Comprehensive Tritium Management Plan

Tritium Task Force
January 31, 2017

Executive Summary

The Tritium Task Force is appointed by the Laboratory Director and was formed after an external review conducted in June 2016 (see External Review of Tritium Management). Tritium management is a challenging issue for Fermilab and will continue to be so for the short- and long-term future. To address this challenge, coordinated human resource and significant budgetary resources in addition to those allocated for routine laboratory support functions will be required. Otherwise, equally important laboratory functions will be compromised. Concerted efforts in tritium management will be needed for the duration of accelerator operations and beyond at Fermilab.

Tritium management at Fermilab is a multi-faceted, complicated challenge. To adequately address each of these facets and understand how they relate to each other, the Tritium Task Force (TTF) has broken down tritium management and planning into six subcategories. They include:

- NuMI
- Booster Neutrino Beam
- Accelerators and New Projects
- Water Systems
- Environmental Monitoring
- Communications

Over the last five months each subcategory has been examined by a panel of personnel familiar with the details of the individual subcategories assigned to understand the short-term and long-term goals associated with each. This document is meant to be a comprehensive plan about how we will approach tritium management at Fermilab. It lays out a proposed roadmap to address immediate and future risks and outline plans for mitigation efforts.

Summary of Risks

The principal risks are two-fold. First, if Fermilab does not fully understand the generation and propagation of tritium from each source to each discharge point at the current beam power, then there is potential to violate Federal and State laws and regulations as the beam power increases. This may jeopardize our ability to continue accelerator operations, an outcome that is detrimental to the overall science mission. Fermilab is obligated by law and regulation to manage tritium. There are limits to air emissions and sanitary discharges of radionuclides that cannot be exceeded, and there are DOE limits for surface water discharges. There is no tolerance level for contamination of Class 1 groundwater located under Fermilab.

A more likely impact of not properly understanding and managing the production and release of tritium at Fermilab is to harm the Laboratory's longstanding excellent relationships with our neighbors and members of the public. While there are no specific regulatory standards, state or federal, below the DOE limits for surface water discharges into the

receiving streams, the tolerance of the public for concentrations in surface water discharges is not known at this time but is likely to be lower, and perhaps much lower, than the DOE limits.

For these reasons, the risks are:

1. If Fermilab approaches or exceeds the tritium limit for sanitary sewer discharge, then Fermilab must cease discharging through the Batavia sanitary system, a result that could jeopardize accelerator operations and other laboratory functions. At this time, the known contributions to the sanitary sewer system are indirect routes from NuMI: drain water from the MINOS holding tank either through the ICW system and CUB regeneration and other processes, or through the evaporation of Target Hall condensate via the air-handler units at MI-65.
2. If Fermilab contaminates Class 1 groundwater resources with tritium, then Fermilab is in violation of the non-degradation rule and presumably would be required to pump, treat, and monitor groundwater according to the direction of the US and Illinois EPAs and will jeopardize accelerator operations in the vicinity of the contamination and most likely elsewhere. There would also likely be a significant public relations concern raised by such contamination. At this time, the maintained capture of any tritiated groundwater surrounding the NuMI Target Hall and decay pipe is the most critical component of this risk. Infiltration mitigation measures at the MI-12/Booster Neutrino Beam area and continued surveillance at the Meson/Neutrino fixed target area are also critical to managing this risk.
3. If Fermilab's surface water discharges of tritium approach levels unacceptable to our neighbors, then Fermilab may garner negative attention, also jeopardizing accelerator operations. Tritium levels in surface waters are directly related to the ICW system, which is supplied by water from NuMI, MI-12, and the remaining sumps in the Main Injector and other accelerator enclosures.

Environmental monitoring results will be evaluated to further understand the migration and release of tritium in waters at Fermilab. Airborne radionuclide emissions will continue to be monitored by the ESH&Q Section and are included as an important consideration in the shielding design of new facilities. This includes tritium as well as all other radionuclides. The emissions from specific beamlines that approach or will be of significance with respect to regulatory limits will be reported to senior Laboratory management through the Project Oversight Group (POG).

The body of this report includes opportunities for mitigating these tritium risks. Thoroughly understanding the sources and migration through the water systems will help to minimize the generation of tritium in our current operational state and also inform the future potential at higher beam power.

Statement on Tritium Projections

A highly desirable outcome of the work of this Task Force would be to develop a methodology of predicting, at least approximately, the tritium volumes and/or concentrations to be discharged into the air and waterways at Fermilab as a function of the delivered beam power integrated over some specified period of time. A limited level of success has been

achieved, in fact, in predicting the concentrations in the NuMI Holding Tank taking into account the functionality of the drainage system and the heating of the shielding steel. To a lesser extent, rainfall events can be correlated with delivered beam power to anticipate the discharges from the Booster Neutrino Beam sump wells. It is concluded at this time that the numerous variables and complexities encountered such as facility configuration, rainfall events, and ongoing deterioration of some shielding components such as the Booster Neutrino Beam liners and sump wells have served to discourage work to develop such predictive tools in the face of addressing more immediate challenges. Such an effort is worthwhile to implement as a medium term goal once the more pressing challenges are successfully addressed. Indeed, some progress on this goal has been made for specific beam targeting conditions, notably for the design of the Long Baseline Neutrino Facility.

