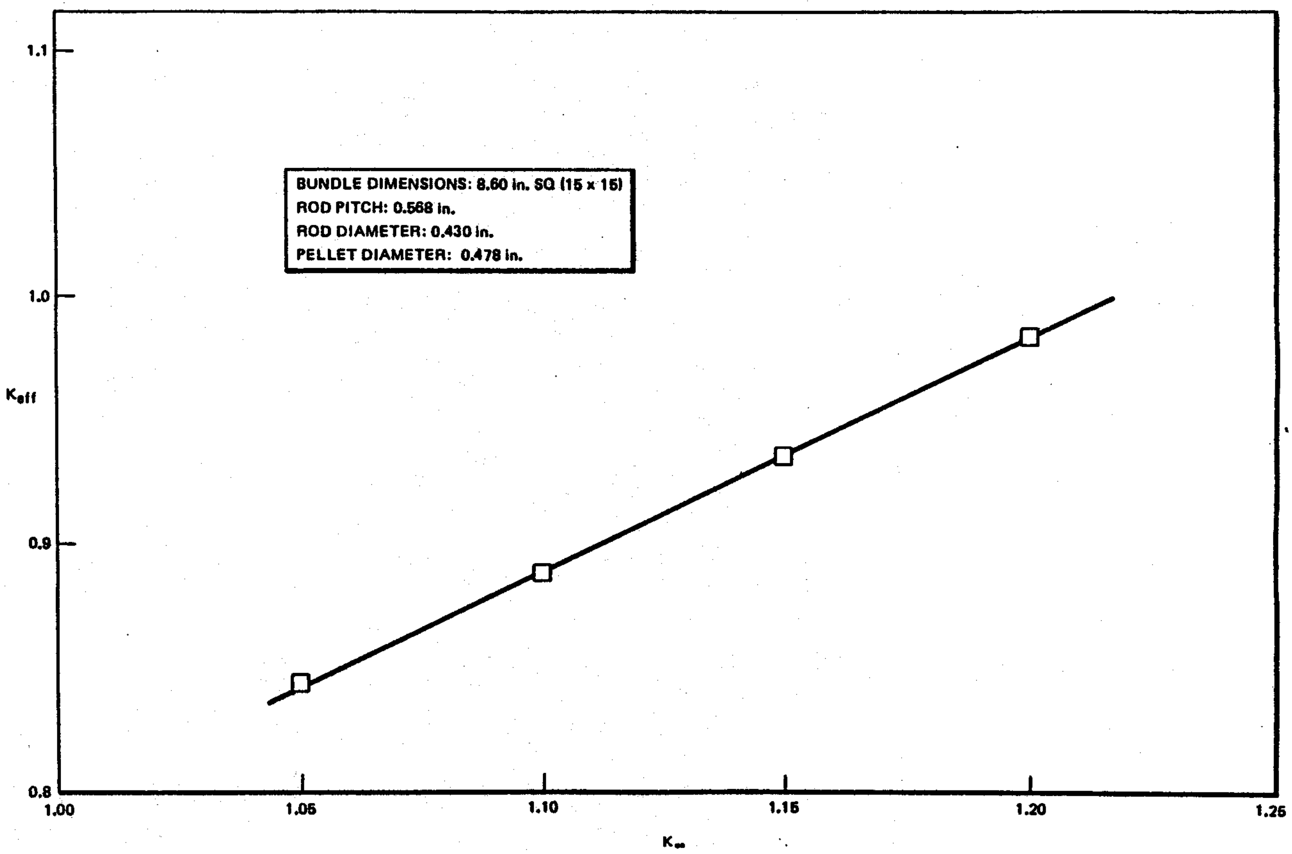


Figure 8-4. PWR fuel bundle array at 2-inch separation.

8.8.3 Missile Impact

The close-packed, pipe sleeve construction of the fuel baskets makes it highly improbable that a missile could cause sufficient compaction of the fuel baskets to cause a criticality accident since the baskets would have to be compressed along two axes simultaneously. Conceivably, a single basket could be driven diagonally into a corner, causing the inner corners of two fuel bundles to be driven together at the top, while the inner corners of the other two elements would at least maintain the designed separation or tend to be spread apart.

Accurate predictions of the effects of the impact of a tornado-borne missile on a system as complex as an array of the fuel storage baskets, would be difficult to make or to prove. To provide insight into the potential increase in neutron multiplication that could arise from reduced spacing, an analysis of three PWR bundles in a "T" configuration, closely spaced over their entire length, was done to estimate the effect of driving three assemblies into a corner. Since this example does not provide consideration of the fourth bundle in the basket, an example of reduced spacing involving four PWR bundles is provided. Such a condition represents an extremely improbable event since the fuel would have to be compacted into a corner from two

directions 90° apart over a substantial portion of its length. Because such a compaction would result in separation of the fuel in the compacted array by more than 10 inches of water from the fuel in the closest baskets, the four-bundle array can be considered isolated. The results of calculations performed by GE personnel for a water-reflected, close-packed, square array of four PWR fuel bundles are shown in Figure 8-5.

