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10 CFR 50 Appendix I

May 15, 2023

Attn: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Pilgrim Nuclear Power Station
Renewed Facility Operating License No. DPR-35
Docket No. 50-293 and 72-1044

Subject: Annual Radiological Environmental Operating Report, January 1 through December 31, 2022.

In accordance with the requirements of Pilgrim Station Defueled Safety Analysis Report, Appendix B-5.6.2, and 10 CFR 50 Appendix I, Holtec Decommissioning International LLC (HDI), on behalf of Pilgrim Nuclear Power Station, herby submits the Annual Radiological Environmental Operating Report for calendar year 2022.

This letter contains no new regulatory commitments.

Should you have any questions or require further information, please contact Mark Lawson, Radiation Protection and Chemistry Manager, at (508) 830-7109 or me at (856) 797-0900, ext. 3578.

Sincerely,

Jean A. Fleming Digitally signed by Jean A. Fleming
Date: 2023.05.15 11:53:23 -04'00'

Jean A. Fleming

Vice President, Licensing, Regulatory Affairs, & PSA
Holtec International

Enclosure: Annual Radiological Environmental Operating Report, January 1st through December 31st, 2022

cc:
USNRC Regional Administrator, Region I
USNRC Project Manager, NMSS - Pilgrim Nuclear Power Station
USNRC Region I, Lead Inspector - Pilgrim Nuclear Power Station
Director, Massachusetts Emergency Management Agency
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PILGRIM NUCLEAR POWER STATION

Facility Operating License DPR-35

Annual Radiological Environmental Operating Report

January 1 through December 31, 2022

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Facility Operating License DPR-35

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

JANUARY 01 THROUGH DECEMBER 31, 2022

Prepared by: _____ 5/7/2023
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INTRODUCTION

This report summarizes the results of the Holtec Decommissioning International (HDI) Nuclear Radiological Environmental Monitoring Program (REMP) conducted in the vicinity of Pilgrim Nuclear Power Station (PNPS) during the period from January 1 to December 31, 2022. This document has been prepared in accordance with the requirements of PNPS Facility Licensing Basis.

The REMP has been established to monitor the radiation and radioactivity released to the environment as a result of previous Pilgrim Station's operation. This program, initiated in August 1968, includes the collection, analysis, and evaluation of radiological data in order to assess the impact of Pilgrim Station on the environment and on the general public. The results from the REMP are used also to validate dose modeling and concentration prediction results in the effluent dose model.

SAMPLING AND ANALYSIS

The environmental sampling media collected in the vicinity of PNPS and at distant locations include air particulate filters, seawater, sediment, shellfish, American lobster, and fishes. Some sample media such as soil, forage, Irish moss, vegetation and cranberries were removed from the discussion of this report as they are no longer a pathway and therefore removed from the ODCM and sampling program. Soil sampling had been previously removed in 2003 in favor of extensive TLD monitoring.

During 2022, there were 389 samples collected from the atmospheric, aquatic, and terrestrial environments. In addition, 155 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs).

312 of 312 air particulate were collected and analyzed as required without any equipment failures or power outages as is usually the case in an area in the Northeast US, but a mild winter and close monitoring of equipment has helped to prevent sample losses. Charcoal cartridge collection was discontinued in the beginning of December 2019 when Iodines had decayed away following the permanent shutdown of PNPS on May 31, 2019. A full description of any discrepancies encountered with the environmental monitoring program is presented in Appendix D of this report.

Analyses on environmental samples were performed by Teledyne Brown Engineering Laboratory in Knoxville, TN. Samples were analyzed as required by the PNPS ODCM.

LAND USE CENSUS

The annual land use census in the vicinity of Pilgrim Station is no longer conducted. All crop-based foods no longer exist within a 5 mile radius of the plant. Cranberries and Irish Moss crops were removed from the ODCM in revision 14. The collection of broad leaf vegetation was to account for deposition of iodine on a type of cattle feed in lieu of sampling for milk. There are no milk farms withing 5 miles. The need to account for changes in new or old gardens diminished once the plant shutdown and not only was no new iodine created, but that which had been created all decayed after 10 half lives for I-131 had passed (1 calendar quarter).
Broadleaf vegetation may still be consumed by humans, and it will be projected and accounted for in dose modeling for all nuclides remaining that are released off site, but the only radionuclide detected in

REMP samples while the plant was operating was Cs-137 from fall out (recently – Chernobyl and Fukushima) which is deposited on and absorbed through the roots of plants and trees and has a 30-year half-life. The current dose model for gaseous release dose calculations utilizes a garden at the site boundary in the predominant downwind direction. As this is the most conservative scenario, no land use census will produce an alternate garden with higher off-site dose potential.

The wind rose maps for Pilgrim RBV mixed mode releases and ground releases show the predominant wind direction from the SSW in both frequency and wind speed. This means the predominant wind direction is from the land out to sea from the WNW to the SSW with SSW the most frequent compass point wind comes from toward the station. Essentially, gaseous effluents from the plant, however minor in quantity compared to when operating, are blown out to sea.

RADIOLOGICAL IMPACT TO THE ENVIRONMENT

During 2022, samples collected as part of the REMP at Pilgrim Station continued to contain detectable amounts of naturally-occurring radioactive materials. No samples indicated any detectable radioactivity attributable to Pilgrim Station operations. Offsite ambient radiation measurements using environmental TLDs beyond the site boundary ranged between 49 and 88 milliRoentgens (1 mR=0.933 mrem) per year. The range of ambient radiation levels observed with the TLDs is consistent with natural background radiation levels for Massachusetts.

RADIOLOGICAL IMPACT TO THE GENERAL PUBLIC

During 2022, radiation doses to the general public as a result of previous Pilgrim Station's operation continued to be well below the federal limits and much less than the collective dose due to other sources of man-made (e.g., X-rays, medical, fallout) and naturally-occurring (e.g., cosmic, radon) radiation.

The calculated total body dose to the maximally exposed member of the general public from radioactive effluents and ambient radiation resulting from PNPS operations for 2022 was approximately 0.16 mrem for the year. This conservative estimate is well below the EPA's annual dose limit to any member of the general public and is a fraction of a percent of the typical dose received from natural and man-made radiation.

CONCLUSIONS

The 2022 Radiological Environmental Monitoring Program for Pilgrim Station resulted in the collection and analysis of hundreds of environmental samples and measurements. The data obtained were used to determine the impact of Pilgrim Station's operation on the environment and on the general public.

An evaluation of direct radiation measurements, environmental sample analyses, and dose calculations showed that all applicable federal criteria were met. Furthermore, radiation levels and resulting doses were a small fraction of those that are normally present due to natural and man-made background radiation.

Based on this information, there is no significant radiological impact on the environment or on the general public due to Pilgrim Station's decommissioning operations.

1.0 INTRODUCTION

The Radiological Environmental Monitoring Program for 2022 performed by Comprehensive Decommissioning International (CDI), now Holtec Decommissioning International (HDI), owned by Holtec for Pilgrim Nuclear Power Station (PNPS) is discussed in this report. This report, which is required to be published annually by Pilgrim Station's Facility Licensing Basis, summarizes the results of measurements of radiation and radioactivity in the environment in the vicinity of the Pilgrim Station and at distant locations during the period January 1 to December 31, 2022.

The Radiological Environmental Monitoring Program consists of taking radiation measurements and collecting samples from the environment, analyzing them for radioactivity content, and interpreting the results. With emphasis on the critical radiation exposure pathways to humans, samples from the aquatic, atmospheric, and terrestrial environments are collected. These samples include, but are not limited to: air, seawater, sediment, shellfish, American lobster, and fish. Thermoluminescent dosimeters (TLDs) are placed in the environment to measure gamma radiation levels. The TLDs are processed, and the environmental samples are analyzed to measure the very low levels of radiation and radioactivity present in the environment as a result of PNPS operation and other natural and man-made sources. These results are reviewed by PNPS's Chemistry staff and have been reported semiannually or annually to the Nuclear Regulatory Commission and others since 1972.

In order to more fully understand how a nuclear power plant impacts humans and the environment, background information on radiation and radioactivity, natural and man-made sources of radiation, radioactive effluent controls, and radiological impact on humans is provided. It is believed that this information will assist the reader in understanding the radiological impact on the environment and humans from the previous operation of Pilgrim Station.

1.1 Radiation and Radioactivity

All matter is made of atoms. An atom is the smallest part into which matter can be broken down and still maintain all its chemical properties. Nuclear radiation is energy, in the form of waves or particles that is given off by unstable, radioactive atoms.

Radioactive material exists naturally and has always been a part of our environment. The earth's crust, for example, contains radioactive uranium, radium, thorium, and potassium. Some radioactivity is a result of nuclear weapons testing. Examples of radioactive fallout that is normally present in environmental samples are cesium-137 and strontium-90. Some examples of radioactive materials released from a nuclear power plants are cesium-137, iodine-131, strontium-90, and cobalt-60. Iodine is no longer an active Pilgrim station isotope as the station no longer produces iodine and that which was previously produced has decayed away.

Radiation is measured in units of millirem, much like temperature is measured in degrees. A millirem is a measure of the biological effect of the energy deposited in tissue. The natural and man-made radiation dose received in one year by the average American is approximately 620 mrem (References 2, 3, 4).

Radioactivity is measured in curies. A curie is that amount of radioactive material needed to produce 37,000,000,000 nuclear disintegrations per second. This is an extremely large amount of radioactivity in comparison to environmental radioactivity. That is why radioactivity in the environment is measured in picocuries. One picocurie is equal to one trillionth of a curie.

1.2 Sources of Radiation

As mentioned previously, naturally occurring radioactivity has always been a part of our environment. Table 1.2-1 shows the sources and doses of radiation from natural and man-made sources.

Table 1.2-1

Radiation Sources and Corresponding Doses [1]

NATURAL		**MAN-MADE**	
Source	Radiation Dose (millirem/year)	Source	Radiation Dose (millirem/year)
Internal, inhalation[2]	230	Medical[3]	300
External, space	30	Consumer[4]	12
Internal, ingestion	30	Industrial[5]	0.6
External, terrestrial	20	Occupational	0.6
		Weapons Fallout	< 1
		Nuclear Power Plants	< 1
Approximate Total	310	Approximate Total	315
Combined Annual Average Dose: Approximately 625 millirem/year			

[1] Information from NCRP Reports 160 and 94

[2] Primarily from airborne radon and its radioactive progeny

[3] Includes CT (150 millirem), nuclear medicine (74 mrem), interventional fluoroscopy (43 mrem) and conventional radiography and fluoroscopy (30 mrem)

[4] Primarily from cigarette smoking (4.6 mrem), commercial air travel (3.4 mrem), building materials (3.5 mrem), and mining and agriculture (0.8 mrem)

[5] Industrial, security, medical, educational, and research

Cosmic radiation from the sun and outer space penetrates the earth's atmosphere and continuously bombards us with rays and charged particles. Some of this cosmic radiation interacts with gases and particles in the atmosphere, making them radioactive in turn. These radioactive byproducts from cosmic ray bombardment are referred to as cosmogenic radionuclides. Isotopes such as beryllium-7 and carbon-14 are formed in this way. Exposure to cosmic and cosmogenic sources of radioactivity results in approximately 30 mrem of radiation dose per year.

Additionally, natural radioactivity is in our body and in the food we eat (approximately 30 millirem/yr), the ground we walk on (approximately 20 millirem/yr) and the air we breathe (approximately 230 millirem/yr). The majority of a person's annual dose results from exposure to radon and thoron in the air we breathe. These gases and their radioactive decay products arise from the decay of naturally occurring uranium, thorium and radium in the soil and building products such as brick, stone, and concrete. Radon and thoron levels vary greatly with location, primarily due to changes in the concentration of uranium and thorium in the soil. Residents at some locations in Colorado, New York, Pennsylvania, and New Jersey have a higher annual dose as a result of higher levels of radon/thoron gases in these areas. In total, these various sources of naturally-occurring radiation and radioactivity contribute to a total dose of approximately 310 mrem per year.

In addition to natural radiation, we are normally exposed to radiation from a number of man-made sources. The single largest doses from man-made sources result from therapeutic and diagnostic

applications of x-rays and radiopharmaceuticals. The annual dose to an individual in the U.S. from medical and dental exposure is approximately 300 mrem. Consumer activities, such as smoking, commercial air travel, and building materials contribute approximately 13 mrem/yr. Much smaller doses result from weapons fallout (less than 1 mrem/yr) and nuclear power plants. Typically, the average person in the United States receives approximately 314 mrem per year from man-made sources. The collective dose from naturally-occurring and man-made sources results in a total dose of approximately 620 mrem/yr to the average American.

