Fire Hazard Analysis
NASA Space Radiation Laboratory
Buildings 956,957,958 & BAF Tunnel
Brookhaven National Laboratory

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TABLE OF CONTENTS

1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for the NASA Space Radiation Laboratory (NSRL), Buildings 956,957,958 and the BAF Tunnel at Brookhaven National Laboratory (BNL), Upton, NY. This report fulfills the requirement for documentation of an FHA as outlined in DOE Order 420.1, Facility Safety. This FHA assesses the risk from fire in Building 930 to ascertain whether the facility meets the objectives of DOE Order 420.1 and the Brookhaven National Laboratory (BNL) Fire Safety Program. The fundamental goal of the BNL Fire Safety Program is to control fire risks such that:

1. Public and employees are not unreasonably endangered by fire;
2. Vital Laboratory missions are maintained without significant interruption from fire;
3. Property losses are limited to less than $1 million dollars per occurrence, and lower when justified by cost-effective, risk reduction measures;
4. Damage to the environment is averted; and
5. The potential for occurrences of fires are avoided whenever economically feasible.

This FHA is an evaluation of the fire hazards (1) that expose the NSRL and (2) that are inherent in the building or operations. The adequacy of the fire safety features in the building and the degree of compliance of the facility with specific fire safety provisions in DOE orders, and related engineering codes and standards, were determined. The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, and the impact on employee and public safety.

The general approach taken to complete this evaluation involved the identification of fire hazards in the building and the fire protection features required to mitigate the adverse consequences of a fire. A determination was made as to the adequacy of the proposed fire protection features to effectively control the fire hazards. Concerns for the protection of safety systems, critical processes, and life safety of building occupants from fire were essential considerations in the analysis. Compliance was determined by a comparison of existing conditions found during the site visits with current code requirements. Where conflicting requirements were found the more conservative requirements were used in this evaluation.

Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) potentials were also evaluated. The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions. Both MPFL and MCFL fire

loss estimates are to include the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

The MPFL scenario was based on a qualitative consideration of several factors; the potential to reach flashover conditions based on combustible loading and the geometry of the space(s) under consideration; adequacy of passive protection features; and continuity of combustibles.

The MCFL scenario is one in which automatic suppression systems function as designed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area of the system, this floor area is used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MPFL and MCFL potentials were determined based on an average dollar density of the building replacement value divided by the floor area of the building. Building values were obtained from 2004 replacement costs. The content and equipment values were calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office areas.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.

The above cost assumptions are considered adequately conservative to address the requirement to include decontamination and cleanup costs.

A qualitative assessment of the risk presented by conditions found to be deficient was also performed and is included in Section 1.3, Findings and Recommendations. This assessment was made by assignment of a risk assessment code (RAC). The RAC methodology is used in a number of industries as a tool to qualitatively prioritize deficiencies and corrective actions and is derived as follows:

1. Hazard Severity. An assessment of the worst potential consequence, defined by degree of occupational injury, illness or property damage which is likely to occur as a result of the deficiency. Hazard severity categories shall be assigned by roman numerals according to the following criteria:

   a. Category I. May cause death, permanent total disability, or loss of a facility/asset.

   b. Category II. May cause permanent partial disability, temporary total disability in excess of 90 days (severe injury or severe occupational illness), or major property damage.

   c. Category III. May cause minor injury, occupational illness, or property damage.

   d. Category IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.

2. Mishap Probability. The probability that a hazard will result in a mishap or loss, based on an assessment of such factors as location, exposure (cycles or hours of operation), affected populations, experience, or previously established statistical information. Mishap probability shall be assigned an English alphabet symbol according to the following criteria:

   a. Subcategory A. Likely to occur immediately or within a short period of time. Expected to occur frequently to an individual item or person or continuously to a fleet, inventory or group.

   b. Subcategory B. Probably will occur in time. Expected to occur several times to an individual item or person or frequently to a fleet, inventory or group.

   c. Subcategory C. May occur in time. Can reasonably be expected to occur some time to an individual item or person or several times to a fleet, inventory or group.

   d. Subcategory D. Unlikely to occur.

3. Risk Assessment Code. Using the matrix shown below, the RAC is expressed as a single Arabic number that is used to help determine hazard abatement priorities.

Hazard Severity	Mishap Probability			
	A	B	C	D
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	6

RAC Definitions

1-Critical
2-Serious
3-Moderate
4-Minor
5 & 6-Negligible

1.2 Summary

Jointly managed during the four-year construction by the U.S. Department of Energy's Office of Science and NASA's Johnson Space Center, the NSRL became operational during summer 2003. The facility employs beams of heavy ions extracted from Brookhaven's Booster accelerator. NSRL also features its own beam line dedicated to radiobiology research, as well as state-of-the-art specimen-preparation areas.

The descriptions are based on field surveys, a review of the as-built documents, and discussions with BNL staff. This assessment and FHA demonstrates the achievement of a reasonable and equivalent level of fire safety that meets DOE improved risk objectives.

Overview of the BNL

This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in the NSRL. The NSRL Support Building is used for cell and animal target preparation and assessment. The cell preparation laboratories will store and prepare cell cultures. Animal study rooms will house and prepare animals.

This FHA includes an analysis of the fire and life safety features of the facility to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that, with the exception of lightning protection and possibly the protection of records, the NSRL complies with DOE Order 420.1 Fire Protection objectives.

1.3 Findings and Recommendations

1.3.1 New Findings and Recommendations

Finding: Data collected from the experiment is vital. This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network).

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-958-01: Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.1.2).

Finding: A lightning protection system is not provided for the building.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-930-04: Based on a risk analysis per NFPA 780, a lightning protection system should be considered for Buildings 957 and 958, (See Section 6.6.1).

The following is a summary of recommendations and their relative priority.

Rec.No.	Recommendation	RAC
HAI-07-958-01	Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.1.2).	3
HAI-07-958-02	Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.6.1).	3

1.3.2 Outstanding Recommendations from Previous Reviews

None.

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted in July 2007, and a review of available drawings.

The following codes and standards were utilized for this evaluation:

The Building Code of New York State 2002 Edition (BCNYS)

International Code Council (ICC), International Building Code (IBC) 2003 Edition;

ICC, International Fire Code (IFC) 2003 Edition

National Fire Protection Association (NFPA) Codes, Standards, and Recommended Practices – See Section 9 (Reference Documents) of this report for a complete list.

3.0 LOCATION

The NASA Space Radiation Laboratory is located in the central west region of Brookhaven National Laboratory (BNL). BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.

4.0 CONSTRUCTION

4.1 Occupancy Classification

The NSRL is classified by BCNYS (Sec. 304) as "Business" occupancy." NFPA 101 (3.3.168.3) classifies this building as "Business" occupancy.

4.2 Construction Type

4.2.1 NSRL Support Building (958)

The Support Building is a one story high pre-engineered structure, with floor dimensions of 100 ft. by 40 ft (interior dimensions). The building is 18 feet high. The building exterior walls are masonry for the first few feet and then constructed of insulated metal panels on steel frames for the remaining height. The roof is a sloped insulated metal roof with fiberglass insulation added beneath. The walls and roof assembles are considered to be equivalent to non-combustible construction. The foundation is poured concrete. Interior walls are concrete block or gypsum board on metal stud. Non-combustible suspended ceiling is being provided. Walls do not go beyond the hung ceilings. There are no interior fire barriers.