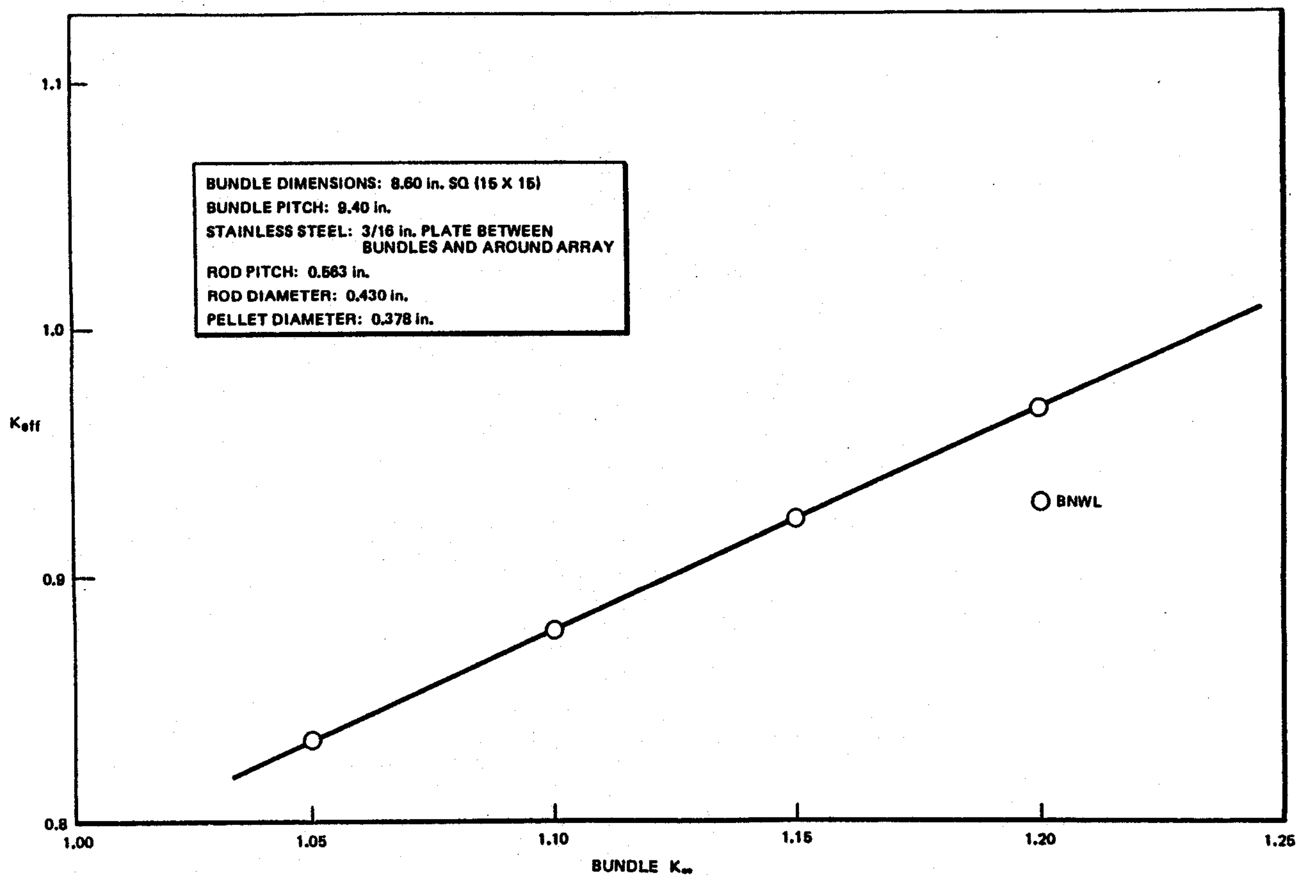


Figure 8-5. Close-Packed array of four PWR bundles.

For such a four-bundle array to become critical, the infinite multiplication factor must average at least 1.23. (Reactivity calculations are discussed in Section 8.9.2)

8.8.4 Consequences of a Criticality Accident

No criticality accidents have occurred in low enriched LWR bundle systems. Accidents have occurred in chemical reprocessing or critical assemblies involving plutonium or highly enriched uranium. Historical criticality incidents in nuclear separation facilities have had fission magnitudes estimated at 1.3×10^{17} to 4×10^{19} fissions. In no case has the reaction been of an explosive nature.

The accidents have either displaced the critical mass such that it was no longer in a critical geometry and thereby terminating the criticality, or the critical mass pulsed in and out of critical geometry.

A criticality accident in the fuel storage basin of GEH-MO is precluded by many factors, some of which include:

a. Geometric constraints imposed by the fuel bundles, storage baskets and holding grid

b. Design and operation of the storage system

c. Administrative procedures for fuel receiving and storage

d. Lower content of fissile material in the fuel bundle than assumed in calculations

e. Neutron poison content in the fuel not assumed in calculations

Nevertheless, a hypothetical criticality is postulated to provide a basis for evaluating the consequences of such an accident. Recovery from a hypothetical criticality would be much the same as from a basket or bundle drop (Section 8.5.2.1), except that a suitable tool suspended from the crane would be used to separate the critical assembly, stopping the reaction. Radiation levels at the pool surface would be low (up to 15 mRem/hr) so that no special protective measures would be required.

8.8.4.1 Assumptions

Primary assumptions used to evaluate a criticality accident include:

a. a point source is assumed at a depth of 16 feet; and

b. Fission gases released to the pool atmosphere as a result of the criticality are negligible. Release of fission gases due to the missile impact is covered by Section 8.7.

Since no reasonable mechanism exists for a criticality accident in GEH-MO fuel storage pools, no meaningful values for characteristics such as reactivity insertion rates, specific power, etc., can be defined. However, a range of 10^{18} to 10^{20} fissions has been evaluated and adequately covers the range of total fissions for such a system.

A depth of 16 ft. was assumed because about 90% of the active fuel is below the 16 ft. level. The top of the active fuel is 14.5 ft. below the water surface.

It is assumed that all the fission products, including fission gases, would be contained within the UO_2 fuel matrix. Temperatures would not be sufficient to drive the fission products from that

matrix. Any products that migrate from the fuel matrix would be contained within the fuel void spaces inside the fuel rod.

The gamma flux at the surface of the pool is approximated by the equation for a point source:

$$(\phi) = \left(\frac{BS}{4\pi t^2}\right)\left(\exp(-ut)\right)$$

where

ϕ = scalar flux (MeV/cm^2-sec);
B = build-up factor;
S = source strength (MeV/sec);
t = distance from source to pool surface (487.68 cm); and
μ = macroscopic cross section for shield material, water (cm^{-1})

Gamma-ray spectra for prompt fission photons are given in Table 8-3. Table data were found in Reactor Physics Contents, ANL-5800, Section 8. The four-group Spectrum B that is given in Table 8-3 was used to calculate the gamma flux. Values for the buildup factors were found in Rockwell's Reactor Shielding Design Manual, page 435.

The dose rate is:

$D' = \phi / c$

where

D' = dose rate mR/hr

c = flux to dose conversion factor $\frac{MeV/cm^2 - sec}{mR/hr}$

Values for c for each energy group are:

$c_1 = 5.2 \times 10^2$

$c_2 = 6.2 \times 10^2$ $\frac{MeV/cm^2 - sec}{mR/hr}$

$C_3 = 7.8 \times 10^2$

$C_4 = 8.6 \times 10^2$

The dose rate in terms of mR/fission is given by:

$\underline{BM(E)e^{-ut}}$

$4\pi t^2 c(3600)$

where

M(E) = energy/fission, or MeV/fission

Table 8-3

PROMPT FISSION GAMMA-RAY SPECTRA

	Spectrum A		Spectrum B	
E (MeV)	N(E) (γ/fission)	M(E) (MeV/fission)	E (MeV)	M(E) (MeV/fission)
0.5	3.1	1.55	-	-
1.0	1.9	1.90	1.0	3.451
1.5	0.84	1.26	-	-
2.0	0.55	1.10	2.0	3.085
2.5	0.29	0.725	-	-
3.0	0.15	0.450	-	-
3.5	0.062	0.217	-	-
4.0	0.065	0.260	4.0	1.035
4.5	0.024	0.108	-	-
5.0	0.019	0.095	-	-
5.5	0.017	0.094	-	-
6.0	0.007	0.042	6.0	0.256
6.5	0.004	0.026	-	-
	7.028	7.827		7.827

Values of M(E) are given in Table 8-3 for Spectrum B. The calculated doses in terms of mR/fission at the surface of the water in a storage basin are given in Table 8-4. The calculated doses at the surface of a basin from 10^{18} fissions, 10^{19} fissions, and 10^{20} fissions are 0.413 mR, 4.13 mR, and 41.3 mR, respectively. These doses are obviously not of serious consequence.

For comparison, extrapolation of actual measurements from an experiment produced a gamma-ray tissue dose rate of 0.18 mRad/hr. These data were taken from Figure 8.8 in Section 8, ANL-5800, showing plots of centerline attenuation data for water measured in the Bulk Shielding Facility at ORNL.[5]

The curves in Figure 8.9 of ANL-5800 also give data for fast neutron dose rate and thermal neutron flux. These data are given as a function of watts for the source, which is a reactor in this case. As indicated, the thermal neutron flux for 16 ft. (approximately 488 cm) is 5 x 10^{-8} n/sq cm - watt. The fast neutron tissue dose curve drops sharply and ends at a value of 2 x 10^{-7}

erg/gm - hr watt for approximately 175 cm. The fast neutron dose at a distance of about 488 cm is negligible.

Table 8-4

DOSE, mR, PER FISSION,
AT BASIN SURFACE

Group	Dose: mR/fission
1	2.118×10^{-25}
2	6.780×10^{-22}
3	1.391×10^{-19}
4	2.736×10^{-19}

A criticality of 10^{18} fissions produces about 8.9 kWh of energy. If it is assumed the event lasts 3 hours, the power level for those 3 hours is about 3 kW. The thermal neutron flux was determined to be approximately ($1.5 \times 10^{-4 \text{ n/sq. cm.}}$) - sec at the surface of the pool. The corresponding dose rate is about 6.2×10^{-7} mRem/hr.

