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Safety Evaluation Report for the Special Nuclear Material License SNM-986 Renewal Application Massachusetts Institute of Technology Cambridge, Massachusetts, 02139

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Enclosure 3

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I INTRODUCTION

The Massachusetts Institute of Technology (MIT) was first issued a Special Nuclear Material (SNM) License in 1966, License SNM-986. The license was subsequently renewed in 1969, 1985, 1994, and most recently in 2006. The current license was scheduled to expire on April 29, 2016. On March 25, 2016 (MIT, 2016a), MIT submitted a timely application for renewal. The request was made pursuant to the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Sections 70.33, “Applications for Renewal of Licenses,” and 10 CFR Paragraph 70.38(a), “Expiration and Termination of Licenses.” The U.S. Nuclear Regulatory Commission (NRC) acknowledged receipt of the application on April 4. 2016. The Acceptance Review was completed on May 26, 2016 (Agencywide Documents Access and Management System [ADAMS] Accession Number ML16130A077). A notice of opportunity to request a hearing on the license renewal application (LRA) was published in the *Federal Register* (FR) on August 8, 2016 (81 FR 52478).

The NRC maintains ADAMS, which provides text and image files of the NRC’s public documents. A publicly available version of this renewal application is filed under ADAMS ML16092A171 (MIT, 2016a). MIT’s LRA proposes that its facility continue to possess and use SNM for training and educational purposes. The NRC staff reviewed the renewal application and issued requests for additional information (RAIs) in the areas of criticality safety, radiation safety and fire safety. MIT supplemented its application with additional submittals in each of these areas. These submittals were dated October 26 2016, ADAMS Package ML16302A013 (MIT, 2016c); December 7, 2016, ADAMS Package ML16343A813 (MIT, 2016d); December 13, 2016, ADAMS Package ML17011A326 (MIT, 2016e); February 13, 2017, ADAMS ML17047A571 (MIT, 2017a); March 1, 2017, ADAMS Package ML17066A318 (MIT, 2017b) and ADAMS ML17047A617 (MIT, 2017c). Additionally, an update to the Safety Analysis Report (SAR) for the reactor (MITR), ADAMS Accession Number ML13322A688 (MIT, 2013b) is cited for review of specific applicable facility information. MIT requested a renewed license term of 10 years. This Safety Evaluation Report (SER) documents the NRC staff’s review.

In addition to MIT’s License SNM-986, MIT holds other licenses issued by the NRC. These licenses are not the subject of this renewal. However, because SNM material possessed under these other licenses may be stored or used in the MIT reactor facility, information associated with these other licenses is discussed when relevant to this renewal. The MIT Reactor (MITR) holds Facility Operating License No. R-37 (Docket No. 05-0020) under the 10 CFR Part 50 regulations for research and test reactors (also called non-power reactors). MIT’s research reactor license was last renewed on November 1, 2010 for a period of 10 years (NRC, 2010a). As part of its review for the renewal of License SNM-986, the NRC staff reviewed MIT’s Facility Operating License R-37 to ensure that the provisions and conditions of both licenses are consistent with the Physical Security Plan (PSP) approved for R-37. MIT also held an NRC-issued license, Broad Scope Materials License Number 20-01537-02, until it was transferred to the Commonwealth of Massachusetts when they became an Agreement State on March 21, 1997. Subsequently, the Commonwealth of Massachusetts issued a new Broad Scope license to MIT, License No. 60-0094 (Docket No. 08-0107), which was most recently renewed on August 13, 2012.

II. SCOPE OF REVIEW

The NRC staff conducted its safety and safeguards review in accordance with 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material;" 10 CFR Part 20, "Standards for Protection Against Radiation;" 10 CFR Part 73, "Physical Protection of Plants and Materials;" 10 CFR Part 74, "Material Control and Accounting of Special Nuclear Material;" and other applicable regulations. The NRC staff used the guidance documents listed in Section V, REFERENCES of this SER, to conduct its safety review. NUREG-1520, "Standard Review Plan (SRP) for Fuel Facilities License Applications" (NRC, 2015), provides guidance to staff reviewers who perform safety and environmental impact reviews of applications using SNM. The NRC staff's safeguards review included the review of MIT's PSP and Material Control and Accounting (MC&A) Plan.

The NRC staff reviewed the information submitted in the renewal application and supplemented information. The renewal application contains two parts; Part I, License Conditions and Part II, Safety Demonstration. Part I describes the possession limits and authorized activities under the license, the organizational and administrative requirements, an overview of the Radiation Protection Program (RPP) and Nuclear Criticality Safety (NCS), Environmental Protection (EP) commitments, and the Decommissioning Funding Plan (DFP). Part II describes in detail facility operations, RPP procedures and equipment, NCS procedures, and accident analyses.

The MIT LRA (MIT, 2016a), addresses all requirements of 10 CFR Part 70 for SNM. Part 1 of the LRA contains 17 chapters addressing regulatory requirements and six appendices (ADAMS ML16081A295 (non-public) and ML16092A171 [publicly available]). Part 2 of the LRA contains Appendix 3, the Agreement State License with the Commonwealth of Massachusetts (License No. 60-0094, Docket No. 08-0107) (ADAMS ML16081A296 [non-public]) and ML16092A190 [publicly available]). The Commonwealth of Massachusetts obtained Agreement State status in 1997 and the program was most recently reviewed by the NRC in 2014 (ADAMS ML14304A312) under the Integrated Materials Performance Evaluation Program (IMPEP). The MIT license itself was renewed under the Agreement State program on August 13, 2012. The Massachusetts License describes the procedures used by MIT in administering the SNM program and is identified as Appendix 3 to the LRA. Appendix 3 is a separate document in ADAMS due to its large size. The Massachusetts License itself contains 16 attachments, which provide programmatic details on MIT's organization and procedures for the use of radioactive material. Attachment 11 to Appendix 3 of the LRA is titled Radiation Protection Procedures and includes 12 appendices addressing selected radiation protection aspects of the MIT program, such as radiation exposure limits, emergency response procedures, and training.

1.0 General Information

1.1 Facility Layout

MIT proposes to use SNM for research and training at various campus locations. The SNM and source material is only used at the following locations: the MIT Campus, Cambridge, MA and the Bates Linear Accelerator, Middleton, MA. The main campus at Cambridge occupies125 acres along the Charles River in Cambridge (Middlesex County) less than one-half mile across the river from Boston. The Nuclear Reactor Laboratory (NRL) and other laboratories where material under this license is used are located on the main campus. The Bates Linear

Accelerator is 20 miles north of Boston in Middleton, Massachusetts (Essex County). Adjacent to the MITR Lab are an industrial building to the north, a parking lot and warehouse building to the east, a warehouse building to the south, and academic and dormitory buildings to the west.

The research reactor site is in an urban area surrounded by multi-story buildings. The nearest prominent natural feature is the Charles River Basin at the southern border of the MIT campus. Appendix 7 of the LRA contains maps of the facilities showing their geographic positions within the MIT campus and within the state. The use and general storage of licensed materials is limited to the MITR Laboratory, the Plasma Science and Fusion Center (PSFC), and several chemistry/analytical laboratories. Experiments and instrument detector calibrations are carried out at the Bates Research and Engineering Center. Maps of the general location and more detailed maps of physical spaces pertinent to the license were provided in Appendix 7 of the application.

1.2 Process Overview

MIT describes its proposed uses of SNM as limited to research experiments and calibration of equipment, for example, using licensed material for instrument detector calibrations, to produce solid and liquid standards, and use of foils in experiments using the MITR. Prior to irradiating materials or conducting experiments with materials under the Facility Operating License No. R-37, MIT shall require the review and approval of the proposed research in advance, in accordance with the terms of the license.

1.3 Descriptive Summary of Licensed Material

The following sections contain a description of the possession limits, authorized activities, place of use, organization, technical qualifications, training, radiation safety, calibration, effluent control, criticality safety, environmental protection, emergency planning, material control and security, financial assurance, and compliance history.

1.3.1 Possession Limits

The maximum quantity of SNM that may be possessed and used is identified by isotope, enrichment, chemical and physical form, and mass in grams. Table 1 lists the quantities requested and the maximum quantities of SNM that may be possessed by MIT under License SNM-986:

TABLE 1. Possession Limits Under License SNM-986

MATERIAL	FORM	QUANTITY
A. Uranium enriched to ≤ 2.0 wt% in the U-235 Isotope	A. UO_2 Pellets, clad in steel, aluminum, or zircaloy	A.
B. Uranium enriched to ≤ 2.0 wt% in the U-235 Isotope	B. Metal or UO2 slugs, foils, pellets and other shapes, clad	B.
C. Uranium enriched to ≤ 2.0 wt% in the U-235 Isotope	C. Metal or UO2 slugs, foils, pellets, and other shapes, unclad	C.
D. Uranium enriched to ≤ 93% wt% in the U-235 isotope	D. Metal, UO2 and other compounds and alloys, solid slugs, foils, fission chambers, pellets, and other shapes, clad and unclad, as laboratory solids and solutions.	D.

E. Plutonium	E. Pu-Be neutron source and Pu-Al neutron filter	E.
F. Plutonium	F. Solid Alpha source	F.
G. Plutonium	G. Solid foils and pellets	G.
H. Natural Uranium	H. Solid and solution	H.
I. Depleted Uranium	I. Any	I.
J. Any byproduct material unseparated and contained in any of the above	J. Unseparated	J. Quantities produced during irradiation
K. U-233	K. Solid	K.
L. Plutonium	L. Any	L.

1.3.2 Authorized Activities

Section 1.7 of the LRA describes the activities for which the licensed material may be used:

1) Alpha sources: Electrodeposited plutonium alpha sources [Material F] are used on the MIT campus and at the Bates Linear Accelerator in the routine calibration of alpha detection devices used in health physics monitoring and radiation safety.

2) Use in fission chambers: Highly enriched U-235 [of Material D] is used for detection and measurement of neutrons generated in the MIT Reactor or PSFC (an on-campus building). There are currently 12 fission chambers at the PSFC containing approximately grams of High-Enriched Uranium (HEU) in total

3) Use of neutrons generated by SNM: Plutonium-beryllium encapsulated neutron sources [Material E] are used for calibration of neutron monitoring devices and for research purposes at the MIT reactor facility. Calibrations of neutron monitoring devices are also performed at the Bates Linear Accelerator. All calibrations are performed consistent with the RPPs.

4) Neutron Irradiations and Flux Measurements: Items D, G, and L are used for measurements of neutron flux or energy, required in reactor irradiation facilities. Foils are also irradiated in these facilities to produce calibration sources with fission spectra.

5) Depleted Uranium for Shielding: Items I and K are machined to be used as shielding from gamma radiation emitted from the reactor core or reactor beam ports.

6) Laboratory solids and solutions: Enriched, natural, and depleted uranium and plutonium are used in various forms, both solid and liquid [Materials B, H, L, and K]. Depleted or enriched uranium and plutonium are used as “spikes” for calibrating analyses of geological specimens. Migration of uranium and plutonium in soil with regards to decontamination of contaminated sites has been studied. Identification and characterization of unknowns in soils requires the use of uranium and plutonium standards. Research and teaching uses involving small quantities (<15 grams) of SNM of low strategic significance are reviewed by the RPP health physics staff and reviewed and authorized by the MIT RPC.

MIT has designated several of the licensed materials, or a portion of the materials, for storage only. These materials, and the quantity designated as storage only, are identified in Table 2. This information is documented in standing License Condition (LC) 12.

TABLE 2. Materials Designated for Storage Only	
Material	Quantity
A. Uranium enriched to < 2.0 wt% in the U-235 isotope	A.
B. Uranium enriched to < 2.0 wt% in the U-235 isotope	B.
C. Uranium enriched to < 2.0 wt% in the U-235 isotope	C.
G. Plutonium	G.
H. Natural Uranium	H.
I. Depleted Uranium	I.
K. U-233	K.

Storage of SNM is allowed only within the restricted area of the NRL of the former Blanket Test Facility (BTF) vault. The BTF vault is in the NRL and is shown in the facility diagram attached to an RAI response 1.3 (MIT, 2016c). The former test facility was used for experiments in the 1960's, and currently its vault is used only for material storage. The vault measures 20 feet by 20 feet and the walls are approximately 12 inches thick. The NRC staff reviewed the LRA and concludes that MIT adequately described its facility and the proposed uses of the SNM for which the renewal is sought. Therefore, the NRC staff concludes the information in the MIT application and supplements meets the requirements of 10 CFR 70.22 and 10 CFR 70.33 and is acceptable.

2.0 Organization and Administration

The staff reviewed the applicant's organization and the qualifications of administrative and radiation protection personnel, generally described in Chapters 2 and 9 of the LRA, against the acceptance criteria in NUREG-1520, Rev. 2, Section 4.4.3.3 (NRC, 2015). The administration of the facility involves operations, organizational structure, and facility security. In addition, an application must present information on the facility's organization, training programs, operational reviews and audits, radiation protection procedures and actions, recordkeeping and reports. The following discussion summarizes the staff's evaluation as to whether the information provided by the applicant meets the criteria.

The applicant's management is headed by and reports to the President of MIT. Principal Officers of MIT are identified in the LRA. The officers are all United States citizens. The MIT is not controlled or owned by any alien, foreign corporation or foreign government. The Executive Vice-President and Treasurer is the senior University official overseeing the safe use of radioactive materials. The Vice-President appoints members to the RPC, which monitors the use of radioactive material to ensure compliance with federal, state, and university regulations. The RPC also performs the functions required of a radiation safety committee, which are described in detail in Chapter 4 of this SER. Appendix 6 to the application provides the organizational chart and shows the management structure of the Radiation Protection Organization. The Radiation Protection Organization reports to the Director of Environmental Safety and Health (ES&H). Operations for the MITR are an independent reporting line to minimize the potential for a conflict of interest. Lines of communication exist between Operations and the Campus Radiation Protection Office (RPO) via a Reactor Radiation Protection Officer (MITR-RPO), who also works for ES&H. An attachment to the Revised LRA

RAI response (MIT, 2016d) submitted December 7, 2016 provides details of the ES&H organization and the Radiation Protection Organization.

MIT has a separate license for its research reactor, under Docket No. 50-0020 (NRC, 2010a and NRC, 2014c). MIT's Facility Operating License No. R-37 is not part of the current licensing review, although the R-37 licensing documentation provides support for the current action. The Campus RPO is supervised by the ES&H. The Campus RPO advises on the implementation of MIT's RPP for both ionizing and non-ionizing radiation sources held under the License SNM-986 and License R-37. The Campus RPO also oversees all byproduct material not held under the R-37 license, that is, materials under the License SNM-986 and Massachusetts License No. 60-0094.

The Director of ES&H also supervises the MITR-RPO and oversees the RPP at the reactor site. The responsibility for the safe use of the reactor and radioactive materials, is assigned to the supervisory personnel or Principal Investigators (PI) of the Department and Laboratory overseeing the specific research.

The division of responsibilities for the accounting of nuclear materials is presented in the organization chart shown in Appendix 6 of the LRA. The Criticality Officer in the NRL provides advisory and technical services on the use, storage, and shipping of SNM, which require consideration of criticality. The MIT- Campus RPO provides accountability for all radioactive material except material held under the R-37 license. The Director of Reactor Operations is responsible for R-37 licensed material. The Accountability Officer in NRL accounts for all source and SNMs held under the R-37 license, at least once annually.

Two committees share responsibility for ensuring the safety of SNM at MIT's facilities. The Reactor Safeguards Committee is responsible for nuclear safety at the MITR. This Committee oversees safety reviews of all materials held under the SNM license when the SNM is used within reactor spaces, and secondly when its use or storage within the restricted area of the reactor could present safety concerns. This Committee has the responsibility for safety reviews of all materials used under the SNM license when the material is used within reactor spaces or its use or storage within the reactor restricted area presents safety considerations. The RPC is responsible for the establishment and continuing review of the RPP at MIT and its off-campus sites. The RPC is also responsible for MIT's compliance with radiation protection regulations required by state, federal, and local agencies. The membership of both committees is via appointment by the MIT President.

The staff has reviewed the organization and administration for MIT against the acceptance criteria in Chapter 2 of NUREG-1520. MIT described its organization and management policies for providing adequate safety management for the safe operation of the facility. The senior organizational management structure and policies were reviewed and found acceptable. The staff has reviewed the information and concluded that MIT has an acceptable organization, administrative policies, and sufficient qualified resources to provide for the safe operation of the facility under both normal and abnormal conditions. Therefore, the NRC staff concludes that the information provided by MIT meets the applicable requirements in 10 CFR 70.22 and 10 CFR 70.33 and is, therefore, acceptable.

3.0 Integrated Safety Analysis Summary

The NRC staff reviewed the LRA to determine whether MIT was required to provide an Integrated Safety Analysis (ISA) Summary, pursuant to the provisions in 10 CFR Part 70, Subpart H, “Additional Requirements for Certain Licensees Authorized to Possess a Critical Mass of Special Nuclear Material.” The NRC staff finds that the activities proposed under the renewed license are not activities described in 10 CFR 70.60. Under its License SNM-986, MIT is not engaged in enriched uranium processing, fabrication of uranium fuel or fuel assemblies, uranium enrichment, enriched uranium hexafluoride conversion, plutonium processing, fabrication of mixed-oxide fuel or fuel assemblies, scrap recovery of SNM or any other activity. The staff determined that MIT’s proposed activities do not fall within any of the listed activities in 10 CFR 70.60 and therefore, could not significantly affect public health and safety. For these reasons, 10 CFR Part 70, Subpart H is not applicable to the LRA. As a result, the NRC staff concludes that MIT is not required to submit an ISA Summary in support of its LRA.

4.0 Radiation Protection

4.1 Purpose of Review

The NRC staff conducted this review to assess whether the RPP described in MIT’s LRA is adequate to protect the radiological health and safety of staff and students, and complies with the regulatory requirements in 10 CFR Part 19, “Notices, Instructions and Reports to Workers: Inspection and Investigations;” 10 CFR Part 20, “Standards for Protection Against Radiation;” and 10 CFR Part 70, “Domestic Licensing of Special Nuclear Material.”

The regulatory requirements for the review of radiation protection are generally described in 10 CFR 70.23(a)(3) and (4). Approval of an application requires that the proposed equipment and facilities are adequate to protect health and safety of the public and the environment, and that the applicant's proposed procedures to protect health and minimize danger to life or property are adequate.

4.2 Staff Review and Analysis

4.2.1 Commitment to Radiation Protection Program Implementation

Paragrah 20.1101(a) of 10 CFR requires that an applicant develop, implement, and document a RPP commensurate with the scope and extent of licensed activities. An application that meets the requirements of 10 CFR Part 20 will describe an adequately staffed and trained organization, the appropriate procedures and approval authority, and the necessary equipment and documentation relative to the material or process requested. The SER identifies and discusses each of the acceptance criteria in NUREG-1520, Section 4.4.1.3

(NRC, 2015) and evaluates whether the information provided by the applicant is consistent with the criteria in the staff’s SRP. A RPP must include:

1) A documented management commitment to keep exposures As Low As Reasonably Achievable (ALARA)

Appendix 3 of the LRA at Attachment 11 references the booklet *MIT Required Procedures for Radiation Protection,* which is given to all new radiation workers during initial radiation safety training. Attachment 11 contains Appendix 7, which describes the MIT ALARA Program (MIT, 2016a). Appendix 7 details MIT's ALARA program and describes the management's commitment to conduct program reviews, committee meetings, and procedural reviews. It fully describes the responsibility of the RPC to review prospective research and other activities, the responsibilities of the RPO, PIs, and material users, and provides radiation exposure limits and the more restrictive internal exposure limits.