Three HVAC zones exist for the building. HVAC zone "A" covers the "A" Lab Area of the building. HVAC zone "B" covers the middle or "B" Lab Area of the building. HVAC zone "C" covers the "C" Lab Area of the building. The Air Handling Units for the HVAC systems are located outside on the east side of the building.

4.2.2 Power Supply Building (957)

The Power Supply Building is 65 ft. by 40 ft. (interior dimensions) with a concrete slab floor. The building is a two-story high building constructed of non-combustible pre-engineered insulated metal walls and roof. The building is 27 feet high. The second floor has been created by the installation of a metal mezzanine. The mezzanine floor is an open grate construction.

One HVAC zone exists for the building. The Air Handling Unit for the HVAC system is located outside on the north side of the building.

A metal cooling tower is installed 6 feet to the west of the Power Supply Building. The structure is non combustible construction but has combustible water fill elements.

An electric substation is located 20 feet to the west of the cooling tower. The 1500 kVa and 2000 kVa electrical transformers and switch gear are arranged to meet the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection.

4.2.3 NSRL Target Room (956)

The Target Room is a 20 ft. by 20 ft. by 10 ft. high (interior dimensions) poured concrete room. The flame spread rating of the finish is considered to meet ASTM E-84 Class A rating. The room is located under ground and is connected to the NSRL Support Building by a poured concrete labyrinth on the west side. The Target Room connects to the tunnel on the south side. The accelerator beam line enters through the tunnel opening. A radiation security gate and door separate the Target Room from the Tunnel. The structure is windowless and does not contain interior fire barriers.

4.2.4 Booster Applications Facility (BAF) Tunnel

The tunnel is constructed from a corrugated metal tube, 11 ft. in diameter. Concrete flooring is provided. The flame spread rating of the finish is considered to meet ASTM E-84 Class A rating. The tunnel is located underneath approximately 15 ft. of earth (for radiation shielding). The structure is windowless and does not contain interior fire barriers. The tunnel has a emergency smoke removal system located mid span of the tunnel. The emergency smoke removal system consists of one 17,000 CFM exhaust fan on emergency power. The tunnel connects to the NSRL target room on the north and has an exterior access way to a parking area on the south east.

One HVAC zone exists for the tunnel. The Air Handling Unit for the HVAC system is located outside on the east side of the tunnel between the Support Building and the Power Supply Building.

NASA Space Radiation Laboratory

Life Safety Code

The LSC does not specify a minimum construction type for existing business occupancies [§39.1.6].

Building Code of New York State

Section 503 and Table 503 of the BCNYS contain criteria for the allowable height and area of buildings based on their occupancies and construction type. The NSRL buildings have the following areas:

Building	Area (ft^2)
956, Target Room	4,829
957, Power Supply	5,160
958, Support	4,554

The buildings are under the base allowable areas for the three occupancies and two construction types. The allowable increase of areas of buildings that have more than 25 percent of their perimeter on a public way is not necessary for any of the buildings.

International Building Code

Based on the occupancies of the three buildings and the construction types, the areas of the buildings are within the base square footages permitted by Table 503 of the IBC. The allowable area increased permitted by Sections 506 and 507 do not need to be applied.

4.3 Passive Fire Protection

Passive fire protection features include fire-resistive construction, fire doors, fire windows, and fire and smoke dampers. The features are provided to limit fire spread and damage from the area of fire origin to other portions of the building

BAF Tunnel and Power Supply Building (957) meets the requirements for occupancy separation as defined by the BCNYS (Table 302.3) and NFPA 101 (Table 6.1.14.4.1.) There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS "302.1.1" or NFPA 101 "6.1.14.1.2" and "6.1.14.1.3."

NSRL Target Room (956) complies with the codes of record with respect to occupancy separations. There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS "302.1.1" or NFPA 101 "6.1.14.1.2" and "6.1.14.1.3." The building does not have the one hour rated occupancy separation requirement now mandated by the latest editions of the BCNYS and NFPA 101 between the Target Room (956) and the NSRL Support Building (958). Compliance with the new requirements would be required only in the case of a change of occupancy or egress path, or major renovation work in either building.

NSRL Support Building (958) complies with the codes of record with respect to occupancy separations. There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS "302.1.1" or FPA 101 "6.1.14.1.2" and "6.1.14.1.3." The building does not have the one hour rated occupancy separation requirement now mandated by the latest editions of the BCNYS and NFPA 101 between the Target Room (956) and the NSRL Support Building (958). Compliance with the new requirements would be required only in the case of a change of occupancy or egress path, or major renovation work in either building.

4.3.1 Fire Areas

A fire area is defined as a portion of a building that is bounded by a combination of fire-resistive walls and floor/ceiling assemblies, and/or exterior walls. In DOE facilities, fire areas are typically provided for property protection. The Implementation Guide for DOE Order 420.1 requires credited fire areas to be separated from the remainder of the building by a minimum of 2-hour fire barriers (walls and horizontal assemblies). Fire areas may also be provided for compliance with building code limitations for building additions.

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to full or segmented portions of this facility can be classified in four categories; Automatic Fire Suppression Systems, Fire Alarm, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing installed systems in the building.

5.1 Automatic Fire Suppression Systems

5.1.1 Site Water Supply

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and one 300,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gallons per minute (GPM) for 4 hours) for BNL with two of the system's largest pumps out of service and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the vicinity of Building 930 has a static supply pressure of 52 pounds per square inch (PSI) at low elevated tank levels; 65 psi normally. The water supply system in the area can supply about 5,500 GPM at 20 PSI (based on the Water Distribution Model Analysis developed by the Fire Protection Engineering Group during the summer of 2004.)

Frost proof Fire hydrants are provided within 300 ft of the entrances into the tunnel. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply and Fire Department Connection

Support Building (958) has a single 4 inch black steel main connected to an 8 inch main located along West 5th Street. The main has a 4 inch Post Indicating Valve (PIV) located more than 40 feet from the building. The PIV is a gate valve type valve. The PIV has an electric tamper switch. The main and the PIV were installed when the building was constructed.

The main enters the Support Building on the west side of the building into the Mechanical on the first floor. The room has an exterior door which cannot be used for Fire Department access since it does not have key mechanism on the exterior door lockset. The 4 inch main is utilized by both the domestic water system and the fire protection systems. The two services split outside of the building the 4 inch fire protection piping continues to the Alarm Check Valve Assembly. This configuration does not meet the current BCNYS requirement of a double check valve on the fire protection system to prevent contamination to the potable water supply.

A Fire Department Connection (FDC) is located on the west side exterior wall of the Support Building adjacent to the mechanical room exterior door. The nearest hydrant is less than 400 feet from the fire department connection as required by code. The two 2 ½ inch outlets on the FDC conform to National Standard Thread couplings standards. The piping between the Fire Department Connection and the supply side of the Alarm Check Valve Assembly is 4 inch. The pipe connects to the discharge side of the Alarm Check Valve.