The consequences of a postulated criticality in the storage basin are no more serious than the short-term operation of a low-power, swimming-pool type nuclear reactor commonly used at some universities.

8.9 REFERENCES

1. According to recent studies in the U.S. and abroad, significant evidence indicates that consequences of a hypothetical fuel melting accident may be less than currently predicted by at least one or two orders of magnitude, see appendices E, F, and G, Report of the President's Commission on the Accident at Three Mile Island.

2. N. R. Horton, W. A. Williams, and J. W. Holtzelaw, Analytical Methods for Evaluating the Radiological Aspects of the General Electric Boiling Water Reactor, March 1969 (APED-5756).

3. RESSAR-41, April 1974.

4. See "IF-300 Shipping Cask Consolidated Safety Analysis Report," NEDO-10084-2, Chapter V.

5. Attenuation in Water of Radiation from the Bulk Shielding Reactor: Measurements of the Gamma-Ray Dose Rate, Fast-Neutron Dose Rate and Thermal Neutron Flux, July 8, 1958 (ORNL-2518).

9.0 CONDUCT OF OPERATIONS

9.1 INTRODUCTION

General Electric Hitachi Nuclear Energy has established a GEH-MO organization such that administrative controls are in place to ensure decisions are made at the proper level of responsibility, with appropriate technical advice, and in a timely manner. The record of safety and regulatory compliance established by GEH-MO throughout its operation has been excellent.

9.2 CORPORATE ORGANIZATION

Principal organizational levels of General Electric Company in effect as of December 2018 are shown in Figure 9-1.

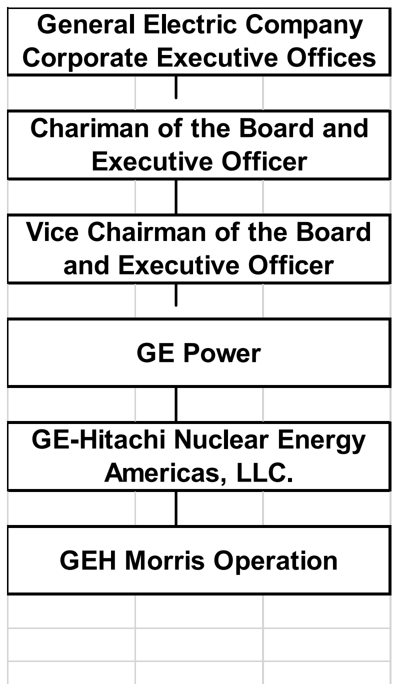


Figure 9-1. GEH Morris Operation relationship to the GE Corporate Offices.

9.2.1 Organization Functions, Responsibilities, and Authorities

Formal policies are established at Corporate, Sector, Operations, Division and Operation levels of GE's organization to ensure safety and quality of products and services and compliance with requirements of government agencies. These policies are applicable to GEH-MO as summarized in the following paragraphs.

9.2.1.1 Company Policies

Formal, Company-level policies are documented in two forms: Company Policy Statements and Company Management Policies. These company policies are a definition of common purposes for organization components of the Company as a whole where it is desirable to foster a uniform course of action.

9.2.1.2 Nuclear Energy Policies

GEH Nuclear Energy (GEHNE) uses a system of documented policy guides and instructions to establish requirements and implement Company policies regarding safety and quality as related to nuclear energy business activities.

9.2.1.3 Operation Policies

Morris Operation (GEH-MO) focuses Company and GEHNE policies to specifically address the Operation's requirements.

9.2.1.4 Irradiation Processing Operation

GEHNE and MO activities are governed by procedures and instructions established in accordance with Company and Operations policy requirements.

9.2.2 GENE Components

Morris Operation is a sub-section of the GEHNE Advanced Programs.

9.2.2.1 Morris Operation

The GEH-MO sub-section is responsible for operation of GEH-MO as an Independent Spent Fuel Storage Installation (ISFSI). This organization and its function are discussed in Section 9.2.3.

9.2.2.2 Regulatory Compliance

GEH-MO Regulatory Compliance is responsible for directing and coordinating activities related to obtaining and support of licenses and permits including developing practices and procedures and compliance verification in accordance with applicable Company and Government requirements.

9.2.3 Morris Operation Organization

The GEH-MO organization (Figure 9-2) is designed to be relatively self-sufficient in ensuring public, personnel, and facility safety. Senior positions and responsibilities within the organization are described in the following paragraphs:

Morris Operation Organization Chart

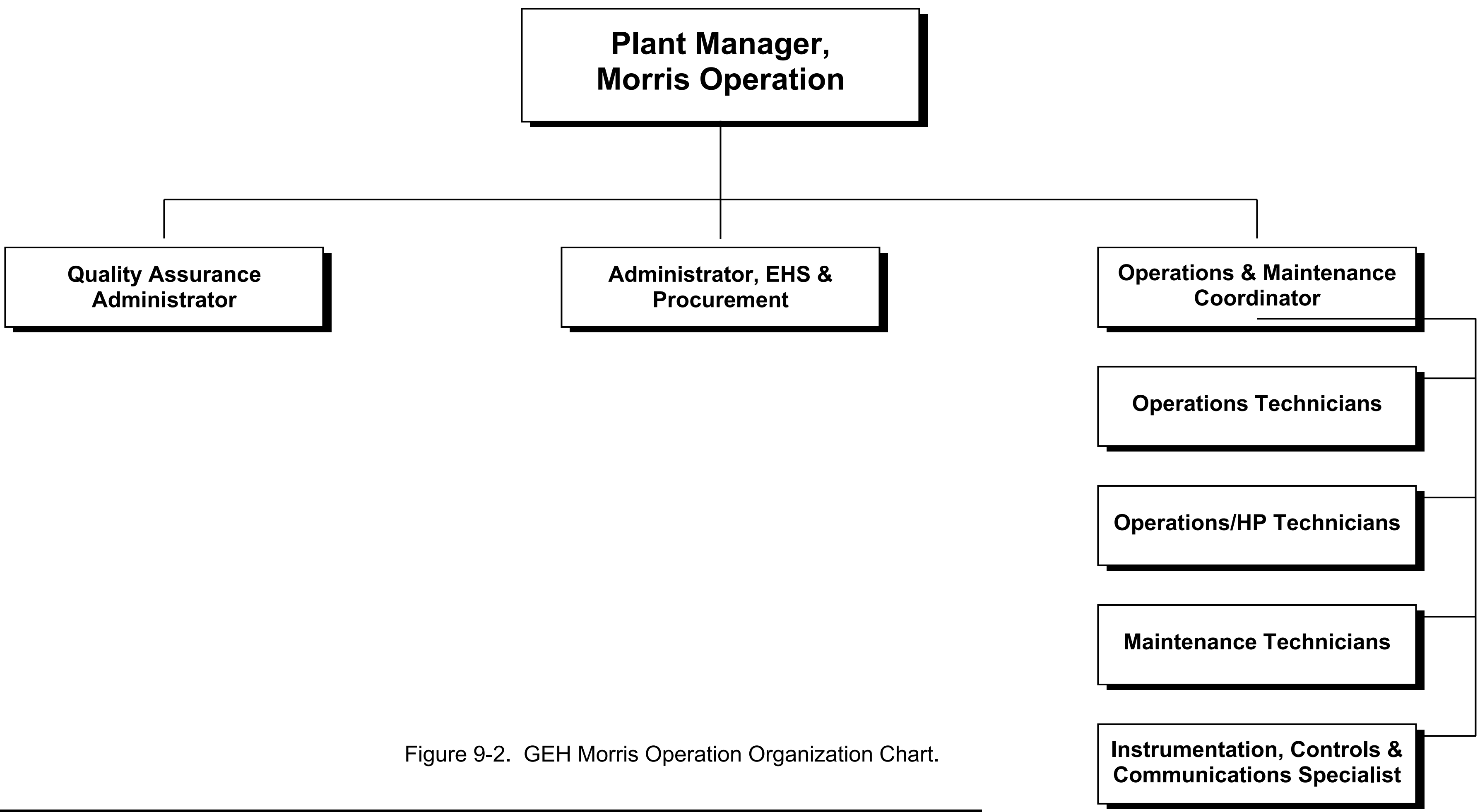


Figure 9-2. GEH Morris Operation Organization Chart.

