14 ENVIRONMENT, SAFETY, & HEALTH, AND QUALITY ASSURANCE

14.1 INTRODUCTION

Brookhaven National Laboratory is committed to the success of the mission objectives of the National Synchrotron Light Source II and to the safety of its users, staff, and the public. The NSLS-II Project Director is responsible for achieving this objective. The NSLS-II Environmental Safety and Health Manager is responsible for ensuring that an ES&H system is established, implemented, and maintained in accordance with requirements. The ES&H Manager will provide oversight and support to the project participants to ensure a consistent ES&H program.

It is our vision to provide a “Best in Class” safety program. We view such a program as essential to the safety of the workers as well as the successful completion of the project. We will seek to provide an injury free work environment and will measure our performance by comparison with only those who have achieved recognition as “Best in Class.” To achieve this vision, safe working conditions and practices are an absolute requirement for all staff and contractors. We expect all design and work to be performed with this goal in mind. We will not be satisfied unless our ES&H program as well as our new facility are both recognized as “Best in Class.” To accomplish this vision, it is essential that ES&H be fully integrated into the project and be-managed as tightly as quality, cost and schedule.

An ES&H Program Plan [14.1] with this vision in mind has been prepared by the ES&H Manager and approved by the NSLS-II Project Director. This plan specifies that the program implemented for NSLS-II shall satisfy its ES&H commitments by:

1. Establishing an Integrated Safety Management Program that implements the DOE Policy, DOE P 450.4, “Safety Management System Policy,” the BNL Subject-Based Management System topic areas, and the requirements of the DOE “Accelerator Safety Order.” The program will protect the environment and the safety of workers and the general public by assuring that:
    a. Facilities, systems, and components needed to meet mission requirements are fully defined and are designed, constructed, and operated in accordance with applicable BNL and DOE requirements
    b. Potential hazards to personnel associated with all NSLS-II systems, structures, and components are identified and controlled through the timely preparation of safety assessment documents
    c. Potential risks to the environment are addressed through the timely and comprehensive preparation of appropriate National Environmental Protection Act documentation
    d. ISO 14001 and OHSAS 18001 criteria are implemented to assure that all ES&H risks are identified and addressed
    e. Requirements in 10 CFR Part 835, part 850, and Part 851 are fully implemented to protect worker safety and health
2. Implementing a QA program that follows DOE Order 414.1-2A, “Quality Assurance Management System Guide,” and incorporates quality requirements from BNL’s SBMS subject areas Quality Management and Graded Approach for Quality Requirements.
3. Implementing an effective construction safety programs to ensure worker safety on the NSLS-II site during construction. All work performed on the NSLS-II site will be conducted in accordance with the NSLS-II Environmental, Safety, and Health Plan.

4. Performing Independent Design Reviews on systems, structures, and components designated as "safety significant" or "safety class" in the SAD or as defined through QA classifications described in the NSLS-II QA Plan.
5. Providing appropriate training to ensure that project staff are adequately trained and qualified to perform their assigned work safely. Job training assessments will be conducted for all staff to ensure knowledge of job-related hazards and their controls. All project staff are responsible for ensuring that their training and qualification requirements are fulfilled, including continuing training to maintain proficiency and qualifications.
6. Developing and implementing operating procedures to control work on NSLS-II technical systems.
7. Performing and documenting safety inspections of all project facilities and work areas, and ensuring prompt correction of any issues identified in the inspection.
8. Reporting and investigating occurrences and incidents in accordance with the BNL Occurrence Reporting Policies and Procedures as defined in the BNL SBMS. Any incident, accident, or other abnormal event will be properly communicated and investigated via established procedures.

Policies and requirements to ensure implementation of these expectations will be established and communicated to all staff, contractors, and vendors.

14.2 Preliminary Hazards Analysis (PHA)

A principal component of an effective ES&H program is to ensure that all hazards have been properly identified and controlled through design and procedure. To ensure that these issues are understood at the conceptual phase, a Preliminary Hazards Analysis [14.2] has been conducted to identify the hazards that will be encountered during the project's construction and operational phases. In addition, the PHA was also used to make the Facility Hazard Categorization; NSLS-II was determined to be an "Accelerator Facility," as defined in DOE Order 420.2B, "Safety of Accelerator Facilities."

Generally, all the hazards and their risks anticipated to be encountered at NSLS-II as identified in the PHA are well known to the accelerator community. Years of experience with such facilities at BNL and within the DOE complex have generated well-defined design criteria and controls to eliminate and/or control these risks. Table 14.1 summarizes the hazards that have been considered and the codes and standards that apply to the reduction of risk associated with each hazard.