1.3 Nuclear Reactor Operations

Pilgrim Station was an operating boiling water reactor whose nuclear steam supply system was provided by General Electric Co. The nuclear station is located on a 1600-acre site approximately eight kilometers (five miles) east-southeast of the downtown area of Plymouth, Massachusetts. Commercial operation began in December 1972. Pilgrim Station was operational until May 31, 2019 before the decision to permanently shut down and decommission the station.

Nuclear-generated electricity was produced at Pilgrim Station by many of the same techniques used for conventional oil and coal-generated electricity. Both systems use heat to boil water to produce steam. The steam turns a turbine, which turns a generator, producing electricity. In both cases, the steam passes through a condenser where it changes back into water and recirculates back through the system. The cooling water source for Pilgrim Station is the Cape Cod Bay.

The key difference between Pilgrim's nuclear power and conventional power is the source of heat used to boil the water. Conventional plants burn fossil fuels in a boiler, while nuclear plants make use of uranium in a nuclear reactor.

Inside the reactor, a nuclear reaction called fission takes place. Particles, called neutrons, strike the nucleus of a uranium-235 atom, causing it to split into fragments called radioactive fission products. The splitting of the atoms releases both heat and more neutrons. The newly-released neutrons then collide with and split other uranium atoms, thus making more heat and releasing even more neutrons, and on and on until the uranium fuel is depleted or spent. This process is called a chain reaction.

The operation of a nuclear reactor results in the release of small amounts of radioactivity and low levels of radiation. The radioactivity originates from two major sources, radioactive fission products and radioactive activation products.

Radioactive fission products, as illustrated in Figure 1.3-1 (Reference 5), originate from the fissioning of the nuclear fuel. These fission products get into the reactor coolant from their release by minute amounts of uranium on the outside surfaces of the fuel cladding, by diffusion through the fuel pellets and cladding and, on occasion, through defects or failures in the fuel cladding. These fission products circulate along with the reactor coolant water and will deposit on the internal surfaces of pipes and equipment. The radioactive fission products on the pipes and equipment emit radiation. Examples of some fission products are krypton-85 (Kr-85), strontium-90 (Sr-90), xenon-133 (Xe-133), and cesium-137 (Cs-137).

Nuclear Fission

Fission is the splitting of the uranium-235 atom by a neutron to release heat and more neutrons, creating a chain reaction. Radiation and fission products are by-products of the process.

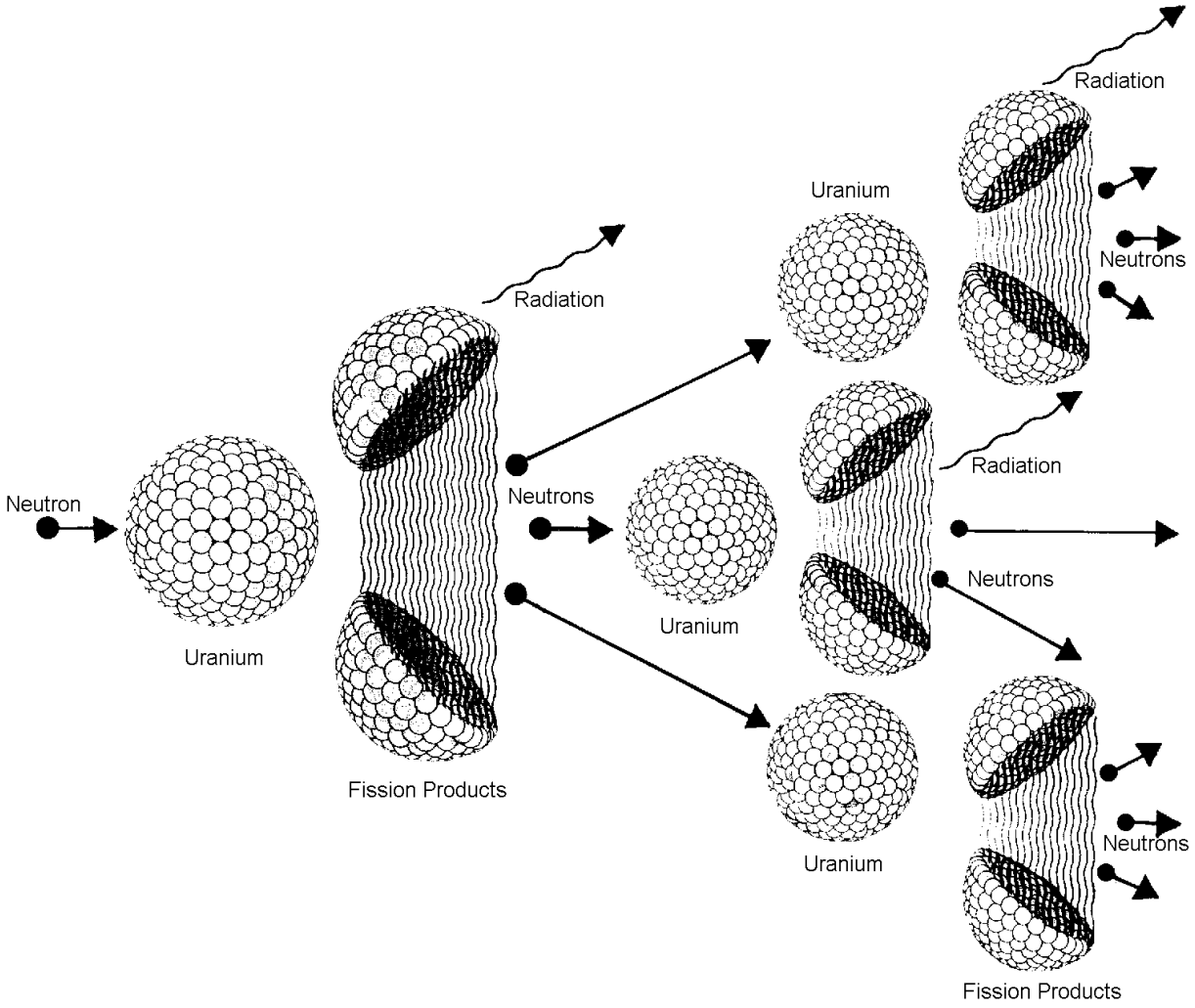


Figure 1.3-1
Radioactive Fission Product Formation

Radioactive activation products (see Figure 1.3-2), on the other hand, originate from two sources. The first is by neutron bombardment of the hydrogen, oxygen and other gas (helium, argon, nitrogen) molecules in the reactor cooling water. The second is a result of the fact that the internals of any piping system or component are subject to minute yet constant corrosion from the reactor cooling water. These minute metallic particles (for example: nickel, iron, cobalt, or magnesium) are transported through the reactor core into the fuel region, where neutrons may react with the nuclei of these particles, producing radioactive products. So, activation products are nothing more than ordinary naturally-occurring atoms that are made unstable or radioactive by neutron bombardment. These activation products circulate along with the reactor coolant water and will deposit on the internal surfaces of pipes and equipment. The radioactive activation products on the pipes and equipment emit radiation. Examples of some activation products are manganese-54 (Mn-54), iron-59 (Fe-59), cobalt-60 (Co-60), and zinc-65 (Zn-65).

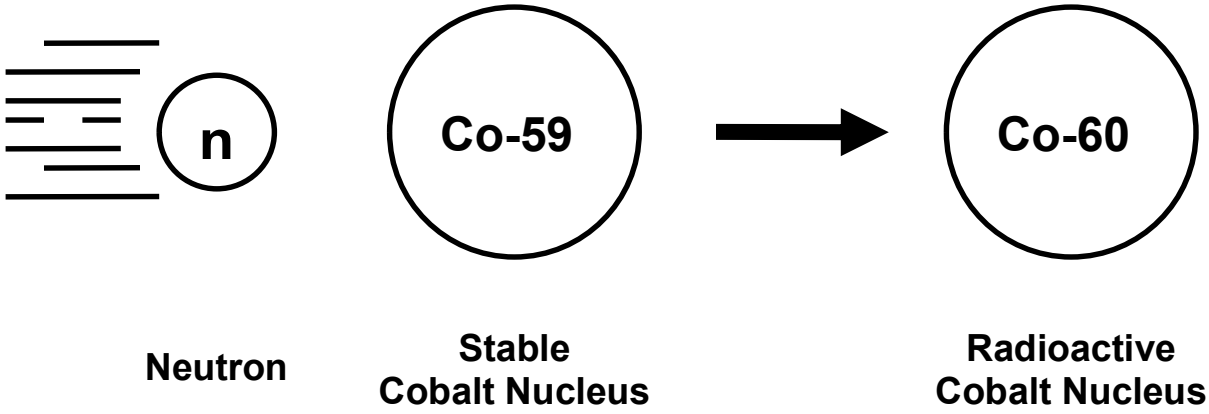


Figure 1.3-2
Radioactive Activation Product Formation

At Pilgrim Nuclear Power Station there were five independent protective barriers that confined radioactive materials during operation. These five barriers, which are shown in Figure 1.3-3 (Reference 5). Following the permanent shutdown and decommissioning of the plant in May of 2019 the only source of released radioactivity is that of the decay of radioactive activation products. Barriers like fuel pellets and cladding are no longer applicable. Building structures still play a part in shielding as discussed below.

SIMPLIFIED DIAGRAM OF A BOILING WATER REACTOR

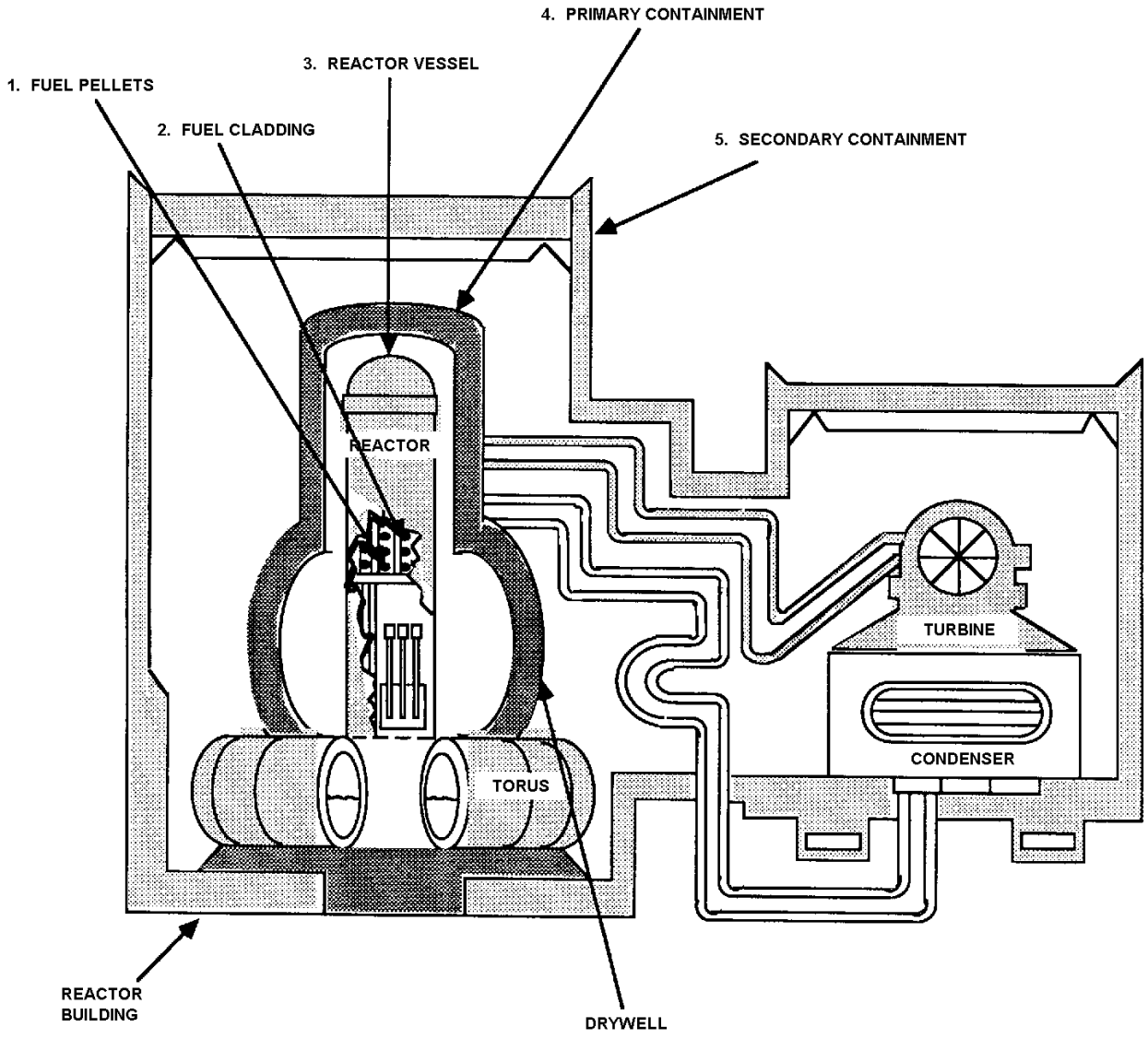


Figure 1.3-3
Barriers To Confine Radioactive Materials

Barrier consisting of the reactor vessel, steel piping and equipment still confine the reactor water. The reactor vessel, which once held the reactor fuel, is a 65-foot high by 19-foot diameter tank with steel walls approximately nine inches thick. This provides containment for radioactivity in the water once used as primary coolant. However, during the course of decommissioning operations and maintenance, small amounts of radioactive fission and activation products can escape through valve leaks or upon breaching of the primary coolant system for maintenance.

