

## *2020 Annual Site Environmental Report*

### *For*

## *Thomas Jefferson National Accelerator Facility*



***Prepared for:***

*United States Department of Energy*

*Thomas Jefferson Site Office*

*Thomas Jefferson National Accelerator  
Facility*

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## EXECUTIVE SUMMARY

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This Annual Site Environmental Report documents the U.S. Department of Energy's (DOE) Thomas Jefferson National Accelerator Facility's (TJNAF, also known as Jefferson Lab) environmental protection program and its performance in 2020. This report presents results from environmental compliance and monitoring programs that are within the scope of TJNAF's existing environmental permits, applicable regulations and the Environmental Management System (EMS). This report also provides the DOE and the public with information regarding the impact of radioactive and non-radioactive pollutants, if any, resulting from TJNAF operations.

Jefferson Science Associates, LLC (JSA), has managed and operated TJNAF for the U.S. Department of Energy since 2006. JSA is a Southeastern Universities Research Association /Pacific Architects and Engineers Limited Liability Company bringing the science and technology focus of more than 60 universities in the Southeast together with the corporate management focus that has successfully managed the infrastructure and business operations at three DOE sites.

*"TJNAF, a forefront U.S. Department of Energy Nuclear Physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community. Specifically, the facility's mission is to:*

- *Deliver discovery-caliber research by exploring the atomic nucleus and its fundamental constituents, including precise tests of their interactions;*
- *Apply advanced particle accelerator and detector technologies to address challenges of modern society;*
- *Advance knowledge of science and technology through education and public outreach, and;*
- *Provide responsible and effective stewardship of resources."*

At the Continuous Electron Beam Accelerator Facility (CEBAF), the electron beam begins its first pass at the injector and proceeds through the underground racetrack-shaped accelerator tunnel at nearly the speed of light. The accelerator uses Superconducting Radio-Frequency (SRF) technology to drive electrons to higher and higher energies. The accelerator's electron beam is capable of simultaneous use by four experimental halls, three of which are circular, partially buried domed chambers. A fourth experimental hall transitions from a below grade to an above grade facility. The special equipment in each experimental hall records the interactions between incoming electrons and the target materials. A continuous electron beam is necessary to accumulate data at an efficient rate, yet ensures that each interaction is separate enough for precise measurements.

In 2020, site characterization and project development work continued in anticipation of the Electron Ion Collider project contract award. Planning and design activities also started for the CEBAF Center Renovation and Expansion project. Commissioning and operation of the Upgraded Injector Test Facility (UITF) were also completed in 2020.





View from flyover of TJNAF, facing towards the north. The racetrack outline of the Facility's accelerator facility is located in the southern portion, while the experimental halls are located at the eastern and western ends of the accelerator loop.

## **LOW ENERGY RECIRCULATOR FACILITY (LERF)**

TJNAF's Low Energy Recirculator Facility, formerly known as the Free-Electron Laser (FEL), was developed using the facility's expertise in superconducting radiofrequency (SRF) accelerators. As an FEL, the facility provided a high-power tunable infrared laser while also providing ultraviolet laser light, including vacuum ultraviolet light, and Terahertz light. Currently, the facility is using the term Low Energy Recirculator Facility, or LERF, to refer to this facility, as future missions with potentially broader scope are under development. The LERF conducted a DarkLight Experiment in 2016. Planning for conducting a radioisotope production and development experiment began in 2018.

## **RESEARCH AREAS**

Staff and visiting scientists continued using the Center for Advanced Studies of Accelerators (CASA), the Institute for SRF Science and Technology, and the Lattice Quantum Chromodynamics Computing Project to perform research and development programs. This research provides technology and associated experience for the construction of new accelerators for DOE Office of Science research projects at other facilities in nuclear physics, basic energy sciences, and high-energy physics.

## **INTEGRATED SAFETY MANAGEMENT (ISM) SYSTEM**

Through ISM, TJNAF incorporates Environment, Safety, and Health (ES&H) requirements into all work procedures. The primary objective of ISM is to ensure that safety, health and environmental protection are a part of routine work that is always included in the planning and execution of routine work and projects.

## **ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)**

TJNAF's EMS is established and maintained to conform to the ISO 14001 Standard for Environmental Management Systems and DOE Order requirements. Its principles continually improve the practices of environmental stewardship at the facility. The EMS is integrated within the ISM System.

## **REQUIREMENTS IDENTIFICATION PROCESS**

Requirements are comprised of the laws, regulations, and standards necessary and sufficient to ensure worker and public health and safety, and to protect the environment. TJNAF continually identifies new and changing requirements for inclusion into its programs. Subject matter experts

follow the development of new requirements, evaluating the applicability to existing facility operations.

## **IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)**

Construction activities, all accelerator upgrades and large/unique experiments are subject to review under the NEPA. The initial construction, two upgrades to CEBAF, and new buildings screened for compliance with NEPA regulations through the preparation of four Environmental Assessments (EAs). Site-specific NEPA Categorical Exclusions cover routine activities and special projects that do not have individual or cumulative significant environmental impacts and do not require the preparation of an EA or Environmental Impact Statement. All approved NEPA reviews and associated documentation are available on DOE's Public Reading Room.

## **RADIOLOGICAL AND NON-RADIOLOGICAL RELEASES TO THE PUBLIC FROM SITE OPERATIONS**

In 2020, there were no unplanned radiological or non-radiological releases to the environment due to accelerator operations. Releases from normal operations were within permit and regulatory limits and had negligible impact to the public and no health or safety implications.

## **ENVIRONMENTAL PERFORMANCE MEASURES**

TJNAF measures its environmental performance in several ways. In 2020, the DOE gave JSA a B+ for its ability to "Sustain Excellence and Enhance Effectiveness of Integrated Safety, Health, and Environmental Protection." Additionally, TJNAF reports annually to the Office of the Federal Environmental Executive and tracks numerous internal environmental performance metrics – all of which indicated success in 2020.

## **INSPECTION**

TJNAF's inspection programs demonstrate its commitment to protect the environment, public health and safety. To ensure operations and activities are performed effectively staff and external agencies, including the DOE Site Office, State of Virginia, and the local sanitation district, conduct inspections. This report includes independent inspection results, including detailed comments on TJNAF's record of compliance with applicable laws and regulations. TJNAF also conducts routine self-inspections for onsite stormwater management, RCRA hazardous waste compliance inspections, TJNAF Hurricane Warden inspections and safety observations.



## GENERAL COMPLIANCE

TJNAF's ES&H Manual facilitates integration of general environmental compliance initiatives into site operations. This report presents TJNAF's environmental compliance activity performance in 2020 and focuses on those dealing with water resources and public health. No significant environmental compliance issues arose during 2020.

## AWARDS AND RECOGNITIONS

In 2020, TJNAF was awarded a DOE Gold GreenBuy Award from the Department of Energy's Office of Sustainable Environmental Stewardship for meeting leadership goals for 12 priority products in 5 different categories. TJNAF achieved the Gold level award for the fourth consecutive year, which also earned the Facility with the GreenBuy Prime Award.

In 2020, TJNAF was awarded with a Hampton Roads Sanitation District (HRSD) Gold Award for perfect compliance with industrial wastewater discharges to sanitary sewer during 2019. Qualifying for this award requires maintaining a perfect compliance record for at least one year, and demonstrating a commitment to environmental excellence. Other criteria for receiving this award includes the requirement for an organization to meet HRSD compliance requirements and have no non-compliance or civil penalties.

In 2020, TJNAF was also recognized by the Virginia Department of Environmental Quality (DEQ) as an Exemplary Environmental Enterprise (E3) facility within the Virginia Environmental Excellence Program (VEEP). The VEEP consists of three levels: E2 – Environmental Enterprise; E3 – Exemplary Environmental Enterprise; and E4 – Extraordinary Environmental Enterprise. The E3 level is for facilities with fully-implemented Environmental Management Systems (EMS), pollution prevention programs and demonstrated environmental performance.



# 1 INTRODUCTION

## 1.1 SITE LOCATION

The Thomas Jefferson National Accelerator Facility (TJNAF), also known as Jefferson Lab is located in the Oyster Point Business Park within the City of Newport News, Virginia. *Figure 1 – Regional and Site Map of TJNAF*, depicts the facility's location and buildings.

*Figure 1 – Regional and Site Map of TJNAF*



## 1.2 SITE HISTORY

Prior to the construction of TJNAF, there were several users of this general area of Newport News. The U.S. Department of Defense (DOD) acquired most of the Oyster Point area, including the land presently used by TJNAF. The U.S. Air Force later acquired the land and installed a Boeing and Michigan Aerospace Research Center (BOMARC) missile site on a portion of the property. After closure of BOMARC, the DOD decommissioned the property and conveyed some land to the Commonwealth of Virginia, the National Aeronautics and Space Administration (NASA), and others. Ownership of the NASA property, including 100 acres of undeveloped land, was conveyed to the DOE in 1987. An additional 52 acres of land was also transferred to the DOE from other sources. The total DOE-owned parcel, upon which TJNAF is built, is 169 acres.

## 1.3 ENVIRONMENTAL SETTING

The most comprehensive reviews that bound the site's environmental constraints are the four EAs completed under the NEPA. Each evaluated the potential impact of the site (or of proposed changes to the site) on cultural resources, air quality, water quality, noise, wetlands, endangered and threatened species, and a host of other subjects.

Environmental Assessments (EAs) conducted at TJNAF include:

- 1987 EA that yielded a "Finding of No Significant Impact (FONSI)" associated with the initial construction of the CEBAF;
- 1997 EA for the CEBAF upgrade (FONSI);
- 2002 EA for the LERF (formerly known as the FEL, or Free Electron Laser) upgrade/five building construction projects (FONSI), and
- 2007 EA for the 12GeV upgrade project (FONSI).

As a result, proposed projects have been completed with the assurance that no harm would come to the environment and therefore there was no need to prepare Environmental Impact Statements.



## 1.4 SITE MISSION

TJNAF, a U.S. Department of Energy nuclear physics research facility, provides world-class, unique research capabilities and innovative technologies to serve an international scientific user community.

Specifically, the mission is to:

- Deliver discovery-caliber research by exploring the atomic nucleus and its fundamental constituents, including precise tests of their interactions;
- Apply advanced particle accelerator, detector and other technologies to develop new basic research capabilities and to address the challenges of modern society;
- Advance knowledge of science and technology through education and public outreach, and;
- Provide responsible and effective stewardship of resources.

### 1.4.1 PRIMARY OPERATIONS AND ACTIVITIES AT THE SITE:

#### CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY (CEBAF)

- The CEBAF accelerator provides continuous wave electron beams with energies of 0.5 to 12 GeV. During 2020, the machine conducted beam operations up to 12 GeV power. However, the CEBAF was limited in operations during portions of the year due to SAD and COVID-19 limitations.

#### END STATIONS

- The Experimental Hall End Stations have complementary experimental equipment to support their primary functions.
  - **Hall A** has a pair of superconducting, high-resolution magnetic spectrometers optimized for precision electron-scattering, coincidence experiments.
  - **Hall B** houses the CEBAF Large Acceptance Spectrometer for the 12 GeV Upgrade (CLAS12). CLAS12 supports studies of both electron- and photon-induced reactions with forward-focused reaction products at increased luminosities.
  - **Hall C** contains two spectrometers, the High Momentum Spectrometer, the Super High Momentum Spectrometer, which enables measurements of particles scattered at up to full beam momentum.



- **Hall D** supports studies of photon-induced reactions using a solenoidal-based detector with high acceptance for charged particles and photons.

### **INSTITUTE FOR SUPERCONDUCTING RADIO FREQUENCY (SRF) SCIENCE AND TECHNOLOGY**

- TJNAF's primary research and development facility provides continuous improvement efforts for the CEBAF and the LERF. Work includes:
  - Support of the operation, improvement and upgrade of the CEBAF.
  - Exploration of techniques for producing improved-performance SRF systems.

### **CENTER FOR ADVANCE STUDIES OF ACCELERATORS (CASA)**

- CASA supports the site accelerators and evaluates future opportunities. Its primary mission is to generate, investigate, and distribute knowledge about advanced accelerator and beam physics, to facilitate and improve the results generated through the work performed at TJNAF. A secondary goal for the organization is to archive information generated by TJNAF's activities and make it available to guide future projects.

### **LOW ENERGY RECIRCULATOR FACILITY (LERF)**

- Designed and built with TJNAF's expertise in SRF accelerator technology. The LERF (formerly known as the FEL) facility was the world's highest-power tunable infrared laser and also provided ultraviolet laser light, including vacuum ultraviolet light, and Terahertz light. Currently, the facility is using the term Low Energy Recirculator Facility, or LERF, to refer to this facility. The LERF generates energy from electrons and then recovers the energy using a superconducting energy-recovering linac (ERL). Within the ERL, an electron beam is recycled back through the accelerator out of phase with the accelerating field, allowing the beam energy generated in its first trip through the accelerator is returned to the SRF cavities.

### **UPGRADED INJECTOR TEST FACILITY (UITF)**

- The UITF is a small scale electron beam accelerator which is designed to support physics experiments and improve on the design of the CEBAF electron beam injector. Commissioning and operation of this accelerator was completed in 2020 and its experimental program began.

### 1.4.2 RELEVANT DEMOGRAPHIC INFORMATION

TJNAF is a world-class research facility. It attracts both resident and visiting physicists, and other scientists from around the world. In 2020, approximately 744 full-time physicists, engineers, technicians, and support staff worked at TJNAF and more than 1,623 academic and industrial researchers, from across the United States and approximately 37 countries and 277 institutions, participated in scientific collaborations.

Each year, research conducted at TJNAF produces more than one-third of all Nuclear Physics PhDs awarded in the United States. Research at TJNAF in 2020 produced four patents.



## 2 COMPLIANCE SUMMARY

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The following sections summarize TJNAF's 2020 compliance status related to local, state, Federal, and DOE requirements.