In the LRA at Appendix 3, Attachment 11, Appendix 7, MIT provides a commitment to the implement the RPP and the ALARA goals. The Executive Vice President and Treasurer, the senior management official for the program, also certified that MIT has implemented the ALARA Program. MIT commits to establish an appropriate administrative organization and to develop the written policies, procedures, and instruction to foster the ALARA concept.

2) A trained and qualified radiation protection organization, which is independent of the facility's operations, has well-defined responsibilities, and has sufficient authority to carry out those responsibilities;

Chapter 2.2 of the application identifies the lines of responsibility and authority for MIT's staff. The primary responsibility for safety rests with the supervisory personnel of the department and laboratory and supervisory personnel, however, the RPO staff is responsible for providing the advisory and technical services necessary to implement the MIT RPP for both ionizing and non-ionizing radiation. Figure I.2-2 (MIT, 2016a) identifies the organizational responsibilities for radiation protection.

3) Adequate facilities, equipment, and procedures to effectively implement the program;

Chapter 10 of the application provides a facility description; diagrams of the facility were provided in a later submittal (MIT, 2016c). Licensed material is used and stored at the facility, as is typical at laboratory facilities in teaching and research institutions. Each department is responsible for providing adequate facilities, equipment, and required instrumentation. There are no large-scale chemical systems used in connection with the licensed material.

Each proposed use of SNM requires an application that is authorized by the PI and reviewed by the Radiation Protection staff. Appendix 3 of the renewal application, Attachment 7 contains MIT's, "Application to Possess and Use Radioactive Materials." This application form requires a thorough description of the proposed uses of material, a physical evaluation of laboratory space where work could be conducted, and a review by the RP staff and RPC approval. The PI provides supervision and instructions to control radiation hazards and to comply with MIT's radiation protection requirements. The adequacy of the facilities to undertake each proposed use is evaluated during the authorization process.

4) Review, at least annually, of the RPP's content and implementation, as required by 10 CFR 20.1101(c). The review should consider facility changes, new technologies, and other process enhancements that could improve the effectiveness of the overall program.

   In Appendix 3 of the renewal application, Attachment 11, the Required Procedures for Radiation Protection states the MIT RPC receives its authority from the Office of the President of MIT. The RPC is charged with auditing the RPP at least annually. In addition, the RPC is required to ensure compliance with radiation protection regulations promulgated by governmental agencies. The committee is also required to provide for continuing review of the adequacy of the RPP at MIT at off campus sites.

Paragraph 20.1101(a) of 10 CFR requires an applicant for an SNM license to have a program commensurate with the scope of activities to be conducted under the license. MIT's RPP for possession, handling, and procedures for the use of materials is appropriately described in Attachment 11. Attachment 11 describes an organizational structure capable of providing appropriate management oversight of materials and ensuring the radiation safety organization is adequately trained and staffed, MIT's staff is provided sufficient independence to safely carry out work and is annually reviewed by key management personnel as required by 10 CFR 20.1101(c). The staff evaluated the MIT's commitments to the acceptance criteria in Section 4.4.1.3 (NRC, 2015). For these reasons, the staff finds that the RPP provides assurance that MIT will satisfy the requirements in 10 CFR 20.1101(a) during the renewed license term. Therefore, the NRC staff finds that the RPP is acceptable.

4.2.2 Commitment to ALARA Program

Paragraph 20.1101(b) of 10 CFR requires a licensee to use, to the extent practical, procedures and engineering controls based on sound radiation protection principles to achieve occupational doses and doses to the members of the public that are ALARA. The staff reviewed the applicant's ALARA program commitments against the acceptance criteria in NUREG-1520, Section 4.4.2.3 (NRC, 2015). Each acceptance criterion and the staff's assessment of whether the applicant's information is consistent with the criterion are discussed below:

1) Establish a comprehensive, effective, and written ALARA program;

   The LRA, Appendix 3, Attachment 11 (Required Procedures for Radiation Protection), contains Appendix 7, the MIT ALARA Program, which identifies MIT's management commitments. Appendix 7 details the oversight responsibilities of the RPC, the RPO, PIs, and personnel. Radiation training requirements, including occupational radiation dose limits, procedures for delegation of authority and for authorization of new procedures, documentation and recordkeeping requirements, and the programmatic reviews to be conducted by the Radiation Protection Officer are described. The senior management official responsible for the RPP is the Executive Vice President and Treasurer, who certified that MIT implemented the ALARA program.

2) Prepare policies and procedures to ensure occupational exposures are maintained ALARA, and that such exposures are consistent with the requirements of 10 CFR 20.1101;

   MIT's Policy on Environment, Health and Safety commits the institution to excellence in environmental health and safety, to minimize adverse impacts to facilities and activities,

to conduct operations to protect human health and the environment, and in achieving and maintaining compliance with federal, state and local laws and good practices in it facilities in Chapter 2 of the application. MIT commits to keeping radiation exposures to employees and to the general public ALARA. Attachment 3 of the LRA contains Attachment 11, Required Procedures for Radiation Protection. In Appendix 7 of the attachment, MIT established administrative exposure limits for their RPP. Personnel exposures are reviewed against these limits as a part of quarterly RPC meetings. If exposure limits are exceeded, processes will be reviewed to determine they are consistent with approved authorizations. If necessary, processes may be revised or supplemental investigational levels may be employed to continue the work.

3) Outline specific ALARA program goals, establish an ALARA program organization and structure, and have written procedures for its implementation in the facility design and operations;

In the LRA, Appendix 3, Attachment 11 (Required Procedures for Radiation Protection), contains Appendix 7, the MIT ALARA Program. MIT management states its commitment to keeping individual and collective doses ALARA. Written procedures and instructions are in place to foster the concept within the research facility. Section 2.c states that the RPC performs a quarterly review of occupational exposures with particular attention paid to instances in which investigation levels are exceeded. MIT has established Investigational Levels, which are 10 percent of the regulatory limits in 10 CFR 20.1201. These function as administrative controls to ensure there is a focus on limitation.

4) Establish an ALARA Committee, or equivalent organization, with sufficient staff, resources, and clear responsibilities to ensure that the occupational radiation exposure dose limits specified in 10 CFR Part 20 are not exceeded under normal operations;

The RPC is a group appointed by MIT's President's Office. Attachment 1 to the LRA identifies the current membership of the committee and its responsibilities. It is made up of voting members, ex-officio members (RP staff), and a graduate student representative. The committee meets no less than quarterly, and represents a variety of engineering and scientific disciplines tasked with specific responsibilities for the oversight and use of materials identified on the application. In the LRA, Appendix 3, Attachment 11 (Required Procedures for Radiation Protection), contains Appendix 7, the MIT ALARA Program, Section 3.c identifies the quarterly responsibility of the RPC to review occupational radiation exposures to assess trends and determine if action is needed if established investigational levels are exceeded.

5) Use the ALARA program as a mechanism to facilitate interaction between RP and operations personnel; and

In the LRA, Appendix 3, Attachment 11 (Required Procedures for Radiation Protection), contains Appendix 7, the MIT ALARA Program presents procedures for the safe use of SNM to be used under the license. Section 3.4 of Attachment 11 of the renewal application details the authorization process MIT personnel must follow prior to using materials. Each prospective user must register with the RPP to initiate the process and complete required training. An Application to Possess and Use Radioactive Material, is completed by the user, reviewed by a PI, and reviewed and approved by the RPC (see Application, Appendix 3, Attachment 7). The qualifications of users and the PS are

reviewed by the RPC and authorizations are reviewed for consideration for renewal every two years.

6) Regularly review and revise, when appropriate, the ALARA program goals and objectives and to incorporate, when appropriate, new approaches, technologies, operating procedures or changes that could reduce potential radiation exposures at a reasonable cost.

   The LRA, Appendix 3, Attachment 11 (Required Procedures for Radiation Protection), contains Appendix 7, the MIT ALARA Program, which requires the RPC to perform a formal annual review of the RPP, including reviews of operating procedures, laboratory audits, inspection results, and dose records. Modifications to operating, maintenance, and experimental procedures, as well as changes in equipment and facilities will be made if they will reduce exposures within justifiable costs.

Chapter 2.1 of the application identifies an MIT policy commitment that all organizational components shall keep radiation exposures to employees and to the general public ALARA. The RPC oversees the use of specifically licensed radioactive material at MIT. In Appendix 3 of the application, Attachment 11, Required Procedures for Radiation Protection and its 12 appendices detail the radiation protection procedures and policies for materials use under the MIT license. MIT commits to ensuring that the release of radioactive material and the exposure of people to ionizing radiation be kept ALARA. The staff finds that MIT's commitment to an effective ALARA program is acceptable because the procedures are based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are ALARA, as required by 10 CFR 20.1101(b).

4.2.3 Organization and Personnel Qualifications

Paragraph 70.22(a)(6) of 10 CFR requires an application for a license to possess and use SNM shall contain the technical qualifications, including training and experience, of the applicant's staff to engage in the proposed activities.

The staff reviewed the applicant's organization and personnel qualifications against the acceptance criteria in NUREG-1520, Section 4.4.3.3 (NRC, 2015). The following discussion identifies each acceptance criterion from NUREG-1520 and summarizes the staff's evaluation as to whether the information provided by the applicant meets the criterion:

1) Appoint radiation protection personnel and identify their authority and responsibilities for implementing the RPP functions;

   Chapter 2.3 of the application states the RPC is responsible for the establishment and continuing review of the RPP at MIT. In Appendix 3, Attachment 11 (Required Procedures for Radiation Protection), Section 2.4 states the RPC has delegated authority for the RPP to the RPO, authorizing specific responsibilities for the implementation of the program. The RPC reviews and approves all uses of material, however for limited quantities of material, the RPO can provide a temporary authorization, subject to final ratification by the RPC. The RPO is tasked with operation of the Central Isotope Laboratory and directing the functions of the RPP to achieve compliance with governmental regulations.

2) Establish clear organizational relationships among the individual positions responsible for the RPP and other line managers;

   Chapter 2.2 of the application outlines organizational relationships and authority for the RPP. Figure I.2-2 (MIT, 2016a) identifies the organizational responsibility for radiation protection, providing the lines of accountability and responsibility. The primary responsibility for safety rests with the supervisor of the department, laboratory, and project. The RPO is responsible for the implementing MIT's RPP for both ionizing and non-ionizing radiation, and the RPO's responsibilities include providing advisory and technical services.

3) Appoint a suitably educated, experienced, and trained RPP director (typically referred to as the radiation safety officer) who (1) has direct access to the plant manager, (2) is skilled in the interpretation of data and regulations pertinent to radiation protection, (3) is familiar with the operation of the facility and radiation protection concerns of the site, (4) participates as a resource in radiation safety management decisions, and (5) will be responsible for establishing and implementing the RPP; and

   Appointments to safety-related positions at the MIT Campus and MITR RP Programs are made by the Director of EH&S. The minimum technical qualification for the position of RPO are established as a bachelor's degree in science or engineering, completion of a basic radiation safety course, and at least two years of work experience in radiation protection. Certification by the American Board of Health Physics (ABHP) in the comprehensive practice of health physics is recognized as fulfillment of these qualifications. The current RPO meets the education requirements and is board certified by the ABHP since 1978. He completed an undergraduate degree in 1975, with graduate studies in 1980. He served as the Assistant RPO for eight (8) years and is currently MIT's RPO and Associate Director of EH&S.

4) Describe the minimum training requirements and qualifications for the RP staff.

   All RPP staff receive initial radiation safety training and specific hands on training carrying out their responsibilities. Staff members are also required to take EH&S provided training in biological safety, chemical safety, hazardous waste management, emergency response, laser safety, x-ray safety, and Occupational Safety and Health Standards. The current staff consists of 10 health physicists of varying education, from B.S. to Ph.D. degrees, and with professional experience ranging from 3 to 40 years. Four of the health physicists on the staff are board certified.

The MIT LRA does not propose any significant changes in its organization and personnel qualifications. The staff evaluated the application commitments pertaining to the acceptance criteria in Section 4.4.3.3 of NUREG-1520 (NRC, 2015), the staff finds the commitments provide assurance that during the renewed license term the RPP organization is adequately staffed, trained, and experienced. The staff also finds the RPP organization will adequately protect health and minimize danger to life and property in accordance with 10 CFR 70.23(a)(4). In addition, the RP staff are currently and will remain qualified by training and experience to use the licensed material in accordance with 10 CFR 70.23(a)(2). Therefore, the NRC staff finds that the organization and personnel qualifications are acceptable.

4.2.4 Commitment to Written Procedures

Paragraph 70.22(a)(8) of 10 CFR states that each application for a license shall contain proposed procedures to protect health and minimize danger to life or property (such as procedures to avoid accidental criticality, procedures for personnel monitoring and waste disposal, post-criticality accident emergency procedures). The staff reviewed the commitments made by the applicant in its written procedures against the acceptance criteria in NUREG-1520, Section 4.4.4.3 (NRC, 2015). The following discussion identifies each acceptance criterion from NUREG-1520 and summarizes the staff's assessment of whether the information provided by the applicant meets the criterion:

1) Prepare written, approved procedures to carry out activities related to the RPP. Procedures should address applicable radiation protection requirements found in 10 CFR Parts 19, 20, 70, and 71 and any other applicable regulations;

   Chapter 2.7.2 of the application states that the use or storage of materials under the SNM license shall be accomplished by means of authorization procedures. Written procedures are required for the use of materials and are a part of an authorization application, required by the user and reviewed by a project supervisor, the RPO, and approved by the RPC. Section 4 of Attachment 11 (see page 8) of Appendix 3 to the application, Required Procedures for Radiation Protection, identifies the responsibilities of MIT researchers and RPP staff using materials under the SNM license. Materials, equipment, procedures, and safety will be reviewed and approved by the RPC prior to the initiation of work.

2) Establish a process for procedure generation or modification, authorization, distribution, and training, such that changes in technology or practices are communicated effectively and in a timely manner. Review and revise procedures, as necessary, to incorporate any facility or operational changes, including changes in the ISA. The radiation safety officer, or an individual who has the qualifications of the radiation safety officer, should approve all procedures related to radiation protection; and

   Sections 3 and 4 of Attachment 11 (see pages 7 and 8) of Appendix 3 to the application, Required Procedures for Radiation Protection, establishes procedures for the safe use of SNM identified in the application and the processes for using material. These procedures apply to all departments, laboratories, and persons at MIT or its off-campus sites that receive, possess, use, transport, or dispose of radioactive material. Section 3.4.1 states that prior to possessing or using radioactive material on MIT property, authorization must be obtained from the RPC. The authorization application form is contained in Attachment 7, Application to Possess and Use Radioactive Materials, of Appendix 3 to the application.

3) Specify written, approved Radiation Work Procedures for activities involving licensed material that are not covered by written radiation protection procedures. The RWPs should define the authorized activities, the level of approval required (a radiation specialist, as a minimum), information requirements, period of validity, expiration and termination times, and recordkeeping requirements.

   MIT is not required to use radiation work procedures because these procedures are for Part 70 fuel facilities. Appendix 3 of the application, Attachment 7, Application to Possess and Use Radioactive Materials provides the authorization form researchers

must complete to use SNM under this license. The form requires the identification of material, the quantity of material, location of use, required radiation protection conditions for use (postings, instruments), and must be reviewed by and approved by high-level MIT officials. Appendix 3 to the application, Attachment 11, Required Procedures for Radiation Protection at Section 2.7 (see page 7) of states that each individual who uses radioactive material shall comply with the conditions of the approval of the authorization, as well as the procedures and precautions contained in Attachment 7.

The procedures used by MIT staff are reviewed by the appropriate radiation safety authority and the RPC supervises and manages the staff. Safety and technical concerns are evaluated under appropriate operating and quality procedures. The MIT LRA does not propose significant changes to its written procedures. MIT will continue to follow the procedures that have been implemented successfully for many years. Based on the staff's evaluation of the application commitments pertaining to the acceptance criteria in Section 4.4.4.3 of NUREG-1520 (NRC, 2015), the staff finds, the commitments provide reasonable assurance that during the renewed license term the procedural controls will adequately protect health and minimize danger to life and property. The staff finds that the written procedures are in accordance with the requirements of 10 CFR 70.23(a)(4), and therefore are acceptable.

4.2.5 Radiation Safety Training

Paragraph 70.22(a)(6) of CFR states that each application for a license shall contain the technical qualification, including training and experience of the applicant and members of his staff to engage in the proposed activities in accordance with the regulations in this chapter. Paragraph 19.12(a) of 10 CFR specifies training requirements for all individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 100 millirem (1 mSv). The staff reviewed the applicant's training commitments against the acceptance criteria in NUREG-1520, Section 4.4.5.3 (NRC, 2015). The following discussion identifies each acceptance criterion from NUREG-1520 and provides the staff's evaluation as to whether the information provided by the applicant meets the criterion:

1) Design and implement an employee RP training program that complies with the requirements of 10 CFR Parts 19 and 20;

   Appendix 3 of the LRA at Attachment 3 to, Training for Individuals Working With or Frequenting Restricted Areas provides training requirements for MIT staff and ancillary personnel. Attachment 3 includes an outline of topical areas for radiation worker training and the MIT Radiation Safety Exam. The application stipulates retraining is required every two years and that additional hands-on training is provided as necessary. MIT has been an Agreement State since March 1997. The radiation protection requirements are codified in the Code of Massachusetts Regulations (CMR) Part 120. The Massachusetts training requirements are specified in 105 CMR 120.753 and correspond to the training requirements specified in 10 CFR 19.12. The authorized user or PI is responsible for assuring that those under his/her supervision attend the appropriate training in basic radiation protection techniques provided by the RPP staff.

2) Provide training, to all personnel and visitors entering restricted areas, that is commensurate with the health risk to which they may be exposed, or provide trained escorts;

Appendix 3 of the LRA at Attachment 3 states that the RPP Staff are responsible for developing a comprehensive radiation safety training program. The training is to ensure that technical radiation safety staff, nurses, waste handlers, animal caretakers, and ancillary staff understand the radiation hazards associated with their work, and are able to take appropriate action to prevent unnecessary exposure. Facilities (housekeeping and maintenance) and Campus Police personnel receive training on radiation hazards and precautions by the RPP, and receive initial training from their direct supervisors. Clerical and other departmental staff who work in the vicinity of radioactive materials (outside the secured area) are offered the opportunity to attend a lecture on radiation hazards and appropriate controls given by an RPP staff member.