9.2.3.1 Manager - Morris Operation

The Plant Manager - MO is responsible for safe operation and maintenance of facilities, including compliance with license conditions and applicable Federal, State, and local regulations to ensure protection of health and safety of public and plant personnel. The Plant Manager is also responsible for licensing compliance activities including special nuclear material accountability and plant physical security. In addition, the PM is responsible for providing industrial and radiological safety support, coordinating site regulatory matters with local, State, and Federal regulatory agencies, and directing site environmental activities. The PM reviews facility and operating procedure changes to determine need for nuclear safety review and reviews fuel data to ensure conformance with criteria for fuel storage.

9.2.3.2 Operations and Maintenance Coordinator

The O&MC is responsible to the Manager - MO for maintaining plant facilities and equipment in safe and operable condition and conducting site operations in compliance with established safety and license requirements and operating procedures.

9.2.3.3 QA Manager

The QA Manager is responsible for preparing and maintaining QA Plan, and supporting documents, and implanting all QA/QC operations.

9.2.4 Safety Committee

In addition to the organization shown in Figure 9-2, a facility Safety Committee (SC) is established within GEH-MO. The SC will consist of members as determined by the Manager - Morris Operation and described in a SC operating procedure. Three members must be present to conduct business. Other individuals may participate in SC meetings. The Manager - Morris Operation serves as committee chairperson when items of particular significance are being considered (e.g., in the evaluation of major operational safety matters, and development of recommended changes in facilities or procedures affecting safety margins).

The SC exercises jurisdiction over those matters having radiological or nuclear safety implications, with review and approval authority.

9.3 TRAINING PROGRAMS

To provide and maintain a flexible, well-qualified work force for safe and efficient operation, a comprehensive training program has been implemented. Training includes:

a. Orientation and Indoctrination

b. Radiation and Industrial Safety

c. Security/Safeguards

d. Emergency Response

e. Quality Assurance

f. Basic Plant Facilities and organization

g. Fuel Shipping and Storage Operations

h. Utilities and Operating Systems

The amount of training and retraining each individual receives is directly related to his function. Personnel are provided general orientation that includes description of GEH-MO and its functions, facility safety, security, emergency plans and general procedures.

9.3.1 Operator Qualification, Training, and Certification

Personnel assigned duties involving operation of systems and equipment directly related to cask movement or loading, movement of fuel, operation of basin water cooling or cleanup systems, radioactive waste management operations, and other activities in the cask-handling and fuel storage areas are trained, tested, and certified as qualified to perform specified duties.

9.3.2 Trained and Certified Personnel

GEH-MO maintains an adequate complement of trained and certified personnel to operate the facility.

9.4 NORMAL OPERATIONS

9.4.1 Facility Procedures

Facility procedures are discussed by category in following paragraphs. Systems and equipment requiring certified personnel may be operated by noncertified personnel only if under direct visual direction of an individual trained and certified for the specific operation.

9.4.1.1 Morris Operation Instructions (MOIs)

MOIs are a system of task specific written instructions that provide guidance and direction for performance of GEH-MO activities. The instructions provide for proper safety, quality, and functional considerations in planning and implementation of plant activities, including

administration, licensing, engineering and maintenance, materials, operations, quality assurance, safeguards, safety field services and transportation.

9.4.1.2 Standard Operating Procedures (SOPs)

Operation of GEH-MO facilities is directed by a system of SOPs that provide detailed guidance and control for anticipated conditions. Individual procedures are prepared by Operations and Maintenance and approved by the SC before being implemented. Operations personnel are authorized to modify standard procedures on an interim basis as required to cover specific conditions arising during operations. SOPs are modified only after due consideration of safety implications of the change. Operating activities are monitored on a shift-by-shift basis by supervisory staff for compliance with SOPs.

9.4.1.3 Environmental Health and Safety Plan (EHSP)

Control of work involving ionization radiation and radioactive materials is provided by a system of radiation protection and standards developed and documented in the Environmental Health and Safety Plan (EHSP). Deviation from established requirements may be required from time to time either on a planned basis under special operating conditions or by emergencies. Planned deviations must have prior approval. Emergency deviations must be reported promptly to the Operations Technician on duty who, in turn, notifies the Plant Manager and the O&MC.

9.4.1.4 Special Work Permits (SWPs)

Special Work Permits (SWPs) address activities involving nonstandard conditions not addressed by routine implementing procedures. They are prepared for interim use on a controlled basis and are based on specific evaluation of safety implications. Definite time limits are set for SWPs during which off-standard conditions are to be corrected or established requirements revised. SWPs are approved by SC Members.

9.4.1.5 Regulated Work Permits (RWPs)

Regulated Work Permits (RWPs) are essentially time extended SWPs that address safety requirements for mundane facility activities in potentially hazardous areas. The RWP system is designed to ensure that such work is accomplished in accordance with standards and requirements required by the EHSP.

Responsibility for the procedural system is assigned to the O&MC including provisions for shift-by-shift monitoring of activities for compliance with control requirements and maintenance of necessary records of such activities. RWPs are approved by the SC and reviewed annually.

9.4.1.6 Equipment Maintenance Programs

A Work Request (WR) system is employed at GEH-MO for initiating requests for maintenance, repairs, modifications, alterations and new installations. WRs are reviewed by the Operations & Maintenance Coordinator (O&MC) or delegate, and Quality Assurance for conformance to facility procedures and instructions. Equipment maintenance is performed in accordance with manufacturers' recommended practices and operating experience. Overall responsibility for equipment maintenance is assigned to the O&MC. Assistance is provided by other components, as required, to ensure safety and operability criteria are correctly interpreted and performance capability maintained.

9.4.2 Records and Reports

Files of activities relating to safety are maintained to demonstrate adequacy of design safety considerations and to ensure consistent application of safety principles and objectives to plant operation and maintenance.

9.4.2.1 Record Retention

Documented records of facility activities are maintained to demonstrate control requirements have been met, including procedural system documentation and compliance records noted in preceding paragraphs; environmental monitoring program reports; personnel exposure data and regulatory activity files.

9.4.3 Facility Modification

GEH-MO employs a formal design review program in accordance with QA requirements. Minor modifications and tests and experiments may be performed under provisions of Section 9.4.4.

9.4.3.1 Project Design Activity

Design activity includes establishing functional classifications, specifications, drawings, and other documentation - all subject to safety committee review. Independent overview is required for design verification. Design activities are performed in accordance with QA program requirements.

9.4.3.2 Licensing Activity

It is the responsibility of the PM to determine if a facility modification requires a formal safety analysis review. A "Changes, Tests, and Experiments" (10 CFR 72.48) report is written with guidance from the PM and approved by the SC. Licensing action is initiated by the PM. Other GEH-MO personnel may be enlisted to provide licensing activity support.

9.4.3.3 Project Implementation

The Manager, MO, may at his discretion, designate a Project Manager who is assigned responsibility for construction, installation, testing, startup, and related activities. The Manager - MO retains full responsibility for project safety and normal concurrent activities involving operation of the facility during modification.