### 2.1 COMPLIANCE STATUS

#### 2.1.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA requires that Federal agencies evaluate projects for the potential to have significant environmental impacts. All projects occurring at TJNAF are evaluated through the preparation of Environmental Assessments (EAs) or managed according to Categorical Exclusions, and no Environmental Impact Statement was necessary. One activity that requiring NEPA evaluation during 2020 was the Measurement of Lepton-Lepton Electroweak Reaction (MOLLER) experiment authorized through an approved Categorical Exclusion.

#### 2.1.2 AIR QUALITY & PROTECTION

TJNAF currently has no process, or associated air emissions that exceed the threshold levels that require air permitting in the State of Virginia. Internal calculations are routinely conducted to confirm this status. All emissions remained well below reportable thresholds in 2020. The City of Newport News has met Environmental Protection Agency (EPA) and Virginia DEQ designated pollutant limits for National Ambient Air Quality Standards (NAAQS) since 2008.

#### STRATOSPHERIC OZONE-DEPLETING SUBSTANCES (ODS)

TJNAF minimizes the use of ODSs by using safe, cost-effective, environmentally preferable alternatives where possible.

To reduce the potential for emissions of ODSs, and comply with Section 608 of the Clean Air Act's Refrigerant Recycling Rule, TJNAF utilizes EPA certified subcontractors and staff to perform all work involving ODS-containing refrigeration and air conditioning equipment on site. There is one ODS recovery machine on-site. The one remaining

chlorofluorocarbon based chiller receives preventive and corrective maintenance by a qualified mechanical subcontractor to ensure optimal performance with minimal loss. An inventory of ODS containing equipment and annual usage onsite is submitted annually to the DOE.

## **GREENHOUSE GAS (GHG) EMISSIONS**

During 2020, TJNAF and DOE continued to assess GHG emissions. Efforts to understand these various emissions allowed for the development of ways to minimize them. See “Department of Energy Executive Orders” section below.

### **2.1.3 WATER QUALITY & PROTECTION**

TJNAF complies with all water quality protection requirements and performs monitoring in compliance with applicable State water quality permits. Combinations of engineering and administrative controls are utilized to maintain groundwater quality during operations. Discharges to surface water are permitted under TJNAF’s Department of Environmental Quality (DEQ) Virginia Pollutant Discharge Elimination System (VPDES) Permit No. VA0089320. Outfall 001 consists of groundwater extracted from beneath Halls A, B and C; Outfall 002 consists of discharges from one of the site’s cooling towers. Discharged wastewater flows to permit-authorized outfalls included in TJNAF’s environmental monitoring program.

Groundwater monitoring wells are sampled routinely under VPDES Permit VA0089320 to ensure that site operations do not degrade groundwater quality.

All stormwater discharges are managed through structural and non-structural Best Management Practices (BMPs) in compliance with TJNAF’s Municipal Separate Storm Sewer System (MS4) permit and the Virginia Stormwater Management Program (VSMP) regulations. Operational control measures include proper storage and minimizing the use of products that could pollute ground and surface water. Applicable site personnel have received training from the Virginia Department of Environmental Quality in the areas of Stormwater Management and Erosion & Sediment Control in order to properly conduct plan reviews (Stormwater Pollution Prevention Plans and Erosion & Sediment Control Plans) and site inspections of all regulated land disturbances. During 2015, TJNAF received initial approval from the DEQ for the preparation of a Chesapeake Bay Total Maximum Daily Load (TMDL) Action Plan as part of Permit No. VAR040079 to meet the newly established requirements of the Virginia Stormwater Management Program (VSMP) set forth on July 1, 2014.

TJNAF held four active water permits in 2020 (*see Figure 2 below*). No regulatory

limits were exceeded and all water quality programs were in compliance.



Figure 2 – TJNAF's Active Water Permits

PERMIT TYPE	# OF OUTFALLS	PARAMETER	# OF PERMIT EXCEEDANCES	# OF SAMPLES TAKEN	# OF COMPLIANT SAMPLES	PERCENT COMPLIANCE
Industrial Wastewater Discharge to Surface and Groundwater Quality (VPDES Permit VA0089320)	2 Outfalls (001 and 002)  16 wells*	Outfall 001 (pH, flow, temperature, Tritium, Sodium 22, Beryllium 7, Manganese 54, Gross Beta Activity);  Outfall 002 (pH, flow, temperature, Ammonia, Chlorine, Copper, Zinc, Phosphorus, Hardness);  A-ring/B-ring wells (groundwater elevation, pH, conductivity, total dissolved solids, Tritium, Sodium 22, Beryllium 7, Manganese 54, Manmade Radioactivity);  GW-15a background well/C-ring wells (groundwater elevation, pH, conductivity, total dissolved solids, Tritium, Sodium 22, Beryllium 7, Manganese 54);  Hall D wells (groundwater elevation, pH, conductivity, total dissolved solids, Tritium, Sodium 22, Beryllium 7, Manganese 54)	0	Outfall 001 (1);  Outfall 002 (4);  A-ring wells (8);  B-ring wells (10);  C-ring wells (3);  GW-15a (1);  Hall D wells (6)	Outfalls (5);  Wells (28)	100  100
***Municipal Separate Storm Sewer System Permit (VAR-0400790)	3	NA	0	**NA	NA	100
Industrial Wastewater Discharge to Sewer (HRSD Permit 0117)	4	Radionuclides, pH  Flow  Temperature	0	24	24	100
Groundwater Withdrawal (Virginia DEQ GW0047201)	1	Volume of dewatering	0	12	12	100

PERMIT TYPE	# OF OUTFALLS	PARAMETER	# OF PERMIT EXCEEDANCES	# OF SAMPLES TAKEN	# OF COMPLIANT SAMPLES	PERCENT COMPLIANCE
<p>*TJNAF's VPDES permit includes two outfalls and the collection and reporting of radionuclide monitoring data from 16 groundwater monitoring wells located throughout the site.</p> <p>**The MS4 program requires TJNAF to implement a wide variety of BMPs to prevent contamination from entering the stormwater system and leaving the site. No sampling, analysis, and reporting of chemical constituents are currently required.</p> <p>***TJNAF applied for renewal of the existing MS4 permit and received authorization during 2018.</p>						

#### **2.1.4 CONFORMANCE WITH ENERGY INDEPENDENCE AND SECURITY ACT (EISA) SECTION 438**

During 2015, TJNAF conducted a conformance assessment of the current stormwater management program as related to EISA Section 438 requirements. Applicable projects were reviewed to determine conformance status and strategies were developed for future projects.

Projects are screened through an environmental compliance checklist that includes the requirement for conformance with EISA Section 438. During 2020, projects that were screened included the MOLLER experiment, the Aviation Plan, and the CTF Upgrade project.

#### **2.1.5 FUTURE STRATEGIES FOR EISA SECTION 438 CONFORMANCE**

In December of 2009, the EPA released the “Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act”. According to this guidance, conformance for future development, or redevelopment projects of >5,000 SqFt, is satisfied by implementing planning, design, construction, and maintenance strategies that achieve Option 1 – Retain the 95<sup>th</sup> percentile rainfall event to the Maximum Extent Technically Feasible (METF) from a sitewide perspective. This is accomplished through review of project design criteria to assure the following strategies have been considered:

- Apply ‘runoff reduction’ as the central stormwater management tool during planning stages of future development by incorporating the use of Low Impact Development (LID)/Green Infrastructure (GI) for stormwater management to the METF as mentioned above;
- Reduce clearing by preserving remaining natural areas as much as possible;
- Reduce regrading by preserving natural drainage patterns on a development site, where feasible;
- Minimize amount of imperviousness for planned development, where feasible;
- Promote runoff across natural features to reduce runoff volumes and pollutant loads.

During the conformance assessment conducted by TJNAF in 2015, it was determined that applicable projects occurring at TJNAF can conform to the technical requirements by:

- Calculating stormwater treatment requirements on a facility-wide basis, as opposed to a project/site specific level;

- The two stormwater retention ponds located on the facility have treatment storage capacity available to accommodate conformance with requirements for the remaining projects that qualify;
- Conformance for future projects may require the intentional routing of stormwater flows into the existing retention ponds for treatment.

### 2.1.6 OTHER ENVIRONMENTAL STATUTES & EXECUTIVE ORDERS

#### OIL POLLUTION CONTROL

A five year review of TJNAF's Spill Prevention, Control, and Countermeasure (SPCC) Plan occurred during 2016. The plan was deemed compliant with the requirements of 40 CFR Part 112 for Oil Pollution Prevention and no technical amendments were required. The SPCC Plan describes methods to prevent, control, and/or mitigate releases of oil and other petroleum substances to the environment. The Plan also describes the proper handling, use and transport of petroleum products on-site along with proper spill containment, clean-up, and disposal of the spilled material. To ensure proper handling and spill response, all staff, working with oil, receives annual SPCC training. On-site oil inventory comprises numerous oil-containing transformers, generators, compressors, above-ground storage tanks, and mechanical equipment. TJNAF's estimated volume of oil is approximately 51,000 gallons; this includes utility-owned electrical equipment. During 2016, TJNAF implemented an SPCC inventory spreadsheet to allow for management of 'real-time' inventory when new oil-containing equipment is brought onsite. Adherence to the SPCC plan continued in 2020.



## 2.1.7 DOE O 436.1 AND E.O. 13834 – SITE SUSTAINABILITY PLAN



The purpose of DOE Order 436.1 is to “....Provide requirements and responsibilities for managing sustainability within the DOE to 1) ensure the [DOE] carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future, 2) institute wholesale cultural change to factor sustainability and GHG reductions into all DOE corporate management decisions, and 3) ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan pursuant to applicable laws, regulations and Executive Orders, related performance scorecards, and sustainability initiatives.”

TJNAF satisfies this Order’s requirements through the implementation of its EMS (see Section 3 – Environmental Management System below) and Site Sustainability Plan, summarized in *Figure 3 below*.

In 2020, TJNAF updated its Site Sustainability Plan. This plan addressed each specific goal in the DOE O 436.1, assessed performance status, and established planned actions and schedules for meeting them. *Figure 3* summarizes major 2020 activities associated with the plan.



*Figure 3 – TJNAF's Sustainability Goal Performance*

DOE Goal	Performance Status	Plans and Projected Performance
<b>Energy Management</b>		
<b>Energy Intensity:</b>  TJNAF energy utilization intensity (EUI) baseline was established in FY15 at 89,778 Btu/GSF for goal subject buildings.	Performance in FY20 measured at 66,958, constituting a 25% reduction from the baseline.	Energy usage and intensity reductions are not strictly limited to goal subject buildings; Several energy conservation measures (ECMs) related to lighting upgrades have been identified and implemented through retrofits. Examples include: 33 of 55 – 1,000-watt high intensity discharge (HID) lights in experimental halls were retrofitted to 300 watt light emitting diode (LED) lights. Due to operational requirements, these lights run continuously, with significant energy reductions expected.
<b>EISA Section 432 Compliance:</b>  Comprehensive set of energy and water audits were conducted during the development of a UESC feasibility study in FY16.	Annual audits have been completed to supplement those performed under the feasibility study and to maintain compliance with EISA 432 requirements. Benchmarking is currently being performed internally using a combination of utility bills and metered data from manual readings as well as an energy dashboard.	During FY21, TJNAF plans to complete the replacement of HID lighting with LED in the experimental halls. Plans also underway to finalize selection of a suitable LED replacement for 960 T-12 light fixtures in the accelerator tunnel.  TJNAF will also continue annual energy audits to comply with EISA 432 requirements in FY21 and subsequent years. These efforts are not anticipated to be negatively impacted by the COVID-19 pandemic. The Facility is also evaluating Portfolio Manager to replace internal benchmarking tools and processes.  Sustainability upgrades for the CEBAF Center and Applied Research Center (ARC) buildings are already included in the scope of the CEBAF Renovation and Expansion (CRE) project and expected to make further significant reductions to EUI I the next 5 years.
<b>Metering:</b>  Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	27% fully metered  60% partially metered  13% not metered	Eliminate 'not metered' status and convert "partially metered" to "fully metered" by 10-15% annually.

DOE Goal	Performance Status	Plans and Projected Performance
<b>Water Management</b>		
<p><b>Potable Water Intensity:</b></p> <p>36% potable water intensity (gal per gross square foot) reduction by FY 2025 from a FY2007 baseline.</p>	<p>TJNAF has extensive inventory of water meters which are closely monitored and used for monthly reporting and utility billing purposes. FY20 potable water consumption decreased by approximately 4.7 million gallons (or 6%) from FY19, however, this still represents a 22% increase from the FY07 baseline. Approximately 58 million gallons of potable water (nearly 80% of total potable water consumption) was required for evaporative cooling of High Energy Mission Specific Facility (HEMSF) operations. Consequently, achievement of any significant reduction in water intensity remains one of the most significant challenges for TJNAF sustainability goals.</p> <p>Multiple water reduction and alternative water source strategies have been evaluated during the past several years. One identified strategy was successfully completed in FY19. The project reduced potable water consumption by 4 million gallons in FY20 by using ultra-pure water (UPW) waste which was previously discharged from the Test Facility building to sanitation and diverting this to a nearby cooling tower for use as a make-up water supply source.</p>	<p>Water intensity reduction plans are designed to provide alternative water sources to primarily satisfy thermal energy (cooling tower water) requirements. A storm water reuse project is currently integrated into the Facility's Campus Plan and capital investment strategy which will provide 50 million gallons of water from a nearby storm water pond source. Construction is anticipated within the next three years.</p>

DOE Goal	Performance Status	Plans and Projected Performance
<b>Waste Management</b>		
<b>Municipal Solid Waste:</b>  Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris.	TJNAF aggressively recycles non-hazardous solid waste. Of the 209 tons of non-hazardous solid waste produced in FY20, approximately 70% (145.4 tons) of building and office waste, paper and metal were recycled and/or diverted from landfill deposit. Verification of recycled material quantities is reported by the recycling service center, and recorded by TJNAF.  Approximately 5.9 tons of non-hazardous waste in FY20 was diverted to the local Hampton – NASA steam plant for incineration.	Overall municipal solid waste is expected to increase with the acquisition of the ARC building. TJNAF will continue existing processes to reduce non-hazardous waste to continue to exceed the goal of 50% waste diversion from landfill. Further, TJNAF will continue to participate in a waste-to energy program.
<b>Construction &amp; Demolition:</b>  Divert at least 50% of construction and demolition materials and debris.	Construction activity at TJNAF in FY20 produced approx 34.5 tons of construction and demolition materials and debris. Approx. 84% (28.8 tons) was recycled/diverted from landfill deposit.	Construction and demolition materials debris are expected to increase over the next several fiscal years relative to FY20 as significant major renovation and construction activities are conducted. TJNAF will continue existing processes to recycle non-hazardous waste to continue to exceed the goal of 50% reduction diversion from landfills.