3) Provide a level of training based on the potential radiological health risks associated with that employee's work responsibilities;

Appendix 3 of the LRA at Attachment 3 discussed MIT's radiological health training procedures. Prior to any person's use of licensed radioactive materials, they undergo a three-hour authorization process, which includes an interview with RPP staff, attendance at a radiation safety lecture and/or web-based training, taking and passing a written exam, and be assigned to an active authorization under the supervision of a PI. A sample exam and the forms for documenting the interview and the exam were provided. Additional individualized training is provided to any individual wanting to use unique devices, such as gammacell irradiators, performing iodinations, or handling large activity sources. Retraining for all authorized radiation workers occurs biennially and typically coincides with the renewal of an authorization.

4) Incorporate, in the RP training program, the provisions of 10 CFR 19.12 and additional relevant topics such as: correct handling of radioactive materials; the storage, transfer, or use of radioactive material as relevant to the individual's activities; minimization of exposures to radiation and/or radioactive materials; access and egress controls and escort procedures; radiation safety principles, policies, and procedures; monitoring for internal and external exposures; monitoring instruments; contamination control procedures, including protective clothing and equipment; ALARA and exposure limits; radiation hazards and health risks; emergency response; and responsibility to report promptly any condition that may lead to, or cause, a violation of regulations and license or create unnecessary exposure; and

The training requirements are specified in 105 CMR 120.753 and correspond to the training requirements specified in 10 CFR 19.12. An outline of the training subjects MIT presents and tests for was provided, and includes Regulatory Climate, Radiation Physics, Radiological Units and Quantities, Radiation Dose Limits, Health Effects, Waste Management, ALARA, Operational Topics, and Emergency Procedures. The subtopics to these areas are consistent with the requirements of 10 CFR 19.12.

5) Review and evaluate the accuracy, effectiveness, and adequacy of the radiation protection training program curriculum and instructors, as applicable, at least every 3 years and to conduct refresher training at least every 3 years.

Retraining for all authorized radiation workers occurs on a biennial basis and typically coincides with the renewal of an authorization. Special training is scheduled as needed in which the terms and conditions of the authorization are reviewed. Retraining sessions are also used to provide general information to staff and investigators relative to audit

results, regulation updates, and current events. Changes to programs or procedures are covered during retraining sessions. The curriculum is reviewed every 2 years to coincide with the refresher training schedule.

Appendix 3 of the LRA, Attachment 3, Training for Individuals Working With or Frequenting Restricted Areas describes the training requirements for MIT staff and ancillary personnel and the staff reviewed this information and finds it acceptable. Appropriate training is provided to individuals likely to receive more than 100 millirem (mRem) of occupational exposure in a year. All such individuals receive training in accordance with 10 CFR 19.12. Based on the staff's evaluation of the application commitments pertaining to the acceptance criteria in Section 4.4.5.3 of NUREG-1520 (NRC, 2015), the staff finds MIT's commitments provide reasonable assurance that the MIT training program will continue to ensure that personnel are qualified by reason of training and experience to safely use licensed material in accordance with the 10 CFR 70.23(a)(2) requirements. Therefore, the NRC staff finds that this program is acceptable.

4.2.6 Ventilation and Respiratory Protection Programs

Paragraph 70.22(a)(7) of 10 CFR states that each application for a license shall contain a description of equipment and facilities which will be used by the applicant to protect health and minimize danger to life or property (such as handling devices, working areas, shields, measuring and monitoring instruments, devices for the disposal of radioactive effluents and wastes, storage facilities, criticality accident alarms, etc.). The staff reviewed the applicant's ventilation and respiratory protection program commitments against the acceptance criteria in NUREG-1520, Section 4.4.6.3 (NRC, 2015). The following discussion identifies each acceptance criterion from NUREG-1520 and provides the staff's evaluation as to whether the information provided by the applicant meets the criterion:

1) Install appropriately sized ventilation and containment systems in areas of the plant identified as having potential airborne concentrations of radionuclides that could exceed the occupational derived air concentration values specified in 10 CFR Part 20, Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," during normal operations. Air flow in buildings housing these operations should be directed towards the area(s) of highest potential contamination;

   Most of MIT's facilities covered under this license do not require special ventilation equipment. The materials under this license are used in classroom demonstrations or instrument calibration, and primarily are sealed sources, as described in Chapter 1 of the LRA and don't require special ventilation requirements. Laboratories evaluate ventilation and respiratory system requirements during the authorization process to ensure systems function properly. Only limited research on and storage of materials occurs in the NRL and reactor building.

   The reactor building ventilation system is a single-pass system that supplies filtered, conditioned air to the containment building, which is collected and exhausted through a stack (NRC, 2010a). The system consists of fans, blowers, filters, dampers, heating and cooling equipment, ductwork, and the exhaust stack. Additionally, the system contains instruments, controls, interlocks, and radiation detectors. The ventilation system provides airflow into clean areas and exhausts air out of areas with the potential for airborne radioactivity or contamination through filtered exhaust ducts. The system maintains the containment building at a negative pressure with respect to the

atmosphere. This ensures that any leakage is into the building and that all air exhausts through a filtered and monitored pathway. The ventilation system provides rapid isolation of the containment building in the case of abnormal airborne radiation levels (MIT, 2010).

Licensee calculations of the airborne concentrations of radioactive materials are significantly less than 1 derived air concentration and calculated occupational dose rates are significantly less than 0.001 mSv/hr (0.1 mRem/hr). Measured annual doses at rooftop monitors on nearby buildings are typically less than 0.005 mSv (0.5 mRem). These results demonstrates MIT's is in compliance with the annual dose constraint on air emissions of radioactive material of 0.1 mSv (10 mRem) specified by 10 CFR 20.1101(d).

2) Describe management measures, including preventive and corrective maintenance and performance testing, to ensure that the ventilation and containment systems designated as items relied on for safety operate when required, and are within their design specifications;

Many of the management measures and performance requirements found in 10 CFR Part 70 do not apply to MIT under its SNM license. MIT is not required to perform an Integrated Safety Analysis, because it is not engaged in the activities listed in 10 CFR 70.62. In addition MIT is not required to evaluate items relied on for safety to ensure they comply with the performance requirements of 10 CFR 70.61. MIT has safety systems and detectors in place that are appropriate for its licensed activities. Section 3.2.3 of the LRA states the reactor containment building ventilation system is equipped with a radiation monitor capable of automatically closing the building vents upon unexpected detection of contamination. Other fixed instrumentation in the reactor building is required by standard operating procedures to include one gaseous monitor and one particulate monitor sampling the exhaust air entering a holdup plenum prior to the exhaust isolation damper and similar monitors downstream of the damper and exhaust high efficiency particulate air (HEPA) filters. Standard operating procedures also specify a monitor in the building exhaust stack. The safety systems provide assurance that excessive releases of airborne activity from licensed material within the reactor containment will be detected and will initiate an alarm if the activity exceeds a specified trip point.

3) Describe the operations criteria for the ventilation and containment systems, including minimum flow velocity at openings in these systems, maximum differential pressure across filters and types of filters to be used;

The reactor building has a ventilation system capable of automatic isolation upon detection of excessive concentrations of radioactive gaseous or particulate materials in the building effluent and equipped with HEPA filters in the exhaust stream (NRC, 2010a). The minimum exhaust flow rate is 3.5 cubic meters per second. When operations performed outside of the reactor building could produce airborne contamination, upon the recommendation of the RPP, approved exhaust ventilation shall be employed with appropriate filtration for effluent air. The concentration of airborne radioactive material entering the duct system of each laboratory, when averaged over 24 hours, must not exceed the limits for unrestricted areas without authorization of the RPP. When an experiment is conducted that could result in a release into the ventilation

system that exceeds the averages specified in 10 CFR Part 20, Appendix B, continuous air sampling of the effluent downstream shall be performed.

4) Describe the frequency and types of tests to measure ventilation and containment systems performance, the acceptance criteria, and actions to be taken when the acceptance criteria are not satisfied;

   In Chapter 3.2.3, the application specifies surveillance requirements for the ventilation system. The requirements include measuring the system flow rate annually, testing interlocks quarterly and before reactor startup, calibrating building differential pressure monitoring equipment annually, and monitoring filter performance. The requirements also include testing the interlock with the hot cell ventilation systems. The types and periodicity of the surveillance requirements are consistent with the guidance in ANSI/ANS-15.1.

5) Establish a respiratory protection program that meets the requirements of 10 CFR Part 20, Subpart H;

   Chapter 12.9 of the LRA explains that all routine work and maintenance activities at MIT's facilities are planned so gaseous concentrations in work areas will not exceed the activities specified in 10 CFR 20, Appendix B, Table 1, Column 1. For these reasons, a respiratory protection program that meets the maximum permissible dose values given in Appendix 1 of Attachment 11 of Appendix 3 to the application, is not required for MITs' facilities. Section 12.5 of Appendix 3 of the application, Attachment 11 (see page 14), MIT Required Procedures for Radiation Protection, specifies the consideration of potential airborne contamination for all requested authorizations. Approved exhaust may require the use of a laboratory hood, or glove box, or local exhaust ventilation. The ventilation used will be approved by the RPP and approved for adequacy by the MIT Industrial Hygiene Program of the EH&S.

Procedures require the annual measurement of system flow rate, calibration of building differential pressure monitoring equipment, and monitoring filter performance. The types and periodicity of the surveillance requirements are consistent with the guidance in ANSI/ANS-15.1. The MIT LRA does not propose any significant changes to the ventilation and respiratory protection programs, which have been successfully implemented for many years. The staff evaluated the commitments to implementing the acceptance criteria in Section 4.4.6.3 of NUREG-1520 (NRC, 2015) and finds MIT's commitments provide reasonable assurance that the equipment and procedures to be used in the ventilation and respiratory protection will continue to adequately protect health and minimize danger to life and property, in accordance with 10 CFR 70.23(a)(3) and (a)(4). Therefore, the NRC staff finds that these programs are acceptable.

4.2.7 Radiation Survey and Monitoring Programs

Paragraph 70.22(a)(8) of 10 CFR states that each application for a license shall contain proposed procedures to protect health and minimize danger to life or property (such as procedures to avoid accidental criticality, procedures for personnel monitoring and waste disposal, post-criticality accident emergency procedures. The staff reviewed the applicant's radiation survey and monitoring program commitments against the acceptance criteria in NUREG-1520, Section 4.4.7.3 (NRC, 2015). The following discussion identifies each

acceptance criterion from NUREG-1520 and summarizes the staff's evaluation as to whether the information provided by the applicant meets the criterion:

1) Provide radiation survey and monitoring programs that are necessary to comply with the requirements of 10 CFR Part 20 and that are reasonable to evaluate the magnitude and extent of radiation levels, the concentrations or quantities of radioactive material, and the potential radiological hazards;

   Chapter 13.5 of the application states that surface contamination surveys are made by means of filter paper wipes routinely (daily, weekly, or monthly), the frequency depends upon the potential for contamination, as prescribed in either written procedures or material authorizations. Surveys are also made routinely during or after experiment changes, maintenance, or other activities where there is a potential for surface contamination. A hand-and-foot monitor is located at the main personnel lock for the reactor containment. All personnel leaving the containment at this point or having reason to suspect possible contamination from other sources on person, tools, and equipment are required to use the monitor. Decontamination facilities are located in the same area for use if needed.

   Section 6 of Attachment 11 to Appendix 3 of the application, "Required Procedures for Radiation Protection," provides generic requirements for each project using radioactive material or sources to possess the appropriate radiation detection equipment to ensure that potential contamination is adequately controlled. Appendix 3 of the application at Attachment 7, Authorization to Possess and Use Radioactive Materials requires the evaluation of instrumentation prior to beginning work with licensed materials. Authorized users are required to conduct surveys at the end of each use of radioactive materials.

2) Prepare written procedures for the radiation survey and monitoring program that include an outline of the program objectives, sampling procedures, data analysis methods, types of equipment and instrumentation to be used, frequency of measurements, recordkeeping and reporting requirements, and actions to be taken when measurements exceed 10 CFR Part 20 occupational dose limits or administrative levels established by the MIT;

   Appendix 3 of the application, Attachment 12, Radiation Survey Technician Training Guide presents the applicant's written procedures for conducting routine radiological surveys. The procedures discuss the purpose of conducting surveys and describe how equipment is obtained, how instruments are inspected and tested for operability, how the instruments are used, and how surveys are documented.

   Appendix 3 of the application at Attachment 10, Survey Technician Receiving and Delivering Radioactive Packages Guide, provide the applicant's written procedures for receiving packages containing radioactive material and for inspecting and surveying for contamination. Labeling descriptions are included, forms for documentation, and required notifications are specified out in the procedure.

3) Design and implement a personnel monitoring program for external occupational radiation exposures that outlines methods or procedures to do the following:

   a. Identify the criteria for worker participation in the program
   b. Identify the types of radiation to the monitored

c. Specify how exposures will be measured, assessed and recorded
d. Identify the type and sensitivity of personal dosimeters to be used, when they will be used, and how the collected data will be processed and evaluated
e. Identify the plant's administrative exposure levels or action levels at which actions are taken to investigate the cause of exposures exceeding these levels;

Attachment 8 to Appendix 3 of the LRA prescribes personnel monitoring requirements. Monitoring of an individual's external radiation exposure is required if the external occupational dose is likely to exceed 10 percent of the annual dose limit appropriate for the individual. Potential exposure levels for individuals are evaluated by the radiation protection office staff during the registration and training of radiation workers. Only a small fraction of radiation workers at the MIT facilities enter designated radiation areas and require dosimeter monitoring under 10 CFR 20.1502, "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose." However, individuals who regularly work within the restricted area routinely use a monitoring device.

Personnel working regularly in the facilities are assigned an individual monitoring device to characterize and measure dose received from gamma, beta, and neutron radiation (MIT, 2016c). A National Voluntary Laboratory Accreditation Program certified vendor supplies and processes the devices as required by 10 CFR 20.1501(c). The sensitivity of these dosimeters is as low as 1 mRem for photon radiation to a maximum of 1000 Rem. The range for beta radiation detection is 10 mRem to 1000 Rem. Neutron sensitivity is as low as 10 mRem. Badges are processed on a quarterly basis and provide the dose record. Extremity dosimeters are available if needed. Radiation monitoring is supplemented with pocket ionization chambers to allow the estimation of personnel dose in between badge readouts. Pocket ionization chambers are calibrated periodically and the results are recorded at pre-set levels.

The data obtained from the badges of all radiation workers who are required to be monitored, provides an annual summary of their exposures. All workers are provided bimonthly radiation dosimetry reports that include the annual exposure totals. These reports are sent to the project supervisor for the authorized project. In addition, all radiation workers required to be monitored are requested to complete form RP-59, Radiation Exposure History.

Administrative Control Levels are established in Appendix 3 of the application, Attachment 11, Required Procedures for Radiation Protection at Appendix 7, ALARA Program. Two tiers of control levels are established and occupational exposures are reviewed on a quarterly basis. Investigational levels are based on a cumulative quarterly dose limit. The Level I Quarterly Investigational Level is based on 2.5 percent of the annual regulatory limit. The Level II Quarterly Investigational Level is based on 7.5 percent of the annual regulatory limit. Exposures that exceed the control levels will result in a review of procedures and practices to evaluate the need for a change in conduct.

4) Design and implement a personnel monitoring program, for internal occupational , radiation exposures, based on the requirements of 10 CFR Sections 20.1201, 20.1204, and 20.1502(b), that outlines methods or procedures to do the following:

a. Identify the criteria for worker participation in the program
b. Identify the type of sampling to be used, the frequency of collection and measurement, and the minimum detection levels
c. Specify how worker intakes will be measured, assessed, and recorded
d. Specify how the data will be processed, evaluated, and interpreted
e. Identify the plant's administrative exposure levels or the levels at which actions are taken to investigate the causes of exposures exceeding these levels;

Section 5 of Attachment 3 of the LRA describes the MIT structure for internal monitoring. Bioassay testing can include in-vivo whole body counting for gamma-emitting radiation, urinalysis for beta-emitting radiation, and fecal analysis for alpha-emitting radioactivity. All radiation workers are given baseline, annual, and termination whole body counts, which are conducted by MIT. Bioassay participation is determined during the authorization process review. Records of bioassay performed are maintained by the RPP.

Depending on radiation exposure history and proposed work at MIT, persons registering with the RPP may be given appropriate bioassay tests to determine body burden of radioactive material prior to starting such work at MIT. Monitoring an individual's intake of radioactive material is required if the intake is likely to exceed 0.1 ALI during the year. Evaluation of the individual's potential internal exposure levels are performed during the registration and training of radiation workers by the RPP staff. Radiation workers are required to complete form RP-50 (see attached) which becomes part of their personnel record at the RPP office. At the completion of the RPP training, an evaluation of bioassay needs is performed based upon the radionuclide used, the material amounts, and requested use.

Action Levels for bioassay measurement are:

a. Investigation action levels: Any measurement result that exceeds 5 percent of the ALI initiates an investigation to evaluate the source of the exposure and the means of improving handling techniques. All such investigations will be fully documented.
b. Administrative action levels: Any measurement result that exceeds 25 percent of the ALI would initiate suspension of the work operations until satisfactory control measures are implemented.

5) Design and implement an air sampling program in areas of the plant identified as potential airborne radioactivity areas, to conduct airflow studies and to calibrate and maintain the airborne sampling equipment in accordance with the manufacturer's recommendations;

The effluent air stream in the main building is monitored by gaseous and particulate radiation detectors, as described in Chapter 3.2.3 of the application. In addition, fixed air samplers in the control room and on the main reactor floor produce continuous readouts. The air sampler filters are analyzed weekly. Portable air samplers are used during maintenance activities, and when there is a potential for airborne radioactivity. Filters measure alpha and gross beta-gamma activity: measuring concentrations orders of magnitude less than regulatory limits. Any detectable increase in levels of radioactivity is investigated.

6) Implement additional procedures, as may be required by 10 CFR Part 20 and the ISA Summary, to control the concentration of airborne radioactive material (e.g., control of access, limitation of exposure times to licensed materials, and use of respiratory protection equipment);

   MIT is not required to have an ISA because it is not engaged in activities listed in 10 CFR 70.60. However, MIT employs procedures to control the concentration of airborne radioactive material. Gaseous releases are released through the containment building stack. These effluents first pass through a roughing filter and then a HEPA filter. Surveillance requirements include measuring the system flow rate annually, testing interlocks quarterly and before reactor startup, calibrating building differential pressure monitoring equipment annually, and monitoring filter performance.

7) Conduct a contamination survey program in areas of the facility identified in the ISA Summary most likely to be radiologically contaminated (the program must include the types and frequencies of surveys for various areas of the facility and the action levels and actions to be taken when contamination levels are exceeded);

   As discussed earlier in this SER, MIT is not required to have an ISA. However, they do employ methods to control surface contamination. The surface contamination surveillance program, includes frequency of surveys, tolerance levels, and action levels, shall be conducted in accordance with the license with the Commonwealth of Massachusetts, submitted as Appendix 3 to this application. Specifically, Appendix 3 of the application, Attachments 12, Radiation Survey Technician Training Guide, and 13, Laboratory Designation Guidelines provide the survey requirements. Contamination in excess of action levels require immediate actions to decontaminate the area. Surface contamination surveys using filter paper wipes are conducted daily, weekly or monthly, the frequency depends on the potential for contamination. Surveys are also conducted during or after experiment changes, maintenance activities, and when activities create a potential for surface contamination.