5.1.3 Sprinkler Systems

The Target Room (956), Booster Applications Facility (BAF) Tunnel, and Power Supply Building (957) are not provided with an automatic sprinkler system. They are not required to be fully sprinklered since they do not exceed the criteria set forth by the "Implementation Guide For The Use With DOE Orders 420.1 and 440.1 Fire Safety Program," section 9.7 which requires fully sprinklered protection in any building exceeding 5,000 square feet in ground floor area or any facility with a Maximum Possible Fire Loss exceeding $1 million. The limited combustible loading and maximum possible fire loss potential of less than $1 million dollars do not warrant a dedicated fire protection system for these building.

In the Support Building (958) Automatic sprinkler system protection, conforming to NFPA 13 is provided throughout the building. There is one sprinkler system zone.

A 4 inch Reliable model 4E Alarm Check Valve assembly is located in the Mechanical room of the Support Building (958). It is U/L and FM listed. The alarm check has a water motor gong that is placed on the exterior of the building per the requirements of NFPA. On the discharge side of the alarm check valve is a water flow switch which provides the required alarm signals for flow activation to the building fire alarm panel.

The wet pipe sprinkler system in the Support Building is hydraulically sized to provide 0.15 GPM per square foot sprinkler density over 2500 sq. ft. of the most hydraulically remote area of the building. The sprinkler heads are spaced to ordinary hazard requirement of NFPA 13. Total inside and outside hose requirement of 250 GPM for ordinary hazard was added to the calculations. The system requires 925 GPM at 43 PSI at the building entrance. Available water supply meets the water supply requirements for the hydraulically calculated sprinkler systems.

5.1.4 Fire Standpipe Systems

The Target Room (956), Booster Applications Facility (BAF) Tunnel, and Power Supply Building (957) are not provided with a Fire Standpipe system. They are not required by code to be provided with Fire Standpipe systems.

An automatic wet standpipe system conforming to NFPA 14 is installed in the NSRL Support Building. The class of standpipe system, as listed in the BCNYS, is "Class III" system. The hose valves are located in hose cabinets in the corridor outside of the "B" Lab Room. The standpipe system is connected to the automatic sprinkler system.

5.1.5 Other Suppression Systems

The facility has a fire alarm system that is connected to the Site fire Alarm system. The two systems are as follows.

5.2 Fire Alarm Systems

The facility has a fire alarm system that is connected to the Site fire Alarm system. The two systems are as follows.

5.2.1 Building Fire Alarm System

The NSRL Support Building has a building fire alarm system consisting of a fire alarm panel, manual stations, and visual and audio alarm notification devices conforming to NFPA 72. The fire alarm panel is located in electrical room on the south-west side of the building. The fire alarm panel is a Grinnell Multi-zone 20 (panel 213). This panel provides supervision for all the buildings and tunnels of the NSRL Facility. The panel is connected to the Site Fire Alarm System via the copper wire in the site underground telecommunication infrastructure network.

5.2.2 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage using a fault tolerant sever infrastructure based multiplexed Site Fire Alarm System. The system is an Andover Continuum; installed in 2005 (Andover is a part of Simplex Grinnell). The system complies with the requirements of NFPA 72 defined as a Style 6 Class “A” System.

Two mirrored servers are located in separate buildings. If the lead server fails the system automatically switches over to the working server. The Site Fire Alarm System operates on a fault tolerant high speed Ethernet infrastructure that utilizes network switches and fiber wiring between each of the major components.

The Site Fire Alarm System monitors fire alarm panels located throughout BNL by using the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Site Fire Alarm System. The panels are divided into 9 communication “loops.” It is currently monitoring 9,700 points. Response time from alarm at the panel to alarm indication at the Central Station is less than 82 seconds, which is within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of Collider-Accelerator Control Room operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

The NSRL Support Building has a building fire alarm system consisting of a fire alarm panel, manual stations, and visual and audio alarm notification devices conforming to NFPA 72. The fire alarm panel is located in electrical room on the south-west side of the building. The fire alarm panel is a Grinnell Multi-zone 20 (panel 213). This panel provides supervision for all the buildings and tunnels of the NSRL Facility. The panel is connected to the Site Fire Alarm System via the copper wire in the site underground telecommunication infrastructure network.

5.4 Fire Extinguishers

Fire extinguishers are provided in the building. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Special Occupancies, Unique Fire Hazards, Housekeeping in Vital Areas, Building Materials, Exterior Exposure Hazards, Natural Phenomenon Hazard Exposure, Toxic Fire Potential, Biological Fire Potential, and Radiation Fire Potential. The following is an evaluation of Building 930 for each category.

6.1 Special Occupancies

Special occupancies include: instrumentation and data processing equipment, vital and important records, trailers, cooling towers, electrical substations, flammable liquid and gas storage, cables and raceways, . The special occupancies applicable to Building 930 are expanded upon in Sections 6.1.1 thru 6.1.7, below.

The Dosimetry Room, located in the Support Building, contains high valued electronics for measuring delivered dose to the target organisms. The “B” Lab Room, also located in the Service Building, contains high valued electronics for data collection. Bldg. 958 is fully sprinklered and the Dosimetry Room and “B” Lab Room have early warning smoke detectors. With early warning smoke detectors and the presence of facility sprinkler protection, the electronic data processing areas are suitable for equipment values over $25 million dollars. Total values of each area are under $1 million dollars.

6.1.1 Instrumentation and Data Processing Equipment

DOE/EP-0108 established levels of protection for Instrumentation and Data Processing equipment and the facility in which it is housed.

Automatic Smoke Detection Protection

Areas in the building that contain instrumentation and data processing equipment are provided with automatic detection coverage since the equipment in the areas exceed the $250,000 limit DOE establishes to require smoke detection protection.

Automatic Sprinkler Protection

Automatic sprinkler system protection, conforming to NFPA 13, is provided in all areas of the building.

Fire Barriers

DOE requires fire barriers if the value of the structure and contents exceeds $50 million. No fire barriers are required by this DOE standard in this facility.

6.1.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or significant extra expense.

Based on the above definitions, the data collected from the experiments are considered vital records. Review of the backup procedure of data collected as part of this program is out of scope of this Fire Hazard Analysis but will be a recommendation to ensure it is being adequately protected in accordance with DOE requirements (**Refer to recommendation HAI-07-958-01**).

6.1.3 Trailers and Portable Structures

There are no trailers or portable structures associated with Building 930.

6.1.4 Cooling Towers

The unit is metal, prefabricated, and serves the BAF magnet cooling water system, and the power supply/buss cooling system. A fire in the cooling tower will not cause damage to the main buildings due to spatial separation and the limited amount of combustibles in the tower.

6.1.5 Electrical Substations

The 1500 kVa and 2000 kVa electrical transformers and switch gear are arranged to meet the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection. The transformers do not present an exposure hazard to the facility or each other.

6.1.6 Flammable Liquid & Gas Storage

The use of flammable liquids in the NSRL is minimal. The use of solvents is less than 1 quart in each laboratory space. Use of flammable liquids follows BNL ES&H Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d481.pdf).

The only use of a flammable gas is for Bunsen burners in the lab spaces in the NSRL Support Building. Propane gas is distributed through a fixed piping system. The use of all flammable gases follows BNL Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d491.pdf).

6.1.7 Cables and Raceways

High voltage, low voltage, control, and signaling cables are segregated in accordance with NEC requirements throughout the NASA Space Radiation Laboratory. The cabling is located in conduits, raceways and cable trays. In most instances, the cables provided in the cable trays meet the flammability test criteria in IEEE 383, VW-1, and/or NEC rated wire for cable trays. These less flammable cables decrease the overall fuel loading and loss potential in the tunnel, making the need for sprinkler protection in the tunnel unnecessary.