DOE Goal	Performance Status	Plans and Projected Performance
<b>Fleet Management</b>		
<p><b>Fleet Petroleum:</b></p> <p>20% reduction in annual petroleum consumption by FY2015 relative to a FY2005 baseline; maintain 20% reduction thereafter</p>	<p>TJNAF annual petroleum consumption decreased to 1,517 gallons in FY19, approximately 54% below the FY05 baseline. Annual alternative fuel consumption increased by approximately 105% as the facility continued to make use of 1,105 gallons of E-85 fuel.</p> <p>TJNAF conducts annual reviews and comparisons of Facility needs and vehicles available for lease through GSA. In FY20, five electric vehicles were traded in and replaced with like vehicles, but otherwise the fleet inventory remained essentially unchanged. Over 70% of the TJNAF leased fleet are low GHG vehicles and agency vehicles are predominately electric vehicles. Industrial fleet vehicles operate on diesel, propane or electric. Alternative fuel vehicles (AFVs) are being extensively used with the exception of some diesel heavy duty pickups that meet the load capabilities required for operations.</p>	<p>TJNAF has no major initiatives or changes to missions relating to this category. Passenger fleet inventory remains well managed and is limited to only what is necessary. As vehicles are scheduled for replacement, existing vehicles are replaced with AFVs, zero emission or hybrids whenever appropriate. TJNAF will continue to investigate opportunities for electric vehicles which meet medium duty pickup needs and industrial fleet vehicles which consume diesel will be replaced by biodiesel capable vehicles when the cost of repairs exceed the long term value of replacement. Electric vehicle charging stations have been evaluated and discussed for budget and infrastructure planning.</p>

DOE Goal	Performance Status	Plans and Projected Performance
<b>Clean and Renewable Energy</b>		
<b>Clean and Renewable Electric Energy:</b>  Clean and Renewable Electric Energy require that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than 25% by FY 2025 and each year thereafter.	TJNAF continues to implement clean/renewable energy technologies. Several existing facilities utilize geothermal heat pump systems producing/consuming approx 5,306 MMBTU/Yr of thermal energy. Additionally, 24% of TJNAF total electric energy (188,803 MWh's) consumption in FY20 was accounted for with renewable energy through purchase of equivalent amount (40,000 MWh's) of renewable energy certificates.  FY16 assessment evaluated opportunities to install photovoltaic systems at that include ground mount, rooftop and canopy options. Two preferred locations were selected based on future plans for the site, payback potential and visibility to campus visitors: <ul style="list-style-type: none"> <li>• 613.8 KW (dc) or 500 KW (ac) facility north of North LINAC</li> </ul> 6.2 KW (dc) or 5 KW (ac) demo system at main entrance of TJNAF adjacent to TED building.	TJNAF will continue to comply with the renewable energy requirements for interim goal years and the 30% by FY 25 goal by implementing renewable electric energy generation projects and/or purchasing renewable energy certificates equivalent to the goal levels. Expanded opportunities for solar are being considered with an alternate location currently under consideration which would be capable of supporting a 6MW solar array.



DOE Goal	Performance Status	Plans and Projected Performance
<b>Sustainable Buildings</b>		
<b>Sustainable Buildings:</b> At least 17% (by building count) of existing buildings greater than 5,000 gross square feet to be compliant with the revised Guiding Principles for HPSB by FY2025, with progress to 100% thereafter.	<p>TJNAF currently has two facilities (10% by building count; 26.47% by gross square feet) fully compliant with High Performance Sustainable Building (HPSB) Guiding Principles.</p> <p>(1) Technology and Engineering Development (TED) Building: 74,000 GSF office, laboratory, and high bay facility earned LEED Gold certification and includes many energy, water efficiency, and other sustainable features including:</p> <ul style="list-style-type: none"> <li>• Geothermal heat pump system provides 80% of HVAC requirements</li> <li>• Grey water reuse system delivers 100% of sanitation water</li> <li>• Solar thermal/domestic water heating system</li> <li>• 44% potable water reduction/low flow plumbing fixtures</li> </ul> <p>(2) Test Facility building expansion: renovation of 95,000 GSF of office, laboratory, and high bay space as well as a 43,600 GSF addition. Also earned LEED Gold certification in compliance with HPSB Guiding Principles.</p>	<p>Recently completed projects are scheduled for benchmarking in Portfolio Manager in FY21 to confirm compliance with the Guiding Principles. Future new construction projects and major renovation projects will be designed to achieve compliance with HPSB Guiding Principles. As these projects are completed, each affected facility will also be benchmarked in Portfolio Manager to ensure compliance:</p> <ul style="list-style-type: none"> <li>• Construction of Environmental, Safety &amp; Health building was completed/occupied in FY17: 12,000-GSF building was designed to comply with all HPSB Guiding Principles. Energy and water efficient sustainable features include LED lighting, solar tube daylight harvesting and highly efficient variable refrigerant flow (VRF) system for heating/cooling.</li> </ul> <p>Renovation of Cryogenics Engineering Office building completed/occupied in FY20: 10,152-GSF building was also designed to comply with all HPSB Guiding Principles.</p>

DOE Goal	Performance Status	Plans and Projected Performance
<b>Acquisition and Procurement</b>		
<b>Sustainable Acquisition:</b>  Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts.	TJNAF actively promotes sustainable acquisition and procurement to the maximum extent possible. FAR clauses regarding sustainability are included in 100% of appropriate acquisition contracts. The facility strives to purchase parts and services that comply with GreenBuy standards and TJNAF has been awarded the GreenBuy Award by the Department of Energy for the third consecutive year. By conducting regular and consistent staff education courses, posting awareness notices, and identifying vendors and products that are environmentally friendly, TJNAF was able to exceed DOE requirements in FY21.	In upcoming fiscal years, no change in mission or other factors are expected to have a significant impact in meeting goals for this category. TJNAF plans to continue existing practices to achieve results that meet or exceed requirements.
<b>EPEAT Product Acquisition:</b>  95% of eligible acquisitions each year are EPEAT-registered products.	Acquisition Strategies: TJNAF purchase requisition/approval processes ensure eligible electronics procurements are environmentally sustainable when possible. In FY20, approximately 95% of eligible products were compliant with EPEAT (bronze, silver, or gold) registration requirements.  Operations Strategies: TJNAF utilizes a central power management system for 100% of desktop computers, laptops, and monitors that can hibernate without impacting facility mission operations. Printing operations are also managed for maximum efficiency. Default queue settings for printers are set for duplex	Continue EPEAT product registered procurement at levels exceeding the 95% target.

	<p>printing in black and white. Users must explicitly select simplex or color printing. Additionally, power management settings on printers and copiers are set to sleep mode when idle for a prescribed time period.</p> <p>End of Life Strategies: Property Management standard procedures ensure that 100% of all excess ADP equipment is screened for first screened for potential reuse whenever possible. When reuse is not possible, however, 100% of disposals are sent to an accredited recycle organization.</p> <p>Data Center Strategies: In FY17, TJNAF completed a major data center consolidation and renovation project that included a significant central chiller plant upgrade and continuous power usage effectiveness (PUE) monitoring energy dashboard. This project included consolidation of a tier III data center operating at a PUE of 2.44 and renovation and reconfiguration of a tier I data center operating at a PUE of 1.70. As a result of the combined high performance and core computing data centers, a new average PUE of 1.30 was achieved. Data center operational efficiency achievements were recognized in FY18 with a Federal Energy and Water Management Award in the data center category.</p>	
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DOE Goal	Performance Status	Plans and Projected Performance
<b>Measures, Funding &amp; Training</b>		
<b>Measures, Funding &amp; Training:</b>  Site set annual targets for sustainability investment with appropriated funds and/or financed contracts for implementation.	<p>TJNAF has invested significantly for many years in achievement or progress regarding various sustainability goals. Funding was obtained through sustainable design of two construction/major renovation LEED Gold facilities (TED Building and Test Facility). Participation in an ongoing demand response program provided funding for sitewide metering system and potential enhancements to the system are currently being evaluated. All new construction/renovation projects include sustainability features designed to continually progress all applicable facilities to achieve compliance with the HPSB Guiding Principles.</p> <p>From FY14 thru FY17, TJNAF pursued Utility Energy Services Contract (UESC) program to finance energy/water efficiency projects and continue progress towards achieving sustainability goals. Feasibility study identified numerous energy conservation measure (ECM) projects: campus wide (interior/exterior) lighting upgrade, central chilled water plant efficiency improvements, and water reduction (domestic water/low flow fixtures) in administrative facilities and an industrial water capture/reuse application. Although TJNAF has been unsuccessful in advancing entire UESC program, ECMs such as lighting upgrades in several facilities and the ultra-pure water (UPW) waste reclaim project.</p>	<p>TJNAF is still seeking to incorporate additional ECMs identified by the UESC feasibility study as well as recent EISA S432 energy and water audits as funding opportunities are identified. In FY21, TJNAF plans to complete additional replacement of pressure dependent control (PDC) valves on chilled water systems with pressure independent control (PIC) valves. Installation of a waterside economizer in the central utility plant (CUP) as well as numerous lighting retrofits and plumbing fixture replacements are included on future capital investment plans. When implemented, the identified projects will contribute especially to achieving the energy utilization intensity goal (25% reduction by FY25 from a FY15 baseline), water intensity reduction, and the HPSB Guiding Principle compliance goal.</p>

DOE Goal	Performance Status	Plans and Projected Performance
<b>Electronic Stewardship</b>		
<b>Electronic Stewardship:</b>  End of Life: 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	<p>Acquisition Strategies: TJNAF purchase requisition and approval processes ensure that eligible electronics procurements are environmentally sustainable whenever possible. In FY20, approximately 95% of eligible products were compliant with EPEAT (bronze, silver, or gold) registration requirements.</p> <p>Operations Strategies: TJNAF utilizes a central power management system for 100% of desktop computers, laptops, and monitors that can hibernate without impacting facility mission operations. Printing operations are also managed for maximum efficiency. Default queue settings for printers are set for duplex printing in black and white. Users must explicitly select simplex or color printing. Additionally, power management settings on printers and copiers are set to sleep mode when idle for a prescribed time period.</p> <p>End of Life Strategies: Property Management standard procedures ensure that 100% of all excess ADP equipment is screened for first screened for potential reuse whenever possible. When reuse is not possible, however, 100% of disposals are sent to an accredited recycle organization.</p> <p>Data Center Strategies: In FY17, TJNAF completed a major data center consolidation and renovation project that included a significant central chiller plant</p>	<p>In FY21, an additional row of hot aisle containment is expected to be constructed in the data center to support expansion of scientific computing equipment. Projected PUE of the data center remains set at 1.30.</p> <p>In upcoming fiscal years, TJNAF has no major initiatives or changes to mission relating to this category. TJNAF plans to continue existing practices to achieve results that meet or exceed requirements.</p>

	<p>upgrade and continuous power usage effectiveness (PUE) monitoring energy dashboard. This project included consolidation of a tier III data center operating at a PUE of 2.44 and renovation and reconfiguration of a tier I data center operating at a PUE of 1.70. As a result of the combined high performance and core computing data centers, a new average PUE of 1.30 was achieved. Data center operational efficiency achievements were recognized in FY18 with a Federal Energy and Water Management Award in the data center category.</p>	
<p><b>Data Center Efficiency:</b></p> <p>Establish a power usage effectiveness target for new and existing data centers; discuss efforts to meet targets.</p>	<p>1.3 PUE established and achieved.</p>	<p>Continue to improve efficiency of power and cooling equipment I current and any future data center expansion projects.</p>



DOE Goal	Performance Status	Plans and Projected Performance
<b>Organizational Resilience</b>		
<p><b>Resilience:</b></p> <p>Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.</p>	<p>Last assessment completed in 2014; improvements to infrastructure and operations have significantly reduced risk of flooding and power outages in key facilities.</p>	<p>Complete a new Climate Vulnerability Assessment and integrate findings into future emergency response operations and infrastructure capital plans</p>

DOE Goal	Performance Status	Plans and Projected Performance
<b>Fugitives and Refrigerants</b>		
<p><b>Greenhouse Gas Emissions:</b></p> <p>50% Scope 1 and 2 (Green House Gas (GHG) emissions reductions by FY 2025 from a FY 2008 baseline.</p> <p>25% Scope 3 GHG emissions reduction by FY 2025 from a FY 2008 baseline.</p>	<p>A variety of activities and operations at TJNAF use greenhouse gases for different purposes. The majority of fugitive GHG emissions in FY20 were due to refrigerant leaks or other corrective maintenance in facility HVAC system equipment. TJNAF reported usage of 108 lbs of R-22 and 400 lbs of R-422B. These emissions, however, are still minimal and represent a significant reduction from the FY08 baseline.</p> <p>Sulfur hexafluoride (SF6) is used at TJNAF in several facilities to suppress arcing in high-voltage DC electron sources. Pressures in these systems are closely monitored and preventative maintenance tasks are conducted to mitigate the risk of leakage or an unexpected release. No new program requirements are expected to increase the use of SF6 and no alternatives are currently being considered or tested. Inventory is closely monitored and controlled. Of the 374 lbs on site in FY20, only 1 lb was lost due to o-ring leakage.</p> <p>When high voltage systems need to be opened for maintenance, two methods of capture and storage are used. The Low Energy Recirculator Facility (LERF) utilizes a custom built recovery system which earned an environmental excellence award from the Commonwealth of Virginia in 2011. The system includes a remote cesiator</p>	<p>Efforts will continue to educate employees about their carbon footprint and maintain results that meet or exceed requirements in this category. The following efficiency measures will be undertaken:</p> <ul style="list-style-type: none"> <li>• In FY21, JSA plans to approve a telework policy which will continue to contribute towards scope 3 GHG reduction goals.</li> <li>• Investigate options for the installation of electric vehicle charging stations for fleet and workplace reimbursable charging.</li> <li>• Encourage TJNAF participation in regional transportation planning, recognition of existing community transportation infrastructure, or incorporation of such efforts into site policy and guidance documents.</li> </ul>