   A hand-and-foot monitor is located at the main personnel lock for the reactor containment building. All personnel leaving the containment at this point or having reason to suspect possible contamination from other sources on person, tools, equipment, etc., are required to use the monitor. Decontamination facilities are located in the same area for use if needed.

8) Implement the facility's corrective action program when the results of personnel monitoring, personnel contamination monitoring, or contamination surveys exceed the applicant's administrative personnel contamination levels;

   MIT is not required to have a formal corrective action program, due to the nature of the limited materials and uses. Chapter 2.8 of the application states that deficiencies identified are reviewed during quarterly administrative update reports and the annual review of radiation protection activities by the RPC. Any deficiencies shall be reported to the appropriate committee with the corrective action taken or recommended. One of the RPO's responsibilities, identified in Attachment 2 to Appendix 3 of the application, is to conduct radiation surveys where indicated and keep records of such surveys, including summaries of corrective measures recommended and/or instituted.

9) Use equipment and instrumentation with sufficient sensitivity for the type or types of radiation being measured and calibrate and maintain equipment and instrumentation in accordance with manufacturers' recommendations or applicable ANSI standards;

MIT possesses a variety of appropriate, portable equipment to support research conducted and to the support RPP. Chapter 3.2.3 of the application states that instrumentation for projects using radioactive materials, other than at the reactor, shall be evaluated by the RPP, approved by the RPC, and specified in the authorization to use radioactive materials. The MIT possesses approximately 250 radiation detection instruments of various types and sensitivity ranges. Radiation survey meters are calibrated annually using NIST traceable sources. Appendix 3 to the application at Attachment 5, RPP Instrumentation identifies the numbers and types of instruments possessed, the method of detection, and calibration frequency. Appendix 3 of the application, at Attachment 6, Survey Instrument Calibration contains MIT's procedure for calibrating the JL Shepherd and Associates Model 81 Beam Calibrator. Attachment 6 also provides the form to certify the calibration.

10) Establish policies to ensure that equipment and materials removed from restricted areas to unrestricted areas are not contaminated above the release levels presented in Appendix A, "Acceptable Surface Contamination Levels," to Regulatory Guide 8.24 (NRC, 2012).

Section 3.2.3 of the application states the release of equipment, facilities, or packages to the unrestricted area or uncontrolled areas onsite shall be in accordance with the attached "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated April 1993. The criteria contained in the Guidelines are consistent with the release levels identified in Regulatory Guide 8.24. The document is part of MIT's Massachusetts Agreement State License.

11) Leak-test all sealed sources consistent with direction provided in Appendix C, "Leak Test Requirements," to Regulatory Guide 8.24 or the applicable regulations for the materials involved (e.g., 10 CFR 31.5(c)(2)) has direction for leak testing of certain byproduct devices);

In Section 3.2.3 of the application, MIT commits to conduct leak tests of sealed plutonium sources identified in the application. Appendices 1 and 2 to the application provide the required procedures for testing sealed sources. Sealed sources will be wipe tested every six months, unless kept in storage. Plate sources will be wipe tested every 3 months. Appendices 1 and 2 to the LRA are consistent with the NRC's position in the Branch Technical Position, "License Condition for Leak-Testing Sealed Plutonium Sources," (NRC, 1993a and NRC, 1993b). Appendix 3 to the application at Attachment 2, Duties and Responsibilities of the Radiation Protection Officer states that the RPO is responsible for the implementation of MIT's RPPs, including the performance of leak tests on all sealed sources, and calibration of radiation survey instruments. Appendix 3 of the application, Attachment 11, Required Procedures for Radiation Protection at Section 4.3.9 states that required radiation protection procedures, including procedures for leak testing and inventory control of sealed sources are administered by the RPP. The RPP is comprised of a staff of health physicists, radiation protection technicians, and administrative support personnel functioning as the operational arm of the RPC. Appendix 3 of the LRA contains MIT's Massachusetts Department of Public Health

(MDPH) Radiation Control Program (RCP) Byproduct Material License. License Condition 19 of the Massachusetts Agreement State License presents MIT's leak test requirements and commitments.

12) Establish and implement an access control program that ensures that (1) signs, labels, and other access controls are properly posted and operative, (2) restricted areas are established to prevent the spread of contamination and are identified with appropriate signs, and (3) step-off pads, change facilities, protective clothing facilities, and personnel-monitoring instruments are provided in sufficient quantities and locations.

    Section 3.2.1 of the application describes access restrictions to the MITR building, where material under License SNM-986 is stored. The reactor containment building and portions of the adjacent building, NW12, are controlled areas. MIT's labs/areas where radioactive materials are used or stored, are also restricted, when the RPC makes this a condition for approval of radioactive material authorizations. All persons with access to controlled areas must register with and be escorted by the RPP or Reactor-RPP, or an equivalent official.

    All personnel, packages and equipment leaving the reactor building shall be monitored for residual activity and/or contamination. Additional controlled areas shall be established as required by either the MIT-RPO or the MITR-RPO. All controlled areas where material under this license is possessed shall be posted with appropriate caution signs. Protective clothing (laboratory coats, coveralls, booties, caps and/or gloves) would be used when there is a potential for contamination, as specified by the RPP in the authorization. A change facility and shower is available within the reactor restricted area.

13) Establish a radiation reporting program consistent with the requirements of 10 CFR Parts 19 and 20.

    Section 2.9 of the LRA, provides the administrative procedures for the investigation and reporting of occurrences. MIT is required to maintain a reactor console log and enter all reactor alarms and unusual conditions involving licensed materials when in use on the reactor. The Agreement State Byproduct Material license and the MDPH RCP regulations, Title 105 Code of Massachusetts Regulations Part 120, require the RPO be notified by the dosimeter processor of external exposures exceeding regulatory limits, of any internal exposures, and any accidental releases. The NRC's regulations at 10 CFR Parts 19, 20, 21, 30, 40, 50, 70, 71, and 73 require that reports of these events be made to the NRC.

The Application for Authorization to Possess and Use Radioactive Materials form (LRA, Appendix 3, Attachment 7), requires a description of the purpose and parameters of proposed activities and it must be completed by MIT staff prior to beginning work with licensed materials. The completed form must be reviewed and approved by the RPC to ensure that radiation survey and monitoring programs are followed. The RPC's approval is conditioned upon the use, storage and disposal of the radioactive material in conformity with requirements set out in MIT's Required Procedures for Radiation Protection (Appendix 3, Attachment 11). The MIT LRA does not propose any significant changes to the radiation survey and monitoring programs, which have been successfully implemented for many years. Based on the staff's evaluation of MIT's commitments to follow the acceptance criteria in Section 4.4.7.3 of NUREG-1520 (NRC, 2015), the staff finds application provides reasonable assurance that the proposed equipment and

procedures to be used in the radiation survey and monitoring programs will continue to adequately protect health and minimize danger to life and property as required by 10 CFR 70.23(a)(3) and (a)(4). Therefore, the NRC staff finds that these programs are acceptable.

4.2.8 Control of Radiological Risk Resulting From Accidents

Paragraph 70.22(a)(8) of 10 CFR states that each application for a license shall contain proposed procedures to protect health and minimize danger to life or property, including procedures to avoid accidental criticality, procedures for personnel monitoring and waste disposal, post-criticality accident emergency procedures. The staff assessed the applicant's program commitments against the acceptance criteria in NUREG-1520, Section 4.4.8.3 (NRC, 2015). The following discussion identifies the acceptance criteria from NUREG-1520 and summarizes the staff's assessment of whether the information in the LRA is consistent with the criteria.

MIT's possession and use license does not authorize the applicant to possess the types and quantities of materials specified in 10 CFR 70.22(i)(1)(i and ii), for this reason, the applicant is not required to have a separate emergency plan. However, MIT developed and implements an emergency plan for the research reactor, and that plan takes into account the materials authorized under License SNM-986. Chapter 8 of the application states that activities under License SNM-986 are addressed in, "Emergency Plan for the MIT Research Reactor", Appendix 13A of the "Safety Analysis Report for the MIT Research Reactor (MITR-II)", Report No. MITNE-115, as amended (MIT, 2013b). In addition, MIT limits the amount of SNM that is possessed outside of the reactor area to sub-critical amounts. For material contained outside of the reactor area, the applicant has an emergency procedure in place to be followed in the event of accidents involving radioactive contamination or exposure of personnel. The reactor emergency plan, together with existing written procedures for building evacuation, fuel vault criticality, medical emergency, fire, riot, hurricane and earthquake, apply to emergencies involving License SNM-986 materials within the reactor restricted area.

4.2.9 Additional Program Requirements

Each licensee shall maintain records of the RPP, including the provisions of the program, survey records, audits and other records identified in Subpart L of 10 CFR Part 20. Each licensee shall make reports and notifications, including theft or loss, notification of incidents, and other reports as required by Subpart M of 10 CFR Part 20. The staff reviewed the applicant's additional program commitments against the acceptance criteria in NUREG-1520, Section 4.4.9.3 (NRC, 2015). The following discussion identifies each acceptance criterion from NUREG-1520 and summarizes the staff's assessment of whether the information provided in the application meets the criterion.

1) Maintain records of the RP program (including program provisions, audits, and reviews of the program content and implementation), radiation survey results (air sampling, bioassays, external-exposure data from monitoring of individuals, internal intakes of radioactive material), and results of its corrective action program referrals, RWPs, and planned special exposures;

   Section 2.10 of the application states that MIT will maintain records appropriate to radiation protection activities, occupational exposure of personnel to radiation, releases of radioactive materials to the environment, staff training, instrument calibrations, safety review committee meetings, and other pertinent activities in such a manner as to

demonstrate compliance with NRC license conditions and regulations. Table I.2-1 of the application lists relevant RP records and indicating retention periods. Records associated with ALARA findings, employee training, personnel radiation exposures, and environmental activities will be generated and retained in such a manner as to comply with the relevant requirements of 10 CFR Part 20.

2) Establish a program to report to the NRC, within the time specified in regulations, incidents specified in 10 CFR 20.2202, "Notifications of Incidents," and safety significant specified in 10 CFR 70.74. Refer reportable events to the facility's corrective action program and report to the NRC both the corrective action(s) taken (or planned) to protect against a recurrence and any proposed schedule to achieve compliance with applicable license conditions;

   In section 2.9 of the application, MIT commits to notifying the NRC of events involving radiation or radioactive materials in accordance with 10 CFR 20.2201, 2202, 2203, and 10 CFR 70.50. Reports will be made to the Headquarters Operations Center and pertinent local or state agencies.

3) Prepare and submit to the NRC an annual report required by 10 CFR 20.2206(b).

   Appendix 3 of the LRA, at Attachment 2, Duties and Responsibilities of the Radiation Protection Officer states the RPO's responsibility to ensure that MIT's staff and investigators are monitored for exposures and that exposures are reported to the appropriate governmental authority. Appendix 3 to the LRA, at Attachment 8, External Exposures states that currently 100 percent of personnel monitored are required either by license condition or convenience badging to monitor all exposure levels. All radiation workers who are monitored are provided an annual summary of their exposure reports. All workers are provided bimonthly radiation dosimetry reports which include the annual exposure totals. These reports are sent to the project supervisor for the authorized project.

4) Refer to the facility's corrective action program any incident that results in an occupational exposure to radiation that exceeds the dose limits in Appendix B to10 CFR Part 20 or in 10 CFR 70.74, and report to the NRC both the corrective action taken (or planned) to protect against a recurrence and the proposed schedule to achieve compliance with the applicable license condition or conditions.

   MIT is not required to have a formal Corrective Action Plan. However, the RPC takes an active role in compliance and safety, reviewing staff and researcher exposures on a quarterly basis to ensure recorded doses are consistent with the authorizations submitted, as recommended in Regulatory Guide 3.75 (NRC, 2014a).

The MIT LRA does not propose any significant changes to the recordkeeping and reporting commitments discussed in section 4.8.2 of its application. Based on the staff's evaluation of the application and MIT's commitments to follow to the acceptance criteria in Section 4.4.8.3 of NUREG-1520 (NRC, 2015), the staff finds the application provides reasonable assurance that MIT will comply with the requirements in 10 CFR Sections 20.2202, 20.2206 and 70.74. Therefore, the NRC staff finds that these program commitments are acceptable.

4.3 Evaluation Findings

The applicant has committed to an acceptable RPP that includes the following:

- an effective, documented program to ensure that occupational radiological exposures are ALARA

    - an organization with adequate qualification requirements for the radiation protection personnel;

    - approved, written radiation protection procedures and RWPs for radiation protection activities radiation protection training for all personnel who have access to restricted areas;

    - radiation protection training for all personnel who have access to restricted areas;

    - a program to control airborne concentrations of radioactive material with engineering controls and respiratory protection;

    - a radiation survey and monitoring program that includes requirements for controlling radiological contamination within the facility and monitoring of external and internal radiation exposures; and

    - other programs to maintain records; report to the NRC in accordance with 10 CFR Part 20 and 10 CFR Part 70; and appropriately respond to, investigate, and prevent incidents and accidents involving radiological exposures or uncontrolled releases of radioactive material.

The NRC staff concludes there is reasonable assurance that during the renewed license term the applicant's RPP will meet the applicable requirements of 10 CFR Parts 19, 20, and 70 as discussed in Section 4.2 above.

5.0 Nuclear Criticality Safety

5.1 Purpose of Review

The purpose of this review was to determine whether MIT's Nuclear Criticality Safety (NCS) Program is adequate to support safe operation of the facility, as required by 10 CFR Part 70. The NCS programmatic review determined that the applicant's NCS Program is adequate to meet the applicable regulatory requirements of 10 CFR Part 70, and provides reasonable assurance that licensed activities will be conducted safely and will be subcritical under both normal and credible abnormal conditions.

5.2 Staff Review and Analysis

The staff conducted its review in accordance with the applicable acceptance criteria in Chapter 5, "Nuclear Criticality Safety," of NUREG-1520, Rev. 2 (NRC, 2015). NUREG-1520 is the Standard Review Plan for fuel cycle facilities licensed under 10 CFR Part 70. The staff recognizes that because MIT is not a fuel cycle facility, not all regulatory requirements and program elements discussed in Chapter 5 of NUREG-1520 apply. For example, compliance

with Subpart H of 10 CFR Part 70 is not required. The applicable acceptance criteria are discussed below.

5.2.1 Authorized Possession and Use of Special Nuclear Material

The total quantity of SNM authorized for possession and use is given in Table 1, Possession Limits under License SNM-986 in Chapter 1 of the LRA. This material is limited to kg of Uranium-235 (^{235}U) enriched to no more than 2 wt% ^{235}U (or kg U), in the form of solid metal or oxide fuel pellets, slugs, foils, etc. Of that amount, no more than kg can be unclad and no more than kg can be clad metal, or oxide in forms other than pellets in fuel rods. The remaining kg ^{235}U is in the form of pellets in clad uranium dioxide (UO_2) fuel rods. This quantity (see Items A, B, and C in LRA Table 1) exceeds the minimum critical mass of kg ^{235}U for a metal-water lattice in American National Standards Institute/American Nuclear Society 8.1 (ANSI/ANS, 1998)). However, criticality under those conditions would require optimum conditions (full flooding, full reflection, optimum pitch) and those conditions are atypical at MIT. In addition to this low-enriched material, MIT's license also authorizes up to 350 g ^{235}U enriched up to 93 wt% ^{235}U (see Item D, Table 1). This higher-enriched material is less than a minimum critical mass. Other materials authorized listed in LRA Table 1 include less than a minimum critical mass of plutonium and ^{233}U (see Items E – G and K). Natural and depleted uranium are also present, but these do not constitute a criticality concern.

While the total quantity of material authorized for possession exceeds a minimum critical mass, the vast majority of this material is solid fuel enriched to less than 2 wt% ^{235}U (see Items A, B, and C of Table 1). All of this material, consisting of kg ^{235}U, has been designated in the LRA as for "storage only" in the BTF Vault in the NRL (see Table 3 in Chapter 1 of the LRA). MIT has further committed that it will not handle more than effective kg of SNM at any location outside the MITR, other than sealed sources. In addition, MIT will store no more than the threshold quantities of SNM in 10 CFR 70.24(a) outside the BTF Vault. As stated in LRA Section 4.1.1, material stored under the reactor license will be stored separately and not intermingled with SNM listed in LRA Table 1. The staff's review of the applicant's calculation for storage of SNM in the vault is discussed in Section 5.2.8.2 of this SER.

Based on these commitments, the types and quantities of material being handled, and the limited nature of licensed activities, the staff determined that the risk of inadvertent criticality is very low and only certain aspects of an NCS Program as described in Chapter 5 of NUREG-1520 are applicable, as discussed in the following sections.

5.2.2 Use of Industry Standards

The acceptance criteria in Section 5.4.3.1.1 of NUREG-1520 state that if an applicant requests permission to conduct activities to which NRC-endorsed standards apply, the applicant should commit to follow the requirements ("shall" statements) of the standard, as modified by Regulatory Guide 3.71 (NRC, 2010b), or justify an alternative.

In LRA Section 4.1.1, MIT committed to performing a criticality code validation consistent with industry standards and committed to follow ANSI/ANS 8.1 (ANSI/ANS, 1998a), 8.7 (ANSI/ANS, 1998b), and 8.24 (ANSI/ANS, 2007a). MIT's commitment is consistent with the acceptance criteria and therefore, is acceptable to the staff.

5.2.3 Criticality Accident Alarm Systems (CAAS)

The acceptance criteria in Section 5.4.3.1.2 of NUREG-1520 provide guidance on meeting the requirements of 10 CFR 70.24(a), which concern Criticality Accident Alarm Systems (CAAS) placement, detection threshold, and detector coverage. The LRA Section 1.7.7 states that the BTF Vault is the only place where materials in excess of the threshold quantities in 10 CFR 70.24(a) are stored, and it is equipped with a permanently-installed CAAS. The LRA Section 3.2.3 states that a criticality monitor will be located in the BTF vault whenever the quantities in 10 CFR 70.24(a) are exceeded. Because all of the material is designated as storage only, in practice a sufficient quantity of material is always present, and because Section 1.7.7 is the more restrictive commitment, it is the NRC's expectation that the CAAS will always be maintained. The staff notes that Section 3.2.3 of the LRA also states that SNM may be combined with reactor fuel in the basement of the reactor building; and when the quantities exceed those in 10 CFR 70.24(a), a CAAS shall be installed there as well. However, the reactor is outside the scope of the Part 70 license.

The LRA Section 3.2.3 states that the trip point is set consistent with the values in 10 CFR 70.24(a), and includes a low-level alarm to automatically detect system failure. In the event of system failure, all activities involving licensed materials that could affect reactivity will be halted until repairs are made. The applicant also commits to perform calibrations and alarm checks in accordance with written procedures.