The last barrier is the reactor building. This reactor building is equipped with a controlled filtered ventilation system that is used to keep the building as at a negative pressure.

These barriers confine most of the remaining activation products. However, small amounts of radioactivity do escape via mechanical failures and maintenance on valves, piping, and equipment associated with the reactor/fuel pool systems. The small amounts of radioactive liquids and gases that do escape the various containment systems are further controlled by the liquid purification and ventilation filtration systems. Prior to a release to the environment, control systems collect and purify the radioactive effluents in order to reduce releases to the environment to as low as is reasonably achievable (ALARA). The control of radioactive effluents at Pilgrim Station will be discussed in more detail in the next section.

1.4 Radioactive Effluent Control

The small amounts of radioactive liquids and gases that might escape the barriers are purified in the liquid and gaseous waste treatment systems, then monitored for radioactivity, and released only if the radioactivity levels are below the federal release limits as permitted.

Radioactivity released from the liquid effluent system to the environment is limited, controlled, and monitored by a variety of systems and procedures which include:

- liquid radwaste treatment system;
- sampling and analysis of the liquid radwaste tanks; and,
- liquid waste effluent discharge header radioactivity monitor.

Water used previously for reactor or spent fuel cooling that might escape the primary cooling system and other radioactive water sources are collected in floor and equipment drains. These drains direct this radioactive liquid waste to large holdup tanks. The liquid waste collected in the tanks is purified again using the liquid radwaste treatment system, which consists of a filter and ion exchange resins.

More recently the option has been added to the ODCM (rev. 15) to be able to utilize the torus as a “tank” (as it no longer serves its original purpose to aid in reactor level/ pressure control) to hold water and process through means other than the established radwaste treatment system (e.g. Demineralizers previously used with in the condensate system) for purification prior to release.

Prior to release, the radioactivity in the liquid radwaste tank is sampled and analyzed to determine if the level of radioactivity is below the release limits and to quantify the total amount of radioactive liquid effluent that would be released. If the levels are below the federal release limits, the tank is released to the liquid effluent discharge header.

This liquid waste effluent discharge header is provided with a shielded radioactivity monitor. This detector is connected to a radiation level meter and a strip chart recorder in the Control Room. The radiation alarm is set so that the detector will alarm before radioactivity levels exceed the release limits.

The liquid effluent discharge header has an isolation valve. If an alarm is received, the liquid effluent discharge valve will automatically close, thereby terminating the release to the Cape Cod Bay and preventing any liquid radioactivity from being released that may exceed the release limits. An audible alarm notifies the Control Room operator that this has occurred.

Some liquid waste sources which have a low potential for containing radioactivity, and/or may contain very low levels of contamination, may be discharged directly to the discharge canal without passing through the liquid radwaste discharge header. One such source of liquids is the neutralizing sump. However, prior to discharging such liquid wastes, the tank is thoroughly mixed and a representative sample is collected for analysis of radioactivity content prior to being released.

Another means for adjusting liquid effluent concentrations to below federal limits is by mixing plant cooling water (salt service water) with the liquid effluents in the discharge canal. This larger volume of cooling water further dilutes the radioactivity levels far below the release limits.

The preceding discussion illustrates that many controls exist to reduce the radioactive liquid effluents released to the Cape Cod Bay to as far below the release limits as is reasonably achievable.

Radioactive releases from the radioactive gaseous effluent system to the environment are limited, controlled, and monitored by a variety of systems and procedures which include:

- reactor building ventilation system;
- sampling and analysis of reactor building vent effluents

The purpose of the reactor building ventilation system is to collect and exhaust reactor building air. Air collected from contaminated areas is filtered prior to combining it with air collected from other parts of the building. This combined airflow is then directed to the reactor building ventilation plenum that is located on the side of the reactor building. A sample stream of the plenum flows through a sampling rack equipped with a particulate filter. Air samples are taken on a weekly frequency from the reactor building vent and are analyzed to quantify the total amount of tritium and radioactive particulate effluents released. This plenum, which vents to the atmosphere, was previously equipped with a gaseous radiation detector. The gaseous radiation monitor was removed from the ODCM in revision 15. All Noble gases have decayed away, save Kr-85 which is sealed in dry storage casks on the Independent Spent Fuel Storage Installation (ISFSI) II pad.

Therefore, for both liquid and gaseous releases, radioactive treatment systems exist to collect and purify the radioactive effluents in order to reduce releases to the environment to as low as is reasonably achievable (ALARA). The effluents are always monitored, sampled, and analyzed prior to release to make sure that radioactivity levels are below the release limits. If the release limits are being approached, isolation valves in the liquid radwaste discharge line flow path will automatically shut to stop the release, or responsible personnel will implement procedures to ensure that federal regulatory limits are always met.

1.5 Radiological Impact on Humans

The final step in the effluent control process is the determination of the radiological dose impact to humans and comparison with the federal dose limits to the public. As mentioned previously, the purpose of continuous radiation monitoring and periodic sampling and analysis is to measure the quantities of radioactivity being released to determine compliance with the radioactivity release limits. This is the first stage for assessing releases to the environment.

Next, calculations of the dose impact to the general public from Pilgrim Station's radioactive effluents are performed. The purpose of these calculations is to periodically assess the doses to the general public resulting from radioactive effluents to ensure that these doses are being maintained as far below the federal dose limits as is reasonably achievable. This is the second stage for assessing releases to the environment.

The types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during each given year are reported to the Nuclear Regulatory Commission annually in the Annual Radiological Effluent Release Report (ARERR). These liquid and gaseous effluents were well below the federal release limits and were a small percentage of the PNPS ODCM effluent control limits.

These measurements of the physical and chemical nature of the effluents are used to determine how the radionuclides will interact with the environment and how they can result in radiation exposure to humans. The environmental interaction mechanisms depend upon factors such as the hydrological (water) and meteorological (atmospheric) characteristics in the area. Information on the water flow, wind speed, wind direction, and atmospheric mixing characteristics are used to estimate how radioactivity will distribute and disperse in the ocean and the atmosphere.

The most important type of information that is used to evaluate the radiological impact on humans is data on the use of the environment. Information on fish and shellfish consumption, boating usage, beach usage, locations of cows and goats, locations of residences, locations of gardens, drinking water supplies, and other usage information are utilized to estimate the amount of radiation and radioactivity received by the general public.

The radiation exposure pathway to humans is the path radioactivity takes from its release point at Pilgrim Station to its effect on man. The movement of radioactivity through the environment and its transport to humans is portrayed in Figure 1.5-1.

EXAMPLES OF PILGRIM STATION'S RADIATION EXPOSURE PATHWAYS

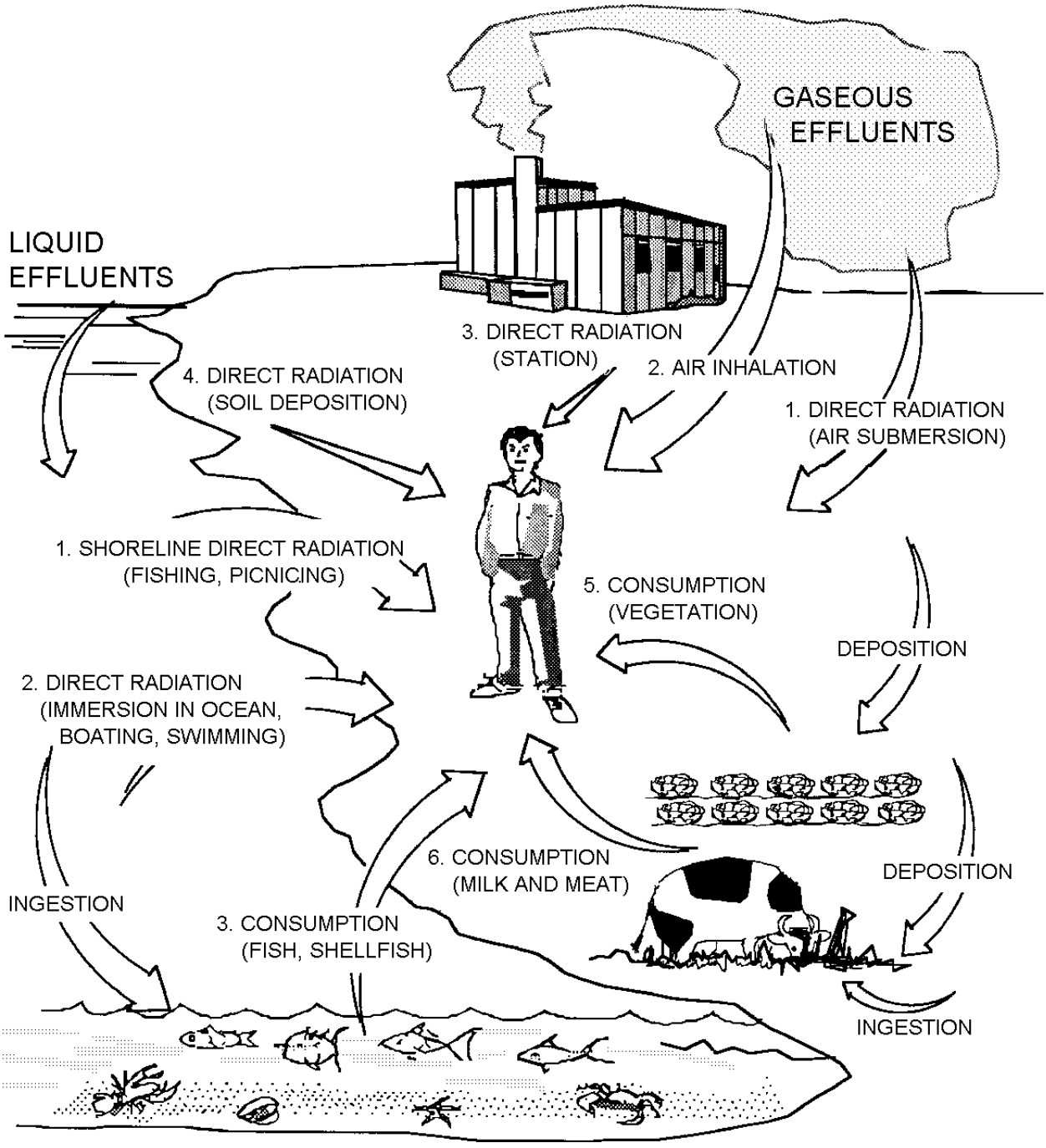


Figure 1.5-1
Radiation Exposure Pathways

There are three major ways in which liquid effluents affect humans:

- external radiation from liquid effluents that deposit and accumulate on the shoreline;
- external radiation from immersion in ocean water containing radioactive liquids; and,
- internal radiation from consumption of fish and shellfish containing radioactivity absorbed from the liquid effluents.

There are six major ways in which gaseous effluents affect humans:

- external radiation from an airborne plume of radioactivity;
- internal radiation from inhalation of airborne radioactivity;
- external radiation from deposition of radioactive effluents on soil;
- ambient (direct) radiation from contained sources at the power plant;
- internal radiation from consumption of vegetation containing radioactivity deposited on vegetation or absorbed from the soil due to ground deposition of radioactive effluents; and,
- internal radiation from consumption of milk and meat containing radioactivity deposited on forage that is eaten by cattle and other livestock.

In addition, ambient (direct) radiation emitted from contained sources of radioactivity at PNPS contributes to radiation exposure in the vicinity of the plant. Smaller amounts of ambient radiation result from low-level radioactive waste stored at the site prior to shipping and disposal.