	<p>– a purification and dehydration component. As a result, the gas is not only safely captured, but it can be conserved and reused rather than being replaced by new product. The second method of capture utilizes newer DILO mini series mobile service carts.</p> <p>Business Travel Strategies: Specific initiatives have not been established to reduce ground or air travel for the purpose of reducing scope 3 GHG emissions. Corporate travel policy does, however, encourage efficiency in business travel. Business travel may be undertaken only when alternative methods, such as videoconferencing, are not available. To assist in this effort, most conference rooms at TJNAF are equipped with video and collaboration equipment.</p> <p>Commute Strategies: Staff commuting emissions are the largest controllable contributor to scope 3 GHG emissions. Current estimates for employee commuting GHG emissions is relatively low at only 854.21 mtCO<sub>2</sub>e. This figure takes into account, however, the limited presence of staff onsite since April 2020 due to the COVID-19 pandemic. Due to limited participation in voluntary surveys, commuter data is obtained by validation of employee home address zip code and periodic field observations.</p> <p>Since limited public transportation alternatives are available in the area, achieving reduction goals primarily relies upon implementation of a successful</p>	
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	<p>staff commuting emissions reduction program. The following steps have been taken as part of this effort:</p> <ul style="list-style-type: none"> <li>• Since FY13, preferred parking spaces around the site have been strategically designated for carpooling and low emission vehicles</li> <li>• In FY19, an alternate work schedule (AWS) policy was implemented. JSA now offers a 4/10 schedule and a 9/80 schedule as options to a standard workweek. These options reduce the total number of days driven to and from work by the workforce.</li> <li>• Communication tools such as newsletters, Earth Day events, and EMS objectives encourage TJNAF personnel to improve commuting habits and use alternatives to single-passenger vehicles.</li> </ul>	
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### **2.1.8 REDUCTIONS IN THE GENERATION AND/OR TOXICITY OF HAZARDOUS WASTE THROUGH POLLUTION PREVENTION**

In 2020, TJNAF continued to incorporate waste minimization and pollution prevention evaluations to site activities during early planning phases. Opportunities to reduce waste generation were identified and implemented across the facility, notable activities include:

- Donating materials and supplies to local schools.
- Recycling over 29 tons of scrap metals.

- Re-use of on-site concrete construction debris.
- Re-utilizing equipment that was excessed from completed projects.



#### **2.1.9      REDUCTION OR ELIMINATION OF ACQUISITION OF TOXIC AND HAZARDOUS CHEMICALS AND MATERIALS**

Purchase requests for hazardous materials are approved by TJNAF's ES&H staff to ensure that the most environmentally preferable products are acquired and used.

#### **2.1.10     ENVIRONMENTALLY PREFERABLE PURCHASING**

TJNAF promotes the purchasing of DOE-Priority Products through the Greenbuy Program and provides ready access to recycled content/remanufactured products. Facilities Management and Logistics explores opportunities to find vendors that recycle items no longer needed for operations.

In 2020, TJNAF was awarded a DOE Gold GreenBuy Award from the Department of Energy's Office of Sustainable Environmental Stewardship for meeting leadership goals for 12 priority products in 5 different categories. TJNAF achieved the Gold level award for the fourth consecutive year, which also earned the Facility with the GreenBuy Prime Award.

#### **2.1.11     ELECTRONIC STEWARDSHIP**

TJNAF utilizes the EPA's Electronic Product Environmental Assessment Tool (EPEAT) when selecting energy efficient desktop/laptop computers and computer monitors,

photocopies, televisions, printers, fax machines, tablets and scanners. The facility tracks the purchase of this type of equipment. Energy savings, based on the rated efficiencies of the equipment, can then be calculated and reported. The EPEAT Purchase Awards program honors organizations showing leadership in the procurement of sustainable products. Each star is awarded to an organization for each category in which eligibility requirements are met. During 2020, approximately 95% of eligible products were compliant with EPEAT (bronze, silver, or gold) registration requirements. A central power management system is utilized for desktop computers, laptops, and monitors that can hibernate without impacting Facility operations. Printers are managed with default settings for printing duplex copies in black and white. Power management settings on printers and copiers are set to sleep mode when idle for specific amount of time.

#### **2.1.12 RECYCLING PRACTICES**

Recycling is standard practice for TJNAF. Recycling containers are featured in every office, conference, and break room. TJNAF staff, users, and subcontractors also utilize facility-wide office product recycling centers. These collect: aluminum cans, small batteries, cardboard, printer cartridges, paper wastes, telephone books, and plastic and glass bottles.

In 2020, with construction debris, scrap metal, and automatic data processing equipment included, approximately 123.5 tons of material was recycled. The overall percentage of material diverted from landfills in 2020 was 69.3%.

#### **2.1.13 RESOURCE CONSERVATION & RECOVERY ACT (RCRA)**

RCRA promotes the protection of health, the environment, and conservation of valuable material and energy resources. As a “Small Quantity Generator (SQG),” TJNAF generates less than 1000 kilograms (kg) of hazardous waste per month (but more than 100 kg). In 2020, approximately 2,368.08 kg of RCRA hazardous waste was generated. TJNAF does not store (outside of SQG allowed quantities/time limits), treat, transport, or dispose of RCRA-regulated waste on site. All RCRA wastes are disposed through licensed waste-handling transport and disposal facilities.

The two largest-volume hazardous wastes generated in 2020 were acid mixtures, used for cavity and component processing; and liquid scale dissolver, used for the cleaning of copper surfaces.

#### **2.1.14 EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT (EPCRA)**



Under EPCRA, as aligned with the Superfund Amendments and Reauthorization Act (SARA), TJNAF provides hazardous material data (characteristics, quantities, and storage locations) to local entities for planning purposes so they can prepare to provide adequate chemical and other emergency response services.

TJNAF meets applicable reporting requirements, such as toxic chemical usage and environmental releases, as required. See Figure 4 below.

*Figure 4 – Status of EPCRA Reporting in 2019*

EPCRA Section	Description of Reporting	Status
EPCRA § 302-303	Planning Notification	Completed
EPCRA § 304	EHS Release Notification	Not Required (No releases occurred)
EPCRA § 311-312	Safety Data Sheets/Chemical Inventory	Completed
EPCRA § 313	Toxic Release Inventory Reporting	Not Required (No reporting thresholds exceeded)

#### **2.1.15 ENVIRONMENTAL RESTORATION & WASTE MANAGEMENT**

Waste streams at TJNAF include Resource Conservation and Recovery Act (RCRA) hazardous waste, non-hazardous solid waste, universal waste, used oil, non-RCRA low-level radioactive waste (LLW), and medical wastes. In 2020, TJNAF conducted waste management activities in accordance with applicable standards and requirements. No environmental restoration activities were required under the Comprehensive Environmental Response, Compensation, and Liability Act.

#### **2.1.16 OTHER WASTES**

Other wastes generated at TJNAF include wastewater discharges to sanitary sewer, non-hazardous solid waste from construction/maintenance activities and office waste bins. The vast majority of this waste is non-hazardous solid, consisting of routine office trash and construction debris. TJNAF has an extensive recycling program that resulted in the recycling of 69.3% of the overall waste generated on site (123.5 tons of material) in 2020. TJNAF also recycled close to 100% of its used oil and excessed computer equipment.

LLW is generated and managed in accordance with DOE Order 435.1 – Radioactive Waste Management. TJNAF generated a small amount of LLW in 2020, but not enough to warrant a waste disposal shipment. LLW is generally shipped for disposal in 25 cubic yard containers.

Only a minor amount of medical waste was generated by TJNAF's on-site clinic in 2020. Its disposal was in accordance with all applicable regulations.

### **2.1.17 RELEVANT DEMOGRAPHIC INFORMATION**

TJNAF is a world-class research facility. It attracts both resident and visiting physicists, and other scientists from around the world. In 2020, approximately 744 full-time physicists, engineers, technicians, and support staff worked at TJNAF and more than 1,623 academic and industrial researchers, from across the United States and approximately 37 countries and 277 institutions, participated in scientific collaborations.

Each year, research conducted at TJNAF produces more than one-third of all Nuclear Physics PhDs awarded in the United States. Research at TJNAF in 2019 produced four patents.

### **2.1.18 FEDERAL INSECTICIDE, FUNGICIDE, & RODENTICIDE ACT (FIFRA)**

FIFRA applies to the storage and use of herbicides and pesticides. Use of these substances has environmental implications, especially where water quality is concerned. Consequently, only subcontractors who have completed the certification program administered by the Commonwealth of Virginia perform the application of herbicides and pesticides at TJNAF.

In order to minimize the chances of herbicides and pesticides washing into local stormwater channels, TJNAF requires that there be no outdoor application of these compounds when rain is expected; no industrial-strength herbicides or pesticides are stored or disposed of on TJNAF property; and only small amounts are allowed to be mixed on site.

## **2.2 UNPLANNED RELEASES**

During 2020, TJNAF ES&H staff continued to provide environmental guidance on spill prevention strategies to incorporate during activities occurring at the facility. Environmental guidance was provided to project managers during the initial planning phases of projects in order to identify potential contaminant sources along with providing strategies for pollution prevention during activities. Oil worker training and chemical safety training was also provided to applicable staff in order to update knowledge of spill prevention and the control of releases that may occur onsite.

TJNAF ES&H continued to document all spills and releases onsite in the effort to identify any potential trends that could lead to potential improvements in spill prevention measures.

The following list summarizes the unplanned releases that occurred onsite during 2020:

### September 17, 2020

JSA staff responded to a small hydraulic oil leak from a cryogenics compressed gas delivery truck located adjacent to Building 8 (CHL nitrogen delivery area) in the central portion of the accelerator facility. JSA staff and subcontractor staff immediately responded to the leak by removing the spilled contents located on the paved road surface, applying absorbent materials and repairing the hydraulic line to stop the release. All materials discharged from the release were contained to the immediate area and did not migrate offsite.

### December 8, 2020

JSA staff responded to a release of propylene glycol within a closed-loop sump system located adjacent to the eastern side of the accelerator guard shack. JSA staff responded immediately by powering off the system to repair and complete the necessary maintenance to the system. A small amount of glycol was released on to an adjacent grass covered area and concrete culvert located immediately down gradient. However, JSA staff responded by placing absorbent materials on the spill area to contain the release to prevent further migration and utilized an on-call subcontractor with vacuum truck to remove all contents spilled onto the ground surface for offsite disposal. All materials released were contained to the immediate areas adjacent to the point of release and did not migrate offsite.

Environmental education and outreach on illicit discharges to sanitary sewer and stormwater conveyances appeared to be effective in 2020. This was due to increased spill response efficiency, increases in preventive measures, and overall improvements in awareness of the consequences of illicit discharges that could occur at TJNAF.

## 2.3 SUMMARY OF PERMITS

TJNAF held four active environmental permits in 2020:

*Figure 5 – Environmental Permits in 2020*

Permit Number	Permit Type
GW0047201	Groundwater withdrawal
VA0089320	Industrial Wastewater to Surface – Groundwater Quality
VAR040079	Municipal Separate Storm-Sewer System (MS4)
HRSD 0117	Industrial Wastewater to Sanitary Sewer

During 2018, TJNAF received a five year extension of the existing MS4 Permit (VAR040079). There were no major changes to the permit, with the exception of new Best Management Practices implemented within the Minimum Control Measures section of the Permit.

## 2.4 RADIATION PROTECTION

All TJNAF activities in 2020 were in full compliance with applicable limits for radiation protection. See Section 4.0 – Environmental Radiological Protection Program and Dose Assessment below.

## 2.5 ENVIRONMENTAL OVERSIGHT

TJNAF's exemplary environmental performance is due to the constant attention it receives from all parties involved in facility operations. The DOE Site Office, JSA, subcontractors, and various Commonwealth and local authorities provide continuous oversight of the Facility's environmental program. This includes routine inspections of construction projects, the MS4 System through Illicit Discharge Detection & Elimination (IDDE) inspections (12 monthly inspections in 2020), routine observations of effluent discharge locations for the sanitary sewer system (6 inspection in 2020), waste storage inspections (50 RCRA CAA inspection; 12 RCRA SAA inspections), MS4 High-priority Areas (12 monthly inspections in 2020) and review of other potential contaminant sources.

Self-assessments, inspections, and work observations are utilized to measure program effectiveness.



## 3 ENVIRONMENTAL MANAGEMENT SYSTEM

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### 3.1 ENVIRONMENTAL OPERATING EXPERIENCE

TJNAF's Environmental Management System (EMS) is designed to:

- Identify facility activities with the potential for environmental impacts.
- Mitigate and otherwise manage the impacts of these activities.
- Maintain compliance with applicable environmental protection requirements.
- Promote the long-term stewardship of the Facility's and our neighbors' natural resources.
- Encourage understanding and promote dialogue with interested parties.
- Assess performance, implement corrective actions where needed, and ensure continual improvement.

TJNAF has invested in a multi-dimensional process to assure that its staff and contractors understand the potential impacts (both positive and negative) of their work on the environment and have the tools and training necessary to minimize the negative ones and maximize the positive ones.

As our compliance history and awards demonstrate, that on-going process has been successful.

Because EMS is about continuous improvement, a cross-cutting team of engineers, and other professionals are assembled, at least annually, to review progress, identify issues, and brainstorm possible solutions to better the system. This group reviews the previous year's EMS performance, discusses changes to facility operations, how these would affect the environment, and determines where the facility should focus its improvement activities. This analysis is reviewed by organizational leadership and identifies major focus areas (Objectives) as well as specific projects to support each focus area (Success Metrics).