Section 5.4.3.1.2 of NUREG-1520 states that the applicant should commit to follow the current endorsed version of ANSI/ANS 8.3 (ANSI/ANS, 1997), and should describe the type of radiation detector, the dose threshold and minimum accident of concern, detector logic, method for determining the radius of coverage and alarm placement, and maintenance and calibration actions. In addition, the alarm system should be resistant to damage due to anticipated events, including being equipped with emergency power or provide for continuous monitoring with portable instruments. In LRA Section 4.1.1, the applicant commits to following ANSI/ANS 8.3 (ANSI/ANS, 1997), and will perform calibration and testing in accordance with its written procedures (MIT, 2017c). The applicant has not provided specific details regarding the design and operation of its CAAS. However, quantities of SNM that exceed the 10 CFR 70.24(a) values are restricted to the small BTF Vault. Fuel cycle facilities normally consist of many processes spread out over large areas, so that detector and alarm placement must be carefully evaluated to account for any intervening shielding and ensure adequate coverage. This is not the case for the BTF Vault, which is heavily shielded and only occupies a 20' X 20' space (MIT, 2016c). Further, the risk of criticality, as discussed in Section 5.2.8.2 of this SER is very low. For these reasons, the staff considers the applicant's commitments with regard to CAAS acceptable.

5.2.4 Emergency Planning and Response

The acceptance criteria in Section 5.4.3.1.3 of NUREG-1520 state that the licensee should commit to follow ANSI/ANS-8.23 (ANSI/ANS, 2007b), should have an emergency plan or satisfy the alternative requirements in 10 CFR 70.22(i)(1)(i), should provide for personnel accident dosimeters in areas covered by the CAAS, and should provide for decontamination and medical treatment of exposed individuals.

The requirement for having a CAAS means a licensee should make provisions for responding to a criticality accident in emergency planning, including evacuation and recovery, as discussed in 10 CFR 70.24(a)(3) and (b). However, MIT is not a fuel cycle facility; the SNM at MIT is located

on a campus situated in a densely populated urban area. Thus, while the risk of criticality is low, a potential exists for exposing workers and members of the public to lethal doses of radiation should it occur. As discussed in LRA Chapter 8, the applicant's reactor emergency plan includes activities under its Part 70 license. The BTF Vault is located in the reactor building, and therefore is covered by emergency procedures for bounding radiation accidents associated with the reactor itself. Section 4.2.8 provides more detailed discussion of Control of Radiological Risk and the documents MIT has provided as the basis of MIT Emergency Response.

5.2.5 Subcriticality and Double Contingency Principle

The acceptance criteria in Section 5.4.3.1.4 or NUREG-1520 describe acceptable methods for demonstrating subcriticality under normal and credible abnormal conditions, and for complying with the double contingency principle (DCP). The applicant's evaluation for the BTF Vault (MIT, 2017d) is based on the widely-accepted Monte Carlo criticality code MCNP4 (Monte Carlo N-Particle), consistent with method (d) of that section. Staff's review of this evaluation and the validation of its methods is provided in SER Section 5.2.8.2.

In Section 4.1.1 of the LRA, MIT commits that storage and experiments with be in accordance with the DCP. The applicant further commits to follow ANSI/ANS-8.1 (ANSI/ANS, 1998a), which requires that before a new operation is started, or an existing operation changed, it shall be determined to be subcritical under normal and credible abnormal conditions, and recommends compliance with the DCP. Therefore, MIT's commitments to ensure subcriticality and comply with the DCP are acceptable to the staff. The staff's review of the BTF Vault analysis below demonstrated compliance with these fundamental principles.

5.2.6 Organization and Administration of NCS Program

The acceptance criteria in Section 5.4.3.1.5 of NUREG-1520 states that the licensee should implement an NCS Program to prevent criticality and protect against its consequences. An NCS Program should include performing and documenting criticality evaluations, establishing controls to ensure criticality and comply with the DCP, maintaining a CAAS and emergency procedures, providing technical support to emergency responders, applying NCS management measures (audits and assessments, peer review, validation, training, procedures), and complying with regulatory requirements regarding event reporting and change control. The description of the program should be consistent with industry practices (ANS-8 standards) and should specify roles and responsibilities, qualifications of personnel, and should be independent of operations to the extent practical.

Because the operations involving SNM at MIT are limited mainly to storage in the BTF Vault, MIT does not require a fully developed NCS Program, which is typically found at a fuel cycle facility. MIT's organization chart is located in Appendix 6 of the LRA. The duties described in Section 5.4.3.1.5 of NUREG-1520 are performed by a Criticality Officer (CO) at MIT, rather than by NCS staff since MIT is not a fuel cycle facility, as stated in Section 2.2 of the LRA. The CO reports to the Director of Reactor Operations, as described in LRA Sections 4.1.2 and 2.2, and Chapter 11, "Organization and Personnel." An Accountability Officer is responsible for ensuring that quantities of SNM do not exceed the amounts in 10 CFR 70.24(a), except within the reactor restricted area. The required qualifications for these officials are specified in LRA Sections 2.5 and 4.1.2. A CO is required to have a college degree in the physical sciences or engineering and at least three years nuclear safety experience, including at least one year in NCS. This is consistent with industry practice and is therefore acceptable to the staff. In LRA Section 2.3,

MIT committed to having at least one member on the Reactor Safeguards Committee (RSC) that meets the same qualifications of the CO.

As stated in LRA Sections 2.3, 2.7.1, and 4.1.3, the criticality review process, which shall include the participation of the CO, shall apply to the handling and storage of more than 350 g ^{235}U or 175 g Pu, or shipment of more than 15 g ^{235}U and/or Pu. The RSC is responsible for safety reviews, including criticality safety, of all materials used under MIT's license when the material is used on the reactor or when its use or storage within the reactor restricted area. Most SNM will be stored within the reactor restricted area, with quantities outside the restricted area limited to less than the amounts in 10 CFR 70.24(a). Therefore, these materials do not pose a criticality hazard. Almost all of the SNM is stored within the restricted area and all is subject to oversight by the RSC. In addition to the CO, at least one individual must be qualified in NCS and must be involved in evaluating operational changes that could affect criticality safety of licensed material. Section 4.1.2 places all SNM within the restricted area under the authority of the CO, and states that in the event of a disagreement with a Research Project Supervisor, the more conservative guidance will be followed. The RSC (or RPC, as appropriate) will decide on any appeals arising from such a dispute.

The staff finds the duties of MIT's CO and other personnel with nuclear criticality safety responsibilities to be consistent with standard industry practice. The staff also finds the qualifications of the personnel to be commensurate with their duties. The authority of the CO over research operations in safety matters involving SNM, and MIT's organizational structure, having the CO report to the Director of Reactor Operations and to be subject to RCS oversight, provides for an acceptable level of independence and peer review. Therefore, the organization and administration of the NCS Program is acceptable to the staff.

5.2.7 Management Measures Applied to NCS

The acceptance criteria in Section 5.4.3.1.6 of NUREG-1520 pertain to the performance of training and audits of assessments to ensure NCS. While management measures aren't required doe MIT, individuals involved with SNM handling and storage activities within the reactor restricted area will receive training in NCS, as stated in LRA Section 2.6. Training and qualification of the CO and individuals having responsibility for NCS are discussed in SER Section 5.2.6 above. All individuals in the restricted area will be given emergency response training, including annual evacuation drills.

The LRA Section 2.8 states that an inspection to ensure labeling, posting, and criticality requirements are met will be conducted annually during the physical inventory. In addition, quarterly audits by the Director of Reactor Operations and/or Reactor Superintendent will focus on criticality safety. The BTF Vault is double locked and access controlled. The SNM may not be removed from the Vault without approval of the RPO, Accountability Officer, and CO, and must be logged upon removal or replacement. These MC&A measures described in LRA Section 2.9 ensure that material may not be easily moved around in Vault, and their configuration is unlikely to be changed between inspections and quarterly audits. Therefore, the inspections and audits described in LRA Section 2.8 are sufficient to provide for NCS over licensed material.

5.2.8 Technical Practices for NCS

The acceptance criteria in Section 5.4.3.1.7 of NUREG-1520 provide guidance for the technical practices used in performing criticality evaluations, including the use of assumptions, validation,

and modeling and control of individual parameters, to ensure subcriticality with an appropriate margin of subcriticality. The applicant has committed to the guidance in NUREG-1520 related to technical practices as discussed in the sections below.

5.2.8.1 Calculational Method Validation

Section 5.4.3.1.7.1 of NUREG-1520 contains acceptance criteria related to the validation of calculational methods for NCS, including a summary description of the validation process as well as commitments to perform validation in accordance with ANSI/ANS 8.24 (ANSI/ANS, 2007a) and standard industry practices. The applicant commits to perform criticality validation in accordance with industry standards and the acceptance criteria in this section of NUREG-1520, in LRA Section 4.1.1. Moreover, the applicant commits to follow ANSI/ANS 8.24 (ANSI/ANS, 2007a).

In response to RAIs (MIT, 2016c), the applicant acknowledged that it did not have a validation report for the MCNP5 criticality code used to perform the calculations in its evaluation of the BTF Vault (MIT, 2017d). The applicant responded that its calculated k_{eff} values were extremely low, not exceeding 0.5. The staff agrees that the subcritical margins in the Vault calculations are unusually large, and provide for reasonable assurance that SNM storage configurations determined to be subcritical will be subcritical within an acceptable margin of subcriticality for safety. The staff also notes the applicant's authorized maximum k_{eff} limit is 0.90, as stated in the MITR-II Technical Specifications (NRC, 2010a). Even though MIT demonstrated a very large subcritical margin, the NRC staff asked for and received assurance that calculated results conform to reality (MIT, 2016e). As indicated in NUREG-1520, Appendix 5-B, a more thorough and rigorous validation may be appropriate to justify a smaller margin of subcriticality. In response to the RAI 5.6, MIT committed to perform a criticality code validation that is consistent with industry standards (MIT 2016b).

In addition, while computer codes such as MCNP are used extensively throughout the nuclear industry, individual users should validate their computer code systems (defined in ANSI/ANS 8.24 (ANSI/ANS, 2007) to include the calculational method, hardware, and software needed to perform calculations) for their individual hardware and software platform, and the specific range of parameters needed to model their systems. Nuclear data, computer processors, and operating systems continually change. The Evaluated Nuclear Data File (ENDF)/B-VII.0 cross section library was released by the Cross Section Evaluation Working Group (CSEWG) in 2006, and the MCNP5-1.60 code package in 2010. In addition, calculational biases in general vary with continuous parameters such as enrichment, the fuel-to-moderator ratio, and the neutron energy spectrum, and for different physical forms, neutron absorbing materials, and so forth. For this reason, validation is deemed necessary to provide reasonable assurance of subcriticality even with large margins or long-accepted codes.

In LRA Section 4.1.3, the applicant committed to request an amendment of its SNM license prior to changing the configuration of safety limits for stored SNM. The applicant also committed to provide a validation report if such changes are made. Staff does not have a concern with the specific calculations modeled for the BTF Vault, which are discussed in the following section, but only with future calculations that are authorized to be performed up to a k_{eff} limit of 0.90. The applicant's commitment therefore provides reasonable assurance of subcriticality because 10 CFR 70.22(a)(8) is met.

5.2.8.2 Criticality Safety Evaluations

Section 5.4.3.1.7.2 of NUREG-1520 contains acceptance criteria related to the performance and documentation of criticality safety evaluations. In accordance with this guidance, activities involving SNM within the restricted area of the reactor site and shipping of more than 15 g ^{235}U and/or Plutonium (Pu) will be subject to criticality review by the NRC staff. The LRA Section 4.1.3 states that criticality reviews will be performed and documented in accordance with administrative procedures in Section 2.7.1. MIT further commits that these reviews will be subject to document control (MIT, 2017c).

The staff reviewed the applicant's criticality safety evaluation for the storage of SNM in the BTF Vault (MIT, 2017c) to verify the adequacy of its commitments. The evaluation provides the basis for the subcritical limits reported in LRA Table 4-1. The evaluation describes the fuel and storage locations in the Vault. The fuel contains clad uranium dioxide fuel rods with a maximum enrichment of   wt% ^{235}U, although the average enrichment is much closer to 1 wt% ^{235}U. The fuel storage rack consists of a 6×5 array of blocks roughly 18 inches square. Each block contains a fuel storage box in the lower-left corner. The fuel boxes are small, they take up about 10% of the space of the blocks and are capable of holding up to   fuel rods. However, the blocks are limited to 100 rods each. As stated in Section 5.2.7 of this SER, the fuel boxes are double-locked and access controlled, so material is not inadvertently moved in and out of the storage array. Under normal conditions the storage array is dry; this modeled configuration is highly subcritical due to the low enrichment, the geometry, and the spacing of the storage array. The applicant's evaluation considered the full spectrum of water densities to ensure it remained subcritical under optimum interspersed moderation. In addition, the staff notes that the storage rack consists of a steel and free-draining, wire mesh frame, which makes flooding extremely unlikely. The MIT campus sits on the north side of the Charles River on high ground above the 500-year flood plain.

The applicant modeled the storage rack using the MCNP5-1.60 criticality code developed at Los Alamos National Laboratory and described in the ENDF/B-VII.0 cross section library. Validation of this code is discussed in Section 5.2.8.1 of this SER. The applicant's model limits the fuel boxes to   rods each, varying the pitch between rods to determine the optimal amount of interspersed moderation. The rack model consists of a 5×4 array of blocks, each with a fuel box of   rods, for a total of   rods. This model bounds the total inventory of fuel in storage (consisting of rods and other forms). The applicant assumed conservative geometric tolerances for the fuel rod and rack dimensions. However, the calculations did not consider structural materials, e.g., the steel racks. Thick concrete was modeled around two sides of the array and water reflectors placed on the other sides. The applicant performed parametric studies, varying the interspersed water density, rod pitch, and enrichment. The water density was varied from 0 to 1 g/cc (dry to fully flooded conditions), and the optimum found to be at a density of 0.12 g/cc. The pitch was increased from the minimum (representing a tightly-packed rectangular rod array) to nearly the maximum allowed by the dimensions of the fuel box. The enrichment was increased from the average up to the maximum of 2 wt% ^{235}U. In all cases, the calculated value of k_{eff} remained highly subcritical, below 0.5.

As stated above, MIT modeled a 5×4 array of blocks for its normal case and parametric studies to determine optimum interspersed moderator, optimum pitch, and sensitivity to enrichment. Its criticality evaluation also modeled a 6×5 array to demonstrate that a reduced size array did not have a significant effect on system k_{eff}. Due to the small size of the fuel boxes and 18-inch spacing between blocks, the boxes are neutronically isolated from each other. The staff observed that for loosely coupled arrays, the optimum interspersed water density normally

occurred at full water density, and that a peak at low density indicated significant neutron interaction between units. The applicant stated that the peak at a water density of 0.12 g/cc was attributable to the neutron interaction between fuel rods, rather than between fuel boxes. By reducing the size of the array to 5×4, it modeled the actual fuel inventory in a more compact configuration.

Staff performed a series of independent calculations to evaluate the applicant's assumptions and calculated results. The calculations consisted of a parametric study to determine the optimum interspersed water density, increased pitch between rods, and reduced spacing between fuel boxes. Staff's bounding model is shown below.

MIT also performed a calculation involving a closely-packed 15×2 array, to simulate the effect of a total structural collapse of the storage rack. This hypothetical scenario is unrealistic and highly conservative considering the tendency of the rods to roll and scatter, rather than remain in a closely packed rectangular array. This model resulted in a calculated k_{eff} of 0.924, which exceeds the license limit of 0.90. However, it would require an inventory substantially greater than that possessed by MIT because it assumed the maximum enrichment of 2 wt% ^{235}U. Based on the modeled enrichment and unrealistic nature of the geometric configuration resulting from a structural collapse of the rack, this is not within the spectrum of credible abnormal conditions that must be demonstrated to be subcritical.

Staff constructed a bounding model using the Standardized Computer Analyses for Licensing Evaluation (SCALE)-6.1 code with the ENDF/B-VII continuous energy cross section library. This provides independent confirmation of the applicant's MCNP5 results. The model, shown below in Figure 1, consisted of a 6×5 fuel box array with the maximum possible fuel rods per storage location. This resulted in a total of fuel rods, which exceeds the actual inventory by a substantial margin. The rods were modeled as UO_2 at full theoretical density, and at the maximum 2 wt% ^{235}U enrichment. The model ignored the rod cladding and instead modeled UO_2 to the outer diameter. The size of the steel frame and wire mesh blocks containing the fuel boxes was reduced from 18 inches to a foot square. Staff performed a parametric study to determine the optimum interspersed water density. As confirmed by the applicant's evaluation, a model in which the pitch between the fuel rods is increased to fill the whole space inside the box is more reactive than a tight-fitting rectangular array. In addition, the more realistic configuration is a triangular-pitched array, which having a smaller void fraction is even more undermoderated than a rectangular-pitched array. Therefore, the optimum-pitch rectangular array is very conservative. With these conservative assumptions including total fuel inventory, enrichment, rod pitch, and array spacing, the maximum calculated k_{eff} was approximately 0.89. While this is just below the regulatory limit of 0.9, it demonstrates a substantial margin of subcriticality. Staff considers the addition of extra rods in each storage location and reduced spacing between fuel boxes to bound credible spacing upsets or the addition of extraneous material to the storage array. Therefore the staff finds the applicant's commitments to criticality evaluation to be adequate.

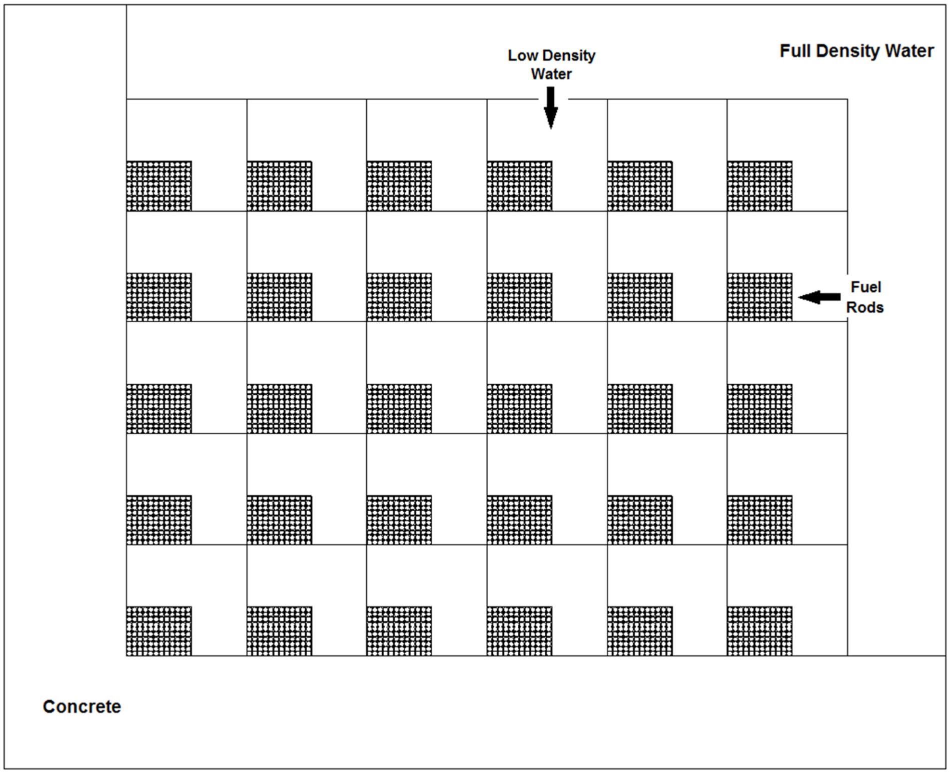

Figure 1. Bounding Model Array for SCALE Analysis

5.2.8.3 Evaluation and Implementation of Controlled Parameters

Section 5.4.3.1.7.3 of NUREG-1520 contains acceptance criteria related to the evaluation and implementation of controlled parameters for criticality safety. The LRA Section 4.1.1 commits to the technical practices described in Section 5.4.3.1.7.3 of NUREG-1520. The staff reviewed the applicant's criticality safety evaluation and determined the implementation of technical practices will provide reasonable assurance of the protection of public health and safety (MIT, 2017d). For these reasons, the staff finds the applicant's commitments to technical practices for criticality safety to be acceptable.