To the extent possible, the radiological dose impact on humans is based on direct measurements of radiation and radioactivity in the environment. When PNPS-related activity is detected in samples that represent a plausible exposure pathway, the resulting dose from such exposure is assessed (see Appendix A). However, the operation of Pilgrim Nuclear Power Station resulted in releases of only small amounts of radioactivity, and, as a result of dilution in the atmosphere and ocean, even the most sensitive radioactivity measurement and analysis techniques cannot usually detect these tiny amounts of radioactivity above that which is naturally present in the environment. Therefore, radiation doses are calculated using radioactive effluent release data and computerized dose calculations that are based on very conservative NRC-recommended models that tend to result in over-estimates of resulting dose. These computerized dose calculations are performed by or for station personnel. These computer codes use the guidelines and methodology set forth by the NRC in Regulatory Guide 1.109 (Reference 6). The dose calculations are documented and described in detail in the Pilgrim Nuclear Power Station's Offsite Dose Calculation Manual (Reference 7), which has been reviewed by the NRC.

Monthly dose calculations are performed by PNPS personnel. It should be emphasized that because of the very conservative assumptions made in the computer code calculations, the maximum hypothetical dose to an individual is considerably higher than the dose that would actually be received by a real individual.

After dose calculations are performed, the results are compared to the federal dose limits for the public. The two federal agencies that are charged with the responsibility of protecting the public from radiation and radioactivity are the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA).

The NRC, in 10CFR 20.1301 (Reference 8) limits the levels of radiation to unrestricted areas resulting from the possession or use of radioactive materials such that they limit any individual to a dose of:

- less than or equal to 100 mrem per year to the total body.

In addition to this dose limit, the NRC has established design objectives for nuclear plant licensees. Conformance to these guidelines ensures that nuclear power reactor effluents are maintained as far below the legal limits as is reasonably achievable.

The NRC, in 10CFR 50 Appendix I (Reference 9) establishes design objectives for the dose to a member of the general public from radioactive material in liquid effluents released to unrestricted areas to be limited to:

- less than or equal to 3 mrem per year to the total body; and,
- less than or equal to 10 mrem per year to any organ.

The air dose due to release of noble gases in gaseous effluents is restricted to:

- less than or equal to 10 mrad per year for gamma radiation; and,
- less than or equal to 20 mrad per year for beta radiation.

- Note: There are no noble gas release at Pilgrim due to gases having decayed away

The dose to a member of the general public from iodine-131, tritium, and all particulate radionuclides with half-lives greater than 8 days in gaseous effluents is limited to:

- less than or equal to 15 mrem per year to any organ.

- Note: There are no iodine release at Pilgrim due to no more produces and that which has been produced by the plant operation having decayed away

The EPA, in 40CFR190.10 Subpart B (Reference 10), sets forth the environmental standards for the uranium fuel cycle. During normal operation, the annual dose to any member of the public from the entire uranium fuel cycle shall be limited to:

- less than or equal to 25 mrem per year to the total body;
- less than or equal to 75 mrem per year to the thyroid; and,
- less than or equal to 25 mrem per year to any other organ.

- Note: There is no longer a “fuel cycle, as normal operations ceased on May 31, 2019.

The summary of the 2022 radiological impact for Pilgrim Station and comparison with the EPA dose limits and guidelines, as well as a comparison with natural/man-made radiation levels, is presented in Section 3 of this report.

The third stage of assessing releases to the environment is the Radiological Environmental Monitoring Program (REMP). The description and results of the REMP at Pilgrim Nuclear Power Station during 2021 is discussed in Section 2 of this report.

2.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

2.1 Pre-Operational Monitoring Results

The Radiological Environmental Monitoring Program (REMP) at Pilgrim Nuclear Power Station was first initiated in August 1968, in the form of a pre-operational monitoring program prior to bringing the station on-line. The NRC's intent (Reference 11) with performing a pre-operational environmental monitoring program is to:

- measure background levels and their variations in the environment in the area surrounding the licensee's station; and,
- evaluate procedures, equipment, and techniques for monitoring radiation and radioactivity in the environment.

The pre-operational program (Reference 12) continued for approximately three and a half years, from August 1968 to June 1972. Examples of background radiation and radioactivity levels measured during this time period are as follows:

- Airborne Radioactivity Particulate Concentration (gross beta): 0.02 - 1.11 pCi/m^3;
- Ambient Radiation (TLDs): 4.2 - 22 micro-R/hr (37 - 190 mR/yr);
- Seawater Radioactivity Concentrations (gross beta): 12 - 31 pCi/liter;
- Fish Radioactivity Concentrations (gross beta): 2,200 - 11,300 pCi/kg;
- Milk Radioactive Cesium-137 Concentrations: 9.3 - 32 pCi/liter;
- Milk Radioactive Strontium-90 Concentrations: 4.7 - 17.6 pCi/liter;
- Cranberries Radioactive Cesium-137 Concentrations: 140 - 450 pCi/kg;
- Forage Radioactive Cesium-137 Concentrations: 150 - 290 pCi/kg.

This information from the pre-operational phase is used as a basis for evaluating changes in radiation and radioactivity levels in the vicinity of the plant following plant operation. In April 1972, just prior to initial reactor startup (June 12, 1972), Boston Edison Company implemented a comprehensive operational environmental monitoring program at Pilgrim Nuclear Power Station. This program (Reference 13) provides information on radioactivity and radiation levels in the environment for the purpose of:

- demonstrating that doses to the general public and levels of radioactivity in the environment are within established limits and legal requirements;
- monitoring the transfer and long-term buildup of specific radionuclides in the environment to revise the monitoring program and environmental models in response to changing conditions;
- checking the condition of the station's operation, the adequacy of operation in relation to the adequacy of containment, and the effectiveness of effluent treatment so as to provide a mechanism of determining unusual or unforeseen conditions and, where appropriate, to trigger special environmental monitoring studies;
- assessing the dose equivalent to the general public and the behavior of radioactivity released during the unlikely event of an accidental release; and,

- determining whether or not the radiological impact on the environment and humans is significant.

The Nuclear Regulatory Commission requires that Pilgrim Station provide monitoring of the plant environs for radioactivity that will be released as a result of normal operations and from postulated accidents. The NRC has established guidelines (Reference 14) that specify an acceptable monitoring program. The PNPS Radiological Environmental Monitoring Program was designed to meet and exceed these guidelines. Guidance contained in the NRC's Radiological Assessment Branch Technical Position on Environmental Monitoring (Reference 15) has been used to improve the program. In addition, the program has incorporated the provisions of an agreement made with the Massachusetts Wildlife Federation (Reference 16). The program was supplemented by including improved analysis of shellfish and sediment at substantially higher sensitivity levels to verify the adequacy of effluent controls at Pilgrim Station.

2.2 Environmental Monitoring Locations

Sampling locations have been established by considering meteorology, population distribution, hydrology, and land use characteristics of the Plymouth area. The sampling locations are divided into two classes, indicator and control. Indicator locations are those that are expected to show effects from PNPS operations, if any exist. These locations were primarily selected on the basis of where the highest predicted environmental concentrations would occur. While the indicator locations are typically within a few kilometers of the plant, the control stations are generally located so as to be outside the influence of Pilgrim Station. They provide a basis on which to evaluate fluctuations at indicator locations relative to natural background radiation and natural radioactivity and fallout from prior nuclear weapons tests.

The environmental sampling media collected in the vicinity of Pilgrim Station during 2022 included air particulate filters, seawater, sediment, shellfish, American lobster, and fishes. The sampling medium, station description, station number, distance, and direction for indicator and control samples are listed in Table 2.2-1. These sampling locations are also displayed on the maps shown in Figures 2.2-1 through 2.2-6.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.2-1 through 2.2-4. The frequency of collection and types of radioactivity analysis are described in Pilgrim Station's ODCM, Sections 3/4.5.

The land-based (terrestrial) samples, seawater, and monitoring devices are collected by station personnel. The aquatic samples are collected by Normandeau Associates, Inc. The radioactivity analysis of samples are performed by the Teledyne Brown Engineering Laboratory, and the environmental dosimeters are analyzed by Stanford Dosimetry.

The frequency, types, minimum number of samples, and maximum lower limits of detection (LLD) for the analytical measurements, are specified in the PNPS ODCM. During 2003, a revision was made to the PNPS ODCM to standardize it to the model program described in NUREG-1302 (Reference 14) and the Branch Technical Position of 1979 (Reference 15). In accordance with this standardization, a number of changes occurred regarding the types and frequencies of sample collections.

In regard to terrestrial REMP sampling, routine collection and analysis of soil samples was discontinued in lieu of the extensive network of environmental TLDs around PNPS, and the weekly collection of air samples at air sample locations. Such TLD monitoring and air sampling would provide an early indication of any potential deposition of radioactivity, and follow-up soil sampling could be performed on an as-needed basis. Also, with the loss of the indicator milk sample at the Plymouth County Farm and the lack of a sufficient substitute location that could provide suitable volumes for analysis, it was deemed unnecessary to continue to collect and analyze control samples of milk. NRC guidance (Reference 14) contains provisions for collection of vegetation in lieu of milk sampling. Such samples have historically been collected near Pilgrim Station as part of the routine REMP program. With the permanent shut

down of the plant and the decay of Iodine the need for vegetation samples is also no longer necessary. Sample collection requirements have since been removed from the REMP program.

In the area of marine sampling, a number of the specialized sampling and analysis requirements implemented as part of the Agreement with the Massachusetts Wildlife Federation (Reference 16) for licensing of a second reactor at PNPS were dropped. When the ODCM was revised in 1999 in accordance with NRC Generic Letter 89-01, the sampling program description was relocated to the ODCM. Steps were taken in 2003 to standardize the PNPS ODCM to the NUREG-1302 model, the specialized marine sampling requirements were changed to those of the model program. These changes include the following:

- A sample of the surface layer of sediment is collected, as opposed to specialized depth-incremental sampling to 30 cm and subdividing cores into 2 cm increments.
- Standard LLD levels of approximately 150 to 180 pCi/kg were established for sediment, as opposed to the specialized LLDs of 50 pCi/kg.
- Specialized analysis of sediment for plutonium isotopes was removed.
- Sampling of Irish moss, shellfish, and fish was rescheduled to a semiannual period, as opposed to a specialized quarterly sampling interval.
- Analysis of only the edible portions of shellfish (mussels and clams), as opposed to specialized additional analysis of the shell portions.
- Standard LLD levels of 130 to 260 pCi/kg were established for edible portions of shellfish, as opposed to specialized LLDs of 5 pCi/kg.

Upon receipt of the analysis results from the analytical laboratories, the PNPS staff reviews the results. If the radioactivity concentrations are above the reporting levels, the NRC must be notified within 30 days. For radioactivity that is detected that is attributable to Pilgrim Station's operation, calculations are performed to determine the cumulative dose contribution for the current year. Most importantly, if radioactivity levels in the environment become elevated as a result of the station's operations, an investigation is performed and corrective actions are recommended to reduce the amount of radioactivity to as far below the legal limits as is reasonably achievable.

The radiological environmental sampling locations are reviewed annually, and modified if necessary.
The accuracy of the data obtained through Pilgrim Station’s Radiological Environmental Monitoring Program is ensured through a comprehensive Quality Assurance (QA) programs. PNPS's QA program has been established to ensure confidence in the measurements and results of the radiological monitoring program through:

- Regular surveillances of the sampling and monitoring program;
- An annual audit of the analytical laboratory by the sponsor companies;
- Participation in cross-check programs;
- Use of blind duplicates for comparing separate analyses of the same sample; and,
- Spiked sample analyses by the analytical laboratory.

QA audits and inspections of the Radiological Environmental Monitoring Program are performed by the NRC, American Nuclear Insurers, and by the PNPS Quality Assurance Audits.

The Teledyne Brown Engineering Laboratory conducts extensive quality assurance and quality control programs. The 2022 results of these programs are summarized in Appendix E. These results indicate that the analyses and measurements performed during 2022 exhibited acceptable precision and accuracy.

2.3 Interpretation of Radioactivity Analyses Results

The following pages summarize the analytical results of the environmental samples collected during 2022. Data for each environmental medium are included in a separate section. A table that summarizes the year's data for each type of medium follows a discussion of the sampling program and results. The unit of measurement for each medium is listed at the top of each table. The left hand column contains the radionuclides being reported, total number of analyses of that radionuclide, and the number of measurements that exceed ten times the yearly average for the control station(s). The latter are classified as "non-routine" measurements. The next column lists the Lower Limit of Detection (LLD) for those radionuclides that have detection capability requirements specified in the PNPS ODCM.

Those sampling stations within the range of influence of Pilgrim Station and which could conceivably be affected by its operations are called "indicator" stations. Distant stations, which are beyond plant influence, are called "control" stations. Ambient radiation monitoring stations are broken down into four separate zones to aid in data analysis based on distance.