6.2 Unique Fire Hazards

There are no unique fire hazards in the building.

6.3 Housekeeping in Vital Areas

For this high value facility, good housekeeping and control of combustibles is achieved. The experimental process screens beam line activities for compliance with this goal. The NSRL self inspection program (Tier I) monitors routine experimental aspects. The BNL Plan Review Process screens conventional construction operations.

6.4 Building Materials

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at the NSRL. Therefore, no special fire protection precautions, beyond those that are generically described in this section, are required for this facility.

6.5 Exterior Exposure Hazards

Any exterior structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to this facility is defined as an exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

Elements Outside of the Facility

The following is a summary of fire exposures to the LINAC facility. All exposures are evaluated using FM Data Sheet 1-20 “Protection against Exterior Fire Exposure.”

North Exposures

Exposures to the North are minimal. Structures are over 150 feet from the facility.

South Exposures

Exposures to the South are minimal. Structures are over 150 feet from the facility.

East Exposures

Exposures to the East are minimal. The tree line is over 100 feet from the facility.

West Exposures

Exposures to the West are minimal. Structures are over 150 feet from the facility.

Components of the Facility

Exposures between components of the facility are minimal. Sprinkler protection and passive fire barriers are in place to provide separation between components of the facility.

6.6 Natural Phenomenon Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.6.1 Lightning Potential

Lightning damage potential of the Target Room (956) and the BAF Tunnel is zero for these two underground facilities.

The lightning damage potential for the NSRL Support building (958) and the NSRL Power Supply building (957) is a concern based on NFPA 780 Appendix H "Lightning Risk Assessment "calculation. Following the Risk Assessment methodology as shown in appendix A the expected lightning frequency (Nd) is greater than the tolerable lightning frequency (Nc). NFPA 780 recommends when (Nd) > (Nc) that a lightning protection system should be installed. (Recommendation 4)

The lightning damage potential for this facility is not a concern based on NFPA 780 Appendix H "Lightning Risk Assessment "calculation. Following the Risk Assessment methodology as shown in appendix A the expected lightning frequency (Nd) is less than the tolerable lightning frequency (Nc). NFPA 780 recommends when (Nd) ≤ (Nc) that a lightning protection system is optional.

6.6.2 Windstorm Potential

There are no windstorm concerns with the underground Target Room and the Tunnel.

Buildings 957 and 958 have 22 gauge steel, 16 inch wide by 2 inch high standing seam roof panels. The roof panels are UL 580 (Standard for Uplift Resistance of Roof assemblies) classified as "Class 90" rated assemblies. R-30 rated 8 inch thick fiberglass insulation is attached to the underside of the roofs. The conditions of the roofs appear to be in good condition. Windstorm potential is a minimal concern for these buildings.

6.6.3 Brush Fire Potential

Based on the criteria presented for evaluating fire potentials from Wildland in the "BNL Wildland Fire Interface Survey Report," dated August 2002, there is no brush fire risk potential exposure to the NSRL.

Based on the analysis, the hazard from wildfire to the NSRL is "LOW" (score of 30, with 40 being the cut-off for low hazard). Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix C of this report.

6.6.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation*" dated April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

6.6.5 Flooding Potential

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation*."

Groundwater runoff from a severe rainstorm is not a concern for NSRL due to the surrounding terrain.

6.7 Toxic Fire Potential

There are no known materials in the LINAC that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

6.8 Biological Fire Potential

There are no known biological materials present in the building that present a release potential due to fire.

BNL has an Institutional Bio-Safety Review committee which reviews materials of this type. The NSRL experimental review committee would pass these experimental requests to them. While biological matter has been used and will be used in the laboratory spaces of the NSRL, the hazard is low. There are no aggressive organisms within the current programs of the NSRL (only BSL II, no BSL III or IV). Other than pre-fire planning information, there is no fire issues related to biological organism at the NSRL.

6.9 Radiation Fire Potential

By the nature of the operations of the accelerator, various pieces of equipment can become activated. Since this is an electron accelerator, any levels are low. This activation is not expected to pose a significant environmental impact in the event of a fire since the material will not be easily disbursed. No other radioactive materials are used or stored in the NSRL.

7.0 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility (http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp). The pre-plan was reviewed as part of this analysis.

7.1 Protection of Essential Safety Class Systems

There is no essential safety class systems associated with this non-nuclear facility.

7.2 Protection of Vital Programs

The operations associated with this facility are not considered to be a DOE vital program. Therefore, no special fire protection precautions, beyond those that are described in this report, are required for this facility.

7.3 Protection of High Value Property

High value equipment is generally regarded as any single item that is valued at $1 million or more, or where the loss of a single item could result in a loss of program continuity of greater than six months.

Based on this definition there is no high value equipment located within the NSRL.

7.4 Critical Process Equipment

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a fire, could delay a significant component of a major program for a period in excess of 6 months.

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a critical fire, could delay a significant component of a major program for a period in excess of 6 months.

By the above definition, there are no areas in the NSRL that are considered critical process equipment.

7.5 Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL)

The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The fire loss estimate includes the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

In accordance with the BNL Fire Safety Program, protection is required for facilities having an MPFL in excess of established thresholds as follows:

- When the MPFL exceeds $1 million an automatic sprinkler system designed in accordance with applicable NFPA standards is required;
- When the MPFL exceeds $25 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $25 million; and
- When the MPFL exceeds $50 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $50 million.

7.5.1 MPFL Scenario

The NSRL is considered one fire area and thus a single MPFL calculation is being performed.

Combustible loading throughout the building is relatively low to moderate consisting primarily of control and instrumentation cabling and typical office equipment and materials. Flashover is possible in this facility. Flashover indicates that the temperature inside an area would be sufficiently hot to cause multiple fuel package ignitions within the space and result in loss of all contents. Associated compartment temperatures at flashover are generally accepted to be between 500°C (900°F) to 600°C (1100°F). Flashover is generally defined as the transition from a growing fire to a fully developed fire. Fully developed fires impose extensive thermal and physical stresses on fire barriers, the failure of which could lead to fire spread throughout the area.

7.5.2 MPFL Calculation

The NSRL has the following replacement values:

Building 956, Tunnel and Target Room:	$3,415,660
Building 957, Equipment	$813,926
Building 958, NSRL	$2,361,888

The building value was obtained from 2004 replacement costs. The average dollar density of the building is the replacement values divided by the floor area of the building:

Building 956, Tunnel and Target Room:	$3,415,660	4,829 ft^2	$707/ ft^2
Building 957, Equipment	$813,926	5,160 ft^2	$158/ ft^2
Building 958, NSRL	$2,361,888	4,554 ft^2	$519/ ft^2

The content and equipment value is calculated based on the following assumptions:

- An average of $20/$ft^2$ for content and equipment value within predominantly office areas.

- An average of $100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.

MPFL Summary

Building	Value	MPFL
956	$3,415,660	$3,415,660
957	$813,926	$813,926
958	$2,361,888	$2,361,888

7.5.3 MCFL Scenario

The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions.