*Figure 6 below summarizes the Objectives for 2020.*



*\*Figure 6 – 2020 EMS Objectives Summary*

EMS Objective	Success Metric(s)	Status
<b>OBJECTIVE 1</b> Water Usage & Discharge: Reduce onsite water consumption in 2020 by redirecting effluent from Ultra-Pure Water (UPW) into adjacent cooling tower	20-40% reduction in UPW effluent to sanitary sewer by 4 <sup>th</sup> quarter FY20	Accomplished
<b>OBJECTIVE 2</b> Hazardous/Toxic Materials Usage: Improvements to RCRA hazardous waste logbook inventory process	Revise overall organization of manual logbook to: organize into separate waste streams, identify container type/size, generation start date, and storage location	Accomplished
<b>OBJECTIVE 3</b> Infrastructure Operations: Utilizing the specific Turtle diagram for this process, conduct internal audit/assessment of: Grease Control Device for onsite cafeteria	Conduct audit/assessment of contributing processes such as: BMPs practiced, routine maintenance schedule, Fats, Oils, Grease inspections compliance. Identify any opportunities for continuous improvement	Accomplished
<b>OBJECTIVE 4</b> Fabrication Operations: Utilizing the specific Turtle diagram for this process, conduct internal audit/assessment of: SRF Acid Waste Neutralization System	Conduct audit/assessment of contributing processes: System diagnostics, chemical buffering, HRSD compliance. Identify any opportunities for continuous improvement	Accomplished
<b>OBJECTIVE 5</b> Purchase of Equipment: Procurement Division to purchase parts and services that are energy efficient, biobased, recycled content, less toxic than alternatives	Purchase of parts and services that comply with DOE GreenBuy standards	Accomplished

\*Excerpts taken from the CY2020 Environmental Management System Objective Implementation Plan.

### 3.2 ACCOMPLISHMENTS, AWARDS, & RECOGNITION

TJNAF was awarded with a DOE Gold GreenBuy Award in 2020 from the Department of Energy's Office of Sustainable Environmental Stewardship for meeting leadership goals for 12 priority products in 5 different categories.

TJNAF received a 2020 Gold Award from the Hampton Roads Sanitation District (HRSD) for perfect compliance with industrial wastewater discharges to sanitary sewer.

TJNAF was also recognized by the Virginia Department of Environmental Quality (DEQ) during 2020 as an Exemplary Environmental Enterprise (E3) facility within the Virginia Environmental Excellence Program (VEEP). The VEEP consists of three levels: E2 – Environmental Enterprise; E3 – Exemplary Environmental Enterprise; and E4 – Extraordinary Environmental Enterprise. The E3 level is for facilities with fully-implemented Environmental Management Systems (EMS), pollution prevention programs, and demonstrated environmental performance.

### **3.3 ENVIRONMENTAL PERFORMANCE MEASUREMENT**

An existing program on [www.FedCenter.gov](http://www.FedCenter.gov) allows Federal agencies to measure EMS performance using metrics developed to gauge the maturity and health of environmental programs, based on the requirements of the ISO 14001 standard. In 2020, TJNAF's EMS received the highest score.

## 4 ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

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### 4.1 RADIOLOGICAL DISCHARGES & DOSES

#### 4.1.1 RADIATION IN THE ENVIRONMENT

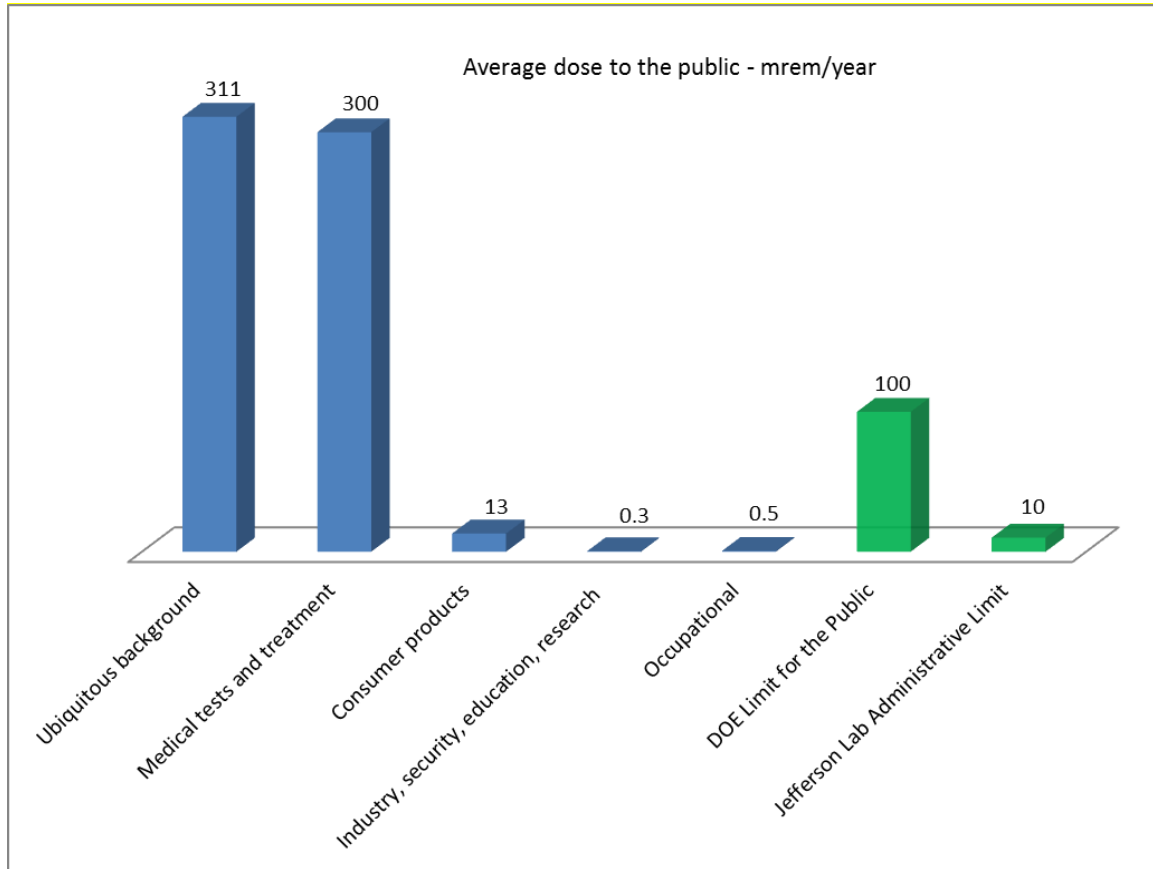
People are exposed to radiation constantly:

- Cosmic radiation from extraterrestrial sources;
- Terrestrial radiation from naturally-occurring elements in the earth's crust; and
- Man-made sources of radiation, notably from medical procedures.

Radiation exposure or “dose” is quantified in units of *rem* (*roentgen equivalent man*), and may be expressed as an individual dose or average amounts among groups or populations. Usually the millirem (mrem) is used to express the small doses associated with occupational and environmental exposure (1 mrem is 1/1000 of a rem). The SI unit in which dose is expressed is the *sievert* or millisievert (mSv). A sievert is equal to 100 rems, so 1 mSv is equal to 100 mrem.

*Figure 7 – Comparison of Sources of Radiation Exposure* shows the relative significance of various sources of radiation exposure to the average member of the public. According to the National Council on Radiation Protection and Measurements, as of 2006, the average individual radiation exposure in the U.S. from all sources now totals about 620 mrem per year, up from an estimated 360 mrem in the early 1980's. The increase can be attributed to medical uses of radiation.

Figure 7 – Comparison of Sources of Radiation Exposure



The DOE limits the potential dose to the public that is attributable to DOE facility operations to 100 mrem per year. TJNAF has established an Alert Level of 10 mrem, either measured or estimated, for protection of the general public.

#### 4.1.2 RADIATION EXPOSURE PATHWAYS AT TJNAF

Two broadly-defined sources of potential radiation exposure exist at the facility: *direct* (or “prompt”) radiation and *induced radioactivity*. Both types are produced during accelerator operations, but direct radiation has a potential impact only within close proximity to an operating accelerator on the site. Accelerator operation (i.e., running an electron beam) produces significant levels of direct radiation within the accelerator enclosure. This radiation is produced within the beam enclosure and its production

stops when an accelerator is turned off. Almost all direct radiation is absorbed by extensive shielding, which is an integral part of accelerator design. Any possible exposure to this radiation decreases rapidly with distance from the accelerators, and is extremely small at the site boundary.

TJNAF has an extensive radiation monitoring network in and around the accelerator. There are approximately 50 active, real-time radiation monitors and a series of passive integrating detectors deployed around the accelerator site. Among these, eight monitors collected direct radiation data around the site boundary in 2020. These monitoring stations are equipped with specialized detection devices, optimized for measuring radiation at close to background levels.

In addition to prompt radiation, the interaction of the accelerator beam with matter can cause the formation of radioactive materials through activation of matter (*induced radioactivity*). The beam lines, magnets, beam line components, targets, detectors, other experimental area equipment, and the energy dissipating devices (beam dumps) used to contain the beam's energy, may become activated. Cooling water, lubricants, and air in the beam enclosure may also become activated. Strict controls limit possible radiation exposure from these activated items and materials.

All materials exposed to the beam or to potential sources of transferable contamination are monitored for radioactivity prior to being released from local control. TJNAF adheres to the DOE release limits for surface contamination, and follows DOE guidance for ensuring that materials being released contain no detectable induced radioactivity.

Controls are in place to minimize exposure from both direct and induced radiation to facility personnel, the environment, and the public. Access to the accelerator site and to areas containing radioactive material is strictly limited. Fencing, safety interlocks, signs, training, and other engineered and administrative controls prevent inadvertent or unnecessary exposures to direct radiation and induced radioactivity.

The largest potential source of environmental impact of a radiological nature at TJNAF is the operation of the CEBAF accelerator. CEBAF has been increasing its operating schedule since the completion of the 12 GeV upgrade in 2014. Little or no high power operations occurred in 2014. A reasonable proxy for the overall environmental radiological impact of operating the CEBAF accelerator is the beam power delivered to experimental halls. Halls A and C receive by far the greatest fraction of beam power. The table below depicts the approximate total beam power delivered to these two halls since 2015. The impact of this beam delivery is reflected in the historical data presented in the following sections.

**Beam Power Delivered to Halls A and C**

<b>Calendar Year</b>	<b>Beam Power (MW-hr)</b>
2016	184
2017	16
2018	1025
2019	481
2020	586

**4.1.3 MONITORING OF POTENTIALLY ACTIVATED WASTEWATER**

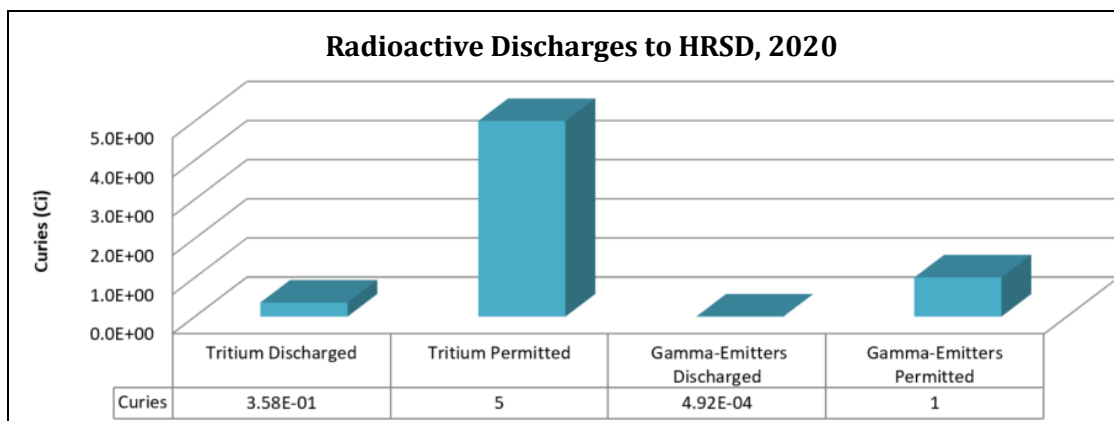
Water that could potentially become activated is sampled, analyzed, and discharged under HRSD Permit No. 0117 and VPDES Permit No. VA0089320. These wastewaters can include:

- CEBAF accelerator enclosure and experimental hall floor drainage
- Beam dump and target cooling water
- Environmental samples, once analyzed
- Groundwater extracted from beneath Halls A, B, and C



The potential radiological constituents of TJNAF's wastewater discharge to HRSD in 2020 (see Figure 8 – Radioactive Discharges to HRSD, 2020) totaled 0.0026 curies (Ci) of tritium (versus a limit of 5 Ci) and 0.000492 Ci of total gamma-emitters (limit = 1 Ci).

**Figure 8 – Radioactive Discharges to HRSD, 2020**



*Figure 8A – Five Year Summary of Radioactive Discharges to HRSD*

Five Year Summary of Radioactive Discharges to HRSD					
Year	Unit	Tritium Discharged	Tritium Permitted	Gamma-Emitters Discharged	Gamma-Emitters Permitted
2020	Curies	2.62E-03	5	8.78E-07	1
2019	Curies	3.58E-01	5	4.92E-04	1



2018	Curies	8.28E-02	5	2.44E-04	1
2017	Curies	3.27E-03	5	2.42E-04	1
2016	Curies	7.28E-04	5	1.43E-04	1

DOE regulates radiological wastewater effluents under DOE Order 458.1. The Order requires wastewater treatment to reduce radioactivity content using the best available technology (BAT) at specified concentration thresholds, in keeping with the ALARA (As Low As Reasonably Achievable) principle. Average discharge concentrations in 2020 remained a small fraction of the BAT treatment threshold.

#### 4.1.4 AIRBORNE RADIONUCLIDES

Essentially all airborne radionuclide emissions from the facility are the result of the release of air from accelerator enclosure vaults containing activation products resulting from beam interactions with the air. The interaction of the beam with air produces short-lived radionuclides such as Oxygen-15, Nitrogen-13, and Carbon-11, and smaller amounts of the longer-lived Hydrogen-3 (tritium). Measurable quantities of airborne radionuclide production (and emission) occur almost exclusively in the CEBAF accelerator at experimental Halls A and C and the beam switchyard portion of the accelerator. Other areas of CEBAF and the LERF contribute only a very small amount to the total emissions. See Figure 9 – Atmospheric Discharges of Radionuclides, 2020 below for a summary of estimated atmospheric releases from TJNAF in 2020.