For each sampling medium, each radionuclide is presented with a set of statistical parameters. This set of statistical parameters includes separate analyses for (1) the indicator stations, (2) the station having the highest annual mean concentration, and (3) the control stations. For each of these three groups of data, the following values are calculated:

- The mean value of detectable concentrations, including only those values above LLD;
- The standard deviation of the detectable measurements;
- The lowest and highest concentrations; and,
- The number of measurements with results greater than the Minimum Detectable Activity (activity which is three times greater than the standard deviation), out of the total number of measurements.

Each single radioactivity measurement datum is based on a single measurement and is reported as a concentration plus or minus one standard deviation. The quoted uncertainty represents only the random uncertainty associated with the measurement of the radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the sampling and analysis process. A sample or measurement is considered to contain detectable radioactivity if the measured value (e.g., concentration) exceeds three times its associated standard deviation. For example, a vegetation sample with a cesium-137 concentration of 85 $\pm$ 21 pCi/kilogram would be considered "positive" (detectable Cs-137), whereas another sample with a concentration of 60 $\pm$ 32 pCi/kilogram would be considered "negative", indicating no detectable cesium-137. The latter sample may actually contain cesium-137, but the levels counted during its analysis were not significantly different than the background levels.

The analytical laboratory that analyzes the various REMP samples employs a background subtraction correction for each analysis. A blank sample that is known not to contain any plant-related activity is analyzed for radioactivity, and the count rate for that analysis is used as the background correction. That background correction is then subtracted from the results for the analyses in that given set of samples. For example, if the blank/background sample produces 50 counts, and a given sample being analyzes produces 47 counts, then the net count for that sample is reported as -3 counts. That negative value of -3 counts is used to calculate the concentration of radioactivity for that particular analysis. Such a sample result is technically more valid than reporting a qualitative value such as "<LLD" (Lower limit of Detection) or "NDA" (No Detectable Activity)".

As an example of how to interpret data presented in the results tables, refer to the first entry on the table for air particulate filters (page 33). Gross beta (GR-B) analyses were performed on 312 routine samples. None of the samples exceeded ten times the average concentration at the control location. The lower limit of detection (LLD) required by the ODCM is 0.01 pCi/m^3.

For samples collected from the six indicator stations, 260 out of 260 samples indicated detectable gross beta activity at the three-sigma (standard deviation) level. The mean concentration of gross beta activity in these 260 indicator station samples was 0.017 ± 0.0048 (1.7E-2 ± 4.8E-3) pCi/m^3. Individual values ranged from 0.0692 to 0.033 (6.9E-3 – 3.3E-2) pCi/m^3

The monitoring station which yielded the highest mean concentration was the sample location PL (Property Line), which yielded a mean concentration of 0.018 ± 0.0055 pCi/m^3, based on 52 detectable indications out of 52 samples observations. Individual values ranged from 0.0076 to 0.033 pCi/m^3.

At the control location, 52 out of 52 samples yielded detectable gross beta activity, for an average concentration of 0.018 ± 0.0051 pCi/m^3. Individual samples at the East Weymouth control location ranged from 0.0070 to 0.031 pCi/m^3.

Analyses for cesium-137 (Cs-137) were performed 24 times (quarterly composites for 6 stations * 4 quarters). No samples exceeded ten times the mean control station concentration. The required LLD value Cs-137 in the PNPS ODCM is 0.06 pCi/m^3.

At the indicator stations, all 20 of the Cs-137 measurements were below the detection level. The same was true for the four measurements made on samples collected from the control location.

Analyses for Beryllium-7 (Be-7) are used to indicate representative sampling for air samplers in environmental applications.

2.4 Ambient Radiation Measurements

The primary technique for measuring ambient radiation exposure in the vicinity of Pilgrim Station involves posting environmental thermoluminescent dosimeters (TLDs) at given monitoring locations and retrieving the TLDs after a specified time period. The TLDs are then taken to a laboratory and processed to determine the total amount of radiation exposure received over the period. Although TLDs can be used to monitor radiation exposure for short time periods, environmental TLDs are typically posted for periods of one to three months. Such TLD monitoring yields average exposure rate measurements over a relatively long time period. The PNPS environmental TLD monitoring program is based on a quarterly (three month) posting period, and a total of 44 locations are monitored using this technique. The number of TLD were reduced in April 2020 after the permanent shut down of the Pilgrim station, then again in 2021 to collapse the outer ring to 3km from the plant. Only the 2 control locations Division of Marine Fisheries (DMF) and East Weymouth (EW) and the indicator station Manomet Elementary (ME) remain outside of the 3km distance. In addition, 4 of the 44 TLDs are currently located onsite, within the PNPS protected/restricted area, as well as 12 out of 44 are currently located outside the protected area but inside the site boundary and area used for business purposes only where the general public does not have access.

Though the “business area only” or “exclusion zone” could *physically* be accessed, jersey barriers, signage and security tours would drastically limit the stay of a person with out proper authorization to be within the areas.

Out of the 176 TLDs posted in the environment during 2022, 155 were retrieved and processed for calculation of dose. The results for environmental TLDs located offsite, beyond the PNPS protected/restricted area fence, are presented in Table 2.4-1. Results from onsite TLDs posted within the restricted area are presented in Table 2.4-2. In addition to TLD results for individual locations, results from offsite TLDs were grouped according to geographic zone to determine average exposure

rates as a function of distance. These results are summarized in Table 2.4-3. All of the listed exposure values represent continuous occupancy (2190 hr/qtr or 8760 hr/yr).

Annual exposure rates measured at locations beyond the PNPS protected area boundary ranged from 48 to 329 mR/yr. The average exposure rate at control locations greater than 15 km from Pilgrim Station (i.e., Zone 4) was 72.8 ± 4.0 mR/yr. When the 3-sigma confidence interval is calculated based on these control measurements, 99% of all measurements of background ambient exposure would be expected to be between 60 and 84 mR/yr. The results for all TLDs within 15 km (excluding those Zone 1 TLDs posted within the site boundary) ranged from 49 to 88 mR/yr, which compares favorably with the preoperational results of 37 - 190 mR/yr.

Inspection of onsite TLD results listed in Table 2.4-2 indicates that all of those TLDs located within the PNPS protected/restricted area yield exposure measurements higher than the average natural background. Such results are expected due to the close proximity of these locations to the movement of station spent fuel into dry casks as well as radwaste material for storage or shipment.

A small number of offsite TLD locations in close proximity to the protected/restricted area indicated ambient radiation exposure above expected background levels. All of these locations are on Pilgrim Station controlled property, and experience exposure increases due to proximity to the onsite fuel storage pad (e.g., locations OA, TC, and P01) and/or transit and storage of radwaste onsite (e.g., locations BLE and BLW). Due to heightened security measures following September 11 2001, members for the general public do not have access to such locations within the owner-controlled area.

It should be noted that several of the TLDs used to calculate the Zone 1 averages presented in Table 2.4-3 are located on Pilgrim Station property. If the Zone 1 value is corrected for the near-site TLDs (those less than 0.6 km from the Reactor Building), the Zone 1 mean falls from a value of 97.5 ± 92.2 mR/yr to 65.4 $\pm$ 9.6 mR/yr. Additionally, exposure rates measured at areas beyond the site's control did not indicate any increase in ambient exposure from Pilgrim Station operation. For example, the annual exposure rate calculated from the TLD adjacent to the nearest offsite residence 0.80 kilometers (0.5 miles) southeast of the PNPS Reactor Building was 59.8 $\pm$ 2.4 mR/yr, which is actually lower than the average control location exposure of 79.8 ± 9.3 mR/yr.

In conclusion, measurements of ambient radiation exposure around Pilgrim Station do not indicate any significant increase in exposure levels. Although some increases and decreases in ambient radiation exposure level were apparent on site property very close to Pilgrim Station especially in areas where decommissioning components move between storage locations, there were no measurable increases at areas beyond the site's control.

2.5 Air Particulate Filter Radioactivity Analyses

Airborne particulate radioactivity is sampled by drawing a stream of air through a glass fiber filter that has a very high efficiency for collecting airborne particulates. These samplers are operated continuously, and the resulting filters are collected weekly for analysis. Weekly filter samples are analyzed for gross beta radioactivity, and the filters are then composited on a quarterly basis for each location for gamma spectroscopy analysis. PNPS uses this technique to monitor locations in the Plymouth area, along with the control location in East Weymouth. At the start and end of 2022 six locations were monitored in total.

Out of 312 filters (6 locations * 52 weeks), 312 samples were collected and analyzed during 2022. There were no instances where power was lost or pumps failed during the course of the sampling period at any of the air sampling stations, which would result in lower than normal sample volumes. Any sample discrepancies are noted in Appendix D.

The results of the analyses performed on these 312 filter samples are summarized in Table 2.5-1. Trend plots for the gross beta radioactivity levels at the near station, property line, and offsite airborne monitoring locations are shown in Figures 2.5-1, 2.5-2 and 2.5-3, respectively. Gross beta radioactivity was detected in 312 of the filter samples collected, including 53 of the 53 control location samples. This gross beta activity arises from naturally-occurring radionuclides such as radon decay daughter products. Naturally-occurring beryllium-7 was detected in 40 out of 40 of the quarterly composites analyzed with gamma spectroscopy. No airborne radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2022, and results of any detectable naturally-occurring radioactivity were similar to those observed in the properational monitoring program.

2.6 Milk Radioactivity Analyses

As included in a provision in standard ODCM guidance in NUREG-1302 (Reference 13), sampling and analysis of vegetation from the offsite locations calculated to have the highest D/Q deposition factor can be performed in lieu of milk sampling. Such vegetation sampling has been routinely performed at Pilgrim Station as part of the radiological environmental monitoring program, but due to plant condition the requirement for sampling no longer applies. Sample requirements and sample locations were removed in ODCM revision 15.

2.7 Vegetable/Vegetation Radioactivity Analyses

Vegetation sampling as well as the Land Use census was discontinued, removed from the ODCM in revision 15 as described in the milk section above. Crop based foodstuffs no longer exist within a 5 mile radius on the plant (previously cranberries and Irish Moss) and were previously removed from the ODCM. The use of broadleaf vegetation was to account for the deposition of iodine on a type of cattle feed in lieu of sampling for milk. As there are no milk farms within the influence of the plant and the need to account for changes in new or old gardens has diminished with the shutdown and fuel removal at the plant, the requirement was removed.

Broadleaf vegetation may still be consumed by humans, and it will be projected and accounted for in the dose modelling for all nuclides remaining that are released off site, but the only radionuclide detected in REMP samples while the plant was operating was Cs-137 from fall out (recently – Chernobyl and Fukashima) which is deposited on and absorbed thru the roots of plants and trees and has a 30-year half-life.

The current dose model for gaseous release dose calculations utilizes a garden at the site boundary in the predominant downwind direction. As this is the most conservative scenario, no land use census will produce an alternat garden with higher off-site dose potential.

2.8 Surface Water Radioactivity Analyses

Samples of surface water are routinely collected from the discharge canal and from the control location at Powder Point Bridge in Duxbury. Grab samples are collected weekly from the Powder Point Bridge location. Samples of surface water are composited every four weeks and analyzed by gamma spectroscopy. These monthly composites are further composited on a quarterly basis and tritium analysis is performed on these quarterly samples.

A total of 32 samples of surface water were collected and analyzed as required during 2022. Bartlett Pond sample point was removed from the ODCM in the fourth Quarter 2019. Results of the analyses of water samples are summarized in Table 2.12-1. Naturally-occurring potassium-40 was detected in all monthly composite samples, especially those composed primarily of seawater. No radioactivity attributable to Pilgrim Station was detected in any of the surface water samples collected during 2022.

In response to the Nuclear Energy Institute Groundwater Protection Initiative, Pilgrim Station installed a number of groundwater monitoring wells within the protected area in late 2007. Because all of these wells are onsite, they are not included in the offsite radiological monitoring program, and are not presented in this report. Details regarding Pilgrim Station's groundwater monitoring effort can be found in the Annual Radioactive Effluent Release Report.

2.9 Sediment Radioactivity Analyses

Samples of sediment are routinely collected from the outfall area of the discharge canal and from three other locations in the Plymouth area (Manomet Point, Plymouth Harbor and Plymouth Beach), and from control locations in Duxbury and Marshfield. Samples are collected twice per year by marine sampling vendor (Normandeau) and are analyzed by gamma spectroscopy.