This PHA process began concurrent with the conceptual design, to ensure that all significant hazards were identified and adequately addressed in the early design work. Each of these issues will be followed as design advances and as construction and installation work commence. A Baseline Hazards List [14.2] was developed as the first step in identifying the potential hazards. This list utilized the best available information, encompassing data from the NSLS-II conceptual design, existing NSLS safety-basis documentation, subject-matter expertise (with conventional facilities, accelerator systems, and ES&H) and lessons-learned from the DOE's accelerator community covering design criteria, regulatory requirements, and related occurrences. It also included a preliminary (pre-mitigation) risk assessment at the subsystem level that identified a risk category before incorporating the ES&H-related design and operational controls that are postulated to mitigate those risks. The identified hazards then were further developed in the PHA, where the proposed ES&H design enhancements were taken into consideration. The PHA re-analyzed the risks, including these enhancements and, in certain cases, operational controls, to establish a post-mitigation risk category. This category affords a realistic assessment of the residual ES&H risks posed by the NSLS-II facility and is input to the Title I design.

Eleven of the hazards reviewed in the PHA are mitigated to low risk or below through design and procedure, and five hazards remain at a moderate level. The latter include: Construction, Electrical, Chemical/Hazmat, Material Handling, and Experimental Operations. While the PHA adequately addresses all risks, those remaining above a low post-mitigation category will require more attention during the Title 1 design process to ensure that they are adequately controlled.

A brief review of each hazard and the means of mitigating risks are provided in the following sections.

Table 14.1 Hazards Considered in PHA and Applicable Codes and Standards.

PHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – PHA-1	Construction hazards Site clearing Excavation Work at elevations (steel, roofing) Material handling Utility interfaces, (electrical, steam, chilled water) Misc. finishing work Weather-related conditions Transition to Operations	29 CFR 1926, Safety and Health Regulations for Construction
NSLS-II – PHA-2	Natural phenomena hazards Seismic Flooding Wind Snow Lightning	DOE Order 420.2B Safety of Accelerator Facilities DOE Guide 420.2-1 Accelerator Facility Safety Implementation Guide DOE Order 420.1B Facility Safety DOE STD 1020-2002 Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities DOE STD 1021-93 Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems and Components. DOE STD 1022-94 Natural Phenomena Hazards Site Characterization Criteria. DOE STD 1023-95 Natural Phenomena Hazards Assessment Criteria. New York State Building Code
NSLS-II – PHA-3	Environmental hazards Construction impacts Storm-water discharge (construction and operations) Operations impacts Soil activation Air activation Cooling-water activation (HVAC and machine) Oils/chemical leaks Discharge/emission points (atmospheric/ground)	BNL Subject Areas NYSDEC Petroleum bulk storage, SCDHS Article 12 40 CFR 61 - Subpart A, National Emissions Standards for Hazardous Air Pollutants (NESHAPS) 6 NYCRR 200 – 234 – NYSDEC Prevention and Control of Air contamination and Air Pollution
NSLS-II – PHA-4	Waste hazards Construction phase Facility maintenance Experimental operations Industrial Hazardous Radiological	BNL Subject Areas 6 NYCRR Part 371, Identification and Listing of Hazardous Wastes 6 NYCRR Part 374.3, Standards for Universal Waste 40 CFR 262.11, Hazardous Waste Determination (EPA 1987) 40 CFR 273, Standard for Universal Waste Management 6 NYCRR Part 374-2 and 225-2, Used Oil Specifications
NSLS-II – PHA-5	Fire Hazards Facility occupancy classification Construction materials Storage Flammable/combustible liquids Flammable gasses Egress/access Electrical Lightning	BNL Subject Areas NFPA 101 Life Safety Code NFPA 45 Fire Protection for Laboratories Using Chemicals Elevator Std

PHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – PHA-6	Electrical hazards Facility Experimental Job-built equipment Low voltage/high current High voltage/high power Maintenance Cable tray overloading/mixed utilities	BNL Subject Areas NFPA 70 National Electrical Code NFPA 70 E Standard for Electrical Safety in the Workplace NFPA 70 B Recommended Practice for Electrical Equipment Maintenance
NSLS-II – PHA-7	Noise/Vibration	BNL Subject Areas OSHA 29 CFR 1910.95 Occupational Noise Exposure
NSLS-II – PHA-8	Cryogenic Oxygen deficiency Thermal Cryogenic distribution system Pressure	BNL Subject Areas American Society of Mechanical Engineers (ASME) Boilers and Pressure Vessel Code, sections I through XII including applicable Code Cases, (2004). * ASME B31 (ASME Code for Pressure Piping) as follows: (i) B31.1—2001—Power Piping, and B31.1a—2002—Addenda to ASME B31.1—2001; (ii) B31.2—1968—Fuel Gas Piping; (iii) B31.3—2002—Process Piping; (iv) B31.4—2002—Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; (v) B31.5—2001—Refrigeration Piping and Heat Transfer Components, and B31.5a—2004, Addenda to 29 CFR 1910.134, OSHA Respiratory Protection Standard
NSLS-II – PHA-9	Confined space hazards	BNL Subject Areas 29 CFR 1910.146, Permit-required confined spaces
NSLS-II – PHA-10	Ozone hazards	BNL Subject Areas DOE G 420.2-1, Accelerator Facility Implementation Guide
NSLS-II – PHA-11	Chemical/hazardous material inventory Toxic Extremely toxic Compressed gas Carcinogens, mutagens, teratogens Combustibles Explosives Flammable gases Lead (shielding)	BNL Subject Areas 49 CFR Department of Transportation ANSI Z358.1-2004 Emergency Eyewash and Shower Equipment OSHA 1910
NSLS-II – PHA-12	Accelerator/Beamline hazards Vacuum/Pressure Cooling water Compressed gas Electrical Heavy equipment handling Magnetic Cryogenic Shielding Mechanical (moving shutters, valves and actuators)	BNL Subject Areas DOE Order 420.2B Safety of Accelerator Facilities DOE G 420.2-1, Accelerator Facility Implementation Guide
NSLS-II – PHA-13	Ionizing radiation hazards Prompt radiation (synchrotron radiation scatter, neutrons, bremsstrahlung) Radioactive contamination Activation (equipment) Radioactive material (dispersible use, storage)	BNL Subject Areas 10CFR 835

PHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – PHA-14	Non-ionizing radiation hazards RF & microwave Magnetic fields Laser Visible light	BNL Subject Areas ANSI Z136.1-2000 Safe Use of Lasers
NSLS-II – PHA-15	Material handling hazards Overhead cranes/hoists Fork trucks Manual material handling Delivery area distribution Manual movement of materials	BNL Subject Areas ASTM B30 Overhead Cranes
NSLS-II – PHA-16	Experimental operations Electrical equipment Transportation of hazardous materials Biological materials Chemicals (corrosive, reactive, toxic, flammable) Nanomaterials (particulates) Elevations Dark-room hazards Clean-room hazards Ionizing radiation Ozone production Slips, trips, falls Machine tools/hand tools Stray static magnetic fields Research gasses (corrosive, reactive, toxic, flammable)	BNL Subject Areas

14.2.1 Construction Hazards (NSLS-II PHA – 1)

BNL has a mature construction safety program, with recent experience in constructing the Research Support Building (64,000 sq ft) and the Center for Functional Nanomaterials (94,000 sq feet). Lessons-learned from these two projects, as well as from other construction projects in the DOE complex, coupled with the existing program, will control risk at the NSLS-II facility. Typical construction hazards anticipated at the NSLS-II construction site include the following:

- Site clearing
- Excavation
- Work at elevations (steel, roofing)
- Utility interfaces, (electrical, steam, chilled water)
- Material handling
- Miscellaneous finishing work
- Weather-related conditions
- Transition to Operations

14.2.1.1 Construction Hazards – Mitigating Factors (Design)

- Engineered and approved excavation systems
- Engineered and approved fall-protection systems
- Permanent fall-protection systems incorporated into facility's roof systems (for future maintenance)
- Modern code-compliant construction equipment with the required safety controls (e.g., backup alarms, seatbelts, load capacity readouts)

14.2.1.2 Construction Hazards – Mitigating Factors (Operational)

- Strict adherence to 29 CFR 1926, OSHA Construction Standard
- Integrated Safety Management (contractually flowed down to subcontractors)
- Contractor-Required Health and Safety Plan (flowed down to subcontractors)
- Pre-qualification of contractors and subcontractors based on their Experience Modification Rate, Days Away, Restricted, Transfer rate, and Total Recordable Case rate
- Independent third-party inspections of construction safety program
- Dedicated onsite construction safety professionals
- Phase hazards analysis for high-risk activities (e.g., site clearing, work at elevations)
- Contractor-safety incentive program
- Frequent ES&H communication with contractor and subcontractors at plan-of-day, "tool box" meetings
- Major construction equipment inspected before arriving on site

14.2.2 Natural Phenomena Hazards (NSLS-II PHA-2)

Natural Phenomena Events, including high winds, floods, and earthquakes, were investigated and documented in the plan DOE Accelerator Order 5480.25, "Implementation Plan for BNL Natural Phenomena Hazards Evaluation – 1994" [14.3]. The data confirmed that all accelerator facilities at BNL were built to the appropriate national consensus codes and standards at the time of their construction. The NSLS-II design will be governed by the Building Code of the State of New York, which is more restrictive than prior codes. The BCNY specifies design criteria for wind loading, snow loading, and seismic events. Furthermore, all accelerator facilities were determined to be low hazard and Performance Category 1 (per DOE STD-1021-93). NSLS-II also was determined to be a Performance Category 1 facility. It will contain only small quantities of activated, radioactive, and hazardous chemical materials. If a NPH were to cause significant damage, the impact would be mission related and would not pose a hazard to the public or the environment.

14.2.2.1 NPE Mitigating Factors (Design)

- Performance Classification designation PC-1
- Strict conformance to Building Codes State of New York
- Snow-loading criteria: 45 psf ground, 30 psf+ for drift design
- Wind design: 120 mph (with 3-second gust)
- Seismic design: to 0.20g acceleration velocity
- Lightning-protection system per NFPA (National Fire Protection Association) 780
- Pitched roofs on structures to preclude localized flooding/roof leaks
- Site drainage designed to shed water

14.2.2.2 NPE Mitigating Factors (Operational)

- Limited and controlled quantities of hazardous materials
- BNL Site Emergency Plan
- NSLS-II site emergency plan (to be developed)
- Emergency drills
- U.S. Weather Service dopplar radar facility on BNL site for early notification of severe weather

14.2.3 Environmental Hazards (NSLS-II PHA 3)

Environmental hazards from NSLS-II include the potential for releasing, in amounts beyond regulatory limits, oils, solvents, chemicals, and radioactive material to the soil, groundwater, air, or sanitary system. The principal initiators for such a release would be the failure of equipment, impact from a natural phenomenon, fire, or a violation of procedures/processes.