Responsibility for liaison with regulatory bodies remains with GEH-MO - usually the Manager, MO. Project management personnel coordinate with the safety committee during project execution to achieve stated project and operation goals. Procedures for the new facility or function are developed and implemented as described in Section 9.4.

Upon completion of startup and turnover operations, project documentation is completed and filed, and responsibility for operations of the new facility or function is assumed by GEH-MO.

9.4.3.4 Audits and Reviews

Policies and resulting requirements established for GEH-MO require periodic audit and review of various aspects of fuel storage activities. General topics for audit include:

Design and Maintenance
Nuclear criticality safety
Radiation protection
Physical security
Emergency plan
Environmental protection
Quality Assurance
Facility Operation

Internal audits are conducted by GEH-MO Management. Formal audits and reviews are conducted by other GEHNE components in accordance with established policies and procedures.

9.4.4 Changes, Tests, and Experiments

Facility alterations, personnel changes, and methods and procedures are changed/revised without prior U.S. Nuclear Regulatory Commission (NRC) approval if the SC deems no lessening of safety or security shall occur. This policy is consistent with 10 CFR 72.48 requirements.

Implementation of such changes, tests, and experiments is accomplished as directed by applicable procedures. In general, implementing procedures requires appropriate analysis and evaluation, with concurrence and license amendment activity when appropriate.

9.4.4.1 Unreviewed Safety and Environmental Issues Criteria

Changes in facility or procedures described in this report and tests and experiments (hereafter referred to as "action") are reviewed for safety and environmental issues previously unreviewed by the NRC under the following criteria:

a. Proposed action shall be deemed to involve an unreviewed safety issue if the probability or consequences of an accident or malfunction of equipment important to safety would exceed technical specification limits or other conditions of the facility license, established by regulations, or if a significant possibility of an accident or malfunction of a type different than previously evaluated would be created.

b. Proposed action shall be deemed to involve an unresolved safety issue if the margin of safety defined in any Technical Specification is significantly reduced.

c. Proposed action shall be deemed to involve an unreviewed safety issue if occupational radiation exposure, either individually or collectively, is significantly increased over that experienced in routine operations involving receipt, storage, and transfer of spent fuel.

d. Proposed action shall be deemed to involve an unreviewed environmental issue if the impact of that action would have a significant environmental effect not considered previously.

9.4.4.2 Records and Reports for Changes, Tests and Experiments

The following special records and reports are required regarding changes, tests and experiments:

a. Records of facility changes shall be made and maintained until termination of license, and shall include bases for determining that changes did not involve unreviewed safety and environmental issues. Changes of a long-term or permanent nature will be recorded by issuing revisions to appropriate sections of this report.

b. Records of temporary facility changes, tests and experiments shall be prepared and maintained until termination of license. These records shall include safety evaluations to document bases for determining that subject changes, tests and experiments did not involve unreviewed safety and environmental issues.

c. An annual report of actions under Section 9.4.4 shall be furnished to the NRC regional office and other addresses required by applicable regulations. The annual report shall contain a brief description of changes, tests and experiments and include a summary of the safety and environmental evaluation of each action.

9.5 EMERGENCY PLAN

9.5.1 Purpose and Scope

An emergency plan is established and personnel are trained in emergency procedures so effective actions can be taken under the stress of emergency conditions.

GEH-MO emergency planning is related to overall emergency planning of GEHNE, and to applicable regulatory requirements. Emergency assistance arrangements are established with law enforcement, medical, and other local agencies and services.

9.5.2 Responsibilities

Establishment of an emergency plan is the responsibility of the Manager - MO. Responsibility for preparation of emergency procedures and instructions has been delegated to the O&MC. Assistance and concurrence of engineering and operation components of GEH-MO are required in developing and approving emergency procedures. Independent review for adequacy and effectiveness is included in SC review activities previously described. Implementation of emergency response procedures is the responsibility of the Emergency Coordinator (EC).

Responsibilities for training, equipping, testing and other preparatory activities necessary to ensure maximum effectiveness when an actual emergency occurs are assigned to appropriate line organization positions.

9.5.3 Action Procedures

An emergency is defined as any set of conditions which requires immediate corrective actions beyond those specified in facility procedures and authorized supplementary instructions to protect health and safety of public and plant personnel.

9.5.3.1 Emergency Classification

Classes of emergencies for which specific action procedures are prepared include:

a. Criticality Incidents: Defined as existence of a local neutron multiplication factor greater than 1.0 anywhere in the plant.

b. Contamination Accidents: Defined as unanticipated appearance of significant quantities of radioactive materials beyond prescribed bounds. Radiation monitors and air samplers are provided in areas of potential contamination to provide continuous assessment of conditions. Local and CAS/SAS alarm systems are provided for strategically located monitors in fuel storage areas.

c. Fire: Detection and alarm systems are provided for areas of concern and are supplemented by manual alarm provision and response procedures.

d. Major Equipment Failures or Operational Accidents: Defined as any component failure or malfunction having significant potential for personnel injury or major damage to plant facilities. Detection systems are provided for certain conditions; detection of others will be by direct observation or by indication that operating characteristics have changed. All such incidents are reported immediately to the EC on duty for prompt assessment and initiation of corrective procedures.

e. Other: Specific action plans exist for external conditions having potential to affect GEH-MO safety such as earthquake, windstorm, accidents at adjacent facilities, etc. Where applicable, provisions are made for advance warning of such conditions so actions can be taken to minimize potential effects (e.g., evacuation of vulnerable areas when a tornado is imminent).

9.5.4 Activation of Emergency Organization

The GEH-MO emergency organization is activated by the EC to the extent appropriate to the emergency. Details are documented in NEDO-31955, "Morris Operation Emergency Plan".

9.5.4.1 Communication Methods

Activation of on-site and off-site emergency personnel, organizations, and support functions depends upon normal communication channels. The facility is equipped with telephone and public address systems and the emergency alarm system. These systems are augmented by radio communications established between GEH-MO and selected law enforcement, fire fighting, and other emergency services.

9.5.4.2 Notification of Off-Site Agencies

The EC shall (without prior management approval) request off-site agency response to an emergency situation. This includes fire department, local law enforcement and hospital/ambulance services. Procedures are established to provide direction for obtaining emergency assistance.

Notification to other agencies is made in accordance with assistance agreements, appropriate governmental regulations, and established GE company policies and operating instructions.

9.6 DECOMMISSIONING

During GEH-MO design and construction, specific attention was directed to control and confinement of radioactive materials and to provide features that would facilitate decontamination and decommissioning. A decontamination and decommissioning plan is contained in Appendix A.7.

10.0 OPERATION SPECIFICATIONS

10.1 INTRODUCTION

These technical specifications govern safe possession, storage and transfer of irradiated fuel from light-water reactors at Morris Operation.