*Figure 9 – Atmospheric Discharges of Radionuclides, 2020*

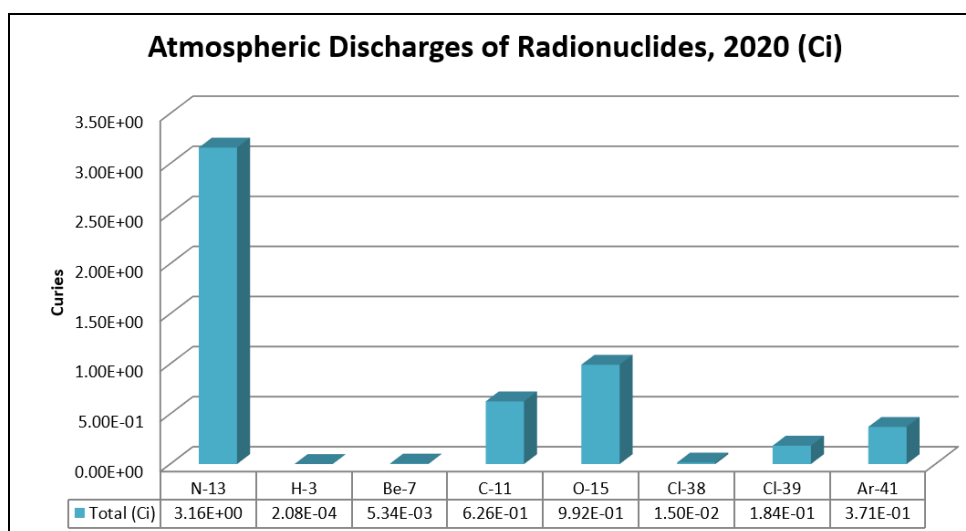


Figure 9A – Five Year Summary of Atmospheric Discharges of Radionuclides

Five Year Summary of Atmospheric Discharges of Radionuclides									
Year	Unit	N-13	H-3	Be-7	C-11	O-15	Cl-38	Cl-39	Ar-41
2020	Curies	3.16E+00	2.08E-04	5.34E-03	6.26E-01	9.92E-01	1.50E-02	1.84E-01	3.71E-01
2019	Curies	6.75E+00	2.61E-04	6.54E-03	9.58E-01	2.60E+00	3.14E-01	3.82E-01	3.07E-01
2018	Curies	6.58E+00	1.31E-01	9.20E-03	1.16E+00	2.07E-00	2.91E-02	2.63E-01	6.46E-01
2017	Curies	2.49E-01	7.51E-03	1.45E-04	3.65E-02	1.20E-01	1.24E-03	1.46E-02	8.24E-03
2016	Curies	8.51E-01	1.56E-03	1.89E-03	1.93E-01	1.87E-01	3.64E-03	4.41E-02	1.44E-01

Compliance with EPA regulations (40CFR61) requires TJNAF to determine the potential for the maximum exposure to this radioactivity by a member of the public. Annual calculations using an EPA-approved computer model (CAP-88 PC, Ver. 4), show that TJNAF's operational emissions remain several orders of magnitude lower than the EPA's 10 mrem/year dose limit for a member of the general public. The calculated 2020 dose to the Maximum Exposed Individual (MEI) among members of the public was 0.0208 mrem/year due to airborne releases. The location of the MEI was approximately 200 meters south of the accelerator, in the Oyster Point office park. This MEI dose represents a very conservative estimate, as the population in the office park would be expected to occupy their location for only 40 hours/week. CAP-88 does not distinguish between commercial or residential (up to 24 hour/day) presence.

#### 4.1.5 DIRECT RADIATION MONITORING

Active (real-time) radiation measurement devices installed along the accelerator site boundary continued to be used to measure dose from direct radiation attributable to facility operations. Figure 11 shows the approximate locations of the Radiation Boundary Monitors (RBMs) that measure and log radiological information, along with the groundwater monitoring well network.

Figure 10 – Direct Radiation Dose at Site Boundary, 2020 displays the radiation doses in mrem at the detectors that saw the largest dose from accelerator operations in 2020. This dose represents direct radiation exposure that would be experienced at the actual on-site boundary monitor location during accelerator operations. Note that the boundary dose shown is the total cumulative dose for the year. This does not, however, represent an estimate of the potential dose to a member of the public; under any credible scenario, that dose would be a small fraction of this amount.

*Figure 10 – Direct Radiation Dose at Site Boundary, 2020*

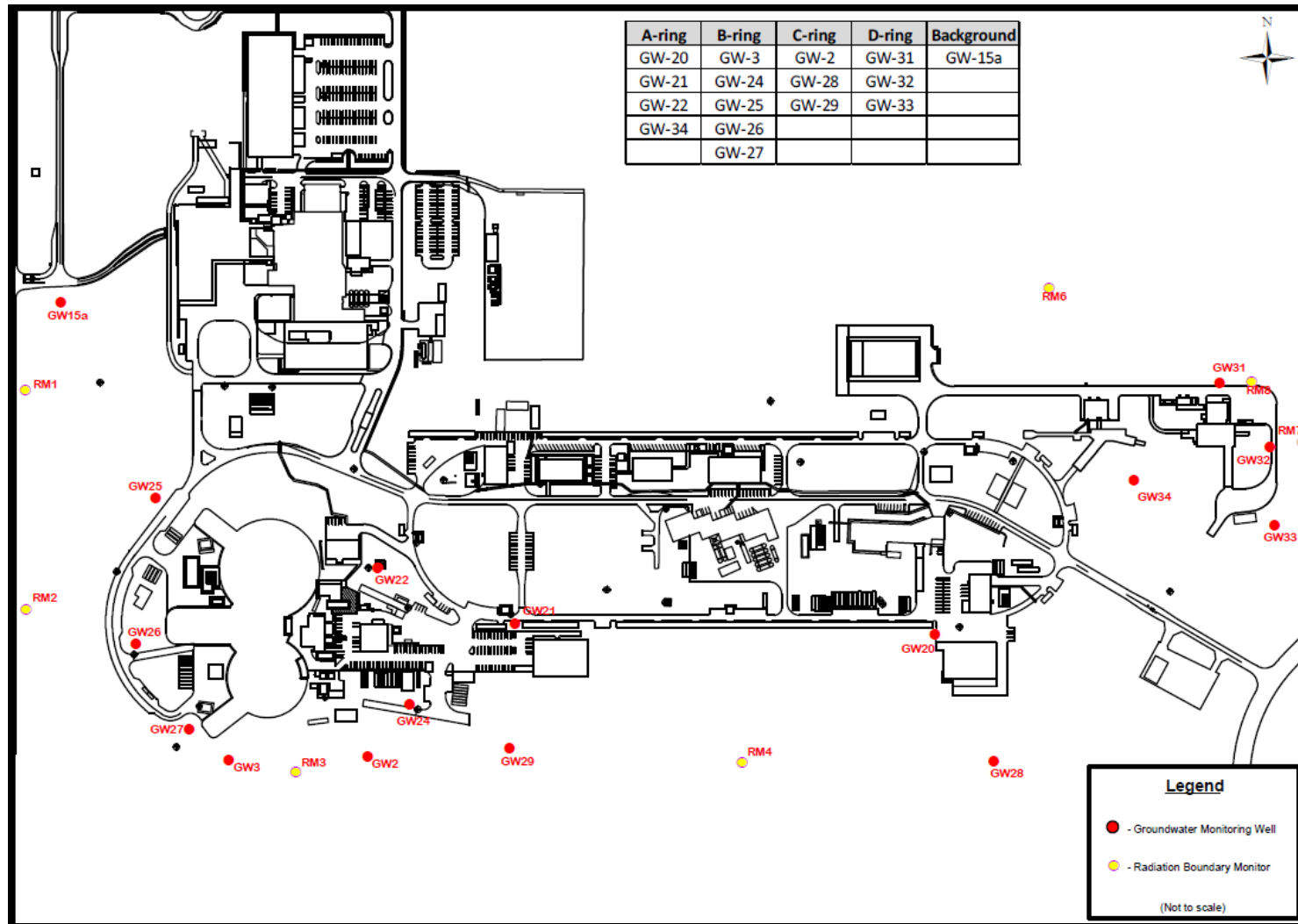
Period	Neutron (mrem)	Gamma (mrem)	Total (mrem)
Jan-June (RBM-3)	0.83	0.15	0.98
July-Dec (RBM-3)	0.47	0.10	0.57
TOTAL	1.30	0.25	1.55

*Figure 10A – Five Year Summary of Direct Radiation Dose at Site Boundary*

Five Year Summary of Direct Radiation Dose at Site Boundary			
Period	Neutron (mrem)	Gamma (mrem)	Total (mrem)
2020	1.30	0.25	1.55
2019	2.45	0.50	2.95
2018	1.10	0.28	1.38
2017	0.071	0.018	0.09
2016	0.50	0.11	0.61

The 2020 dose is approximately 15% of the Facility's design goal of 10 mrem/year (one-tenth of the DOE dose limit). See [Potential Dose to the Public and to Biota](#) for estimates of potential doses to the public.

Figure 11 – Radiation Boundary Monitors and Groundwater Monitoring Wells



#### 4.1.6 GROUNDWATER MONITORING

The underground CEBAF and associated experimental end stations lie in the Yorktown Formation. Groundwater occurs site-wide at a depth of approximately 3 to 25 feet below ground surface.

Under VPDES Permit No.VA0089320, TJNAF monitors groundwater that is pumped from around the experimental halls and is discharged through Outfall 001 to the surface. The vast majority of the surface water leaving the site flows to the Big Bethel Reservoir via Brick Kiln Creek; with a smaller amount going to the lower James River.

In 2020, sixteen of the site's thirty-four wells (*See Figure 11 – Radiation Boundary Monitors and Groundwater Monitoring Wells*) were routinely monitored for radioactivity, using EPA or other approved sampling and analysis protocols. Wells are designated as A-ring, B-ring, C-ring, Hall D, or background. A-ring wells, located closest to the accelerator, are most likely to show the effects of soil and groundwater activation. B-ring wells are located further from potential sources of activation. Both A-ring and B-ring wells are sampled semi-annually. C-ring wells, positioned to represent conditions near the property boundaries, are sampled annually, along with the background well. Monitoring of Hall D wells were conducted on a semiannual basis.

Groundwater samples are analyzed for H-3 (tritium), Be-7 (beryllium 7), Mn-54 (manganese 54), and Na-22 (sodium 22). The VPDES permit specifies limits for radioactivity in the wells based on their location with respect to the accelerators. No accelerator-related radionuclides were detected in the groundwater and no permit exceedances occurred in 2020.

#### 4.1.7 OTHER ENVIRONMENTAL SURVEILLIANCE

TJNAF routinely collects environmental samples not required by any regulation or permit. Sediments from storm drainage channels and soils in areas that could potentially be affected (by contaminated runoff or storage and handling of radioactive materials) are sampled at a variety of locations on a location-specific frequency. Results of sampling continue to show that no significant radioactivity is being released to the environment through these pathways.

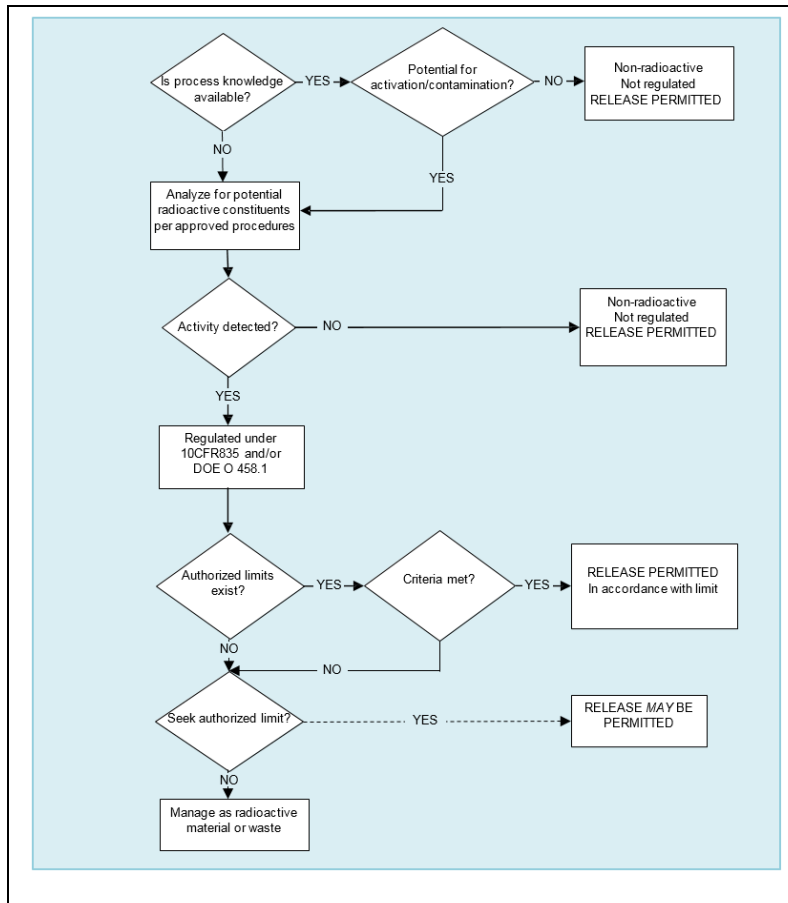
## 4.2 CLEARANCE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

TJNAF does not release any residual radioactive material, such as contaminated concrete or soil, so there are no resulting dose impacts to the public. The Facility has developed a process to determine if potentially radioactive materials are to be managed as material containing residual radioactivity or as non-radioactive. All potentially activated or contaminated material and equipment is monitored prior to release from control. The program involves many hundreds of radiological surveys annually.