The NSLS-II facility established a goal of obtaining Leadership in Energy and Environmental Design certification that contains requirements for sustainable design principles, pollution prevention, and waste minimization during construction and operations.

14.2.3.1 Environmental Hazards – Mitigating Factors (Design)

- Recirculating (closed-loop) cooling systems
- Minimal need for the regeneration of filter beds, through the use of water-treatment chemicals and disposable pre-filters
- Handling and storage facility for control of waste water
- Design to Suffolk County Article 12 (secondary containment) requirements
- NSLS-II will include sustainable design principles with the goal of obtaining LEED certification

14.2.3.2 Environmental Hazards – Mitigating Factors (Operational)

Implementation of an environmental management program designed to international standards (ISO 14001), where chemical use is minimized through review and less hazardous chemicals and processes are substituted where possible. Controls are based on the following:

- Process Assessments
- ES&H Committee, Beamline Review Committee, design reviews
- Work Planning, Experimental Safety Reviews, Tier I inspections
- Training/qualification
- NSLS-II Environmental Assessment
- NESHAP evaluation (to be developed)

14.2.4 Waste Hazards (NSLS-II PHA-4)

Waste-related hazards from NSLS-II include the potential for releasing waste materials (oils, solvents, chemicals, and radioactive material) to the environment, injury of personnel, and a possible reactive or explosive event. Typical initiators would be transportation accidents, incompatible materials, insufficient packaging/labeling, failure of the packaging, and a natural phenomenon.

The types and volume of wastes that will be generated by NSLS-II are not anticipated to differ markedly from those generated by the existing NSLS. During a typical year of operation, NSLS-II will generate 3,000 to 5,000 pounds (1,400 to 2,300 kilograms) of waste.

14.2.4.1 Waste Hazards – Mitigating Factors (Design)

- Two 90-day waste accumulation areas on opposite sides of ring
- 90-day areas are designed with 2-hr fire rating, independent exhaust ventilation, fire detection, alarm pull box, communications (phone) system, access control (card reader), and secondary containment

14.2.4.2 Waste Hazards – Mitigating Factors (Operational)

- NSLS-II chemical use and waste production will be minimized through review; less hazardous chemical and processes will be substituted where possible
- Local Satellite Accumulation Areas in laboratories or at beamlines

- 90-day weekly inspections
- Periodic New York State Department of Environmental Conservation inspections of the 90-day areas and Satellite Accumulation Areas
- Hazardous Waste Generator training
- Experimental Safety review process
- Work planning and control
- Facility-Specific safety orientation
- Tier I inspections
- Process Assessment forms
- Tritium sampling program for accelerator’s cooling-water systems
- Waste reduction, pollution prevention, and recycling
- HazMat transportation procedures per DOT and site Transportation Safety Document

14.2.5 Fire Hazards (NSLS-II PHA – 5)

Operational experience at accelerators throughout the DOE complex has demonstrated that most fires in accelerator facilities are electrically initiated, typically by component failure. However, other sources of fire are considered in the design of the NSLS-II facility. They include the combustibility of building construction materials, the accumulation of combustible materials by occupants, the use of pyrophoric or reactive materials, improper storage or use of flammable materials, lightning storms, and static discharge.

14.2.5.1 Fire Hazards – Mitigating Factors (Design)

- Design to BCNY and appropriate NFPA standards
- Preliminary Fire Hazards Analysis
- Noncombustible construction throughout facility
- Early-warning fire-detection systems (e.g., smoke detectors, rate of rise detectors)
- Automatic fire suppression (e.g., sprinkler system)
- Emergency power supply for essential systems
- Hazardous material storage areas: rated, vented, alarmed
- Lightning protection system for facilities
- Adequate grounding systems

14.2.5.2 Fire Hazards – Mitigating Factors (Operational)

- Manual fire suppression provided by sufficient portable fire-extinguishers
- Alarm systems to alert occupants and summon fire department (e.g., fire alarm bells/strobes, manual pull stations, connected to on-site fire department)
- Full-time, BNL Fire/Rescue Group with mutual aid arrangements with local fire departments
- Ongoing inspection program to minimize combustibles and ignition sources
- Ignition-source control programs (cutting/welding permits, no smoking policy)
- Experimental Safety Review to minimize fire hazards of experiments by design features
- Fire evacuation drills

14.2.6 Electrical Hazards (NSLS-II PHA – 6)

The NSLS-II will have a large amount of facility-related and experimental electrical equipment. Electrical hazards from NSLS-II include the potential for serious injury, death, and equipment damage. Electrical shock and arc flash can be caused by exposed conductors, defective and substandard equipment, lack of adequate training, or improper procedures.