10.1.1 DEFINITIONS

The following definitions apply for the purpose of these technical specifications:

a. Administrative Controls: Provisions relating to organization and management procedures, recordkeeping, review and audit, and reporting necessary to assure that operations involving storage of spent fuel at Morris Operation are performed in a safe manner.

b. Design Features: Features of the facility associated with basic design such as construction materials, geometric arrangements, dimensions, etc., which, if altered or modified, could have a significant effect on safety.

c. Functional and Operating Limits: Limits on fuel handling and storage conditions necessary to protect the integrity of the stored fuel; to protect employees against occupational exposures; and to guard against the uncontrolled release of radioactive materials.

d. Fuel Bundle: Unit of nuclear fuel in the form used in the core of a light-water reactor (LWR). Normally, will consist of a rectangular arrangement of fuel rods held together by end fittings, spacers and tie rods. The BWR fuel bundle does not include the reusable fuel channel which is not shipped with the fuel bundles.

e. Limiting Conditions: The lowest functional capabilities or performance levels of equipment required for safe operation of the facility.

f. Surveillance Requirements: Surveillance requirements include:(i) inspection and monitoring of spent fuel in storage; (ii) inspection, test and calibration activities necessary to ensure the integrity of required systems and components and the stored spent fuel is maintained; (iii) confirmation that facility operation is within required functional and operating limits; (iv) a confirmation that limiting conditions required for safe storage are met.

g. Tonne (Te): One metric ton, equivalent to 1000 kg or 2204.6 lb. Fuel quantity is expressed in terms of the fuel heavy metal content, measured in metric tons, and written TeU.

10.2 FUNCTIONAL AND OPERATING LIMITS

10.2.1 AUTHORIZED MATERIALS

10.2.1.1 Specification

a. Light-water reactor nuclear fuel stored at GEH-MO has previously met specific requirements detailed in earlier revisions of this document. Fuel currently in storage has been at GEH-MO since 1989, the basins are essentially full. No new fuel will be received and storage is limited to the current inventory as shown below.

Station	Type	Cladding	Bundle Array	1st Bundle Received	Last Bundle Received	Total Bundles
Connecticut Yankee	PWR	SS	15x15	01-13-72	08-05-87	82
Cooper	BWR	Zircalloy	7x7 & 8x8	08-24-84	01-27-89	1054
Dresden	BWR	Zircalloy	7x7	09-05-75	03-31-77	753
Monticello	BWR	Zircalloy	8x8	11-21-84	04-24-87	1058
San Onofre	PWR	SS	14x14	03-27-72	09-07-80	270

b. Tools and equipment incidental to the conduct of GE Hitachi Nuclear Energy and nuclear related business, which have become radioactively contaminated may be possessed, stored, repaired and decontaminated. The total contamination of all tools and equipment shall not exceed 10 Ci as determined by external exposure from the items as received. Items containing smearable contamination shall be packaged for storage.

c. Tools and equipment specifically related to the conduct of fuel storage operations, such as shipping cask internals, contaminated with radioactive materials may be possessed, repaired and/or decontaminated.

10.2.1.2 Basis

The design criteria and subsequent safety analysis of GEH-MO assumed certain characteristics and limitations for fuels that have been received and are currently stored. Specification 10.2.1.1a assures these bases remain valid by defining the authorized stored fuel inventory.

The design bases for criticality analyses were selected from detailed analytical studies based on the physical parameters of specific fuel designs (See Table A.10-1, Appendix A.10). The largest bundle cross-sectional area and infinite bundle length were assumed in the calculations. These limits were based on unirradiated clean fuel and include allowance for the poisoning effect of the stainless steel baskets. Fuel centerline locations and other orientations were assumed to be those giving the maximum system reactivity.

Specification 10.2.1.1b provides for storage of tools and equipment incidental to the conduct of GE Hitachi Nuclear Energy businesses while awaiting decontamination, reuse, or ultimate disposal. Activity will be calculated from exposure rate measurements from a package, assuming the radiation originates from a uniform volumetric source having approximately the same dimensions as the package. Unless otherwise determined, gamma emissions of 1 MeV/disintegration will be assumed.

Specification 10.2.1.1c provides for storage of tools and equipment specifically related to the conduct of General Electric fuel storage operations, such as cask internals and yokes while awaiting decontamination, reuse, or ultimate disposal. These tools and equipment may be contaminated with Co-60, Cs-137, or other isotopes as encountered in fuel handling and storage activities.

10.2.2 FUEL STORAGE PROVISIONS

10.2.2.1 Specification

Irradiated fuel bundles shall be stored in authorized fuel storage baskets, mounted in a support grid, under water in a fuel storage basin.

10.2.2.2 Basis

The design criteria and subsequent analysis for GEH-MO assume irradiated fuel is stored under water in fuel storage baskets, mounted in a support grid in a fuel storage basin. Specification 10.2.2.1 assures that these assumptions remain valid. The fuel storage baskets and support grid are those described in Section 5.

10.3 LIMITING CONDITIONS

10.3.1 LIMITING CONDITION – WATER SHIELD

10.3.1.1 Specification

The depth of water between the top of the fuel bundle upper tie plate and the surface of the basin water shall be a minimum of nine (9) feet.

10.3.1.2 Basis

This specification establishes a minimum water shielding depth to limit radiation dose rate in the basin area. This specification applies to all fuel in storage or being transferred from storage to cask (also, see Section 10.5.2).

Tests have shown the water surface dose rate does not increase above background until the water depth is decreased to about 7 feet. A conservative water shield depth of 9 feet has been chosen to provide an increased margin of safety.

10.3.2 LIMITING CONDITION – CRITICALITY

10.3.2.1 Specification

A structure (unloading pit doorway guard: Figure 5-5)[1] shall be used at the doorway between the unloading basin and storage Basin No. 1 to prevent a basket from tipping in a manner such that its contents may be emptied into the unloading basin.

10.3.2.2 Basis

The analysis of a fuel basket drop accident (Section 8) indicates that a basket dropped or tipped over in Basin No. 1, near the doorway to the cask unloading basin, could empty its contents into the unloading basin. It is assumed that the fuel might fall into a critical configuration in the bottom of the unloading basin. The unloading pit doorway guard assures that a basket cannot empty its fuel into the unloading basin.

10.4 SURVEILLANCE REQUIREMENTS

There is no credible event, planned discharge or design basis accident identified at GEH-MO that would expose a member of the public to radiation in excess of the limits specified in 10 CFR 72.104 or 10 CFR 72.106. However, surveillance of various radiation levels, water levels, and other physical quantities, as well as inspections and other periodic activities are contained in this Section to provide assurance that these limits are met. These requirements are summarized in Table 4-1 from details contained in 10.4.1 through 10.4.

Table 4-1 Surveillance Requirements Summary

Section	Quantity or Item	Period	Value
4.1.1	Effluent air	Weekly	ß: 4×10^{-8} µCi/ml
4.2.1	Water-evaporation pond and sanitary lagoons	Monthly	ß: 10^{-5} µCi/ml α: 5×10^{-6} µCi/ml
4.3.1	Sealed sources ß, γ, n, ∝ Sealed sources - α	Semiannual Quarterly	α or ß: 0.005 µCi α: 0.005 µCi
4.4.1	Instruments	(see Table 4-2)	

4.5.1	Basin water	Monthly	Conductivity: <1.35 µMho/cm
4.6.1	Basin water	Monthly	<0.02 µCi/ml

10.4.1 EFFLUENT AIR

10.4.1.1 Specification

Effluent air shall be continuously sampled for particulates at a location between the main stack and the sand filter. Samples shall be analyzed weekly for gross bets (β) activity. The maximum values shall not exceed a weekly average of $4x10^{-8}$ µCi/ml.

10.4.1.2 Basis

This specification requires sampling of ventilation air leaving the sand filter to demonstrate that offsite concentrations do not exceed 10 CFR 20 limits. The GEH-MO sampling and analysis program provides data for estimating the amounts of radioactive material released to the environment during routine or accident conditions.

10.4.2 HOLDING BASINS

10.4.2.1 Specification

Water in the sanitary holding basin and evaporative pond shall be sampled at least once each month, and analyzed for gross alpha and gross beta radiation. The maximum concentrations shall not exceed 10^{-5} µCi/ml beta and $5x10^{-5}$ µCi/ml alpha radiation. If either pond is dry [2] no sampling of that pond is required.