TJNAF adheres to DOE limits for radioactive surface contamination (although little material with surface contamination is generated here). DOE Order 458.1 does not prescribe a specific limit for release of volumetrically-activated materials; therefore, the Facility has adopted methods and procedures that ensure equipment and materials being released contain no radioactivity distinguishable from background. Materials with potential for internal contamination or volumetric radioactivity that cannot be reliably assessed are treated as radioactive materials and are not released to the public.

Figure 12 – General Process for Materials Classification - summarizes TJNAF's process. This process is consistent with the approach recommended upon by a multi-agency task group regarding defining impacted areas and classifications of material.

*Figure 12 – General Process for Materials Classification*



The application of process knowledge comprises the first step in the characterization of materials for possible release. The approach at TJNAF has historically been a conservative one: if materials were in the accelerator enclosure during beam operations, it is assumed that they may be activated, and they are subject to further analysis. Surveys and sampling and analysis are conducted by trained technicians using written procedures. Results of the surveys or other analyses are documented appropriately.

In 2020, the estimated volume of materials released through the process described above was about 5.7 tons of solid waste and an estimated 3 tons of scrap metals for recycling.

Potential doses to the public from undetected radioactivity in released materials have been assessed and documented as prescribed in various national and international standards. These standards and DOE requirements apply a dose constraint of 1 mrem/year for determining the significance of potential dose to the public. The measurement sensitivity of the Facility's procedures was evaluated against this



benchmark as part of its technical basis, confirming that potential dose to a member of the public through this pathway is insignificant.

Independent review of TJNAF's process for releasing materials from radiological control is conducted periodically by DOE or a designated third party.

TJNAF sought no Authorized Limits for the release of material containing residual radioactivity in 2020. All materials that exhibit radiation above background levels were managed as radioactive material, and either saved for beneficial reuse, or classified as waste. Almost all radioactive waste generated at TJNAF is low-level waste (LLW), with an occasional small additional amount of mixed-LLW. TJNAF made no radioactive waste shipments in calendar year 2020.

### 4.3 POTENTIAL DOSE TO THE PUBLIC

Controls are in place to minimize exposure from both direct radiation and radiation from activated materials to facility personnel, the environment, and the public. Access to the Accelerator Site and to areas housing radioactive material is strictly limited. Fencing, safety interlocks, signage, training, and other engineered and administrative controls prevent inadvertent exposures to direct and induced radiation.

The direct dose and air emissions discussed above are the only sources for which any contributions to public dose can be directly measured or calculated. Other sources involve only hypothetical doses. In *Figure 13 – TJNAF Radiological Dose Summary for 2020* - the maximum possible dose to the public assumes a 24-hour a day, 365-days-a-year exposure to the highest levels measured at the site boundary. However, it is not credible under any plausible conditions for a member of the public to actually receive this dose. The southern and western boundaries of the site, where the monitors are located, are heavily wooded and mostly undeveloped or adjacent to a major roadway. All site boundaries are also posted with "U.S. Government – No Trespassing" signs.

Figure 13 - TJNAF Radiological Dose Summary for 2020

Pathway	Dose to Maximally Exposed Individual, mrem	% of 100 mrem/yr DOE Limit	Estimated Population Dose, person-rem
Air*	0.0208	0.0208	0.0144
Water**	~0	~0	~0
Release of materials**	≤1	≤1	~0
Direct radiation***	1.55	1.55	~0
Total, all pathways	≤2.58	≤2.58	~0
Plausible scenario †	0.093	0.093	-
<p>*From 2020 atmospheric modeling results for National Emission Standards for Hazardous Air Pollutants (NESHAP) reporting</p> <p>** See text below</p> <p>*** From Boundary Radiation Monitors, before applying realistic exposure scenario (see text)</p> <p>† Total effective dose using a conservative, reasonable exposure scenario (see text)</p>			

One can construct an exposure scenario in which a more realistic estimate of the maximum potential dose to a member of the public is obtained. A reasonably conservative scenario might involve exposure at the boundary in which an individual spent two hours per day walking along the site boundary or waiting for a Jefferson Avenue bus, and did so for 250 days of the year. Under this scenario, we can assign the average dose rate from monitoring to the individual for the entire occupancy duration. This hypothetical case represents a reasonably conservative scenario for the MEI for this source. Given these conditions, the MEI for this exposure path would have received 0.088 mrem in 2020 from direct radiation, 0.088% of the DOE limit of 100 mrem.

The potential dose from air releases is also modeled using a 100% exposure time assumption. A reasonable modification would be to adjust this value for a typical occupational duration (2000 hours) at the location of concern. This results in a dose of 0.0047 mrem. Doses from these two sources represent the only reasonably quantifiable exposure pathways to the public from Facility operations. If we combine the dose from these two scenarios, the maximum postulated dose from all pathways to a member of the public from TJNAF operations in 2020 is approximately 0.093 mrem.

There is no public or private use of the shallow aquifer in the vicinity of TJNAF; thus, there is no exposure to the public via contact with or ingestion of groundwater. No accelerator-produced radioactivity was detected in any of the samples from the End Station Sump or in surface water. Considering the extremely small quantities of radioactivity that are potentially present in this effluent, the potential dose to a member of the public or biota from this pathway is insignificant. A 2013 RESRAD-based evaluation found that the total dose from pathways such as ingestion of plants, fish, meat, and milk, as well as all pathways related to surface water, was in the range of  $10^{-8}$  mrem/year.

The total “potentially exposed population” reported herein is defined by DOE as those living within 80 km (50 miles) of the site. Population data from the 2010 Census uses an outer radius of 70 km. Population dose estimates in this report are based entirely on the NESHAP dose calculation. Dose beyond the site’s boundary is so low it cannot be reliably measured.

## **4.4 ADDRESSING RADIATION PROTECTION FOR BIOTA IN ASER**

### **4.4.1 DOSE RATE LIMITS FOR PROTECTION OF BIOTA & METHODS FOR COMPLIANCE**

TJNAF can only estimate absorbed dose to local biota (aquatic or terrestrial). The DOE has provided guidance on evaluating dose that may be received by biota. DOE-Standard-1153-2002 provides screening values for both terrestrial and aquatic organisms. The internationally recommended dose limit for terrestrial biota, 0.1 rad/day, is the lowest limit for any biota. The rad is a dose unit similar to the rem, but it does not contain any of the risk factors associated with exposure to humans. Therefore, all criteria are met if doses do not exceed 0.1 rad/day.

The best indicators of dose to biota are the passive dosimeters placed at various locations around the property. These are the same types of dosimeters used to monitor worker exposure. In 2020, 38 locations were monitored by this method for purposes of estimating environmental dose.



During 2020, the site provided habitat for deer, foxes, raccoons, squirrels, groundhogs and other small mammals, reptiles, aquatic macroinvertebrates, and a wide variety of birds. The birds and some of the mammals roam the site, but others (like the groundhogs) live in an established burrow. The biota expected to receive the maximum dose would be ground-dwelling animals living in the earthen domes over the experimental halls.

*Figure 14 – Distribution of 2020 Dose Reflected by Environmental Dosimeters* - shows the frequency distribution of annual (2020) doses from the network of dosimeters. The maximum recorded dose was 208 mrad, measured at the southwest side of the Hall C dome. Dividing this value by 365 days yields a daily dose of 0.00057 rad/day, far below the most stringent criteria. *Figure 15 – Environmental Radiation vs. Limit* - illustrates these data.

Figure 14 –Distribution of 2020 Dose Reflected by Environmental Dosimeters

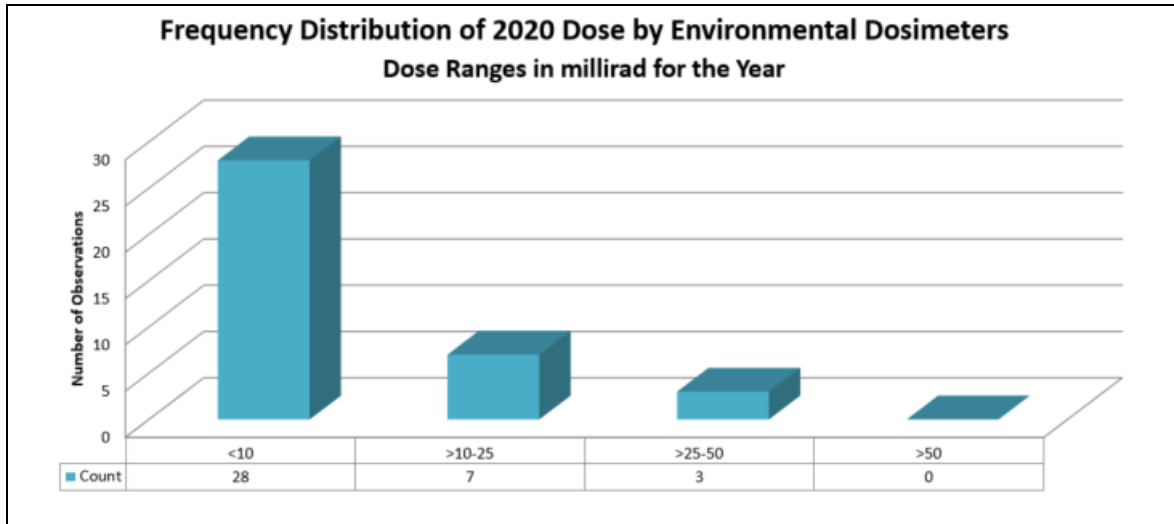


Figure 14A – Five Year Summary of Distribution of Dose in millirad/year Reflected by Environmental Dosimeters

Five Year Summary of Distribution of Dose in millirad/year Reflected by Environmental Dosimeters							
Year	<10	>10-25	>25-50	>50	>50-75	>75-100	>100
2020 Count	28	7	3	-	-	-	-
2019 Count	28	8	0	2	1	-	1
2018 Count	27	8	1	2	-	-	2
2017 Count	28	8	1	1	-	-	-
2016 Count	28	8	1	1	-	-	-

Figure 15 – Environmental Radiation Dose vs. Limit

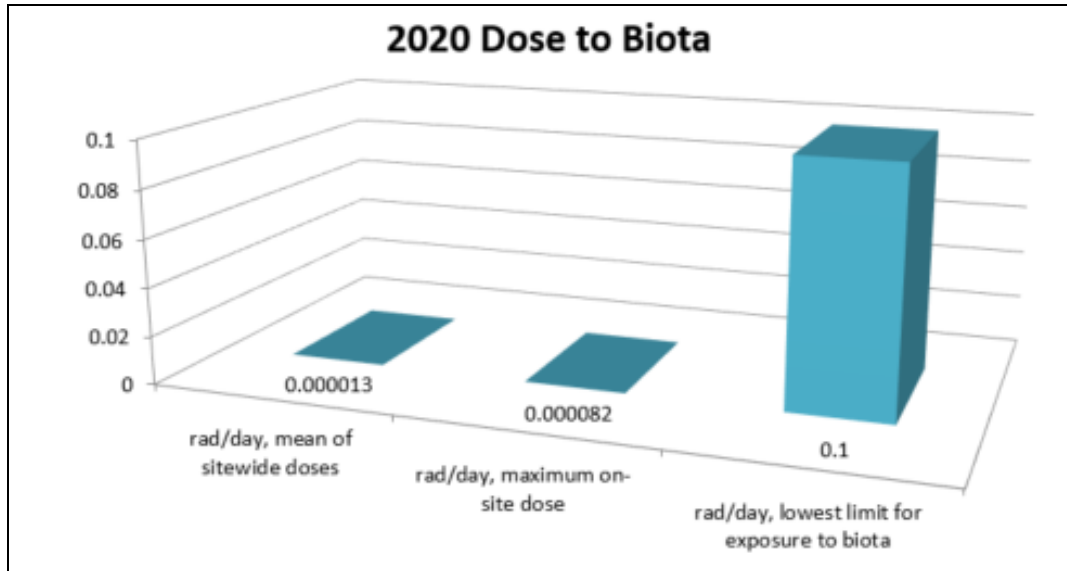


Figure 15A – Five Year Summary of Dose to Biota

Five Year Summary of Dose to Biota			
Year	Rad/day, mean of site-wide doses	Rad/day, maximum on-site dose	Rad/day, lowest limit for exposure to biota
2020	0.000013	0.000082	0.1
2019	0.000029	0.00057	0.1
2018	0.000037	0.00058	0.1
2017	0.000017	0.00019	0.1
2016	0.000065	0.002	0.1

## 4.5 UNPLANNED RADIOLOGICAL RELEASES

TJNAF had no unplanned radiological releases in 2020.

## 4.6 ENVIRONMENTAL RADIOLOGICAL MONITORING

Ionizing radiation and a variety of radioactive materials are by-products of research activities at TJNAF. Any potential impacts have been significantly reduced by adhering to the philosophy of “as low as reasonably achievable” (ALARA) in dealing with potential sources of radiation. The potential dose to members of the public from various pathways, such as inhalation, ingestion, and skin absorption, is evaluated by the ES&H Division to demonstrate compliance with regulatory limits (as required by DOE Order 458.1, “Radiation Protection of the Public and the Environment”).



## 5 GROUNDWATER PROTECTION PROGRAM

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*Figure 16 – Typical Cross Section of Boring at TJNAF Site*, compiled from several on-site boring logs, depicts a typical cross section. The CEBAF tunnel and experimental end stations are located underground within the Yorktown Formation. Activation of the groundwater and soil are a potential source of groundwater contamination. Groundwater occurs site-wide at a depth of approximately 3 to 25 feet below grade. Groundwater quality in the soil surrounding the accelerator complex is the Commonwealth's greatest concern with site operations.

*Figure 16 – Typical Cross Section of Boring at TJNAF Site*

Depth, ft.	Description	
0	Loose to stiff, gray, sandy CLAY	
5	Loose, orange-brown clayey fine SAND	
7	Loose gray silty fine SAND	
12	Loose to firm, gray fine to medium SAND	
22	Very stiff, gray, shelly, sandy SILT	
27	Firm, white, cemented shells	
32	Firm, gray, very silty, fine SAND with shell fragments	
37	Very stiff, very sandy SILT with shell fragments	
40	Boring Terminated	

The monitoring of VPDES-permitted wells for groundwater quality continued in 2020, and provided much of the basis for the Groundwater Protection Program. Through a combination of engineered

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controls (e.g. shielding) designed into the CEBAF and LERF facilities, and adherence to operational limits, no measurable groundwater activation was produced on or offsite.