14.2.6.1 Electrical Hazards – Mitigating Factors (Design)

- Design to NFPA 70 and 70 E National Electric Code
- Adequate power distribution (beamlines and laboratories)
- Segregated power and utility distribution (cable/utility trays)
- Electrical and mechanical equipment rooms adequately sized and accessible from outside of ring
- Electrical distribution/disconnect equipment located in unobstructed areas (physically marked to provide clear access)
- Where possible, NRTL-certified equipment

14.2.6.2 Electrical Hazards – Mitigating Factors (Operational)

- Non NRTL-certified equipment inspected and certified by competent person
- Engineering and beamline design reviews
- Operation of equipment at <50 volts where feasible
- SBMS procedures for electrical safety
- Electrical safety training
- Operational procedures to keep electrical equipment unobstructed
- Ongoing inspection program

14.2.7 Noise and Vibration Hazards (NSLS-II PHA – 7)

Hazards from noise and vibration include overexposure of personnel to OSHA noise limits and permanent hearing loss, also known as Permanent Threshold Shift. The vibration of equipment can contribute to high noise levels, as well as potentially damage or interfere with sensitive equipment.

NSLS-II will incorporate a wide variety of equipment that will produce a range of noise and vibration. Support equipment (e.g., pumps, motors, fans, machine shops, and general HVAC) all contribute to point source- and overall ambient-noise levels. While noise will typically be below the OSHA 8-hr time-weighted average, certain areas with mechanical equipment could exceed that criterion and will require periodic monitoring, posting, and the use of Personal Protective Equipment. Ambient background noise is of a greater concern from the standpoint of users' comfort, stress level, and fatigue. Background noise in the accelerator and experimental areas at the existing NSLS is a common quality-of-life complaint and interferes with broadcast safety announcements and alarm systems.

14.2.7.1 Noise and Vibration – Mitigating Factors (Design)

- Separate mechanical/utility areas from work areas
- Isolate operations and experimental process equipment (e.g., pumps); utilize service chase concept, hutches, or individual equipment enclosures
- Use low-noise fans in HVAC systems
- Incorporate sound-absorbing materials into structure (wall and ceiling panels, baffles)

14.2.7.2 Noise and Vibration – Mitigating Factors (Operational)

- Baseline and periodic area noise surveys
- Personnel noise dosimetry
- Noise-exposure medical protocol where required
- New equipment reviews for noise and vibration levels as part of procurement process

14.2.8 Cryogenic Hazards (NSLS-II PHA – 8)

Cryogenic hazards at NSLS-II will include the potential for oxygen-deficient atmospheres due to catastrophic failure of the cryogenic systems, thermal hazards (cold burns) from cryogenic components, and pressure hazards. Initiators could include the failure or rupture of cryogenic systems from overpressure, failure of insulating vacuum jackets, mechanical damage or failure, deficient maintenance, or improper procedures.

Large volumes of inert cryogen liquid (nitrogen and possibly helium) will be piped into and around the NSLS-II facility from a centralized distribution point. In addition, dewar vessels (typically up to 500 liters) will be used locally in experiments.

Liquid nitrogen and liquid helium will be used for cooling experimental samples such as protein crystals, and also to cool beamline equipment, such as detectors, for enhanced sensitivity. Similarly, liquid coolants will chill accelerator components such as magnetic insertion devices, to make them superconducting (i.e., have zero resistance to electrical current).

14.2.8.1 Cryogenic Hazards – Mitigating Factors (Design)

- Design piping systems and pressure vessels per ASTM and ANSI codes or equivalent
- Install oxygen sensors and alarms
- Install interlocks and automatic exhaust system/quench
- Relief mechanisms in all piping and dewar systems

14.2.8.2 Cryogenic Hazards – Mitigating Factors (Operational)

- Develop the review process
- Pressure-test initial systems
- Cryogenic Safety Committee reviews and tests as required by SBMS
- Prepare and conduct NSLS-II facility-specific access training
- Conduct compressed-gas safety training
- Conduct cryogen safety awareness training
- Conduct Oxygen Deficiency Hazard training
- Maintain ODH classification and controls
- Conduct system-specific training

14.2.9 Confined Space Hazards (NSLS-II PHA – 9)

Hazards from confined spaces could result in death or injury due to asphyxiation, compressive asphyxiation, smoke inhalation, or impact with mechanical systems. Initiators would include failure of cryogenic systems releasing gas, fire, or the failure of mechanical systems.

Two types of confined spaces should be considered for the NSLS-II facility. The first are those associated with the facility's support/maintenance and typically include sump pits and HVAC plenums that would only be accessed by Plant Engineering's maintenance personnel or vendor personnel. The second category is those confined spaces created by the experimental programs and may include pits for support equipment or large tanks installed to recover inert gases.

14.2.9.1 Confined-Space Hazards – Mitigating Factors (Design)

- Definition of confined space criteria for designers – "design out," where possible
- Design of multiple means of egress, where possible

- Adequately size mechanical enclosures to allow maintenance

14.2.9.2 Confined-Space Hazards – Mitigating Factors (Operational)

- Identification and posting of all confined spaces
- Facility-specific safety orientation to identify spaces
- Work Planning and Control program
- Site's maintenance personnel identify their confined spaces

14.2.10 Ozone Hazards (NSLS-II PHA-10)

Synchrotron radiation can generate significant levels of ozone when the unattenuated beam passes through air. Experience at the current NSLS demonstrated that in some instances, ozone concentrations may approach or exceed the ACGIH Threshold Limit Values and precautions are needed to control potential exposures.