It is the goal of the Environmental Monitoring plan to develop a mechanism to track the tritium loads (products of tritium concentration and volumetric flow) that are produced, migrate through systems and are released from Fermilab. The short-term, high-frequency plan involves collecting tritium data (and beam power measurements) over at least a one-year period to capture fluctuations in seasonal, operational and infrastructure conditions to better understand the complex interconnections between systems. Comparison of the calculated tritium loads at sources and release points should indicate whether there are sources or migration/release components yet to be identified. For instance, if the calculated loads decrease from sources to release points, either losses are indicated or there are components missing from the monitoring network. Conversely, if the calculated loads increase from sources to release points then there may be an unidentified source. The degree of acceptable error in the calculated loads and comparisons will need to be determined, as will the acceptable degree of imbalance between source and release loads. Comparison of the produced versus migrating versus released tritium loads will help determine where there is uncertainty in our understanding of the contributing factors to tritium production and migration and can be used to make risk-based decisions to manage tritium under present and future operating conditions.

Evaluation of the short-term data will be used to develop a more streamlined long-term monitoring network that can be used to manage any impacts to tritium production, migration and release due to changes in climate, beam operation or infrastructure.

Summary of Immediate Actions

This report details the work performed to date and the necessary actions over the short-term (FY17), mid-term (5 years) and long-term time frames for each Tritium Task Force panel. The following is a summary of the critical actions that must be taken immediately in order to support later actions necessary to address tritium management at Fermilab, in addition to rough order of magnitude costs for these immediate actions:

NuMI: Continue to monitor the performance of the dehumidification, air injection and drainage systems to maintain the capture of tritium in the target hall and surrounding groundwater zones. Basic NuMI tritium monitoring is already being covered by existing resources. The operation of the new continuous Acetic Acid injection system needs some additional test method to be devised to retrieve samples from under the decay pipe, so pH can

be measured. That work is estimated to require 1-FTE-month. Analysis and modeling of NuMI tritium release will take several FTE-month this year, but this is being done under LBNF currently.

Booster Neutrino Beam: Identify a remedy to reduce water infiltration into the decay pipe liner system in order to reduce the transport of tritiated water and propose a properly-prepared work package to the Director and secure approval. MI-12 condensate will be evaporated through the MI-65 system. Historically, collecting, shipping and disposing of infiltrated water has cost $120,000-$200,000 per year. The immediate addition of gutters to MI-13 to redirect infiltration is at an estimated cost of $5,000 and upgrading the evaporator system at MI-65 is expected to cost $30,000. Both of these actions will require a funding source.

Accelerators and New Projects: Continue to monitor MI sumps for tritium production from new collimators and ensure that the design of new facilities minimizes or eliminates additional delivery of tritium to the site waters or sewers. To complete this task, we will need to install additional sump monitoring at three locations in the tunnel. This will require approximately $60,000 in materials and services.

Water Systems: Develop a process description/diagram of how condensate from the AHUs (air handling units) in the MI-65 building moves through the system to better understand the mechanism of how tritium may be entering the sanitary system. This is needed to prepare design documents for a collection system of the MI-65 air-handling unit condensate in order to isolate condensate from the sanitary sewer system so that it may monitored for volume generated and tritium load produced. Other contributions of tritiated water to the sanitary sewer will continue to investigated and monitored. The resource requirements for these activities are included as operating reserve task orders as part of the FESS Engineering Department. The civil works required to actually modify the condensate collection system will require a funding source, estimated in the $25,000-$35,000 range.

Environmental Monitoring: Design and budget the installation of an auto-sampler at the MC-1 lift station in the Muon Campus area, which will continue to be a key monitoring location for tritium migration in the sanitary sewer system over the mid- and long-terms as lab facilities and utilities are built and/or modified. This is a key location for high-frequency (weekly) monitoring in the short-term environmental monitoring plan. The civil works required to construct the housing and electrical connections for the autosampler and purchase of the autosampler itself will require a funding source, estimated in the $30,000-$50,000 range. No additional hiring or cost is anticipated to cover the collection and analysis of samples proposed in the short-term environmental monitoring plan.

Communications: Fermilab needs to affirm its commitment to go beyond merely satisfying the regulatory standards. We need to continue to strive to keep the tritium discharges as low as reasonably achievable, keep the public fully informed, and engage the public in forming our goals and plans. The Communication panel recommends that lab representatives meet with representatives in the neighboring communities to update them on the latest status of tritium in surface water at Fermilab, including the low, but measurable levels of tritium now being found in water discharged into Ferry Creek. The resource requirements for these activities are included as operating costs as part of the Office of Communication.