Eleven of twelve planned program samples of sediment were collected during 2022. The vendor was unable to obtain a sample at one location due to environmental conditions and access restrictions. Gamma analyses were performed on these samples. Results of the gamma analyses of sediment samples are summarized in Table 2.13-1. Naturally-occurring potassium-40 was detected in all of the samples and actinium/thorium-228 were detected in 9 out of 11 samples. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2022, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.10 Shellfish Radioactivity Analyses

Samples of blue mussels and soft-shell clams are collected from the discharge canal outfall and one other location in the Plymouth area (Plymouth Harbor), and from control locations in Duxbury and Marshfield. All samples are collected on a semiannual basis, and edible portions processed in the laboratory for gamma spectroscopy analysis.

Eight of the ten required samples of shellfish meat scheduled for collection during 2022 were obtained and analyzed. The vendor was unable to obtain a sample at one location due to environmental conditions and access restrictions. Results of the gamma analyses of these samples are summarized in Table 2.15-1. Naturally-occurring potassium-40 was detected in seven of the eight the samples. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2022, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.11 Lobster Radioactivity Analyses

Samples of lobsters are routinely collected from the outfall area of the discharge canal and from control locations in Cape Cod Bay. Samples are collected monthly from the discharge canal outfall from June through September and once annually from the control locations. All lobster samples are normally analyzed by gamma spectroscopy.

Five samples of lobsters were collected as required during 2022. Results of the gamma analyses of these samples are summarized in Table 2.16-1. Naturally-occurring potassium-40 was detected in five of the five of the samples. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2022, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.12 Fish Radioactivity Analyses

Samples of fish are routinely collected from the area at the outfall of the discharge canal and from the control locations in Cape Cod Bay and Buzzard's Bay. Fish species are grouped into four major categories according to their biological requirements and mode of life. These major categories and the representative species are as follows:

- Group I – Bottom-Oriented: Winter Flounder, Yellowtail Flounder
- Group II - Near-Bottom Distribution: Tautog, Cunner, Pollock, Atlantic Cod, Hake
- Group III - Anadromous: Alewife, Smelt, Striped Bass
- Group IV - Coastal Migratory: Bluefish, Herring, Menhaden, Mackerel

Group I fishes are sampled on a semiannual basis from the outfall area of the discharge canal, and on an annual basis from a control location. Group II, III, and IV fishes are sampled annually from the discharge canal outfall and control location. All samples of fish are analyzed by gamma spectroscopy.

Five samples of fish were collected during 2022. The seasonal sample of Group III fish (alewife, smelt, striped bass) from the Discharge Outfall becomes increasingly more difficult. Many fish species gravitated to the warmer waters. With the shutdown of the station the discharge flow and heat was reduced. These discrepancies are discussed in Appendix D. Results of the gamma analyses of fish samples collected are summarized in Table 2.17-1. The only radionuclide detected in any of the fish samples was naturally-occurring potassium-40. No radioactivity attributable to Pilgrim Station was detected in any of the fish samples collected during 2022, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

Table 2.2-1

Routine Radiological Environmental Sampling Locations
Pilgrim Nuclear Power Station, Plymouth, MA

Description	Code	Distance	Direction
Air Particulate Filters			
East Rocky Hill Road	ER	0.9 km	SE
Property Line	PL	0.5 km	NNW
Pedestrian Bridge	PB	0.2 km	N
East Breakwater	EB	0.5 km	ESE
Cleft Rock	CR	1.3 km	SSW
East Weymouth (Control)	EW	40 km	NW
Surface Water			
Discharge Canal	DIS	0.2 km	N
Powder Point (Control)	PP	13 km	NNW
Sediment			
Discharge Canal Outfall	DIS	0.8 km	NE
Plymouth Harbor	Ply-H	4.1 km	W
Duxbury Bay (Control)	Dux-Bay	14 km	NNW
Plymouth Beach	PLB	4.0 km	WNW
Manomet Point	MP	3.3 km	ESE
Green Harbor (Control)	GH	16 km	NNW
Shellfish			
Discharge Canal Outfall	DIS	0.7 km	NNE
Plymouth Harbor	Ply-H	4.1 km	W
Duxbury Bay (Control)	Dux-Bay	13 km	NNW
Manomet Point	MP	4.0 km	ESE
Green Harbor (Control)	GH	16 km	NNW
Lobster			
Discharge Canal Outfall	DIS	0.5 km	N
Plymouth Harbor	Ply-H	6.4 km	WNW
Duxbury Bay (Control)	Dux-Bay	11 km	NNW
Fishes			
Discharge Canal Outfall	DIS	0.5 km	N
Vineyard Sound (Control)	MV	64 km	SSW
Buzzard’s Bay (Control)	BB	40 km	SSW
Cape Cod Bay (Control)	CC-Bay	24 km	ESE

Table 2.4-1

Offsite Environmental TLD Results

TLD Station		TLD Location*	Quarterly Exposure - mR/quarter (Value ± Std.Dev.)				2022 Annual** Exposure mR/year
ID	Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Zone 1 TLDs: 0-3 km		0-3 km	26.0 ± 28.5	24.1 ± 21.4	24.3 ± 22.2	23.3 ± 20.7	97.5 ± 92.2
BLW	BOAT LAUNCH WEST	0.11 km E	47.3 ± 2.8	31.5 ± 2.8	30.0 ± 1.1	29.7 ± 1.4	138.5 ± 34.2
OA	OVERLOOK AREA	0.15 km W	26.7 ± 1.6	130.4 ± 12.4	135.6 ± 10.6	127.4 ± 6.8	420.1 ± 210.1
TC	HEALTH CLUB	0.15 km WSW	17.6 ± 0.8	57.5 ± 2.2	58.2 ± 2.8	55.0 ± 2.9	188.3 ± 78.9
BLE	BOAT LAUNCH EAST	0.16 km ESE	79.0 ± 4.0	25.9 ± 0.9	22.1 ± 0.7	21.7 ± 0.8	148.6 ± 111.9
ISF-3	ISFSI-3	0.21 km W	160.1 ± 4.9	Removed	Removed	Removed	160.1 ± 4.9
P01	SHOREFRONT SECURITY	0.22 km NNW	17.2 ± 0.6	29.2 ± 1.5	30.6 ± 2.2	30.4 ± 2.5	107.4 ± 26.0
ISF-2	ISFSI-2	0.28 km W	34.0 ± 1.4	44.0 ± 1.6	41.1 ± 3.1	38.4 ± 1.8	157.6 ± 17.5
ISF-1	ISFSI-1	0.35 km SW	19.4 ± 0.6	20.6 ± 1.0	21.1 ± 0.9	20.2 ± 0.7	81.2 ± 3.3
PA	SHOREFRONT PARKING	0.35 km NNW	16.8 ± 0.8	19.7 ± 1.2	20.8 ± 0.7	19.4 ± 0.8	76.6 ± 7.0
A	STATION A	0.37 km WSW	M ± M	19.2 ± 1.0	19.2 ± 0.8	18.4 ± 0.7	75.8 ± 2.7
EB	EAST BREAKWATER	0.44 km ESE	22.2 ± 0.9	20.4 ± 0.9	19.4 ± 0.8	18.6 ± 0.7	80.5 ± 6.4
B	STATION B	0.44 km S	21.4 ± 0.8	21.3 ± 0.9	21.2 ± 1.0	20.4 ± 0.8	84.3 ± 2.6
PMT	PNPS MET TOWER	0.44 km WNW	17.3 ± 0.8	19.7 ± 1.0	19.5 ± 0.6	18.6 ± 0.7	75.1 ± 4.8
L	STATION L	0.50 km ESE	27.6 ± 1.4	17.0 ± 0.6	16.2 ± 0.6	16.4 ± 0.7	77.3 ± 22.3
G	STATION G	0.53 km W	M ± M	15.1 ± 0.7	16.2 ± 0.6	15.3 ± 0.6	62.1 ± 2.9
PL	PROPERTY LINE	0.54 km NW	18.0 ± 0.9	19.0 ± 0.8	20.0 ± 0.8	18.9 ± 0.8	75.9 ± 3.6
HB	HALL'S BOG	0.63 km SE	18.0 ± 0.6	20.1 ± 1.0	20.1 ± 0.6	19.0 ± 0.6	77.2 ± 4.2
GH	GREENWOOD HOUSE	0.65 km ESE	16.4 ± 0.6	16.4 ± 0.9	16.8 ± 0.7	16.7 ± 1.0	66.3 ± 1.8
WR	W ROCKY HILL ROAD	0.83 km WNW	21.8 ± 1.1	21.6 ± 1.1	22.5 ± 1.0	22.1 ± 1.1	88.0 ± 2.6
ER	E ROCKY HILL ROAD	0.89 km SE	14.3 ± 0.6	15.2 ± 0.6	14.8 ± 0.5	15.5 ± 0.8	59.8 ± 2.4
CR	CLEFT ROCK	1.27 km SSW	17.8 ± 0.6	19.3 ± 0.7	20.0 ± 0.8	18.3 ± 0.7	75.4 ± 4.2
BD	BAYSHORE/GATE RD	1.34 km WNW	18.3 ± 0.6	18.5 ± 0.6	18.5 ± 0.9	17.6 ± 0.7	72.9 ± 2.2
EM	EMERSON ROAD	1.53 km SSE	15.6 ± 0.7	15.7 ± 0.6	15.8 ± 0.6	16.1 ± 0.6	63.2 ± 1.6
EP	EMERSON/PRISCILLA	1.55 km SE	15.4 ± 0.6	15.4 ± 0.8	15.6 ± 0.6	15.9 ± 0.8	62.3 ± 1.7
BS	BAYSHORE	1.76 km W	18.0 ± 1.0	18.0 ± 0.6	18.7 ± 0.7	17.9 ± 0.8	72.6 ± 2.1
JG	JOHN GAULEY	1.99 km W	15.6 ± 0.7	16.6 ± 1.0	17.0 ± 0.9	16.4 ± 0.6	65.6 ± 2.9
J	STATION J	2.04 km SSE	13.8 ± 0.6	14.8 ± 0.6	15.6 ± 0.5	15.0 ± 0.8	59.1 ± 3.4
RC	PLYMOUTH YMCA	2.09 km WSW	14.3 ± 0.5	15.1 ± 0.5	15.7 ± 0.7	15.3 ± 0.7	60.4 ± 2.7
TT	TAYLOR/THOMAS	2.26 km SE	M ± M	15.7 ± 1.0	15.0 ± 0.7	15.3 ± 0.6	61.4 ± 2.3
YV	YANKEE VILLAGE	2.28 km WSW	15.3 ± 0.6	16.5 ± 0.9	17.2 ± 0.7	16.1 ± 0.7	65.1 ± 3.4
GN	GOODWIN PROPERTY	2.38 km SW	11.9 ± 0.6	12.4 ± 0.6	13.0 ± 0.8	12.1 ± 0.5	49.4 ± 2.3
RW	RIGHT OF WAY	2.83 km S	13.1 ± 0.6	13.4 ± 0.5	13.5 ± 0.5	12.7 ± 0.6	52.7 ± 1.8
TP	TAYLOR/PEARL	2.98 km SE	14.6 ± 0.5	14.5 ± 0.5	15.1 ± 0.6	14.9 ± 0.8	59.1 ± 1.6

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.
*** TLDs missing will be noted with M.

Table 2.4-1 (continued)

Offsite Environmental TLD Results

TLD Station		TLD Location*	Quarterly Exposure - mR/quarter (Value ± Std.Dev.)				2022 Annual** Exposure mR/year
ID	Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Zone 2 TLDs: 3-8 km		3-8 km	16.4 ± 0.4	17.4 ± 0.7	16.9 ± 1.2	17.0 ± 0.8	67.6 ± 2.8
ME	MANOMET ELEM	3.29 km SE	16.4 ± 0.4	17.0 ± 0.7	16.1 ± 0.9	M ± M	66.0 ± 2.5
MS	MANOMET SUBSTATION	3.60 km SSE	16.3 ± 0.6	17.7 ± 0.8	17.7 ± 0.6	17.0 ± 0.8	68.7 ± 2.9
Zone 3 TLDs: 8-15 km		8-15 km	Removed	Removed	Removed	Removed	Removed
Zone 4 TLDs: >15 km		>15 km	17.1 ± 1.0	19.7 ± 1.9	20.0 ± 1.4	20.5 ± 1.2	77.4 ± 7.0
DMF	DIV MARINE FISH	20.97 km SSE	17.7 ± 0.5	18.4 ± 0.7	19.1 ± 0.7	19.8 ± 0.8	75.0 ± 3.8
EW	E WEYMOUTH SUBST	39.69 km NW	16.5 ± 0.8	21.1 ± 0.8	20.9 ± 0.8	21.3 ± 0.9	79.8 ± 9.3

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.
*** TLDs missing will be noted with M.