14.2.10.1 Ozone Hazards – Mitigating Factors (Design)

- Direct the beam path through evacuated or inert gas atmosphere containing pipes
- Minimize beam's horizontal and vertical dimensions
- Minimize beam path's length
- Filter beam to eliminate lower photon energies
- Scrub air round beam path with ozone filters
- Install ozone monitoring at potential problem areas

14.2.10.2 Ozone Hazards – Mitigating Factors (Operational)

- Experimental and beamline review program
- Delay personnel entry time to allow ozone to degrade

14.2.11 Chemicals and Hazardous Materials (NSLS-II PHA – 11)

The use of chemical and hazardous materials (HazMat) at NSLS-II could result in injury and death, or in exposures that exceed regulatory limits. Initiators could be experimental operations, transfer of material, failure of packaging, improper marking/labeling, failure of fume hood or glove box, reactive or explosive event, improper selection (or lack) of personal protective equipment, or a natural phenomenon.

14.2.11.1 Chemical and HazMat Hazards – Mitigating Factors (Design)

- Dedicated Chemical Storage Area with segregation, ventilation, fire-protection system, flammable, and O_2 monitors and access control
- Chemical delivery area located adjacent to loading dock
- Vented chemical storage cabinets in laboratories with lab quantities of hazardous material
- Gas cabinets for toxic and highly toxic gasses, individual venting and purging capacity and exterior access
- Double-wall stainless tubing for distributing toxic and highly toxic gasses
- Dedicated storage for biological- and infectious-materials
- Bulk gas piped in, (Liquid Nitrogen, Gaseous Nitrogen, Air) number of individual bottles limited
- Exhausted fume hoods in laboratories, (specialized hoods, e.g., HEPA where necessary)
- Covered centralized location for storing gas. (Satellite location due to size of ring)

- Safety showers and eyewashes in each laboratory (tepid water)
- Loading dock with leveling system to reduce material handling
- All lead material encapsulated/painted
- Hutches with exhaust ventilation to exterior of building

14.2.11.2 Chemical and HazMat Hazards – Mitigating Factors (Operational)

- Chemical Inventory control system (barcode); Chemical Management System (CMS)
- Lab Standard/Hazcom Training
- Transport of materials per DOT and BNL Hazardous Material Transportation Manual (HMTM)

14.2.12 Accelerator/Beamline Hazards (NSLS-II PHA – 12)

Hazards from the accelerator and beamlines include the cooling water, chemicals, compressed gas, electrical, material handling, and magnetic/cryogenic/ radiation.

The accelerator and beamlines will have various electrical equipment and associated power supplies. High-power equipment includes vacuum pumps, vacuum gauges, detectors and beam-position monitors (higher voltage-biased system).

Two important hazards are synchrotron scatter from beamline optics and bremsstrahlung radiation from loss of high-energy electrons from the orbit. Both hazards are found along the beamline. Synchrotron scatter will mostly be from the first optical elements. Bremsstrahlung radiation is confined to the beamline vacuum chamber with lead collimators until it can be directed into a beam stop. On many beamlines, the synchrotron light is offset from the bremsstrahlung cone at the monochromator and can be stopped there. For lines that have insufficient offset, a backstop is placed in the hutch behind the endstation.

14.2.12.1 Accelerator/Beamline Hazards – Mitigating Factors (Design)

- Engineered safety-systems in place will protect the ring and beamlines from vacuum, cooling-water flow, extreme temperatures, and compressed air faults
- Vacuum faults will cause the accelerator's interlock systems to close the sector and front-end valves, thus dumping beam; beamline interlocks will close a beamline valve and/or a front-end valve; insertion device beamline interlocks will close the fast valve and dump RF
- Any reduced flow of cooling water is sensed, causing the accelerator's interlocks to dump RF and the beamline interlocks to close the safety shutters
- Elevated magnet temperature sensors will turn off the magnet's power supply. If sensed on ring components, RF will be dumped. If sensed in the pump room water, RF and magnet power supplies will be dumped.
- Loss of primary compressed air supply from the Central Chilled Water Facility will activate the NSLS-II backup supply and alert the control room
- Loss of backup compressed air supply (affecting operation of front-end masks, safety shutters, and fast valves) will alert the control room

14.2.12.2 Accelerator/Beamline Hazards – Mitigating Factors (Operational)

- Safety Analysis Document and Accelerator Safety Envelope (to be developed)
- Operational procedures
- Systems design review

14.2.13 Ionizing Radiation Hazards (NSLS-II PHA – 13)

Potential hazards from ionizing radiation include prompt radiation (x-rays, neutrons, bremsstrahlung) produced during machine operation, induced activity in machine components, and radioactive material (use, storage). Typical initiators of radiation exposure would include operating machines, maintenance work, and using radioactive materials. Accidental exposure could result from failure of an interlock or other protective system, inadequate design or control of shielding, or an inadequate procedure.