10.4.2.2 Basis

Morris Operation is designed to preclude the release of radioactive materials in normal liquid effluents. As a precautionary measure the sanitary lagoons, which receive and retain plant sewage and some ground water runoff, are periodically sampled to detect inadvertent contamination by radioactive materials.

10.4.3 SEALED SOURCES

10.4.3.1 Specification

Each licensed sealed source (not irradiated fuel) containing radioactive material in excess of

100 µCi of beta-gamma emitting material or 10 µCi of alpha-emitting material shall be tested for leakage at least once every 6 months, except that each source designed for the purpose of emitting alpha particles shall be tested at intervals not to exceed 3 months. The maximum level of removable (non-fixed) contamination shall be less than 0.005 µCi total for each source, using dry-wipe testing techniques.

10.4.3.2 Basis

Surface contamination is measured to determine that a sealed source has not developed a leak. The limitations on removable contamination are based on 10CFR 70.39(c) limits for plutonium, but other provisions of this reference are not applicable.

10.4.4 INSTRUMENTATION

10.4.4.1 Specification

Systems and equipment shall be tested for operability and calibrated at least once during the intervals specified in Table 4-2. Calibration shall be performed in accordance with manufacturer's recommendations, specific GEH-MO approved procedures, and operational tests shall be performed to check alarm functions and demonstrate other operational features of the system or equipment

Table 4-2 Summary Requirements System and
Equipment Test Calibration

System or Equipment	Operability Test	Calibration
Basin Leak Detection System	Weekly	Monthly
Area Radiation Monitors	Quarterly	Quarterly
Criticality Monitors	Annual	Quarterly

10.4.4.2 Basis

Bases for these test and calibration requirements are as follows:

a. Basin Leak Detection System: Operation of this system ensures that a leak in the basin liner will be promptly detected so that corrective action can be initiated. Since the operation of the system is related to the level of water in the detection system, the level alarm set point is checked and instruments receive periodic calibration.

a. Area Radiation Monitors: The audible alarm system for these monitors is tested (operated), and the alarm set point calibrated periodically to provide assurance of reliable operation within equipment specifications, to avert personnel to radiation above preset levels.

b. Criticality Monitors: The audible alarm systems for these monitors, which warn personnel of a criticality, are tested (operated) and the alarm set point calibrated periodically to provide assurance of reliable operation within equipment specifications.

10.4.5 BASIN WATER CHEMICAL CHARACTERISTICS

10.4.5.1 Specification

Basin water chemistry shall be maintained as follows:

Item	Acceptable Analysis
Conductivity	less than 1.35 μMho/cm (equivalent to pH of 5.5 to 8.0 in demineralized water)

10.4.5.2 Basis

Basin water chemical characteristics are selected to maintain a benign environment for fuel and equipment stored in the basin water.

10.4.6 BASIN WATER RADIOACTIVE CONTAMINANTS

10.4.6.1 Specification

Additional basin water cleanup measures shall be initiated if the concentration of radioactive materials in the water exceeds 0.02 μCi/ml beta.

10.4.6.2 Basis

Periodic sampling of basin water is required to assure that concentration of radioactive materials remain as low as reasonably achievable. The values selected are consistent with current decontamination practices.

10.5 DESIGN FEATURES

10.5.1 FUEL STORAGE BASIN

The energy-absorbing pad on the cask set-off shelf shall not be altered without appropriate safety review and documentation as required by 10 CFR 72.48.

10.5.1.1 Basis

The cask drop accident was analyzed for the IF-300 cask with the energy-absorbing pad in place (Section 8).

10.5.2 FUEL STORAGE SYSTEM

The following pieces of equipment employ favorable geometry, specific materials, and methods of construction to assure nuclear criticality safety and radiation protection and are considered important to safety. Modifications to the design in dimensions, construction materials or construction methods shall not be made without appropriate safety review and documentation in accordance with 10 CFR 72.48.

a. Fuel Storage Basin - concrete walls, floors, and expansion gate are principal elements in protection of stored fuel, and in isolation of basin water from the environment.

b. Fuel Storage Basin - stainless steel liner forms a second element in fuel protection and basin water isolation, facilitating decontamination.

c. Fuel Storage System, including baskets and supporting grids is a principal element in protection of stored fuel.

d. Unloading Pit Doorway Guard - is designed to prevent a loaded fuel basket from being tipped so that fuel bundles could fall into the cask unloading pit. The unloading pit doorway guard is an element in protection of fuel during movement of a loaded basket.

e. Filter Cell Structure - the concrete cell part of the basin pump room area provides radiation shielding to reduce occupational exposure.

f. Fuel Storage Basin building – the steel structure that surrounds/protects the fuel Basins.

g. Fuel Basket Grapple – Used to remove the fuel baskets from their storage location in the fuel basin support grid.

h. Fuel Grapple – Used to remove the fuel bundles from the fuel baskets when they are in the unloading pit.

i. Fuel Basin Crane – Crane utilized to move the full fuel baskets to the unloading pit.

j. Fuel Handling Crane – Crane used to remove the fuel bundles from the fuel storage baskets and place into a cask.

k. Cask Crane – 125 Ton overhead crane used to lift a fully loaded cask from the unloading pit and place cask onto transport vehicle.

l. Spent Fuel Cladding – Fuel in Morris Operation basins are clad with SS or zircalloy.

10.6 ADMINISTRATIVE CONTROLS

10.6.1 RESPONSIBILITY

The Manager, Morris Operation shall be responsible for overall facility operation in accordance with these specifications and applicable government regulations, and shall delegate in writing the succession of this responsibility during his absence. Operations involving licensed materials shall be performed by, or under the supervision of individuals designated by the Manager, Morris Operation, or his delegate.

10.6.2 ORGANIZATION

10.6.2.1 The facility staff organization is shown in the CSAR, Figure 9-2 and senior positions and responsibilities within the organization are described in CSAR 9.2.3.

10.6.3 PLANS AND PROCEDURES

Plans and procedures shall be established and implemented to assure compliance with these technical specifications and applicable governmental regulations.

10.6.3.1 Changes to Plans and Procedures

All changes or revisions of established plans or procedures required by this section shall be made in accordance with the GEH-MO modification control practices described in Section 9.

10.6.3.2 Plans and Procedures – Minimum Requirements

Plans and procedures required by this section shall include:

a. A safety manual defining responsibilities and specifying actions to protect the health and safety of employees and others while onsite, appropriate safety training programs, and other measures to maintain exposures as low as reasonably achievable.

b. Requirements for analysis of cask drop accident consequences prior to handling spent nuclear fuel shipping casks not previously handled at GEH-MO per 10 CFR 72.48.

c. Procedures for the conduct of routine fuel storage operations.

d. A Preventive maintenance system for structures, systems and components important to site radiological and criticality safety.

e. Arrangements for providing makeup water to the storage basins under normal and emergency conditions.

10.6.4 REVIEW AND AUDIT

10.6.4.1 Safety Committee

Plans, procedures and operations carried out under established plans and procedures involving elements of radiological safety shall be reviewed and approved by a Safety Committee. Three members must be present to conduct business. Other individuals may participate in Safety Committee meetings. This committee will consist of five members as determined by the Manager, Morris Operation and described in Safety Committee operating procedure and CSAR Section 9.0, Figure 9-2.

The Safety Committee shall normally meet on a monthly basis, but at no greater than 45-day intervals. The Manager, Morris Operation shall establish appropriate procedures and practices for the conduct of Safety Committee responsibilities.