Table 2.4-2

Onsite Environmental TLD Results

TLD Station		TLD Location*	Quarterly Exposure - mR/quarter (Value ± Std.Dev.)				2022 Annual** Exposure mR/year
ID	Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Onsite TLDs							
P17	FENCE-EXEC.BUILDING	107 m W	38.6 ± 2.5	288.6 ± 18.9	196.4 ± 11.1	189.4 ± 6.2	713.0 ± 414.6
P11	FENCE-TCF GATE	183 m ESE	101.8 ± 7.7	36.4 ± 1.2	30.7 ± 1.0	37.6 ± 1.3	206.5 ± 134.6
P27	FENCE-TCF/BOAT RAMP	185 m ESE	57.0 ± 3.5	25.4 ± 1.2	22.0 ± 0.7	21.6 ± 0.7	126.0 ± 68.4
P10	FENCE-TCF/INTAKE BAY	223 m E	91.8 ± 3.2	29.8 ± 1.4	21.6 ± 0.8	21.4 ± 0.9	164.7 ± 136.1

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.
*** TLDs missing are noted with M.
-Components are quite frequently moved around site to different storage areas depending on station need. Due to this the quarters can fluctuate up and down accordingly.

Table 2.4-3

Average TLD Exposures By Distance Zone During 2022

Exposure Period	Average Exposure ± Standard Deviation: mR/period			
	Zone 1* 0-3 km	Zone 2 3-8 km	Zone 3 8-15 km	Zone 4 >15 km
Jan-Mar	26.0 ± 28.5	16.4 ± 0.4	Removed	17.1 ± 1.0
Apr-Jun	24.1 ± 21.4	17.4 ± 0.7	Removed	19.7 ± 1.9
Jul-Sep	24.3 ± 22.2	16.9 ± 1.2	Removed	20.0 ± 1.4
Oct-Dec	23.3 ± 20.7	17.0 ± (1)	Removed	20.5 ± 1.2
Jan-Dec	97.5 ± 92.2	67.6 ± 2.8	Removed	77.4 ± 7.0

* Zone 1 extends from the PNPS restricted/protected area boundary outward to 3 kilometers (2 miles) and includes several TLDs located within the site boundary.

** When corrected for TLDs located within the site boundary, the Zone 1 annual average is calculated to be 65.4 ± 9.6 mR/yr.

(1) No Standard deviation due to single data point.

Table 2.5-1
Air Particulate Filter Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

MEDIUM: Air Particulates (AP) UNITS: pCi/cubic meter

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Gross Beta	312 0	0.01	1.7E-2 ± 4.8E-3 6.9E-3 – 3.3E-2 260 / 260	EW: 1.8E-2 ± 5.1E-3 7.0E-3 – 3.1E-2 52 / 52	1.8E-2 ± 5.1E-3 7.0E-3 - 3.1E-2 52 / 52
Be-7	24 0		1.1E-1 ± 2.3E-2 6.2E-2 - 1.4E-1 20 / 20	EW: 1.2E-1 ± 1.4E-2 1.0E-1 - 1.3E-1 4 / 4	1.2E-1 ± 1.4E-2 1.0E-1 - 1.3E-1 4 / 4
Cs-134	24 0	0.05	4.3E-5 ± 5.4E-4 -1.1E-3 - 9.2E-4 0 / 20	PL: 3.1E-4 ± 3.5E-4 -2.5E-5 - 6.4E-4 0 / 4	-4.8E-4 ± 6.5E-4 -1.1E-3 - 2.3E-4 0 / 4
Cs-137	24 0	0.06	6.7E-5 ± 5.0E-4 -1.1E-3 - 1.0E-3 0 / 20	EB: 3.4E-4 ± 3.4E-4 7.1E-5 - 7.4E-4 0 / 4	1.2E-4 ± 3.2E-4 -6.1E-5 - 4.7E-4 0 / 4

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.7-1
Vegetable/Vegetation Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

As stated in summary sections earlier in this report, vegetation sampling has been discontinued.

Table 2.8-1
Surface Water Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

MEDIUM: Surface Water (WS) UNITS: pCi/L

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
H-3	12 0	3000	-6.8E+1 ± 1.2E+2 -2.1E+2 - 3.8E+1 0 / 8	PwPt: -3.7E+1± 8.6E+1 -1.5E+2 - 5.1E+1 0 / 4	-3.7E+1 ± 8.6E+1 -1.5E+2 - 5.1E+1 0 / 4
K-40	24 0		2.8E+2 ± 5.2E+1 2.2E+2 - 3.6E+2 12 / 12	PwPt: 2.9E+2 ± 5.3E+1 2.0E+2 - 3.5E+2 12 / 12	2.9E+2 ± 5.3E+1 2.0E+2 - 3.5E+2 12 / 12
Mn-54	24 0	15	-1.0E+0 ± 2.3E+0 -5.1E+0 - 3.6E+0 0 / 12	PwPt:7.0E-1 ± 2.3E+0 -3.8E+0 - 3.7E+0 0 / 12	7.0E-1 ± 2.3E+0 -3.8E+0 - 3.7E+0 0 / 12
Fe-59	24 0	30	9.8E-1 ± 3.9E+0 -8.0E+0 - 6.9E+0 0 / 12	PwPt: 1.4E+0 ± 5.9E+0 -8.3E+0 - 1.4E+1 0 / 12	1.4E+0 ± 5.9E+0 -8.3E+0 - 1.4E+1 0 / 12
Co-58	24 0	15	-2.2E-1 ± 1.3E+0 -2.3E+0 - 1.6E+0 0 / 12	Dis: -2.2E-1 ± 1.3E+0 -2.3E+0 - 1.6E+0 0 / 12	-2.3E-1 ± 1.6E+0 -3.2E+0 - 1.8E+0 0 / 12
Co-60	24 0	15	1.6E+0 ± 1.1E+0 -4.6E-1 - 3.6E+0 0 / 12	Dis: 1.6E+0 ± 1.1E+0 -4.6E-1 - 3.6E+0 0 / 12	-2.2E-2 ± 2.6E+0 -5.2E+0 - 3.4E+0 0 / 12
Zn-65	24 0	30	-3.2E+0 ± 4.3E+0 -1.1E+1 - 4.7E+0 0 / 12	PwPt: -3.1E+0 ± 4.4E+0 -1.2E+1 - 4.7E+0 0 / 12	-3.1E+0 ± 4.4E+0 -1.2E+1 - 4.7E+0 0 / 12
Zr-95	24 0	30	9.2E-1 ± 5.3E+0 -9.8E+0 - 8.7E+0 0 / 12	Dis: 9.2E-1 ± 5.3E+0 -9.8E+0 - 8.7E+0 0 / 12	8.7E-1 ± 3.9E+0 -5.3E+0 - 5.9E+0 0 / 12
Nb-95	24 0	15	8.4E-1 ± 1.7E+0 -1.8E+0 - 3.7E+0 0 / 12	Dis: 8.4E-1 ± 1.7E+0 -1.8E+0 - 3.7E+0 0 / 12	-4.3E-1 ± 2.3E+0 -4.3E+0 - 2.8E+0 0 / 12
Cs-134	24 0	15	-2.3E-1 ± 2.3E+0 -3.3E+0 - 3.5E+0 0 / 12	PwPt: 8.8E-1 ± 2.4E+0 -2.9E+0 - 4.6E+0 0 / 12	8.8E-1 ± 2.4E+0 -2.9E+0 - 4.6E+0 0 / 12
Cs-137	24 0	18	4.6E-1 ± 2.0E+0 -2.0E+0 - 3.8E+0 0 / 12	Dis: 4.6E-1 ± 2.0E+0 -2.0E+0 - 3.8E+0 0 / 12	-8.7E-1 ± 2.6E+0 -4.7E+0 - 4.2E+0 0/ 12
Ba-140	24 0	60	-3.9E+0 ± 2.6E+1 -4.9E+1 - 4.0E+1 0 / 12	PwPt: 2.3E+0 ± 2.1E+1 -3.3E+1 - 4.1E+1 0 / 12	2.3E+0 ± 2.1E+1 -3.3E+1 - 4.1E+1 0 / 12
La-140	24 0	15	1.4E+0 ± 6.8E+0 -1.5E+1 - 8.9E+0 0 / 12	PwPt: 2.0E+0 ± 7.0E+0 -5.1E+0 - 1.8E+1 0 / 12	2.0E+0 ± 7.0E+0 -5.1E+0 - 1.8E+1 0 / 12

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.9-1
Sediment Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

MEDIUM: Sediment (SE) UNITS: pCi/kg dry

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
K-40	11 0		9.6E+3 ± 1.9E+3 8.0E+3 - 1.3E+4 7 / 7	DuxBay:1.7E+4 ± 5.4E+3 1.4E+4 - 2.1E+4 2 / 2	1.4E+4 ± 4.8E+3 1.1E+4 - 2.1E+4 4 / 4
Cs-134	11 0	150	2.6E+1 ± 1.3E+1 1.1E+1 - 4.7E+1 0/ 8	PlyHrb: 3.9E+1 ± 1.7E+1 3.0E+1 - 4.7E+1 0 / 2	1.6E+1 ± 1.9E+1 -5.7E+0 - 3.1E+1 0 / 4
Cs-137	11 0	180	1.1E+0 ± 2.7E+1 -4.9E+1 - 3.3E+1 0 / 8	DuxBay: 2.6E+1 ± 1.9E+1 1.5E+1 - 3.7E+1 0 / 2	4.0E+0 ± 2.8E+1 -2.1E+1 - 3.7E+1 0 / 4
AcTh-228	11 0		2.7E+2 ± 1.1E+2 1.7E+2 - 4.3E+2 5/ 5	DuxBay: 7.9E+2 ± 1.1E+2 7.3E+2 - 8.6E+2 2 / 2	6.0E+2 ± 2.3E+2 3.9E+2 - 8.6E+2 4 / 4

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.10-1
Shellfish Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

MEDIUM: Shellfish (SF) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
K-40	8 0		1.5E+3 ± 1.6E+2 1.4E+3 - 1.6E+3 4/ 4	PlyHrb: 1.5E+3 ± 1.8E+2 1.4E+3 - 1.6E+3 3/ 3	1.4E+3 ± 2.6E+2 1.0E+3 - 1.6E+3 4 / 4
Mn-54	8 0	130	2.7E+0 ± 1.3E+1 -1.1E+1 - 1.3E+1 0 / 4	PlyHrb: 7.2E+0 ± 1.1E+1 -2.8E+0 - 1.3E+1 0 / 3	-6.1E+0 ± 8.6E+0 -1.5E+1 - -1.0E+0 0 / 4
Fe-59	8 0	260	-1.1E+1 ± 2.7E+1 -4.0E+1 - 2.0E+1 0 / 4	GrnHrb: 8.5E+0 ± 6.1E+1 -3.3E+1 - 5.0E+1 0 / 2	5.2E+0 ± 3.7E+1 -3.3E+1 - 5.0E+1 0 / 4
Co-58	8 0	130	-8.9E+0 ± 2.3E+1 -3.3E+1 - 2.0E+1 0 / 4	GrnHrb: 8.8E+0 ± 1.2E+1 3.2E+0 - 1.4E+1 0 / 4	1.6E+0 ± 1.7E+1 -2.1E+1 - 1.4E+1 0 / 4
Co-60	8 0	130	-6.9E-2 ± 7.7E+0 -5.3E+0 - 6.5E+0 0 / 4	Dis: 2.1E+0 ± 1.2E+1 2.1E+0 - 2.1E+0 0 / 1	-1.3E+1 ± 9.0E+0 -1.8E+1 - -5.6E+0 0 / 4
Zn-65	8 0	260	-7.0E+1 ± 6.9E+1 -1.2E+2 - 6.0E+0 0 / 4	Dis: 6.0E+0 ± 2.4E+1 6.0E+0 - 6.0E+0 0 / 1	-7.7E+1 ± 5.3E+1 -1.3E+2 - -1.0E+1 0 / 4
Cs-134	8 0	130	-1.2E+1 ± 2.5E+1 -4.1E+1 - 1.8E+1 0 / 4	GrnHrb: 4.4E+0 ± 9.4E+0 4.3E+0 - 4.5E+0 0/ 2	1.5E-1 ± 2.2E+1 -2.9E+1 - 2.1E+1 0 / 4
Cs-137	8 0	150	-1.1E+1 ± 2.1E+1 -2.6E+1 - 1.8E+1 0 / 4	GrnHrb: 9.5E+0 ± 1.5E+1 1.5E+0 - 1.7E+1 0 / 4	2.4E+0 ± 2.9E+1 -3.7E+1 - 2.7E+1 0 / 4

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.11-1
Lobster Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