To address these issues, the NSLS-II design will incorporate the requirements specified in 10 CFR 835 and the accelerator-specific safety requirements as set by DOE Order 420.2B, Safety of Accelerator Facilities. The facility will be designed and operated in a manner to maintain radiation exposure to staff, users, and the general public personnel within DOE and BNL dose limits and control levels [14.4]–[14.8].

A full discussion of radiation shielding at NSLS-II is given in Chapter 15.

14.2.13.1 Ionizing Radiation – Mitigating Factors (Design)

- Shielding for accelerators and beamlines to reduce dose to design levels
- Redundant interlock systems for accelerator enclosures and beamline hutches
- Redundant radiation safety critical devices (e.g., transfer line beam stops, beamline safety shutters)
- Real-time beam loss monitoring systems for injection and storage-ring operation
- Routine area monitoring of dose levels by passive dosimeters for neutrons and gammas on the experimental floor

14.2.13.2 Ionizing Radiation – Mitigating Factors (Operational)

- Radiological protection program incorporating requirements of 10 CFR 835 and BNL SBMS Radiological Control Manual
- Strict configuration control of shield systems
- Radiological safety training (e.g., GERT, Radiation Worker I)
- Facility-specific Safety Orientation and ES&H Orientations
- Work control procedures ensuring adequate planning and ALARA reviews before work authorizations

14.2.14 Non-Ionizing Radiation Hazards (NSLS-II PHA – 14)

Anticipated non-ionizing radiation hazards at NSLS-II include radio frequency, microwave, magnetic and laser hazards. The NSLS-II accelerators and storage rings will depend on the reliable operation of pulsed klystrons and continuous-wave high-power radio-frequency (RF) systems for injecting electrons and maintaining the stored beam. Both of these devices generate electromagnetic radiation within the RF and microwave energy ranges (30 KHz – 300 GHZ) and also pose significant electrical hazards. The devices typically are operated and maintained such that these energies will be shielded and, therefore, will not thermally or electrically expose nearby personnel.

The NSLS-II experimental program will use Class 1, 2, 3a, 3b, and 4 lasers. Many of them will occupy permanent locations, while others will be part of short-term beamline experiments, in place for just days to weeks at a time. Lasers, particularly those in Class 3b and 4, have associated electrical hazards, and some laser procedures require the use of solvents, dyes, and halogen gasses, which can also be hazardous.

14.2.14.1 Non-Ionizing Radiation Hazards – Mitigating Factors (Design)

- Equipment designed with integral shielding and interlock systems, as needed
- Laser interlock systems
- Gas cabinets for lasers using halogens (fluorine gas) vented outside the building

14.2.14.2 Non-Ionizing Radiation Hazards – Mitigating Factors (Operational)

- Baseline and routine surveys for stray magnetic fields, RF, and microwave
- Training for static magnetic fields, RF, microwave, and laser hazards
- Equipment ES&H review during installation
- Laser Safety Officer reviews
- Personnel protective equipment

14.2.15 Material-Handling Hazards (NSLS-II – 15)

The consequences of hazards encountered in material handling include serous injury or death to equipment operators and bystanders, damage to equipment, and interruption of the program. These hazards could be initiated by a dropped or shifted load, equipment failure, improper procedures, or insufficient training or qualification of operators.

14.2.15.1 Material-Handling Hazards – Mitigating Factors (Design)

- Hoists and attach points designed to ASTM/ANSI standards
- Piped-in gasses to reduce material handling of cylinders

14.2.15.2 Material-Handling Hazards – Mitigating Factors (Operational)

- Routine inspection and maintenance of all material-handling equipment
- Only trained and qualified personnel allowed to use equipment
- Equipment is locked to prevent unauthorized use
- Daily and annual inspection as required by supervisors to assure proper condition of equipment.

14.2.16 Experimental Hazards (NSLS-II – 16)

The consequences from experimental operation hazards range from minor to severe injuries, possible death, and danger to the experimental, accelerator, or facility equipment, as well as a programmatic impact. Initiators would include the release or unexpected reaction of hazardous material, the failure of protective systems, laser hazards, the use of radioactive materials and of biological materials, operators' error, lack of training, poorly designed/installed equipment, failure of equipment, unexpected chemical reactions, and undefined hazards or risks from material not considered in experimental safety reviews. Many of the anticipated hazards are discussed in the specific hazard-analysis sections (e.g., ozone, non-ionizing radiation).

Inert and various research gases will be used in experiments; inert gases include nitrogen, helium, and argon. Small amounts of flammable gasses, such as hydrogen, propane, and butane, may be required. Various toxic gases, such as hydrogen sulfide, carbon monoxide, or nitrogen oxides might also be used in liter quantities. Small-scale use of oxygen and the halogens also is anticipated. Liquid nitrogen and liquid helium will be used to cool experimental samples such as protein crystals.

The NSLS-II team continues to work with the DOE "nano" community to share the latest information on the hazards of nanoparticles and to fully implement the Secretarial Policy Statement on Nanoscale Safety (DOE P 456.1). Future changes in design guidance and equipment/systems may be necessary due to emerging information.