In addition to the commitments related to technical practices, MIT included specific subcritical limits in LRA Section 4.2. The description of the storage vault and spacing limits are bounded by the applicant's criticality evaluation (MIT, 2017c). The LRA Table 4-1, "Storage Limits," contains limits for UO_2 and U-metal rods, in terms of numbers of rods and uranium and ^{235}U mass. Staff checked these numbers for consistency, and noted that the evaluation for the BTF Vault (MIT, 2017d) did not specifically address the safety basis for the storage of uranium metal rods. The applicant stated that the enrichment and diameter of these rods are significantly less than for UO_2 rods, and therefore is bounded by the analysis. Staff agrees, based on the results of its confirmatory analysis using SCALE-6.1 (discussed in Section 5.2.8.2 of this SER).

The LRA Section 4.2.2 states that other forms of SNM may be stored in the Vault provided that it is no more than 350 g ^{235}U per storage location, and separated 12 inches from other material. Mixed oxide Plutonium Dioxide-Uranium Dioxide (PuO_2-UO_2) rods may be stored up to the possession limit of 159 g in a single tray. These are not specifically addressed in the applicant's criticality evaluation, but these masses are much less than the mass of ^{235}U contained in a

single storage location in the applicant's model; the first row of LRA Table 4-1 shows that 100 UO_2 fuel rods enriched to 2 wt% ^{235}U contains 2,061 g ^{235}U. Staff's confirmatory analysis shows that a 6×5 array of such groups of fuel rods is subcritical with optimum interspersed moderation, reflection, and a reduction in both horizontal and vertical spacing of as much as 12 inches. Based on the applicant's and staff's analysis, staff considers the storage of these quantities of material in the Vault—either in a storage location in the rack or in nearby containers—to be acceptable.

LRA Section 5.2.3 states that laboratory solids and solutions containing up to 350 g ^{235}U may be stored under Item D in the possession limit table (Table 1). As noted in Section 5.2.1 of this SER, this is less than a minimum critical mass—even allowing for double batching. Therefore, the staff finds the storage parameters acceptable. The LRA Section 5.2.4 states that shipping of SNM will be conducted under Department of Transportation (DOT) and NRC regulations. Licensed material will be stored in shipping configuration shipping containers certified to meet criticality safety requirements contained in 10 CFR Part 71. Therefore, the staff finds MIT's transportation procedures to be acceptable.

5.2.8.4 Additional NCS Program Commitments

Section 5.4.3.1.8 of NUREG-1520 contains acceptance criteria related to miscellaneous duties of the NCS Program, including audits and assessments, problem identification and corrective action, stop work authority, management measures applied to criticality safety controls, change control process, and event reporting. The applicant's management measures are described in Section 5.2.7 of this SER. The applicant's change review process is described in Section 5.2.6 of this SER is therein deemed acceptable. Furthermore, the applicant committed to changing the configuration of licensed material only with prior NRC approval. Because the scope of MIT's licensed activities is limited—the vast majority of licensed materials being designated for storage only—and the forms and quantities of material being handled and stored under the SNM license, staff considers the applicant's commitments in this area to be adequate.

Staff also reviewed LRA Chapter 15, the NCS portion of Part II of the license that addresses NCS. Chapter 15 contains technical information related to licensed activities, but does not contain commitments. Staff reviewed this information for consistency with the description and limits for licensed activities in LRA Chapter 4 and used it in evaluating the applicant's criticality evaluation. Staff did not identify any issues with the information in LRA Chapter 15.

5.3 Evaluation Findings

Staff reviewed MIT's description of its NCS Program in LRA Chapter 4, the safety demonstration in LRA Chapter 15, and its criticality safety evaluation for the storage of SNM in the BTF Vault. The staff determined the applicant's NCS Program meets the applicable regulatory requirements of 10 CFR Part 70. Based on this review, the staff has reasonable assurance that the NCS Program will ensure subcriticality under normal and credible abnormal conditions and will protect against the consequences of inadvertent criticality.

6.0 Fire Protection

6.1 Purpose of Review

The purpose of this review was to determine, with reasonable assurance, that the applicant designed a facility that provides adequate protection against fires and explosions that could

affect the safety of licensed materials and thus present an increased radiological risk. The review also established that the application considered radiological consequences of fires and instituted suitable safety controls to protect workers, the public, and the environment.

6.2 Staff Review and Analysis

6.2.1 Fire Hazards Analysis

Section 7.4.3.2 of the NRC's Standard Review plan (NRC, 2015) states that a licensee should conduct an fire hazards evaluation for each facility (or part), that if totally consumed by fire, could release special nuclear material in quantity and form that could cause at least an intermediate consequence, as defined in 10 CFR 70.61. The staff finds the quantities of licensed materials possessed by MIT and the activities conducted under MIT's License SNM-986 do not fall within the requirements of 10 CFR 70.61 and thus, a formal fire hazards analysis is not required. In accordance with 10 CFR 70.60, the facility is not required to have an ISA Summary of hazards, including fires. The ISA requirements are found in 10 CFR 70.62(c) and discussed in Chapter 3 of this SER.

6.2.2 Facility Design

As stated in Section 1.5 of the license application (MIT, 2016a) and the RAI responses (MIT, 2016c), the majority of the nuclear material is stored in the restricted area of the Nuclear Reactor Laboratory within the NW12 building. Small amounts of materials are also used at MIT's Cambridge Campus and the Bates Linear Accelerator in Middleton, MA. These MIT buildings are compliant with the Massachusetts Comprehensive Fire Safety Code and the Massachusetts State Building Code.

The NW12 building is constructed of brick. All facilities within the building are in adherence with National Fire Protection Association (NFPA) 45, "Standard on Fire Protection for Laboratories Using Chemicals" (NFPA, 2015) and NFPA 801, "Standard for Fire Protection for Facilities Handling Radioactive Materials" (NFPA, 2014). The building is outfitted with an automatic fire detection and a fire suppression system. The fire suppression system is activated by the fire detection system. The BTF vault is constructed of concrete and contains no combustible materials. All SNM stored within is solid material.

6.2.3 Fire Protection and Detection Systems

In the RAI responses (MIT, 2016c), the applicant states that the fire protection program at MIT is under the supervision of the Committee on Safety and the EHS Safety Office. The NW12 building, where the majority of the materials under License SNM-986 are stored, is outfitted with automatic detection and suppression systems. No fire protection systems are in place for specific laboratory equipment. The building is compliant with NFPA 801 and NFPA codes regarding the inspection, testing, and maintenance of alarm systems.

In the event of an evacuation, signage with evacuation instructions and routes are posted in the restricted areas in the event of a fire emergency.

6.2.4 Training and Emergency Response

In Section 2.6 of the application (MIT, 2016a) and RAI responses (MIT, 2016c), the applicant states that at all MIT facilities under License SNM-986 , workers who have unescorted access

privileges are required to take emergency response, fire extinguisher, and emergency preparedness plan training. They are also required to participate in annual fire evacuation drills.

In the responses to the RAIs (MIT, 2016c), the applicant states that the Cambridge Fire Department (CFD) will respond in the event of a fire. The CFD is well trained in the hazards at the various facilities that house nuclear material and has a hazardous materials response group within the department. MIT works with the CFD to provide training on radiation safety and the proper response to radiation emergencies, with refresher training provided biennial. A joint walkthrough of the Nuclear Reactor Laboratory is performed annually.

6.3 Evaluation Findings

The staff reviewed the fire hazards and facility fire protection, and the fire safety and emergency responses in MIT's application. MIT provided information on potential fire hazards, fire consequences, and required controls, and the staff finds the procedures meet the requirements of 10 CFR 70.22(a)(7) and 70.65(a). The NRC staff also determines that MIT demonstrated compliance with the performance requirements of 10 CFR 70.61 for fire protection, related to postulated accident scenarios. The design proposed by the applicant also satisfies the requirements of 10 CFR 70.64(a), Baseline Design Criterion (3) "Fire Protection," as well as 10 CFR 70.64 (b), defense in depth. MIT is not required to comply with the criteria of 10 CFR 70.64, but the MIT design meets the standard.

7.0 Decommissioning Funding Plan and Financial Assurance

7.1 Purpose of Review

The NRC staff conducted this review to determine, with reasonable assurance, that the applicant will be able to decommission the facility safely and in accordance with NRC regulations. Nuclear facilities licensed under 10 CFR Part 70 are required to comply with financial assurance and recordkeeping requirements in 10 CFR 70.25, "Financial Assurance and Recordkeeping for Decommissioning." In addition, licensees must submit decommissioning plans for NRC approval in accordance with 10 CFR 70.38(g).

7.2 Staff Review and Analysis

Financial assurance and decommissioning funding requirements are found in 0 CFR 70.22(a)(9) and 70.25, which require licensed nuclear facilities to establish financial assurance to cover the estimated costs for site decommissioning, decontamination and reclamation. Paragraph 70.25(a)(2) of 10 CFR requires an applicant for a specific license that authorizes possession and use of unsealed SNM in certain quantities to submit a DFP. Paragraph 70.25(e)(2) of 10 CFR requires a licensee, at the time of license renewal, to resubmit a DFP with adjustments that are necessary to account for any changes to costs or the amount of contamination. The NRC staff reviewed the DFP in accordance with the staff guidance in NUREG-1757, Vol. 3, Rev. 1, Section 4 and Appendix A.3.

7.2.1 Decommissioning Funding Plan

By letter dated February 24, 2016 (MIT, 2016a), MIT submitted a renewal application to NRC for its License SNM-986 (MIT, 2016a). The submission included a DFP in Chapter 7 of the LRA prepared by applicant staff on February 11, 2016. Table 1, Possession Limits under License

SNM-986, in Section 1.3.1 of the LRA identifies the types and quantities of SNM that fall under MIT's a license. The applicant submitted the DFP with its timely LRA.

The NRC staff reviewed the DFP submitted with the LRA. An update to the DFP submittal was submitted to NRC staff by letter dated September 30, 2016 (NRC, 2016b), and was also reviewed by the staff. The NRC staff determined that the types of materials and the quantities of SNM are authorized under its license. Therefore, the NRC staff finds that the applicant meets the requirement of 10 CFR 70.25(a)(2).

7.2.2 Detailed Cost Estimate

Paragraph 70.25(e)(1)(i)-(iv) of 10 CFR requires that the DFP, submitted for review and approval by NRC, contain a detailed cost estimate for decommissioning that reflects: the cost of an independent contractor to perform the work; the cost of meeting the 10 CFR 20.1402 criteria for unrestricted use; the volume of contamination in the onsite subsurface material that will require remediation; an adequate contingency factor; identification and justification for key assumptions used in the cost estimate; a description of the method of assuring funds will be available for decommissioning; and a certification statement by the applicant that financial assurance has been provided in the amount of the cost estimate for decommissioning.

The cost estimate includes: a description of the facility where the SNM and source materials are used and stored; types and quantities of material; a description of how the materials are used; quantities of materials or waste accumulated prior to shipping or disposal; number and dimensions of facility components; labor costs for planning and preparation of the facility for decommissioning of the radioactive facility; final surveys; packaging, shipping, and disposal of radioactive wastes; equipment and supplies; and NRC oversight costs.

The applicant's submittal states that MIT's operations plans and cost estimates are based upon meeting the release limit of 10 CFR 20.1402. Section 20.1402 states a, "site will be considered acceptable for unrestricted use if residual radioactivity that is distinguishable from background radiation results in a TEDE [total effective dose equivalent] to an average member of the critical group that does not exceed 25 mRem per year." Because licensed activities under License SNM-986 activities are conducted in spaces and facilities also subject to NRC License R-37 and Massachusetts License Number 60-0094, MIT states that decommissioning will involve more than SNM. The return of these facilities to unrestricted use will also be subject to the decontamination and restoration requirements of these additional licenses (NRC, 2010a, NRC, 2014c, and MIT, 2016a).

The applicant's submission does not include any volume of onsite subsurface material containing residual radioactivity that will require remediation. The applicant's submission states that "there is no current residual fixed contamination of SNM or source material in any of MIT's facilities." The applicant notes that this is due to proper controls in the uses of unsealed materials and the fact that other materials are in a solid metal or contained/sealed form. The applicant's submittal includes a 25 percent contingency factor that was added to the total decommissioning cost estimate. The submission does not state that any credit was taken for salvage value. MIT's current total decommissioning cost estimate is $340,000. The total cost is based on current dollars, at the time of submission.

In the cost estimate, the applicant assumes that the Department of Energy (DOE) will remove all sources that are DOE-owned from the site. This means that 98 percent of the enriched uranium and all of the natural uranium material currently controlled by MIT under SNM-986 is owned by

DOE; the remaining 2 percent is owned by MIT. The applicant states that no license amendments are anticipated during decommissioning and that shipment of radioactive waste is possible. The cost estimate assumes that one year of generated waste is currently awaiting disposal. With the addition of decommissioning waste, the total amount of rad waste will be slightly higher. Because all current materials are sealed or contained sources, no significant amount of waste is expected to be produced.

In addition, MIT does not anticipate the need to restore contaminated areas on its facility grounds because radioactive materials will not cause external contamination. Furthermore, future contamination is not expected from routine licensed uses. MIT has not identified areas that will require site stabilization or long term surveillance, and none are expected. Labor rates for the various activities are based upon rates from the Health Physics Society Salary Survey, Bureau of Labor Statistics, and General Services Administration.

In the submittal MIT commits to continue to maintain a surety amount of $1,125,000, which is $785,000 more that the current estimated costs of decommissioning and restoration. Furthermore, the difference between the cost estimate and surety amount provides a significant buffer against unforeseen events, including spills. The applicant does not anticipate that the cost of decommissioning and restoration will exceed the surety amount at the next renewal in ten years. In addition, 10 CFR 70.25(e)(2) requires that MIT submit an updated DFP every three years and at license renewal to account for future inventories, contamination, and changes in costs. Finally, the applicant adjusts costs for inflation and scales up to adjust for SNM decommissioning and final site survey.

By submittal dated September 30, 2015 (MIT, 2015), MIT submitted the annual financial test, a certification statement signed by its Executive Vice President and Treasurer stating the $1,125,000 certified amount of financial assurance is provided through a self-guarantee agreement, and the name of the facility, its location, and license number. The NRC previously approved the annual financial test submission that included the certification statement (NRC, 2016e).

The NRC staff has reviewed MIT's cost estimate and determined the estimate:

1) reflects the costs to carry out all required decommissioning activities prior to license termination; assumes costs for an independent third party contractor;
2) includes the costs of meeting the 10 CFR 20.1402 criteria for unrestricted use;
3) includes a statement that there is no onsite subsurface material containing residual radioactivity that will require remediation;
4) includes an contingency factor of 25 percent; identifies and justifies key assumptions;
5) describes the methods of assuring funds through its cost estimate adjustments; and
6) includes the previously submitted and approved certification statement that financial assurance has been provided in the amount of the cost estimate.

Therefore, the NRC has determined that the applicant meets the requirements of 10 CFR 70.25(e)(1)(i)-(iv).

7.2.3 Financial Assurance Mechanism

Paragraph 70.25(e)(1)(v) of 10 CFR requires that the DFP include a signed original, or, if allowed, a copy, of the financial instrument to be used to cover the decommissioning costs. In

addition, 10 CFR 70.25(f)(2)(ii) requires that a standby trust agreement be established to receive funds from a surety method such as insurance if such a mechanism is used.

By letter dated May 11, 2010 (ML101340587), the applicant submitted its financial assurance mechanism in the form of a signed original self-guarantee agreement. The wording of the agreement is consistent with the model wording in Appendix A of NUREG-1757, Vol. 3, Rev. 1 (NRC, 2012). The amount of financial assurance provided in the self-guarantee agreement is $1,125,000 which is well above the cost estimate amount and remains the applicant's current certified amount of financial assurance. In addition, by letter dated April 10, 2014, the applicant submitted its signed original standby trust agreement. The standby trust agreement is consistent with NUREG-1757, Vol. 3, Rev. 1, Appendix A.12.4.

7.3 Evaluation Findings

The NRC staff has reviewed the self-guarantee agreement and the standby trust agreement. Based on this review, the NRC staff has determined that the financial assurance mechanisms submitted by the applicant are adequate to ensure that sufficient funds will be available to carry out all required decommissioning activities prior to license termination, and therefore, meets the requirements in 10 CFR 70.25(e)(1)(v) and 70.25 (f)(2)(ii).

8.0 Chemical Process Safety

8.1 Purpose of Review

The NRC staff conducted the chemical process safety review to ensure that the applicant will adequately protect workers, the public, and the environment from chemical hazards of licensed material and hazardous chemicals produced from licensed material. The applicant must also protect against facility conditions or operator actions that could affect the safety of licensed materials and thus present an increased radiological risk. This section discusses the evaluation of the MIT program for identifying and managing chemical hazards that could arise from the activities it will conduct under License SNM-986. This review applies the requirements for approval of applications identified in 10 CFR 70.23 with a focus on those elements which facilitate the identification and management of the chemical hazards for activities that will be conducted under SNM-986.

8.2 Staff Review and Analysis

The NRC staff examined the renewal application (MIT, 2016a) and responses to RAIs (MIT, 2016c). The regulatory basis for this review is found in 10 CFR 70.22 and 10 CFR 70.23. These sections describe the required contents of the application and the requirements for NRC approval of applications. The review focused on those elements that address chemical safety. Section 6.4.3 of NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications," (NRC, 2015) outlines the acceptance criteria for the NRC's review of chemical process safety of applicant's regulated under 10 CFR 70, Subpart H. As previously discussed in the SER, the staff determined that 10 CFR Part 70, Subpart H does apply to the activities covered by this license.

The staff's chemical safety review evaluated the chemical safety information in the application to ensure the specific requirements in 10 CFR 70.23 were met. Specifically, the staff evaluated:

1) whether the applicant's personnel are qualified by training and experience to use the material; for the purpose requested in accordance with the regulations in this chapter;
2) whether the applicant's proposed equipment and facilities are adequate to protect health and minimize danger to life or property; and
3) whether the applicant's proposed procedures are adequate to protect health and to minimize danger to life or property.