The maximum credible fire scenario is one in which automatic suppression systems function as designed. For the purposes of the MCFL determination a design area of 2,000 ft^2, is assumed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area this floor area was used in the determination of MCFL potentials when protected by automatic sprinkler systems. For those buildings without sprinkler protection the MCFL is the same as the postulated MPFL for that area. The following building cost factors are approximated and have been utilized in the determination of the MCFL:

Building	**Cost ($)**	**Area (ft^2)**	**Factor ($/ft^2$)**
956	$3,415,660	4,829	$707
957	$813,926	5,160	$158
958	$2,361,888	4,554	$519

MCFL Summary

NSRL		$ Value
956	Not Sprinklered	$3,415,660
957	Not Sprinklered	$813,926
958	2000 ft^2 x $519/$ft^2$ =	$1,038,000

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
956	$3,415,660	$3,415,660
957	$813,926	$813,926
958	$2,361,888	$1,038,000

7.6 Recovery Potential

Within the facilities of the NASA Space Radiation Laboratory, critical process parts have been identified by the Department. Critical process parts are those items essential to the operations of the accelerator that require a long lead-time for replacement. These spares are stored in a separate building, not subject to a common incident.

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. A minimum of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM "Class A" Pumpers, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to Building 930 is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency. Roadways are located on the north, east and south sides of the building.

7.9 Security Considerations Related to Fire Protection

The facility has security measures to restrict access, including the use of card readers and iris scanners. Provisions have been made for Fire/Rescue access via card reader programming, provision of master key, or installation of interlocked crash doors. Ingress includes interlocked crash panels in the doors to allow emergency entry.

8.0 LIFE SAFETY CONSIDERATIONS

Life safety considerations for this facility include means of egress consisting of exit access, exits and exit discharge, exit signage, and emergency lighting. This building is required to comply with state building codes and NFPA 101®, the Life Safety Code (LSC). The requirements of both the 2002 edition of the Building Code of New York State (BCNYS) and the 2006 edition of the LSC have been applied to this analysis. It should be noted that the BCNYS is not intended to apply to existing structures. Appendix K of the BCNYS addresses alterations to existing structures.

This building was likely constructed to comply with the latest version of the Life Safety Code NFPA 101 at the time of construction. DOE now requires all buildings to conform to local building codes and NFPA 101.

8.1 Occupancy Load Factor and Calculations

For the NSRL Target Room (956), BAF Tunnel, and Power Supply Building 957 the BCNYS (Table 1003.2.2.2) occupancy load factor is 100 sq. ft. gross per occupant. The NFPA 101 occupancy load factor for these buildings is zero. NFPA 101 (Table 7.3.1.2) states that "Special Purpose Industrial Use" load factor calculation is not applicable.

For the NSRL Support Building (958) the BCNYS (Table 1003.2.2.2) occupancy load factor is 100 sq. ft. gross per occupant. The NFPA 101 (Table 7.3.1.2) occupancy load factor for this building is 100 sq. ft. gross per occupant.

NSRL Target Room (956) has a gross area of 4830 square feet. Per the BCNYS the calculated occupant load for this building is 49 occupants. Based on NFPA 101, the occupant load calculation for this building is considered to be zero on both levels.

Power Supply Building 957 has a gross area of 2,600 square feet per level. Per the BCNYS the calculated occupant load for Building 957 is 26 for the ground floor and 26 for the mezzanine level. Based on NFPA 101, the occupant load calculation for this building is considered to be zero on both levels.

Building 958 has a gross area of 4,554 square feet. Per the BCNYS the calculated occupant load for this building is 46 occupants. Based on NFPA 101 the occupant load calculation result for the building is 46 occupants.

8.2 Means of Egress

The means of egress for the building meets the present code requirements for number and arrangement of exits, capacity of exits, travel distance, common path of travel, dead ends, and security considerations related to egress. The following subsections provide the egress detail for each of the elements.

8.2.1 Number and Arrangement of Exits

NSRL Target Room (956) has two 36 inch clear width doors leading out of the area. One exit leads to the BAF Tunnel and the other one to NSRL Support Building (958).

BAF Tunnel has two 36 inch clear width doors leading out of the area. One exit leads to the NSRL Target Room (956) and the other one to the parking lot south of the Power Supply Building 957.

Power Supply Building 957 has three 36 inch clear width doors leading to the outside on the ground floor. There are two means of egress on the mezzanine level. A 44 inch clear width open stair leads to the ground floor on the south-central side of the building, and a fixed fire escape ladder on the northwest side leads down to the ground floor. There are no code issues with regard to the ladder. NFPA 101 (7.2.9.1(4)) allows a fire escape ladder for "Industrial - Special Purpose" occupancy provided it is a secondary means of egress subject to occupancy not to exceed three persons who are capable of using the ladder. The ladder is not recognized by the BCNYS as a means of exit. However, BCNYS (Table 1004.2.1) allows "Factory Industrial F-1 Moderate Hazard" occupancies to have only one means of egress provided the occupancy load is less than 50.

NSRL Support Building (958) has four 36 inch clear width doors leading out of the area. One exit leads to the NSRL Target Room (956) and the other three lead to the parking lot west of the building. Exit separation.

8.2.2 Capacity of Exits

NSRL Target Room (956) and the BAF Tunnel exit capacity exceeds the occupant loading based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a non sprinklered facility.

Power Supply Building (957) exit capacity exceeds the occupant loading on both the ground and mezzanine levels based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a non sprinklered facility.

NSRL Support Building (958) exit capacity exceeds the occupant loading on both the ground and mezzanine levels based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a sprinklered facility.

8.2.3 Travel Distance

NSRL Target Room (956), BAF Tunnel, and the Power Supply Building (957) egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 300 feet in this type of non-sprinklered occupancy. NFPA 101 (Table 40.2.6) limits egress travel distance to 400 feet in this type of non-sprinklered occupancy.

NSRL Support Building (958) egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 400 feet in this

type of sprinklered occupancy. NFPA 101 (Table 40.2.6) limits egress travel distance to 250 feet in this type of sprinklered occupancy.

8.2.4 Common Path of Travel

NSRL Target Room (956) and the BAF Tunnel do have common path of travel issues as defined by BCNYS and NFPA 101.

Power Supply Building (957) does not exceed the common path of travel distance limits of BCNYS and NFPA 101. The only common path of travel distance is on the mezzanine level and the distance is 45 feet. NFPA 101 "Table 40.2.5" limits common path of travel distance to 50 feet in this type of non-sprinklered occupancy. BCNYS (1004.2.5) limits common path of travel distance to 75 feet in this type of non-sprinklered occupancy.

NSRL Support Building (958) does not exceed the common path of travel distance limits of BCNYS and NFPA 101. The longest common path of travel distance is in the "C" lab area and the distance is 50 feet. BCNYS (1004.2.5(1)) and NFPA 101 (Table 40.2.5) limits common path of travel distance to 100 feet in this type of sprinklered occupancy.

8.2.5 Dead Ends

Per Section 40.2.5.2 of the Life Safety Code, and the Fire Code of New York State (FCNYS) (Table 1010.17.2) a dead end corridor cannot exceed 50 feet. The building is in compliance with this criterion.