Many other programs at TJNAF contribute to groundwater protection: spill prevention and control, pollution prevention and waste minimization, materials storage, and waste management are a few.

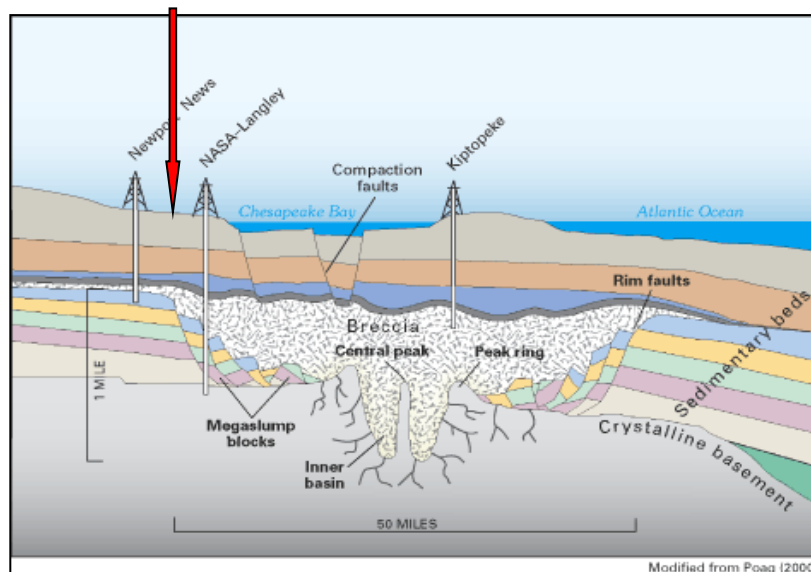
Relatively recent information places TJNAF in a unique geologic position. Approximately 35 million years ago, a giant bolide<sup>1</sup> blasted a huge crater into the continental shelf. A bolide of this magnitude creates a complex crater with inner and outer rims.

As *Figure 17 – Delineation of Inner and Outer Craters* indicates, the outer rim of the crater lies across Newport News. The inner and outer rims have complex, characteristic stratigraphic features, as shown in *Figure 18 – Location of TJNAF Relative to the Outer Rim of the Chesapeake Bay Bolide Crater*.

*Figure 17 – Delineation of Inner and Outer Craters*



*Figure 18 – Location of TJNAF Relative to the Outer Rim of the Chesapeake Bay Bolide Crater*



The red arrow (*Figure 18 – Location of TJNAF Relative to the Outer Rim of the Chesapeake Bay Bolide Crater*) indicates the approximate location of TJNAF relative to the Chesapeake Bay bolide crater. Site geology could be more complex than once thought. Notably, in this area, the Yorktown-Eastover aquifer is greatly diminished. Extensive studies of the groundwater characteristics within the outer rim show that even deeper aquifers were affected by the bolide, which evaporated water more than a mile deep. That water was replaced by saline water, which remains present to this day in the Potomac aquifer and other, deeper groundwater sources.

TJNAF activities to date have involved only the Yorktown-Eastover aquifer; that aquifer is the focus of our Groundwater Protection Program. The Yorktown-Eastover aquifer is represented in the above figure by the blue layer between the orange-tan (Yorktown) and dark gray (Eastover) formations.

Semiannual monitoring of wells installed around the Hall D complex was initiated in the Fall of 2016, as a result of the reissuance of VPDES Permit VAR0089320. Groundwater data from wells around Hall D for 2020 is consistent in quality with the remainder of the TJNAF site.

## 6 QUALITY ASSURANCE (QA)

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Extensive QA activities ensure that TJNAF's environmental monitoring program continually performs in accordance with the principles of the QA Program (DOE Order 414.1D) and the requirements of DOE Order 458.1. The QA Program includes:

- Qualification of the laboratories that provide analytical services.
- Verification of certification to perform analytical work.
- Review of performance test results.
- Assessment of the adequacy of each subcontractor's internal quality control (QC) practices, recordkeeping, chain of custody, etc.

In addition to the internal QA performed by TJNAF's Environment, Safety, and Health Division, independent assessments are performed by Performance Assurance, the DOE Site Office, regulatory agencies such as the EPA and Virginia Department of Environmental Quality, and oversight groups within DOE. No QA concerns regarding environmental sampling protocols or results were noted in 2020.

An independent laboratory (James R. Reed & Associates) collected most of 2020's VPDES and HRSD permit-required water samples. Other samples that involve radionuclide analysis, including some required by the HRSD permit, are collected by the ES&H Division and analyzed in TJNAF's radiological analysis facility (RAL). Eberline Services performed all subcontracted radiological analyses. James R. Reed is a Virginia Environmental Laboratory Accreditation Program (VELAP) certified facility as administered by the Virginia Division of Consolidated Laboratory Services (DCLS). The DCLS administers the certification/accreditation program and conducts inspections of environmental laboratories to ensure consistency with the National Environmental Laboratory Accreditation Program (NELAP).

Samples collected by external analytical laboratories are analyzed for radiological (and non-radiological) attributes using standard EPA-approved analytical procedures. Both external facilities and TJNAF have a continuing program of analytical laboratory QC. Participation in inter-laboratory crosschecks, analysis of various blanks, and replicate sampling and analysis verify data quality. ES&H Division staff and other responsible TJNAF personnel review all analytical data for the samples analyzed under their subcontracts. The analytical results are reviewed relative to the accompanying QA/QC results and compared with regulatory limits for acceptability. These reviews include inspection of chain-of-custodies, sample stewardship, sample handling and transport, and sampling protocols. When applicable to the analysis requested, analytical labs must be appropriately certified.

On-going precision and accuracy are monitored by analysis of the following with each batch of samples taken under Permit VA0089320: laboratory standards, duplicate determinations, matrix spikes, and matrix spike duplicates. These data are used to calculate the relative standard deviation on all applicable parameters. The quality of the data is then evaluated and compared to regulatory

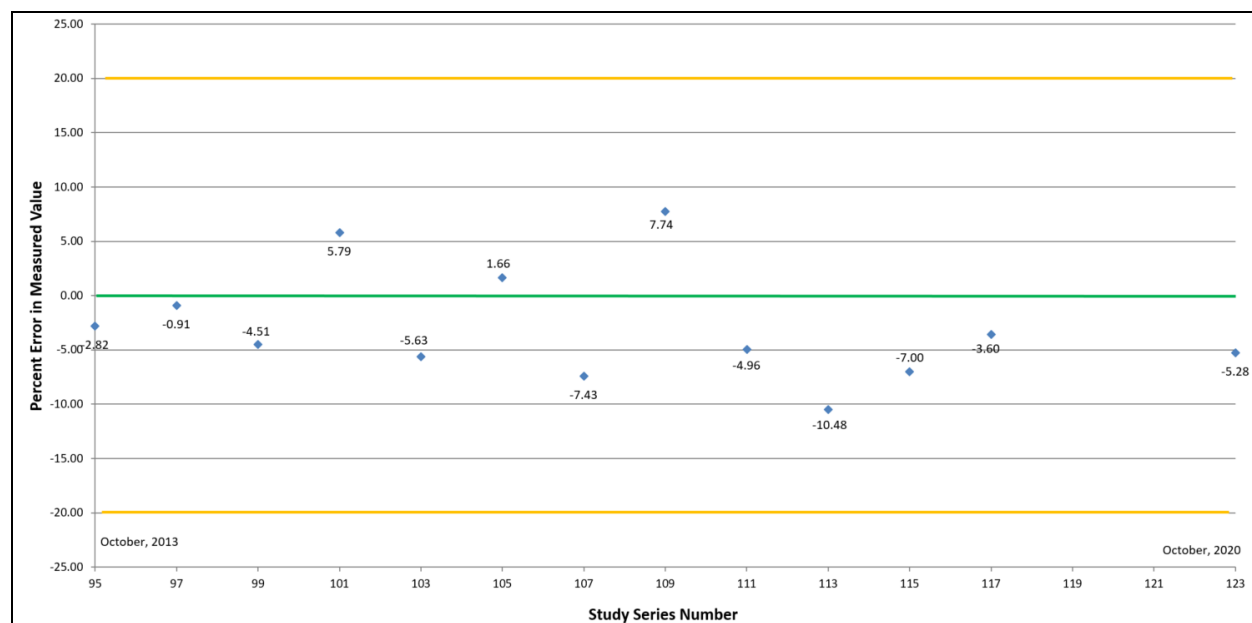
limits to determine acceptability. Satisfactory results from the vendors enable TJNAF to validate compliance with the QA requirements in the permit.

TJNAF and Eberline Services participate in the Mixed Analyte Performance Evaluation Program (MAPEP) conducted by DOE's Radiological and Environmental Services Laboratory, which is available to all DOE subcontractors. This program tests the quality of environmental radiological and non-radiological measurements and provides DOE with complex-wide comparability of measurement performance. In the two rounds of MAPEP QA testing in 2020, overall performance by both TJNAF and Eberline was acceptable (TJNAF participated in only one round due to COVID-19), with only minor potential quality concerns associated with false positive results or results for constituents that are not of concern at TJNAF. Results of the MAPEP testing can be found at:

<http://www.id.energy.gov/resl/mapep/mapepreports.html>.

TJNAF also participates in an annual quality test for analysis of tritium. *Figure 19 – Environmental Resource Association (ERA) Quality Control Program for Tritium Analysis* - demonstrates the agreement between the control samples and the values reported by our radioanalytical laboratory over time (note: two rounds of testing – late 2019 and early 2020 – were not conducted due to the COVID pandemic).

*Figure 19 – ERA Quality Control Program for Tritium Analysis*



## 7 ACRONYM LIST

ALARA	As Low As Reasonably Achievable
AFV	Alternative Fuel Vehicles
ASHRAE	American Society of Heating, Refrigerating, and Air-conditioning Engineers
BAT	Best Available Technology
BDX	Beam Dump Experiment
Be-7	Beryllium-7
BMP	Best Management Practices
BOMARC	Boeing and Michigan Aerospace Research Center
BTU	British Thermal Unit
CASA	Center for Advanced Studies of Accelerators
CD	Critical Decision
CEBAF	Continuous Electron Beam Accelerator Facility
CFR	Code of Federal Regulations
CHL	Central Helium Liquifier
Ci	Curie
CLAS12	CEBAF Large Acceptance Spectrometer for 12 GeV Upgrade
CMSA	Central Material Storage Area
CRAD/LOI	Criteria Review and Approach Document/Lines of Inquiry
CRE	CEBAF Center Renovation & Expansion
CTF	Chiller Treatment Facility
DCLS	Virginia Division of Consolidated Laboratory Services
DEQ	Virginia Department of Environmental Quality
DOD	Department of Defense
DOE	Department of Energy

EA	Environmental Assessment
ECM	Energy Conservation Measures
EEL	Experimental Equipment Facility
EISA	Energy Independence and Security Act
EIU	Energy Intensity Utilization
EMS	Environmental Management System
E.O.	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPEAT	Electronic Product Environmental Assessment Tool
ERA	Environmental Resource Association
ES&H	Environment, Safety and Health
ES&H	Environment, Safety, and Health
FAR	Federal Acquisition Regulation
FEL	Free Electron Laser
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FML	Facilities Management & Logistics
FONSI	Finding of No Significant Impact
FY	Fiscal Year
GeV	Billion (Giga)-electron Volts
GHG	Greenhouse gas
GP	Guiding Principles
GSF	Gross Square Foot
H-3	Tritium
HEMSF	High Energy Mission Specific Facility
HPSB	High Performance and Sustainable Building



HRSD	Hampton Roads Sanitation District
ILA	Industrial, Landscaping, and Agricultural
ISM	Integrated Safety Management
ISO	International Organization for Standardization
TJNAF	Thomas Jefferson National Accelerator Facility
JSA	Jefferson Science Associates, LLC
kg	Kilogram
kW	Kilowatt
LED	Light-Emitting Diode
LEEDS	Leadership in Energy and Environmental Design
LERF	Low Energy Recirculator Facility
LQG	Large Quantity Generator
LID/GI	Low Impact Development/Green Infrastructure
LLW	Low Level Radioactive Waste
Mn-54	Manganese-54
MAPEP	Mixed Analytic Performance Evaluation Program
MBTU	One Million British Thermal Units
MDA	Minimum Detectable Activity
MEI	Maximum Exposed Individual
METF	Maximum Extent Technically Feasible
MOLLER	Measurement of Lepton-Lepton Electroweak Reaction
mrem	millirem
mSv	millisievert
MS4	Municipal Separate Storm Sewer Systems
Na-22	Sodium-22
NAAQS	National Ambient Air Quality Standards

NASA	National Aeronautics and Space Administration
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOV	Notice of Violation
ODS	Ozone-Depleting Substance
QA	Quality Assurance
QC	Quality Control
PC	Personal Computer
PUE	Power Utilization Effectiveness
PV	Photo Voltaic
Radcon	Radiation Control
RAL	Radiological Analysis Laboratory
RBM	Radiation Boundary Monitor
RCRA	Resource Conservation and Recovery Act
REC	Renewable Energy Credit
REM	Roentgen equivalent man
RESRAD	Residual Radiation
SARA	Superfund Amendments and Reauthorization Act
SPCC	Spill Prevention, Control, and Countermeasure
SqFt	Square Feet
SQG	Small Quantity Generator
SRF	Superconducting Radiofrequency
SARA	Superfund Amendments and Reauthorization Act
TEDF	Technology Engineering and Development Facility
TJNAF	Thomas Jefferson National Accelerator Facility

TJSO	Thomas Jefferson Site Office
TMDL	Total Maximum Daily Load
UESC	Utility Energy Service Contract
UIM	Utility Infrastructure Modernization
UITF	Upgrade Injector Test Facility
VELAP	Virginia Environmental Laboratory Accreditation Program
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program
W	Watt

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