14.2.16.1 Experimental Hazards – Mitigating Factors (Design)

- Each laboratory will have a tailored design (be "programmed") based on its anticipated use and possible future use (user input in design process, historical inventories/hazards considered).
- The NSLS-II facility will be designed for Bio-safety Level 2.
- Chemical fume hoods installed in laboratories will be appropriate to experimental work, (based on the design programming).
- HEPA filtered hoods will be used for work with nanomaterial particulate and radiological dispersible materials (once-through systems).
- An adequate power supply (GFCI protected) will be designed into the laboratories to support anticipated equipment needs and future growth.
- Equipment bonding system will be installed.
- There will be provisions for adequate chemical storage.
- Outdoor-vented cabinets for storing flammable gasses in laboratories
- Laboratories designed for easy access/egress, process flow, ease of cleaning
- Laboratories located near beamlines, reducing movements with experimental materials
- Facility and laboratories designed to meet OSHA 1910 (walkways, stairs, egress)
- Safety shower and eye wash in each chemical laboratory (hands-free, tepid water)

14.2.16.2 Experimental Hazards – Mitigating Factors (Operational)

- Experimental safety review program
- Control of hazardous materials (inventory, storage)
- ES&H support staff (subject-matter experts, monitoring technicians)
- Principal Investigator's R2A2 and training
- Adequate beamline staffing

14.3 NEPA Compliance

In compliance with the National Environmental Protection Act (NEPA) and its implementing regulations (10 CFR 1021 and 40 CFR 1500-1508) and in accordance with the requirements of DOE Order 451.1B, an Environmental Assessment (EA) was prepared to evaluate the potential environmental consequences of constructing and operating NSLS-II at DOE's preferred site (BNL) has been carried out [14.9]. The EA analyzed the potential environmental consequences of the facility and compared them to the consequences of a No Action alternative. The assessment included detailed analysis of all potential environmental, safety, and health hazards anticipated as the design, construction, and operation of the facility progresses. The EA determined that there would be no significant impact from the construction and operation of the proposed facility and that an Environmental Impact Statement (EIS) was not required. A Finding of No Significant Impact (FONSI) was approved by the DOE Brookhaven Site Office (BHSO) Manager and made available to the general public and project stakeholders [14.10].

14.4 Quality Assurance

NSLS-II management will design and build a world-class user facility for scientific research with the assistance of a fully involved Quality Assurance (QA) Program.

The NSLS-II Project Director is responsible for achieving performance goals. The NSLS-II Quality Assurance Manager is responsible for ensuring that a quality system is established, implemented, and maintained in accordance with requirements. The QAM will provide oversight and support to the project participants to ensure a consistent quality program.

A QA Program Plan [14.11] has been prepared by the QA Manager and approved by the NSLS-II Project Director. This plan specifies the program requirements that apply to all NSLS-II work. The primary objective of the QA program is to implement quality assurance criteria in a way that achieves adequate protection of the workers, the public, and the environment, taking into account the work to be performed and the associated hazards. The objectives include:

- "Designing in" quality and reliability
- Assuring that all personnel involved in the project uphold the NSLS-II Quality Assurance Plan
- Promoting early detection of problems to minimize failure costs and impact on schedule
- Developing appropriate documentation to support construction and operational requirements
- Assuring that personnel have the necessary training as needed before performing critical activities, especially activities that have environmental, safety, security, or health consequences
- Defining the general requirements for design and readiness reviews, including environmental, safety, security, and health issues related to NSLS-II and contractor hardware, software, and processes.

References

[14.1] NSLS-II Environment, Safety, and Health Plan.
[14.2] NSLS-II Preliminary Hazards Analysis.
[14.3] DOE Accelerator Order 5480.25 Implementation Plan for BNL Natural Phenomena Hazards Evaluation – 1994.
[14.4] NSLS-II Technical Note 00012; "Preliminary Radiological Considerations for the Design and Operation of NSLS-II Linac"; PK Job and WR Casey July25, 2006.
[14.5] NSLS-II Technical Note 00013; "Preliminary Radiological Considerations for the Design and Operation of NSLS-II storage Ring and Booster Synchrotron; PK Job and WR Casey July25, 2006.
[14.6] NSLS-II Technical Note 00014; "Preliminary Shielding Estimates for NSLS-II Beamlines and Front Ends"; PK Job and WR Casey July 25, 2006.
[14.7] J. Pankkal, W.R. Casey, "Preliminary Activation Analysis of Accelerator Components and Beam Stops at the NSLS-II"; NSLS-II Technical Note 00015; August 1, 2006.
[14.8] NSLS-II Technical Note 00016; "Preliminary Activation Analysis of Soil, Air and Water near the NSLS-II Accelerator Enclosures"; PK Job and WR Casey August 15, 2006.
[14.9] NSLS-II Environmental Assessment.
[14.10] Finding of No Significant Impact for NSLS-II Project, approved by BHSO, September 27, 2006.
[14.10] NSLS-II Quality Assurance Plan.