8.2.1 Qualification of the applicant to use the material

MIT identified the activities to be conducted under the SNM license in Section 1.7 of the LRA. These include the use of plutonium alpha sources for instrument calibration and classroom demonstration of alpha detection, the use of highly enriched uranium fission chambers for the detection and measurement of neutron generator, and the use of neutrons generated by Plutonium-Beryllium (PuBe) sources for instrument calibration. Chapter 10 states that no large-scale chemical systems are used with licensed materials. In addition, MIT's licensed materials are used and stored in laboratory facilities typical of those at teaching and research institutions. Chapter 14 states the only nonradioactive materials with the potential to be released are small quantities of chemicals normally found in teaching and research laboratories.

Section 2.2 of the application, discusses the safety responsibility of the department, laboratory, or center (DLC) head as well the PI. Section 2.3(b) discusses the role of the RPC with the establishment and continuing review of the RPP, as well as their role in the approval of uses of radiation sources.

Section 2.5 of the application, Personnel Education and Experience Requirements, describes the general training requirements for professional staff and investigators. Training is specific for certain positions, such as the RSO, which states the minimum requirements for the RSO is a bachelor's degree in science or engineering, completion of a basic radiation safety course and at least 2 years of experience in radiation protection. For other staff and personnel, required training is a function of responsibilities and area access. All personnel handling radioactive materials are trained as radiation workers. Appendix 3 to the LRA, Attachment 3, "Training for Individuals Working in or Frequenting Restricted Areas," discusses training content and training requirements for different staff.

The NRC requested additional information which included questions on the qualifications of the PI who has primary safety responsibility. MIT provided a response to the request for additional information (MIT, 2016c) and an update to the application (MIT, 2016d).

The response to RAI 8.1 stated that PIs possesses a Ph.D. and typically has research experience in the use of radioactive material. This information is also stated in Section 12.3 of the revised application (MIT, 2016d). PIs receive training on their responsibilities and the hazards of the materials handled in the lab, including chemical hazards (MIT, 2016d). PIs are required to take two classes: "PI of a Radioactive Materials Authorization" and "Radiation Safety Laboratory". The response to RAI 8.3 (MIT, 2016c) and Section 12.2 of the revised LRA (MIT, 2016d) state that the PI's responsibilities include the identification of potential chemical and biological hazards.

8.2.2 Proposed equipment and facilities

Chapter 10 of the LRA presents a brief description of the MIT facilities, noting that there are no large-scale systems and that most of the licensed material is in solid form (MIT, 2016a).

Chapter 10 further states that the adequacy of the facilities is evaluated for each specific activity that is authorized. The MIT evaluation of facility adequacy is discussed in Chapter 12 of the revised application (MIT, 2016d).

8.2.3 Proposed procedures

The staff reviewed the MIT review process that identifies chemical hazards and ensures appropriate controls are identified and implemented. After reviewing the initial application (MIT, 2016a), the NRC requested additional information on the procedures used for the identification, evaluation, and independent review of hazards related to chemical safety.

Responses to RAIs 8.2, 8.3, and 8.4 clarified that “all hazards” reviews are conducted, and that these include chemical hazards and these reviews are approved by RP health physicists as well as by the RPC (MIT, 2016c). Chapter 12 of the revised application (MIT, 2016d), specifically section 12.2, describes the role of the RPC, discusses the review as addressing “all potential hazards,” including chemical hazards. Section 12.4 of the revised application states that persons authorized to work with licensed material and ancillary staff receive training in biological safety, chemical safety, hazard awareness, and physical safety.

Section 12.2 of the revised application also discusses how MIT assesses the adequacy of laboratory facilities during each authorization review. The evaluation considers the proposed uses of licensed material, includes a tour of the proposed lab space, and when required, the examination of emergency showers/eyewashes, chemical fume hoods, and ventilation filtration. MIT’s evaluation considers of hazardous chemicals.

8.3 Evaluation Findings

The staff reviewed in the information supplied in the original license application (MIT, 2016a), the responses to RAIs (MIT, 2016c), and the revised application (MIT, 2016d). The staff finds that MIT provided information identifying and managing chemical safety issues related to its licensed activities, as required under 10 CFR 70.22. The staff reviewed this information against requirements of 10 CFR 70.23, “Requirements for the approval of applications” with a focus on chemical safety issues. The staff concludes that MIT’s personnel is qualified by training and experience to manage the chemical hazards associated with the use of SNM. The staff concludes that the applicant’s process for evaluating laboratory facilities for specific activities are adequate to protect health and minimize danger to life or property from chemical hazards. The staff concludes that the applicant’s procedures for identifying and managing chemical hazards associated with licensed activities are adequate to protect health and minimize danger to life or property from chemical hazards associated with licensed activities.

9.0 Material Control and Accounting

9.1 Purpose of Review

The purpose of this review was to determine whether MIT’s MC&A practices are adequate to detect and protect against the loss, theft, or diversion of SNM that the applicant possesses, stores, and utilizes at its facility, and to comply with the applicable regulatory requirements in 10 CFR Part 74, “Material Control and Accounting of Special Nuclear Material.”

9.2 Staff Review and Analysis

MIT provided information to support this review in the LRA (MIT, 2016a) in a response to a RAI (MIT, 2016c), and in the revised applications (MIT, 2016d, MIT, 2017a, MIT, 2017b). In accordance with 10 CFR 70.22(b), applicants requesting a license to possess SNM must submit a full description of their program for the control and accounting of SNM in the applicant's possession and must show compliance with 10 CFR Sections 74.31, 74.33, 74.41, or 74.51. However 10 CFR 70.22(b) excludes licensees governed by 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Non-power reactors (e.g., research and test reactors) and users of SNM as sealed sources, such as MIT, are excluded. The MC&A requirements in 10 CFR Sections 74.31, 74.33, 74.41, and 74.51, which contain specific control and accounting requirements for certain licensees, depending on the different types and quantities of SNM in possession.

In Section 1.4, "Types and quantities of materials authorized under SNM-986," of the LRA (MIT, 2017a), the MIT states that it shall not possess and use SNM in a quantity exceeding one effective kilogram except those uses involved in the operation of the research reactor and as sealed sources. Therefore, the MC&A requirements in 10 CFR Sections 74.31, 74.33, 74.41, and 74.51 do not apply. The MC&A requirements applicable to MIT are contained in 10 CFR Part 70, Subpart B, "General Reporting and Recordkeeping Requirements."

Licensees who possess, transfer or receive SNM in a quantity of one gram or more of contained uranium-235, uranium-233, or plutonium are subject to the general reporting and recordkeeping requirements of 10 CFR Sections74.11, 74.13, 74.15, and 74.19. The following discussion identifies each of the applicable MC&A requirements and summarizes the NRC staff's evaluation as to whether the information provided in the MIT's LRA meets the requirement.

9.2.1 Reports of Loss or Theft of Attempted Theft

Section 74.11 of 10 CFR requires each licensee that possesses one gram or more of contained uranium-235, uranium-233 or plutonium to notify the NRC Operations Center within 1 hour of discovery of any loss or theft or other unlawful diversion of SNM which the licensee is licensed to possess, or any incident in which an attempt has been made to commit a theft or unlawful diversion of SNM.

In Section 2.9, "Investigation and Reporting of Occurrences," of the LRA (MIT, 2017a), the applicant affirms that controls and activities are performed to ensure compliance with the reporting requirements of 10 CFR 74.11. This includes the commitment to notify the NRC Operations Center within 1 hour of the discovery of a suspected loss or attempted theft of SNM.

The NRC staff reviewed the description of MIT's process for notifying the NRC of loss or theft of SNM. The applicant provided a description of the actions that are taken if a loss, theft, or diversion of SNM is discovered or suspected. Those actions included meeting the applicable reporting requirements of 10 CFR 74.11. On the basis of the review, the NRC staff has determined that the applicant's MC&A measures include adequate procedures to ensure that NRC is notified in a timely manner in the event of a loss or theft or attempted theft of SNM. Therefore, the NRC staff finds that the applicant meets the requirement of 10 CFR 74.11.

9.2.2 Material Status Reports

Section 74.13 of 10 CFR requires each licensee possessing SNM in a quantity totaling one gram or more of contained uranium-235, uranium-233, or plutonium to complete and submit, in computer-readable format, Material Balance Reports detailing the SNM received, produced, possessed, transferred, consumed, disposed, or lost by the licensee.

In Sections 1.7.7, "Possession for Purposes of Storage and Disposition Only," and 2.8, "Audits," of the LRA (MIT, 2016a), MIT affirms that a physical inventory is conducted at least annually by applicant staff. The results of the annual physical inventory are submitted electronically to the Nuclear Material Managements and Safeguards System (NMMSS) by the SNM Accountability Officer. The inventory results are included in the physical inventory listings and material balance reports that are submitted to NMMSS.

The NRC staff reviewed the applicant's description for material status reports, to be submitted pursuant to 10 CFR 74.13. The applicant provided a description of the actions that are taken concerning material balance reports and inventory listing reports. On the basis of the review, the NRC staff has determined that the applicant's MC&A practices provide adequate assurance that material balances and physical inventory listings are reported as required. Therefore, the NRC staff finds that the applicant meets the requirement of 10 CFR 74.13.

9.2.3 Nuclear Material Transaction Reports

The NRC regulations at 10 CFR 74.15 requires each licensee who transfers or receives SNM in a quantity of one gram or more of contained uranium-235, uranium-233, or plutonium to complete, in computer-readable format, a Nuclear Material Transaction Report. In addition, each licensee who adjusts the inventory in any manner, other than for transfers and receipts, shall submit a Nuclear Material Transaction Report, in computer-readable format, to coincide with the submission of the Material Balance report. Each licensee who transfers SNM shall submit a Nuclear Material Transaction Report no later than the close of business the next working day. Each licensee who receives SNM shall submit a Nuclear Material Transaction Report within ten days after the material is received.

In Section 2.10, "Records," of the LRA (MIT, 2016a), the applicant affirms that any transfers or receipts of material are documented on nuclear material transaction reports. Transfers of SNM will be submitted to NMMSS no later than the close of business the next working day, and receipts of SNM will be submitted to NMMSS within 10 days of receiving the material.

The NRC staff reviewed the MC&A practices that MIT follows in preparing nuclear material transaction reports. The reports document the receipt and shipment of SNM. MIT identifies the SNM accounting procedures, the process for completing material transaction reports, and the MIT official responsible for overseeing the MC&A practices. The NRC staff finds the applicant's MC&A practices include adequate procedures to ensure that nuclear material transaction reports are complete and submitted as required. Therefore, the NRC staff finds that MIT meets the requirement of 10 CFR 74.15.

9.2.4 Recordkeeping

The NRC's regulations at 10 CFR 74.19(a) require each licensee to keep records showing the receipt, inventory (including location and unique identity), acquisition, transfer, and disposal of all SNM in its possession regardless of its origin or method of acquisition. Each record relating

to material control or material accounting must be maintained and retained for the period specified by the appropriate regulation or license condition. Each record of receipt, acquisition, or physical inventory of SNM must be retained as long as the licensee retains possession of the material and for 3 years following transfer or disposal of the material. Each record of transfer of SNM to other persons must be retained by the licensee who transferred the material until the Commission terminates the license authorizing the licensee's possession of the material.

In Section 2.10, "Records," of the revised LRA (MIT, 2017a), the applicant affirms that material control records are maintained under the supervision of the SNM Accountability Officer pursuant to 10 CFR 74.19(a). Furthermore, all records for receipt, inventory, material balance reports, acquisition, transfer and disposal of all SNM in possession of MIT are maintained at the Nuclear Reactor Laboratory longer than 3 years.

The NRC staff reviewed the applicant's description for material control records. The description included the position responsible for maintaining the SNM inventory records, completing all of material balance and inventory listing reports, and all material transaction reports. On the basis of the review, the NRC staff has determined that the applicant's MC&A practices include adequate procedures to ensure that material control records are completed and maintained as required. Therefore, the NRC staff finds that the applicant meets the requirement of 10 CFR 74.19(a).

9.2.5 Physical Inventory

Paragraph 74.19(c) of 10 CFR requires certain licensees who are authorized to possess SNM in a quantity greater than 350 grams of contained uranium-235, uranium-233, or plutonium, to conduct a physical inventory of all SNM in its possession, under this license, at intervals not to exceed 12 months. The results of these physical inventories shall be retained in records by the licensee until the Commission terminates the license authorizing the possession of the material.

In Section 2.2, "Organizational Responsibilities and Authority," of the LRA (MIT, 2016a), the applicant affirms that a physical inventory of all SNM held under its license is conducted at least annually by the SNM Accountability Officer. In Sections 1.7.7 and 2.8, MIT affirms that once the physical inventory is completed, the inventory results are submitted to NMMSS in accordance with 10 CFR 74.13.

The NRC staff reviewed the MIT's description of the actions that are taken concerning physical inventory of its SNM. The description included the minimum inventory frequency and completion and submittal of all required material balance and inventory listing reports. On the basis of the review, the NRC staff has determined that the applicant's MC&A practices include adequate procedures to ensure physical inventories of its SNM are completed at the required frequency and the results are reported. Therefore, the NRC staff finds that the applicant meets the requirement of 10 CFR 74.19(c).

9.3 Evaluation Findings

Based on the review of the LRA and subsequent submittals, the NRC staff finds that the applicant's MC&A practices as described provides assurance that the applicant will satisfy the applicable requirements found in 10 CFR Sections 74.11, 74.13, 74.15, and 74.19 during the renewed license term. Therefore, the NRC staff finds that the applicant's MC&A practices are acceptable.

10.0 Environmental Review

Very little SNM contaminated waste is generated under MIT's license. In Section 5.1 of the LRA MIT states, that all solid SNM scrap is retained and all liquid SNM waste will be converted to a solid for disposal; solid waste will be transferred to an authorized recipient (MIT, 2016a). No measurable liquid effluent streams are anticipated. Contaminated waste, including water from experiments, will be controlled and disposed of in accordance with MIT's written procedures. MIT commits that there shall be no routine, measurable discharge of gaseous radioactive material held under this license (except radon) to gaseous effluent streams. The NRC staff finds this commitment to the control of contaminated liquids and solid waste and the lack of routine gaseous and liquid effluents is adequate to assure effluents are maintained within regulatory limits.

Because the licensed material will be used for research and development and for educational purposes, renewal of SNM-986 is an action that is categorically excluded from a requirement to prepare an environmental assessment or environmental impact statement, pursuant to 10 CFR 51.22(c)(14)(v). The renewal of SNM-986 does not affect the scope or nature of the licensed activity and will not result in a significant change in the types or amounts of effluents released offsite. There will not be any significant increase in individual or cumulative occupational radiation exposure, and there will not be any significant increase in the potential or consequences from radiological accidents. There is no construction associated with these changes, so there will not be any impact from construction. The staff concludes that the MIT program, as described in the LRA, is adequate to protect public health and safety and the environment for the license renewal term, and complies with the applicable regulatory requirements in 10 CFR 20.1301, "Dose Limits for Members of the Public," and 20.2003, "Disposal by Release into Sanitary Sewerage."

11.0 Physical Security

11.1 Introduction

As discussed in Section 2 of this SER, MIT has a separate license for its research reactor, Facility Operating License R-37 (NRC, 2010a and NRC, 2014c), which is not part of the current LRA review. However, physical security documentation supporting the License R-37 was evaluated, because it describes the physical protection program associated with License SNM-986. The "Physical Security Plan for the MIT Research Reactor Facility," was submitted to the NRC on dated July 24, 2013 (MIT, 2013a). An updated Safety Analysis Report for MIT's research reactor describing the physical security plan was submitted November 7, 2013 (MIT, 2013b). MIT's License R-37 renewal application and its Physical Security Plan were approved by the NRC on May 12, 2014 (NRC, 2014c). MIT provided additional information on its security plan and described how it meets the applicable regulations in an RAI response related to the current LRA (MIT, 2016c).

11.2 Staff Review and Analysis

The NRC staff reviewed MIT's physical security plan documents to determine if all requirements for fixed-site and in-transit physical protection requirements for SNM of low strategic significance (SNM-LSS) are adequately met. The staff completed its technical evaluation of MIT's physical security plan (the Plan) and found it is in compliance with the applicable

regulations at 10 CFR 73.67 and 10 CFR 73.71 (NRC, 2014c). Non-sensitive information from the Plan is summarized in Sections 11.3 and 11.4 of this SER.

11.3 Fixed Site General Performance Objectives

The applicable physical protection requirements specified in 10 CFR 73.67 provide the general performance objectives. The fixed site physical protection requirements of 10 CFR 73.67(a) are applicable because of the amount of material MIT is authorized to possess in license SNM-986.

The Plan sections 1.2, "Restricted Area of building NW12," and 1.1, "Reactor Containment Building," describe the physical characteristics of the special nuclear material controlled access area and temporary controlled access areas. Access control measures are described in Plan section 3, "Access Control." Detection and assessment features are described in Plan section 2, "Detection Devices and Procedures." Response measures, including local law enforcement agency responsibilities, are described in Plan section 4, "Security Organization." The establishment and maintenance of the physical protection system for the licensed SNM is adequate because the elements described for the physical protection system, which include maintenance procedures for the detection and assessment systems, are sufficient, and the training for those responsible for escorting visitors and providing a security response, are satisfactory. The NRC staff finds the requirements of 10 CFR 73.67(a)(1), to have a physical protection system established and maintained for License SNM-986 are met by the information submitted in MIT's License R-37 renewal application (NRC, 2010a) and its Physical Security Plan approved by the NRC (NRC, 2014c).

Section 2.1.2 of the Plan, "Restricted Area of Building NW12," describes how (through the use of detection, assessment and response measures) the possibility of unauthorized removal of the SNM is minimized. The applicant verifies operational reliability by:

1) the detection and assessment systems operability testing described in section 2.1.2 of the Plan;
2) the training of the local law enforcement agency response personnel, described in section 4 of the Plan; and
3) the access control provisions described in section 3 of the Plan.

The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(1)(i), to have a physical protection system established and maintained that has the objective to minimize the possibilities for unauthorized removal of SNM consistent with the potential consequences of such actions.

In section 5 of the Plan, "Communications," the applicant describes various communication features of the MIT physical protection system. In addition, section 6 of the Plan, "Response Procedures," describes the response procedures that have been implemented. Specifically, within Plan section 6.3, "Theft of SNM or Threat of Theft," adequate response procedures for the protection of the SNM are described. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(1)(ii), to have a physical protection system established and maintained that has the objective to facilitate the location and recovery of missing SNM.

In section 2 of the Plan, the applicant states an adequate means of detecting unauthorized access by an external adversary within the controlled access area where the SNM is being stored and temporary controlled access areas. In addition, section 4 of the Plan describes dedicated local law enforcement assets that will respond and assess conditions when

indications are received that could potentially be from the malevolent actions of an external adversary within a controlled access area. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(2)(i), to have a physical protection system that provides early detection and assessment of unauthorized access or activities by an external adversary within the controlled access area containing SNM.

In section 2 of the Plan, the applicant describes the means of detecting unauthorized access by an external adversary within the controlled access area, where the SNM is being stored or temporarily used. Temporary controlled access areas are described in the Plan and are established when SNM is used outside of its primary storage location. In addition, section 4 of the Plan describes dedicated local law enforcement assets that will respond and assess conditions when indications are received that could potentially be from the removal of SNM from a controlled access area. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(2)(ii), to have a physical protection system that provides early detection of removal of SNM by an external adversary from a controlled access area.