8.2.6 Security Considerations Related to Fire Protection

The BAF Tunnel Radiation security barrier exterior door has measures to restrict access, including card readers and an iris scanner. Provisions were made for Fire/Rescue to gain emergency access to the Tunnel by the installation of interlocked crash panels.

Between NSRL Target Room (956) and the NSRL Support Building (958) is a Radiation security barrier door. The door has measures to restrict access into the Target Room, including card readers and an iris scanner. In an emergency, the door can be opened by the interlocked crash panels.

NSRL Support Building (958) and Power Supply Building (957) do not have special access controls to restrict egress or ingress.

8.2.7 Separation of Means of Egress

Where two exits or exit access doors are required, they must be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §]. The building is provided with a two primary exits that are compliant, that meet this requirement.

8.3 Exit Signs and Emergency Lighting

Placement of exit signs in the building meets NFPA 101 and BCNYS "1003.2.10."

Emergency lighting of all means of egress is provided in the building by florescent light fixtures wired to the emergency power system.

8.4 Emergency Roof Exits

A means of escape is defined as a way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out [LSC §3.3.152]. The building has no such arrangement.

8.5 Egress through Adjoining/Intervening Spaces

Exit access from rooms or spaces is permitted to be through adjoining or intervening rooms or areas, provided that such rooms or areas are accessory to the area served and the intervening rooms or areas are not spaces identified under Protection from Hazards (e.g., storage rooms) [LSC §7.5.1.6]. The building complies with this requirement.

8.6 Exit Discharge

All exits discharge to a public way.

8.7 Horizontal Sliding Doors

There are no horizontal exit doors utilized in Building 930.

8.8 Fire Escape Ladders

Fire escape ladders complying with 7.2.9 are permitted in industrial and business occupancies [§40.2.2.10; §39.2.2.10]. Fire escape ladders are permitted as means of egress only where one of the following conditions exists:

- Access to unoccupied roof spaces as permitted by 7.2.8.3.4.
- Secondary means of egress from boiler rooms or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.
- Means of egress from towers and elevated platforms around machinery or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.

A fire escape ladder is provided as a secondary means of egress from the mezzanine.

8.9 Door Heights

Means of egress are required to provide a headroom clearance of not less than 6 ft 8 in. at doorways [LSC §7.1.5.1]. The existing doors meet this requirement.

8.10 Discharge to Roofs

Exits are permitted to discharge to roofs or other sections of the building where the following criteria are met and with approval by the authority having jurisdiction [LSC §7.7.6]:

- The roof/ceiling assembly construction has a fire-resistance rating not less than that required for the exit enclosure.
- A continuous and safe means of egress from the roof is available.

There are no exits that discharge to the roof of the building.

8.11 Barriers

8.11.1 Occupancy Separations

BAF Tunnel and Power Supply Building (957) meets the requirements for occupancy separation as defined by the BCNYS (Table 302.3) and NFPA 101 (Table 6.1.14.4.1.) There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS "302.1.1" or NFPA 101 "6.1.14.1.2" and "6.1.14.1.3."

NSRL Target Room (956) complies with the codes of record with respect to occupancy separations. There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS "302.1.1" or NFPA 101 "6.1.14.1.2" and "6.1.14.1.3." The building does not have the one hour rated occupancy separation requirement now mandated by the latest editions of the BCNYS and NFPA 101 between the Target Room (956) and the NSRL Support Building (958). Compliance with the new requirements would be required only in the case of a change of occupancy or egress path, or major renovation work in either building.

NSRL Support Building (958) complies with the codes of record with respect to occupancy separations. There are no areas in these facilities that are defined as incidental or accessory occupancy use areas as noted in BCNYS "302.1.1" or FPA 101 "6.1.14.1.2" and "6.1.14.1.3." The building does not have the one hour rated occupancy separation requirement now mandated by the latest editions of the BCNYS and NFPA 101 between the Target Room (956) and the NSRL Support Building (958). Compliance with the new requirements would be required only in the case of a change of occupancy or egress path, or major renovation work in either building.

8.11.2 Incidental Use Areas

Incidental use areas or hazardous areas are considered those spaces that pose a relatively higher hazard than the predominant occupancy of the area in which they are located. Such spaces are not necessarily classified as high-hazard (Group H) occupancies. Hazardous areas include general storage rooms, boiler or furnace rooms, and maintenance shops. The LSC requires hazardous areas to be separated from adjoining areas by a 1-hour fire resistance-rated barrier without windows or protected by automatic fire suppression systems [LSC §8.7.1.1]. Rooms with severe hazards such as maintenance shops with woodworking and painting are required to have both fire barrier enclosure and automatic fire suppression.

There are no such rooms associated with the NSRL.

8.11.3 Separation of Means of Egress

Not applicable to Building 930.

8.11.4 Exit Access Corridors

There are no exit access corridors in Building 930, thus this criterion does not apply.

8.11.5 Vertical Opening Barriers

None

8.11.6 Egress Stairways

Egress stairways are provided around the Collider Ring. See Section 8.2.1.

8.12 Fire Protection Systems Required by Code

Automatic sprinkler protection is not required to address life safety conditions found in the building.

8.13 Operational Requirements that are Required by Code

When performed, cutting and welding operations in the building are required to be conducted in accordance with NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition.

There are no other fire protection related operational requirements required by code.

9.0 REFERENCE DOCUMENTS

9.1 National Fire Protection Association

NFPA 10, *Standard for Portable Fire Extinguishers*, 2002 Edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 Edition

NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition

NFPA 70, *National Electrical Code*®, 2005 Edition

NFPA 72®, *National Fire Alarm Code*®, 2002 Edition

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2002 Edition

NFPA 101®, *Life Safety Code*®, 2006 Edition

NFPA 220, Standard on *Types of Building Construction*

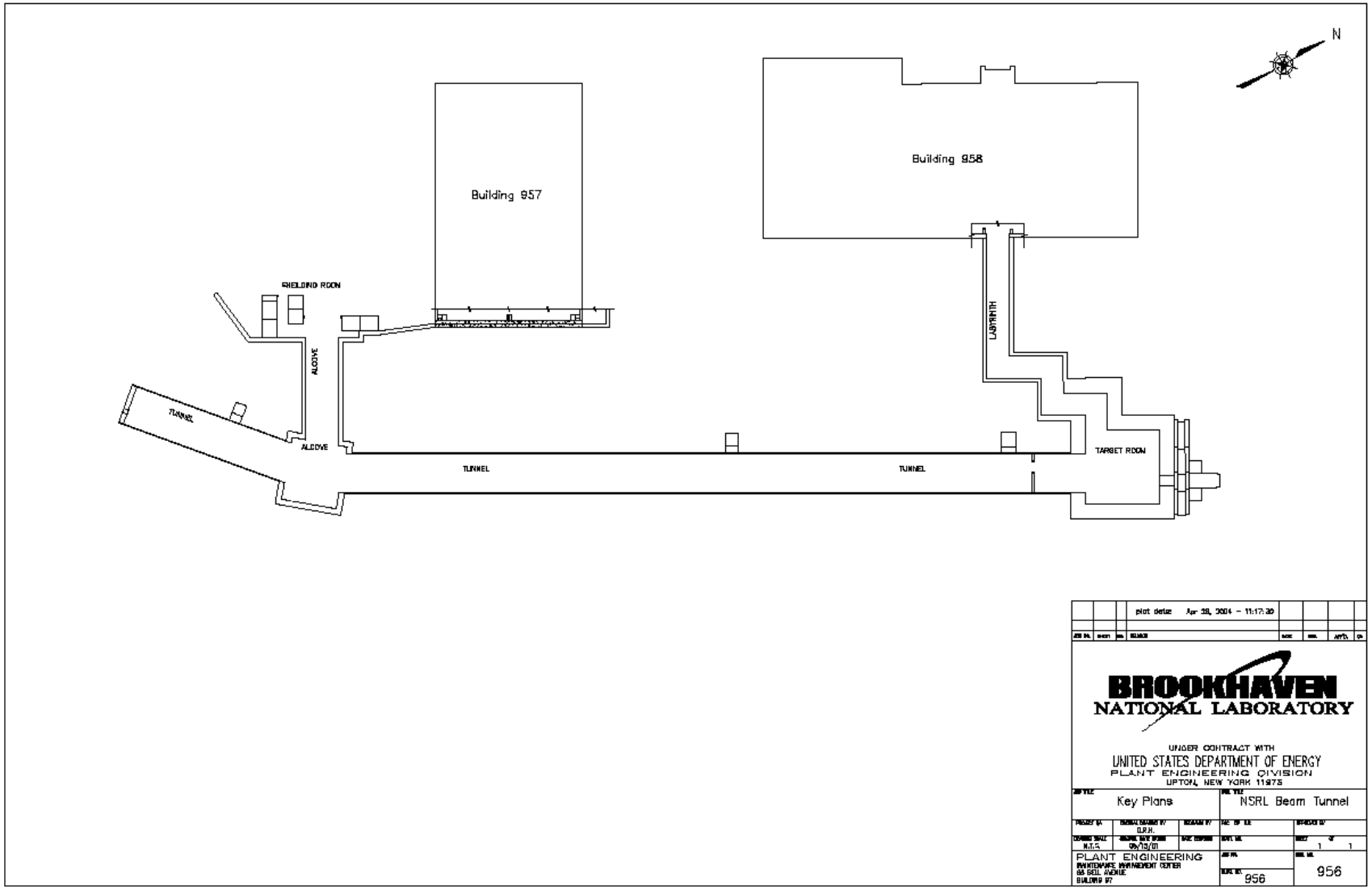
NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 Edition

NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

9.2 FM Global Loss Prevention Data Sheets

None.

APPENDIX A – FHA FIGURES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Building 958
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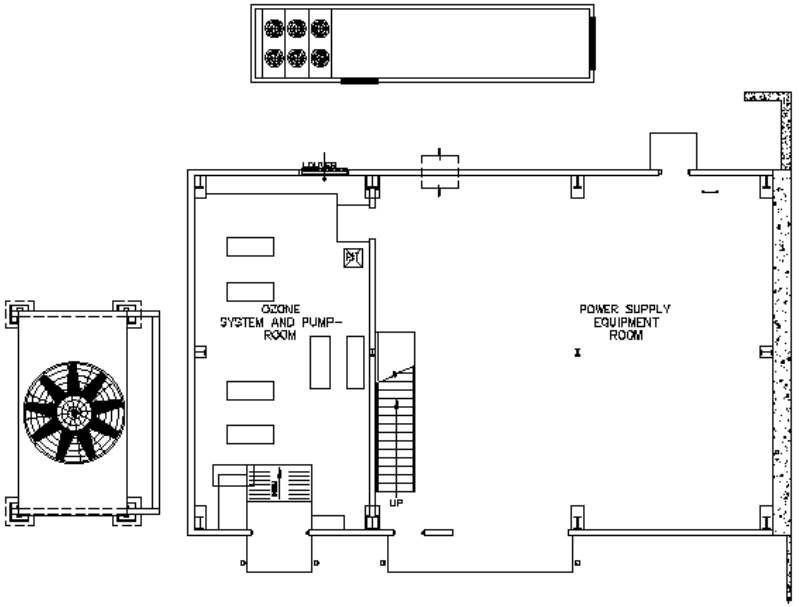
NATIONAL LABORATORY
UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
PLANT ENGINEERING DIVISION
UPTON, NEW YORK 11973
Key Plans
NSRL Beam Tunnel
PLANT ENGINEERING
956
956



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BROOKHAVEN
NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
PLANT ENGINEERING DIVISION
UPTON, NEW YORK 11973

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PROJECT ENGINEER: M.T.S.	DRAWN BY: D.P.H.
ORIGINAL DATE ISSUED: 04/21/01	SHEET: 1 OF 2
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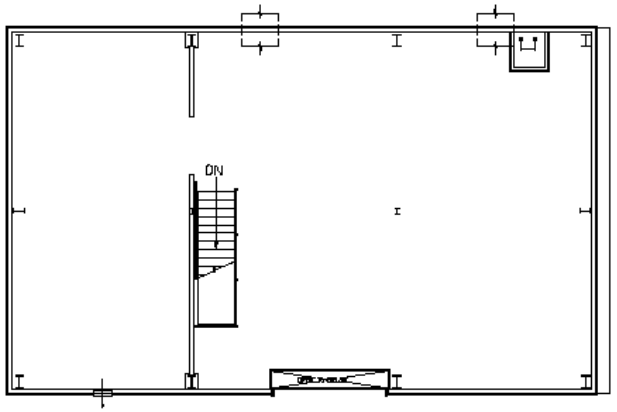
	DWG NO.: 957-1



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BROOKHAVEN NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
PLANT ENGINEERING DIVISION
UPTON, NEW YORK 11973

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ORIGINAL DRAWING BY: D.R.H.	
ORIGINAL DRAWING DATE: 08/21/01	
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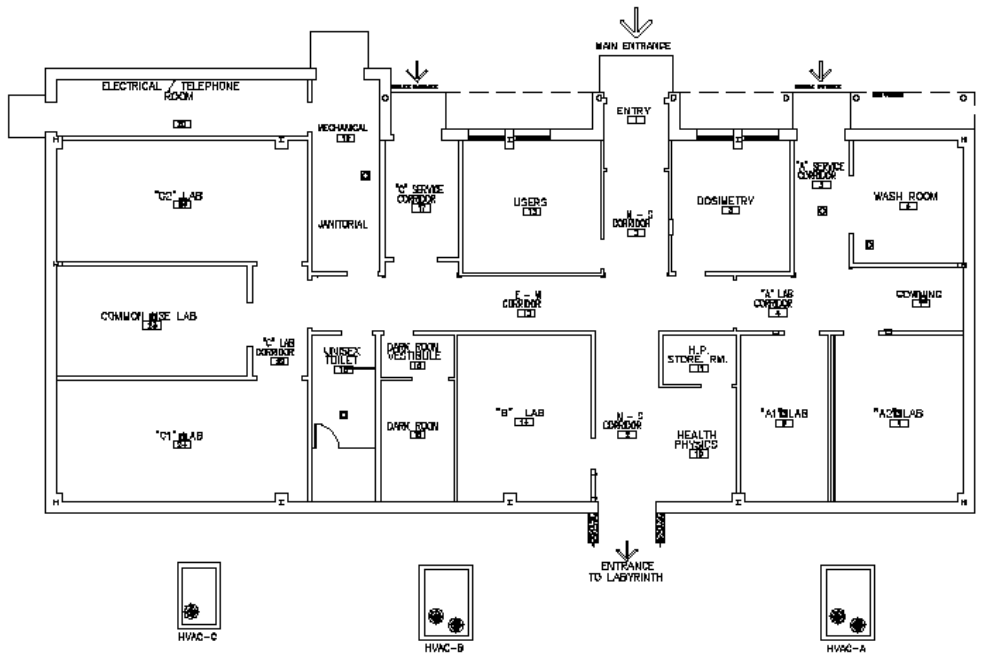

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BROOKHAVEN NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
PLANT ENGINEERING DIVISION
UPTON, NEW YORK 11973

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DRAWN BY: D.R.H.	
SCALE: N.T.S.	ORIGINAL ISSUE DRAWN: 08/21/01
SHEET: 1	
PLANT ENGINEERING MAINTENANCE MANAGEMENT CENTER 98 BELL AVENUE BUILDING 317	BLDG. NO. 958
DWG. NO. 958	

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0** and the tolerable lightning frequency (Nc) is **0.0002**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed.