10.6.4.2 Audits

Morris Operation activities shall be audited to ascertain the degree of compliance with specifications, standards and procedures. Audits shall be conducted by organizations and persons, at such times as designated by GE Hitachi Nuclear Energy Management. Audits and audit response shall be performed in accordance with General Electric procedures.

10.6.5 ACTION REQUIRED FOR SPECIFICATION NONCOMPLIANCE

10.6.5.1 Functional and Operating Limits

The following actions shall be taken if a functional or operating limit is exceeded:

a. Prompt action shall be taken to assure timely return of operations to specification compliance.

b. The Safety Committee shall be promptly notified of the noncompliance.

c. NRC Operations Center shall be notified as specified in 10 CFR 72.75, advising them of events that resulted in a noncompliance condition.

d. A review of the incident shall be made by the Safety Committee to establish the cause and to define means to prevent reoccurrence in accordance with the GEH-MO Reporting of Defects and Non-compliances program as documented in NEDE-31559 and implementing procedures.

10.6.5.2 Limiting Conditions

The following actions shall be taken if a limiting condition is exceeded:

a. Prompt corrective action shall be taken to assure timely return of operations to specification compliance.

b. The Safety Committee shall be advised of the noncompliance within 24 hours.

c. A report shall be sent to the NRC Operations Center as specified in 10 CFR 72.75 to advise them of events resulting in limiting conditions being exceeded.

d. A review of the incident shall be made by the Safety Committee to establish the cause and to define means to prevent reoccurrence in accordance with the GEH-MO Reporting of Defects and Non-compliances program as documented in NEDE-31559 and implementing procedures.

10.6.5.3 Surveillance Requirements

The following actions shall be taken if surveillance requirements are not satisfied:

a. The Manager, Morris Operation, or his delegate, shall take such action as may be required to assure future compliance with surveillance requirements and, if necessary, to assure return of operations to specification compliance in minimum time.

b. The Safety Committee shall be advised of any event, or sequence of events, involving surveillance requirements that involve systems directly related to radiological safety. The Committee shall investigate such events and recommend corrective action.

10.6.5.4 Design Features

Design features shall only be changed in accordance with specification 6.3.1, Chapter 9, and 10 CFR 72.48. Unauthorized modifications of specified design features, or unauthorized

introduction of unapproved tools, fixtures or other equipment shall require action as specified for functional and operating conditions in Specification 6.5.1.[3]

10.6.6 LOGS, RECORDS AND REPORTS

10.6.6.1 Logs and Records

a. A shift log shall be maintained to record nonroutine and significant events that may occur during a shift.

b. Minutes of the Safety Committee shall be documented, including copies of reports required in Section 6.5.1, and other actions of the Safety Committee.

c. Records of facility changes, and changes in procedures described in the CSAR shall be maintained throughout the lifetime of the facility.

d. Records of tests or experiments conducted under provisions of Section 9 and 10 CFR 72.48 shall be maintained throughout the facility lifetime, and shall include written safety evaluations that provide the bases for determining if the test or experiment did not involve unreviewed safety or environmental questions.

10.7 REFERENCES AND NOTES

1. The use of the unloading pit doorway guard is described in CSAR Chapters 1 and 5.

2. Dry to the extent that water samples cannot be obtained in the usual manner.

3. Authorized modifications and approved tools, fixtures, or other equipment are those processed under the provisions of CSAR Section 9.

10.8 ENVIRONMENTAL MONITORING PROGRAM

10.8.1 Specification

The licensee will maintain the effectiveness of the environmental monitoring program detailed in specific GEH-MO Compliance and Operability Test procedures and in CSAR Section 7.7.1.

10.8.2 Basis

The environmental monitoring program results from over 20 years of Morris Operation environmental monitoring experience. These years of operational experience with the monitoring program provide a sound basis for evaluating the programs effectiveness.

10.9 ANNUAL ENVIRONMENTAL REPORT

10.9.1 Specification

An annual report will be submitted to the NRC Region III office with a copy to the Director, Office of Nuclear Material Safety and Safeguards, within 60 days after January 1 of each year, specifying the quantity of each of the principal radionuclides released to the environment in liquid and gaseous effluents during the previous 12 months of operation and such other information as may be required by the Commission to estimate maximum potential radiation dose commitment to the public resulting from effluent release and direct radiation at the site property protection area.

10.9.2 Basis

The report of Specification 7.3.1 is required pursuant to 10 CFR 72.44(d)(3).

11.0 QUALITY ASSURANCE

11.1 INTRODUCTION

Activities at Morris Operation (GEH-MO) are conducted in accordance with a quality assurance plan reviewed and accepted by the USNRC and implemented by instructions and procedures at GE-MO.

11.2 QUALITY ASSURANCE (QA) HISTORY

QA program requirements during initial design and construction of GEH-MO, as a fuel reprocessing plant, were developed by GE. During construction, the USAEC -- then the regulatory agency -- increased emphasis on specific methods of achieving quality assurance, proposing amendment of 10 CFR 50 to include Appendix B, "Quality Assurance Criteria for Nuclear Power Plants."

Prior to promulgation of Appendix B, GE had incorporated quality assurance provisions into the over-all safety assurance program for the reprocessing plant. Except for specific requirements related to documented record accumulation, key elements required by the proposed amendment (as applicable to fuel reprocessing facilities) had been included in the GE program. The program was documented in Supplement 3 to the "Design and Analysis Report - Midwest Fuel Recovery Plant." Construction of the facility was completed under this program.

GE curtailed operation of the facility in late 1974. At that time, GE proposed installation of a new fuel storage system. This system was licensed by the USNRC in December 1975. Design, fabrication and installation were performed under the current quality assurance plan, in accordance with applicable requirements of 10 CFR 72 Subpart G.

11.3 STRUCTURES, SYSTEMS, AND COMPONENTS IMPORTANT TO SAFETY

No credible event, planned discharge or design basis accident at GEH-MO is identified that would expose a member of the public to radiation in excess of limits specified in 10 CFR 72.104 or 10 CFR 72.106.

It is therefore, the position of GEH-MO that the term "basic components" in the sense defined by 10 CFR 21.3(1)(i)(c) and 10 CFR 21.3 (2) is not applicable to GEH-MO.

However, "structures, systems and components important to safety" as promulgated in 10 CFR 72.122, "Overall Requirements" are identified below.

a. Fuel storage basin - concrete walls, floors, and expansion gate are principal elements in protection of stored fuel, and in isolation of basin water from the environment.

b. Fuel storage basin - stainless steel liner forms a second element in fuel protection and basin water isolation, facilitating decontamination.

c. Fuel storage system, including baskets and supporting grids is a principal element in protection of stored fuel.

d. Unloading pit doorway guard - is designed to prevent a loaded fuel basket from being tipped so that fuel bundles could fall into the cask unloading pit. The unloading pit doorway guard is an element in protection of fuel during movement of a loaded basket.

e. Filter cell structure - the concrete cell part of the basin pump room area provides radiation shielding to reduce occupational exposure.

f. Fuel Storage Basin building – the steel structure that surrounds/protects the fuel Basins.

g. Fuel Basket Grapple – Used to remove the fuel baskets from their storage location in the fuel basin support grid.

h. Fuel Grapple – Used to remove the fuel bundles from the fuel baskets when they are in the unloading pit.

i. Fuel Basin Crane – Crane utilized to move the full fuel baskets to the unloading pit.

j. Fuel Handling Crane – Crane used to remove the fuel bundles from the fuel storage baskets and place into a cask.

k. Cask Crane – 125 Ton overhead crane used to lift a fully loaded cask from the unloading pit and place cask onto transport vehicle.

l. Spent Fuel Cladding – Fuel in GEH-MO basins are clad with SS or zircalloy cladding.