In section 1 of the Plan, "Use Storage and Vital Areas," the applicant describes the placement protocols for SNM in the restricted area of building NW12 and the reactor containment building. In addition, reactor administrative procedure number 1.19, section 1.19.1, "Nuclear Materials," provides the pertinent details for the transfer of custody of SNM. NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(2)(iii), to assure proper placement and transfer of custody of SNM.

In section 5 of the Plan, the applicant describes various ways that dedicated response forces may be alerted of a potentially malevolent act. In addition, section 6 of the Plan describes procedures, which include those for the response to theft of SNM. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(2)(iv), to have a physical protection system that shall respond to indications of an unauthorized removal of SNM and then notify the appropriate response forces of its removal in order to facilitate its recovery.

11.3.1 Fixed-Site Physical Protection Requirements

The physical protection requirements of 10 CFR 73.67(f), state that, "Fixed site requirements for special nuclear material of low strategic significance. Each licensee who possesses, stores, or uses special nuclear material of low strategic significance at a fixed site or contiguous sites, except those who are licensed to operate a nuclear power reactor pursuant to Part 50, shall:

1) Store or use the material only within a controlled access area;
2) Monitor with an intrusion alarm or other device or procedures the controlled access areas to detect unauthorized penetrations or activities;
3) Assure that a watchman or offsite response force will respond to all unauthorized penetrations or activities; and
4) Establish and maintain response procedures for dealing with threats of thefts or thefts of this material. The licensee shall retain a copy of the current response procedures as a record for three years after the close of period for which the licensee possesses the special nuclear material under each license for which the procedures were established. Copies of superseded material must be retained for three years after each change.

The fixed site physical protection requirements of 10 CFR 73.67(f) are applicable to MIT because of the amount of material they are authorized to possess in materials license

SNM-986. In section 1 of the Plan, the applicant describes the controlled access areas where the SNM of low strategic significance is stored and used. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(f)(1), to store or use the material only within a controlled access area.

In section 2 of the Plan, the applicant describes the monitoring provisions for the controlled access areas. These provisions include electronic detection devices and human surveillance techniques. The location of the electronic detection devices, in parallel with the human surveillance techniques, provide adequate probability of detection to unauthorized penetrations or activities in or nearby controlled access areas. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(f)(2), to monitor with an intrusion alarm or other device or procedures the controlled access areas to detect unauthorized penetrations or activities.

In section 5 of the Plan, the applicant describes the infrastructure of established communication capabilities that enable a response to be initiated in reaction to a detected potentially unauthorized penetration or activity. In addition, section 6.9 of the Plan, “MIT Police Response to Intrusion, SNM Theft, or Threats or Either,” describes the detailed response actions that are to be followed by the dedicated local law enforcement agency. The NRC staff finds the requirement of 10 CFR 73.67(f)(3), to assure that a watchman or offsite response force will respond to all unauthorized penetrations or activities, is met.

In section 6.3 of the Plan, the applicant describes the response actions to be carried out by MIT reactor staff and local law enforcement. In addition, MIT is required maintain records of changes to its response procedures in accordance with 10 CFR 50.59 (d)(3), which requires a 5 year retention protocol for changed procedures. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(f)(4), to establish and maintain response procedures.

11.4 In-Transit General Performance Objectives

The physical protection requirements of 10 CFR 73.67(a), provide the, “General Performance Objectives. The in-transit physical protection requirements of 10 CFR 73.67(a) are applicable because of the amount of material they are authorized to possess in materials license SNM-986.

In section 7 of the Plan, “Material Transportation Requirements,” the applicant describes that the physical protection system is established and maintained for the transport of SNM. The NRC staff finds the requirement of 10 CFR 73.67(a)(1), to establish and maintain a physical protection system, is met.

In section 7 of the Plan, the applicant describes how the in-transit physical protection requirements of 10 CFR 73.67(g) are met. All applicable 10 CFR 73.67 requirements for the transport of SNM, including those of 10 CFR 73.71, “Reporting of safeguards events,” are adequately addressed in the Plan. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(1)(i), to minimize the possibilities for unauthorized removal of SNM consistent with the potential consequences of such actions.

In section 7.5.1 of the Plan, “Response Procedures,” the applicant describes their response actions which will facilitate the location and recovery of SNM. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(1)(ii), to “Facilitate the location and recovery of missing special nuclear material,” is met.

In section 2 of the Plan, the applicant describes how unauthorized access or other activities caused by an external adversary are detected within controlled access areas. In addition, section 4 of the Plan describes pertinent local law enforcement procedures and training for the assessment of detection alarms, for local law enforcement agency personnel. The combination of the detection and assessment provisions planned for and implemented by the applicant ensure that early detection and assessment of activities within controlled access areas are accurately evaluated. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(2)(i), to provide “Early detection and assessment of unauthorized access or activities by an external adversary within the controlled access area containing special nuclear material.”

In section 2.1.1 of the Plan, “Restricted Area of Building NW12,” the applicant describes both detection systems and compensatory measures for degraded detection systems that will ensure that the removal of special nuclear material from a controlled access area will be detected within the recommended time frame. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(2)(ii) to provide “Early detection of removal of special nuclear material by an external adversary from a controlled access area.”

In section 1 of the Plan, the applicant describes the placement of SNM in the Restricted Area of Building NW12 and the Reactor Containment Building. In addition, the applicant describes their controls for the transfer of custody in the reactor Administrative Procedure 1.19, subsection 1.19.1, “Nuclear Materials.” Also, Plan sections 7.4, “Transportation of SNM-LSS,” 7.5, “In-Transit Physical protection of SNMLSS,” and 7.6, “Receipt of SNM-LSS,” describe transportation, in-transit physical protection, and receipt of, special nuclear material of low strategic significance. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(2)(iii), to assure proper placement and transfer of custody of special nuclear material.

In section 5 of the Plan, the applicant describes various mechanisms available to perform emergency notification to local law enforcement. In section 6.3 of the Plan, the applicant describes actions by MIT staff, and local/federal law enforcement to facilitate location and recovery of missing SNM. In section 7.5.1 of the Plan, the applicant describes their response procedures for in-transit physical protection of SNM. In addition, section 7.5.3 of the Plan, “Investigation of Lost or Delayed Shipments,” provides details of their investigation protocols. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(a)(2)(iv), to respond to indications of an unauthorized removal of SNM and then notify the appropriate response forces of its removal in order to facilitate its recovery..

Each licensee subject to the provisions of 10 CFR Sections 73.20, 73.37, 73.50, 73.51, 73.55, 73.60, or 73.67 shall notify the NRC Operations Center within 1 hour of discovery of the safeguards events described in paragraph I(a)(1) of appendix G to this part.” In section 6 of the Plan, the applicant describes the procedure to notify the NRC upon recognition of events as listed in 10 CFR 73 Appendix G, I.(a)(1). The NRC staff finds the Plan meets the requirement of 10 CFR 73.71(b)(2), to provide notification to the NRC upon discovery of a pertinent safeguards event.

11.4.1 In-Transit Physical Protection Requirements

The physical protection requirements of 10 CFR 73.67(g), provide the, “In-Transit Requirements for Special Nuclear Material of Low Strategic Significance. The in-transit physical protection requirements of 10 CFR 73.67(g) are applicable because of the manner in which special nuclear material of low strategic significance is described in the MIT materials license SNM-986.”

In section 7.4.1 of the Plan, “Advance Notification and Receiver Confirmation,” the applicant describes the advance notification measures that are taken in order to notify the receiver of a planned shipment(s) of SNM of low strategic significance. The NRC staff finds the requirements of 10 CFR 73.67(g)(1)(i), to provide advance notification to the receiver of any planned shipments specifying the mode of transport, estimated time of arrival, location of the nuclear material transfer point, name of carrier and transport identification, are met.

In section 7.4.1 of the Plan, the applicant describes the actions taken to obtain confirmation that the receiver is ready to accept a shipment of SNM of low strategic significance. The NRC staff finds the requirement of 10 CFR 73.67(g)(1)(ii), to receive confirmation from the receiver prior to commencement of the planned shipment that the receiver will be ready to accept the shipment at the planned time and location and acknowledges the specified mode of transport, is met.

In section 7.4.3 of the Plan, “Container Seal,” the applicant describes the procedure to use and inspect tamper-indicating container seals. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(g)(1)(iii), to transport the material in a tamper indicating sealed container.

In section 7.4.4 of the Plan, “Inspection Before Shipment,” the applicant describes that shipment containers, and tamper-seals applied to those containers, are to be checked prior to shipment. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(g)(1)(iv), to check the integrity of the containers and seals prior to shipment.

In section 7.5 of the Plan, “In-Transit Physical Protection of SNM-LSS,” the applicant states that arrangements will be made for in-transit physical protection unless the receiver is an applicant and has agreed to provide such services in writing. In addition, section 7.5 of the Plan describes the required actions to be taken by MIT for in-transit physical protection of SNM of low strategic significance, when the receiver is not a licensee and has not agreed in writing to arrange for physical security. The NRC staff finds the requirements of 10 CFR 73.67(g)(1)(v), to arrange for the in-transit physical protection of shipments leaving the MIT facility in accordance with 10 CFR 73.67(g)(3), are met.

In section 7.6 of the Plan, “Receipt of SNM-LSS,” the applicant describes their procedures to check the integrity and seals of the container utilized for shipments of SNM of low strategic significance upon receipt. The NRC staff finds the requirement of 10 CFR 73.67(g)(2)(i), to check the tamper seals of containers of SNM upon receipt, is met.

In section 7.6 of the Plan, the applicant describes the procedure to notify the shipper of receipt of the material. However, the incorrect regulation is cited in section 7.6.2 of the Plan. In a response to a RAI (MIT, 2016c), MIT commits to correct the Plan by adding 10 CFR 74.15 “Nuclear material transaction reports” and removing 10 CFR 70.54. The NRC staff finds the revised Plan meets the requirement of 10 CFR 73.67(g)(2)(ii) to “Notify the shipper of receipt of the material as required in 10 CFR 74.15 of this chapter.”

In section 7.6 of the Plan, the applicant describes both the arrangements to be made for a licensed shipper to provide physical protection, and their procedures to provide in-transport physical protection. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(g)(2)(iii), to arrange for the in-transit physical protection for shipments to be received.

The applicant describes the reactor staff’s response actions, including providing notifications to the NRC, in sections 7.5.1 and 7.5.3 of the Plan. MIT’s records retention protocol is implemented by a procedure titled “Reactor Technical Specification,” which describes their

5-year retention protocol in subsection 7.8.1(h). The NRC staff finds the Plan meets the requirements of 10 CFR 73.67(g)(3)(i) to, “Establish and maintain response procedures.”

Section 7.5.2 of the Plan, provides a description of MIT’s receipt notification protocol, and section 7.5.3 of the Plan describes the protocols for lost or unaccounted for shipment protocols. NRC staff finds the requirement of 10 CFR 73.67(g)(3)(ii) to, “Make arrangements to be notified immediately of the arrival of the shipment at its destination point, or of any shipment that is lost or unaccounted for after the estimated time of arrival at its destination,” is met.

In section 7.5.3 of the Plan, the applicant describes the qualifications of the reactor staff and the protocols the MIT staff follows to notify the NRC of shipments that are unaccounted for or lost after the estimated time of arrival. In addition, MIT describes in Reactor Abnormal Operating Procedure 5.8.21, “Sabotage or Theft of Special Nuclear Material or Threat of Sabotage or Theft,” which specifies the timing for notifying the NRC. The NRC staff finds the Plan meets the requirements of 10 CFR 73.67(g)(3)(iii), to perform trace investigations for lost or unaccounted for shipments, and notify the NRC of these activities.

In section 8 of the Plan, “Export and Import Requirements,” the applicant states that they do not plan to export or import SNM of low strategic significance. In addition, the applicant states that any plans to import of export this material will be submitted for NRC staff review and approval four months prior to a planned shipment. The NRC staff finds the Plan meets the requirements of 10 CFR 73.67(g)(4), that “[e]ach licensee who exports special nuclear material of low strategic significance shall comply with the appropriate requirements specified in paragraphs (c) and (g) (1) and (3). In addition, MIT Plan meets the requirements to retain each required record “for three years after the close of period for which the licensee possesses the special nuclear material under each license that authorizes the licensee to export this material” and to retain copies of superseded material for three years after each change.

The NRC also staff finds that the MIT Plan at section 8, meets the requirements of 10 CFR 73.67(g)(5), that [e]ach licensee who exports special nuclear material of low strategic significance shall comply with the appropriate requirements specified in paragraphs (c) and (g) (2) and (3). In addition, the MIT Plan meets the record retention and NRC notification requirements of 10 CFR 73.67(g)(5)(i) and (ii).

11.5 Evaluation Findings

The NRC staff reviewed the MIT LRA and subsequent submittals for SNM license SNM-986, and finds that the applicable requirements in 10 CFR 73.67 are met. In addition, the MIT renewal application adequately addressed the applicable requirements in 10 CFR 73.71 and the staff finds these requirements are met.

12.0 National Environmental Policy Act Review for the MIT License Renewal

As discussed in Section 1.3.2 of the SER, MIT’s license authorizes research and development activities under parts 30 and 70 of the NRC’s regulations. Paragraph 51.22(c)(14)(v) of 10 CFR provides a categorical exclusion for the category actions under the MIT license. The NRC has determined that the renewal of materials licenses issued under 10 CFR Parts 30 or 70, for research and development and for educational purposes, does not individually or cumulatively have a significant effect on the human environment. Therefore, because the MIT license renewal is a categorically excluded action, the preparation of an Environmental Assessment (EA) or Environmental Impact Statement is not required.

III. CONCLUSION

The NRC staff concludes that the information in MIT's LRA and subsequent submittals, provide reasonable assurance that an adequate level of safety will be maintained for operations during the proposed license renewal term. The staff concludes that the LRA meets the requirements of 10 CFR 70.23, "Requirements for the Approval of Application." The staff also finds the proposed operations at MIT will not have an adverse impact on the public health and safety, the common defense and security, or the environment. The staff concludes that MIT will continue to meet the applicable requirements in 10 CFR Parts 19, 20, 70, 73, and 74, as discussed in this SER.

In addition, NRC staff conducted inspections of the MIT's facilities in 2007, 2012, and 2016 and no violations or findings were identified. Therefore, the NRC staff finds the license should be renewed for a 10-year term in accordance with the statements, representations, and conditions in the LRA dated February 24, 2016, as amended, and subject to the license conditions detailed in this SER. For these reasons, the staff approves the MIT request to renew the SNM license for a 10 year period, in accordance with the commitments and subject to the license conditions specified in this SER. MIT agreed to and incorporated these commitment and conditions in the renewed license.

IV. PRINCIPAL CONTRIBUTORS

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V. REFERENCES

(MIT, 2016a) Massachusetts Institute of Technology, Request for Renewal Application for SNM-986, dated February 24, 2016 (ADAMS Accession Package Nos. (ADAMS) ML16081A294 (non-public) and ML16092A171 (publicly available)). The non-public application has two parts: Part 1 of the MIT application contains Chapters 1 – 17 and all the appendices of the MIT Application, except Appendix 3 (ADAMS Accession No. ML16081A295) and Part 2 of the application contains Appendix 3, MIT's State of Massachusetts License and Procedures (ADAMS Accession Number ML16081A296). The publicly available application also has two parts: Part 1 of the application contains Chapters 1 – 17 and all the appendices of the MIT Application, except Appendix 3 (ADAMS Accession No. ML16092A175) Part 2 of the application contains Appendix 3, MIT's State of Massachusetts License and Procedures (ADAMS Accession No. ML16092A190).

The non-public and public versions Appendix 3, the Massachusetts License, contains 16 attachments, which provide programmatic details on MIT's organization and procedures for the use of radioactive material. Attachment 11 to Appendix 3 of the LRA is titled Radiation Protection Procedures and includes 12 appendices addressing selected radiation protection aspects of the MIT program, such as radiation exposure limits, emergency response procedures, and training.

(NRC, 2016b) Massachusetts Institute of Technology (MIT) - Compliance Submissions, Self- Guarantee Agreement Pursuant to 10 CFR Part 50, 10 CFR Part 70 and NUREG-1757, Vol.3, dated September 30, 2016 (ADAMS Accession No. ML16286A207.

(MIT, 2016c) Massachusetts Institute of Technology, Response to Requests for Additional Information, date October 26, 2016 (ADAMS Accession No. ML16302A013 (non-public)).

(MIT, 2016d) Massachusetts Institute of Technology, Revised Request for Renewal Application of SNM-986, dated December 7, 2016 (ADAMS Accession No. ML16343A813 (non-public)).

(MIT, 2016e) Massachusetts Institute of Technology, Criticality Calculations Documentation, dated December 13, 2016 (ADAMS Accession No. ML17011A326 (non-public)).

(MIT, 2017a) Massachusetts Institute of Technology, Revised Request for Renewal Application and Responses to Requests for Additional Information, dated February 13, 2017 (ADAMS Accession No. ML17047A571 (non-public)).

(MIT, 2017b) Massachusetts Institute of Technology, Revision to MIT Special Nuclear Materials License Renewal Application, dated March 01, 2017 (ADAMS Accession No. ML17066A318 (non-public)).

(MIT, 2017c) MIT-NRL-16-06, Rev. 1, "Criticality Study for Special Nuclear Material Storage Vault," dated January 31, 2017 (ADAMS Accession No. ML17047A617 (non-public)).

(MIT, 2013b) Update of MIT Safety Analysis Report for the MIT Research Reactor (MITR-II), Report No. MITNE-115, dated November 7, 2013 (ADAMS Accession No. ML13322A688 (non-public)).

(MIT, 2013a) July 24, 2013 cover letter transmitting the "Physical Security Plan for the MIT Research Reactor Facility," dated July 22, 2013 (Without Safeguards Enclosure) (ADAMS Accession No.ML13210A239 (publicly available)).

(NRC, 2010a) Massachusetts Institute of Technology, Issuance of Renewed Facility Operating License No. R-37 for the MIT Reactor, dated November 1, 2010 (ADAMS Accession No. ML102310545 (publicly available)).

(NRC, 2015) U.S. Nuclear Commission, "Standard Review Plan for Fuel Cycle Facilities and License Applications," NUREG-1520, Revision 2, June 2015 (ADAMS Accession Number ML15176A258).

(NRC, 2014a) Integrated Materials Performance Evaluation Program (IMPEP) – Agreement States Letter, dated November 14, 2014 (ADAMS Accession No. ML14304A312 (publicly available)).

(ANSI/ANS-15.1, 2013) The Development of Technical Specifications for Research Reactors, American National Standards Institute/American Nuclear Society, LaGrange Park, Illinois, 2013.

(NRC, 2010b) U.S. Nuclear Regulatory Commission Regulatory Guide (RG) 3.71, Nuclear Criticality Safety Standards for Fuels and Materials Facilities (ADAMS Accession No. ML103210345).

(NRC, 2012) U.S. Nuclear Regulatory Commission Regulatory Guide (RG) 8.24. Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication (ADAMS Accession No. ML110400305).

(ANSI/ANS, 2007a) ANSI/ANS 8.24, "Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations," American National Standards Institute, R2012.

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