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 ANNEX L

$$N_d = (N_g)(A_e)(C_1)(10^{-6})$$

N_d = **0.0121** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **0.25** = the environmental coefficient

(A_e) = **24,188** = the equivalent collective area of the structure in square meters from calculation below

Length (L)	**650**	Feet
Width (W)	**30**	Feet
Height (H)	**45**	Feet

0.25

Figure H.4.2(a) Results 24,188 sq. meters

Figure H.4.2(b) Results 5,319 sq. meters

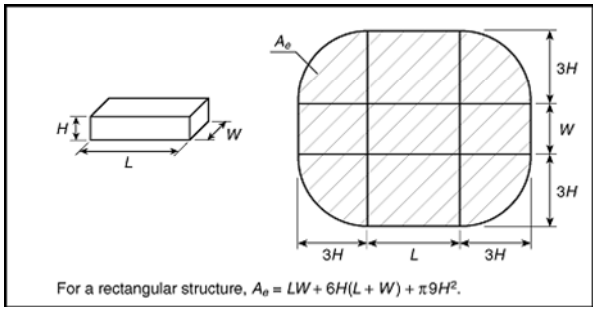
Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$	1
Isolated structure on a hilltop	2

Assume

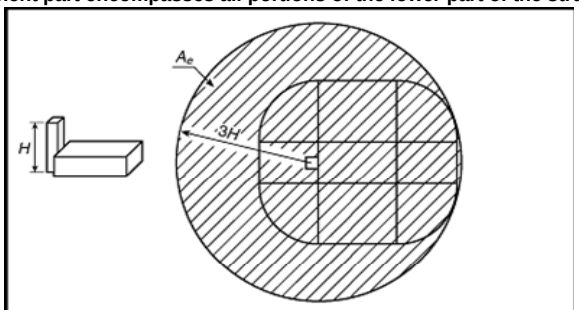
0.50

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.



For a rectangular structure, $A_e = LW + 6H(L + W) + \pi 9H^2$.

Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



Note: For a structure where a prominent part encompasses all portions of the lower part, $A_e = \pi 9H^2$

= input required

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX L

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0002**

= input required

Assume **1.0**

C_2 — Structural Coefficients			
	Roof		
Structure	Metal	Nonmetallic	Flammable
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **2.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **1.0**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

APPENDIX C – Determination of Wildfire Hazard Severity

Using NFPA 1144

WILDLAND FIRE RISK AND HAZARD SEVERITY ASSESSMENT FORM
Appendix A, Figure A.4.2 from NFPA 1144

ELEMENT	POINTS
A. Means of Access	
1. Ingress and egress	
a. Two or more roads in/out	**0**√
b. One road in/out	7
2. Road width	
a. >= 24 ft	0
b. >= 20 ft and < 24 ft	**2**√
c. < 20 ft	4
3. All-season road condition	
a. Surfaced road, grade <5%	**0**√
b. Surfaced road, grade > 5%	2
c. Non-surface road, grade < 5%	2
d. Non-surface road, grade > 5%	5
e. Other than all-season	7
4. Fire Service Access	
a. <= 300 ft with turnaround	**0**√
b. > 300 ft with turnaround	2
c. < 300 ft with no turnaround	4
d. >= 300 ft with no turnaround	5
5. Street Signs	
a. Present	**0**√
b. Not present	5
B. Vegetation (Fuel Models)	
1. Characteristics of predominate vegetation within 300 ft.	
a. Light (e.g., grasses, forbs, sawgrassess, and tundra) NFDRS Fuel Models A,C,L,N,S, and T	5
b. Medium (e.g. light brush and small trees) NFDRS Fuel Models D,E,F,H,P,Q, and U	**10**√
c. Heavy (e.g. dense brush, timber, and hardwoods) NFDRS Fuel Models B,G, and O	20
d. Slash (e.g. timber harvesting residue) NFDRS Fuel Models J,K, and L	25
2. Defensible space	
a. More than 100 ft of vegetation treatment from the structures	1
b. 71 ft to 100 ft of vegetation treatment from the structures	3
c. 30 ft to 70 ft of vegetation treatment from the structures	**10**√
d. < 30 ft of vegetation treatment from the structures	25

C. Topography Within 300 of Structures

1.	Slope < 9%	**1**√
2.	Slope 10% to 20 %	4
3.	Slope 21% to 30%	7
4.	Slope 31% to 40%	8
5.	Slope > 41%	10

D. Additional Rating Factors

1.	Topographical features that adversely affect wildland fire behavior	0-5 [**0**√]
2.	Areas with a history of higher fire occurrence than surrounding areas due to special situations	0-5 [**0**√]
3.	Areas that are periodically exposed to unusually severe fire weather and strong dry winds.	0-5 [**0**√]
4.	Separation of adjacent structures that can contribute to fire spread	0-5 [**0**√]

E. Roofing Assembly

1.	Class A roof	**0**√ (underground structure)
2.	Class B roof	3
3.	Class C roof	15
4.	Nonrated	25

F. Building Construction

1.	Materials		
	a.	Noncombustible/fire-resistive siding, eaves, and deck	**0**
	b.	Noncombustible/fire-resistive siding and combustible deck	5
	c.	Combustible siding and deck	10
2.	Building setback relative to slopes of 30% or more		
	a.	>= 30 ft to slope	1√
	b.	< 30 ft to slope	5

G. Available Fire Protection

1.	Water source availability			
	a.	Pressurized water source availability		
		500 gpm hydrants <= 930ft apart	**0**√	
		250 gpm hydrants <= 930ft apart	1	
	b.	Nonpressurized water source availability		
		>= 250 gpm continuous for 2 hours		3
		< 250 gpm continuous for 2 hours		5
	c.	Water unavailable		10
2.	Organized response resources			
	a.	Station <= 5 miles from structure		**1**√

	b. Station > 5 miles from structure	3
3.	Fixed fire protection	
	a. NFPA 13	**0**
	b. None	5√
H.	**Placement of Gas and Electric Utilities**	
1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5
I.	**Total**	**30**

Hazard Assessment	Total Points
Low hazard	**< 40**
Moderate hazard	40-69
High hazard	70-112
Extreme hazard	> 112

A Wildfire Severity Level of 30 = A **LOW** Hazard