MEDIUM: American Lobster (HA) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
K-40	5 0		2.7E+3 ± 3.7E+2 2.2E+3 - 3.1E+3 4 / 4	Dis: 2.7E+3 ± 3.7E+2 2.2E+3 - 3.1E+3 4 / 4	2.5E+3 ± 3.0E+2 2.5E+3 - 2.5E+3 1 / 1
Mn-54	5 0	130	3.1E+0 ± 5.4E+0 3.7E-1 - 7.5E+0 0 / 4	CcBay: 1.6E+1 ± 1.1E+1 1.6E+1 - 1.6E+1 0 / 1	1.6E+1 ± 1.1E+1 1.6E+1 - 1.6E+1 0 / 1
Fe-59	5 0	260	1.1E+1 ± 2.6E+1 -1.0E+1 - 4.6E+1 0 / 4	CcBay: 1.9E+1 ± 2.4E+1 1.9E+1 - 1.9E+1 0 / 1	1.9E+1 ± 2.4E+1 1.9E+1 - 1.9E+1 0 / 1
Co-58	5 0	130	7.1E+0 ± 1.4E+1 -1.1E+1 - 2.1E+1 0 / 4	CcBay: 3.2E+1 ± 1.3E+1 3.2E+1 - 3.2E+1 0 / 1	3.2E+1 ± 1.3E+1 3.2E+1 - 3.2E+1 0 / 1
Co-60	5 0	130	4.8E+0 ± 6.2E+0 2.0E-1 - 1.1E+1 0 / 4	Dis: 4.8E+0 ± 6.2E+0 2.0E-1 - 1.1E+1 0 / 4	-3.6E+1 ± 1.3E+1 -3.6E+1 - -3.6E+1 0 / 1
Zn-65	5 0	260	-4.2E+1 ± 1.9E+1 -6.5E+1 - -2.9E+1 0 / 4	Dis: -4.2E+1 ± 1.9E+1 -6.5E+1 - -2.9E+1 0 / 4	-6.3E+1 ± 3.1E+1 -6.3E+1 - -6.3E+1 0 / 1
Cs-134	5 0	130	-3.3E-1 ± 4.9E+0 -2.9E+0 - 1.7E+0 0 / 4	Dis: -3.3E-1 ± 4.9E+0 -2.9E+0 - 1.7E+0 0 / 4	-3.8E+0 ± 1.5E+1 -3.8E+0 - -3.8E+0 0 / 1
Cs-137	5 0	150	-4.6E+0 ± 1.0E+1 -1.7E+1 - 4.0E+0 0 / 4	CcBay: 2.8E+1 ± 1.1E+1 2.8E+1 - 2.8E+1 0 / 1	2.8E+1 ± 1.1E+1 2.8E+1 - 2.8E+1 0 / 1

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.12-1
Fish Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2022)

MEDIUM: Fish (FH) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
K-40	5 0		3.3E+3 ± 4.7E+2 3.0E+3 - 3.6E+3 2 / 2	BuzBay: 3.7E+3 ± 1.6E+3 2.0E+3 - 4.7E+3 3 / 3	3.7E+3 ± 1.6E+3 2.0E+3 - 4.7E+3 3 / 3
Mn-54	5 0	130	-8.0E+0 ± 8.5E+0 -8.6E+0 - -7.4E+0 0 / 2	BuzBay: 1.1E+1 ± 1.6E+1 -1.9E+0 - 2.4E+1 0 / 3	1.1E+1 ± 1.6E+1 -1.9E+0 - 2.4E+1 0 / 3
Fe-59	5 0	260	4.4E+1 ± 1.9E+1 4.2E+1 - 4.7E+1 0 / 2	Dis: 4.4E+1 ± 1.9E+1 4.2E+1 - 4.7E+1 0 / 2	2.6E+1 ± 7.4E+1 -4.9E+1 - 9.4E+1 0 / 3
Co-58	5 0	130	-6.6E+0 ± 1.2E+1 -1.3E+1 - -2.5E-1 0 / 2	BuzBay: 3.6E+0 ± 1.8E+1 -1.4E+1 - 1.6E+1 0/ 3	3.6E+0 ± 1.8E+1 -1.4E+1 - 1.6E+1 0 / 3
Co-60	5 0	130	-8.9E+0 ± 2.3E+1 -2.4E+1 - 6.4E+0 0 / 2	BuzBay: 7.1E+0 ± 1.4E+1 -4.3E+0 - 1.9E+1 0 / 3	7.1E+0 ± 1.4E+1 -4.3E+0 - 1.9E+1 0 / 3
Zn-65	5 0	260	-6.2E+1 ± 4.5E+1 -9.0E+1 - -3.3E+1 0 / 2	BuzBay: -4.5E+1 ± 6.0E+1 -8.8E+1 - 1.9E+1 0 / 3	-4.5E+1 ± 6.0E+1 -8.8E+1 - 1.9E+1 0 / 3
Cs-134	5 0	130	-6.9E+0 ± 1.8E+1 -1.8E+1 - 3.7E+0 0 / 2	BuzBay: -1.2E+0 ± 2.6E+1 -2.9E+1 - 1.8E+1 0 / 3	-1.2E+0 ± 2.6E+1 -2.9E+1 - 1.8E+1 0 / 3
Cs-137	5 0	150	-4.1E+0 ± 1.7E+1 -1.4E+1 - 6.1E+0 0 / 2	BuzBay: 1.8E+1 ± 2.3E+1 4.9E+0 - 4.2E+1 0 / 3	1.8E+1 ± 2.3E+1 4.9E+0 - 4.2E+1 0 / 3

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Figure 2.2-1

Environmental TLD Locations Within the PNPS Protected Area

TLD Station		Location*
Description	Code	Distance/Direction
TLDs Within Protected Area		
FENCE-EXEC.BUILDING	P17	107 m W
FENCE-TCF GATE	P11	183 m ESE
FENCE-TCF/BOAT RAMP	P27	185 m ESE
FENCE-TCF/INTAKE BAY	P10	223 m E

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-1 (continued)
Environmental TLD Locations Within the PNPS Protected Area

Figure 2.2-2

TLD and Air Sampling Locations: Within 1 Kilometer

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
BOAT LAUNCH WEST	BLW	0.11 km E	PEDESTRIAN BRIDGE	PB	0.21 km N
OVERLOOK AREA	OA	0.15 km W	EAST BREAKWATER	EB	0.44 km ESE
HEALTH CLUB	TC	0.15 km WSW	PROPERTY LINE	PL	0.54 km NNW
BOAT LAUNCH EAST	BLE	0.16 km ESE	E ROCKY HILL ROAD	ER	0.89 km SE
ISFSI DOSE #3	ISF-3	0.21 km W			
SHOREFRONT SECURITY	P01	0.22 km NNW			
ISFSI DOSE #2	ISF-2	0.29 km W			
ISFSI DOSE #1	ISF-1	0.35 km SW			
SHOREFRONT PARKING	PA	0.35 km NNW			
ISFSI DOSE #4	ISF-4	0.35 km WSW			
ISFSI DOSE #5	ISF-5	0.37 km WSW			
STATION A	A	0.37 km WSW			
ISFSI DOSE #6	ISF-6	0.41 km WSW			
STATION B	B	0.44 km S			
EAST BREAKWATER	EB	0.44 km ESE			
PNPS MET TOWER	PMT	0.44 km WNW			
ISFSI DOSE #7	ISF-7	0.45 km W			
STATION L	L	0.50 km ESE			
STATION G	G	0.53 km W			
PROPERTY LINE	PL	0.54 km NNW			
HALL'S BOG	HB	0.63 km SE			
GREENWOOD HOUSE	GH	0.65 km ESE			
W ROCKY HILL ROAD	WR	0.83 km WNW			
E ROCKY HILL ROAD	ER	0.89 km SE			

Figure 2.2-2 (continued)

TLD and Air Sampling Locations: Within 1 Kilometer

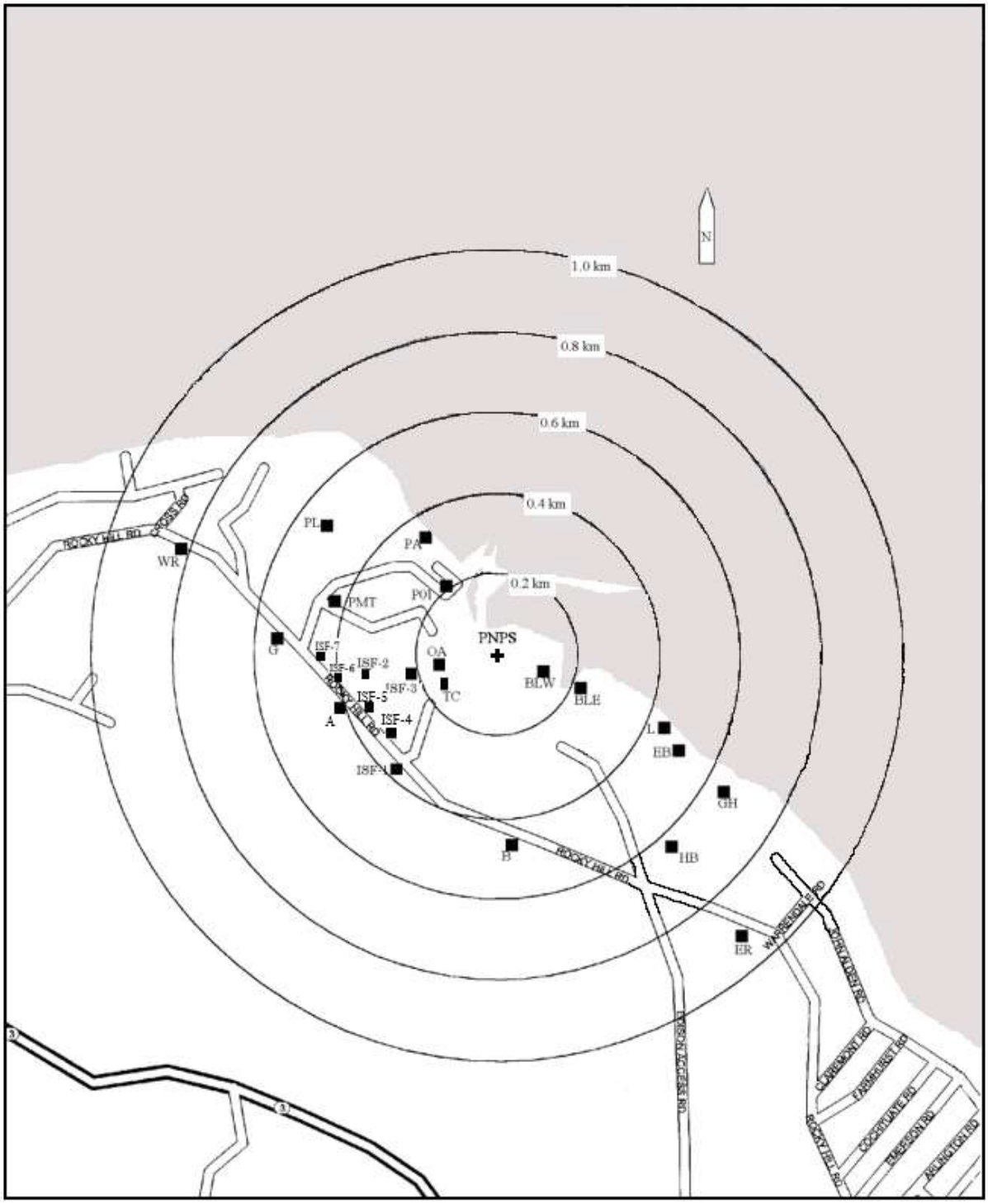


Figure 2.2-3

TLD and Air Sampling Locations: 1 to 5 Kilometers

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km			CLEFT ROCK	CR	1.27 km SSW
CLEFT ROCK	CR	1.27 km SSW			
BAYSHORE/GATE RD	BD	1.34 km WNW			
EMERSON ROAD	EM	1.53 km SSE			
EMERSON/PRISCILLA	EP	1.55 km SE			
BAYSHORE	BS	1.76 km W			
JOHN GAULEY	JG	1.99 km W			
STATION J	J	2.04 km SSE			
PLYMOUTH YMCA	RC	2.09 km WSW			
TAYLOR/THOMAS	TT	2.26 km SE			
YANKEE VILLAGE	YV	2.28 km WSW			
GOODWIN PROPERTY	GN	2.38 km SW			
RIGHT OF WAY	RW	2.83 km S			
TAYLOR/PEARL	TP	2.98 km SE			
Zone 2 TLDs: 3-8 km					
MANOMET ELEM	ME	3.29 km SE			

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-3 (continued)

TLD and Air Sampling Locations: 1 to 5 Kilometers

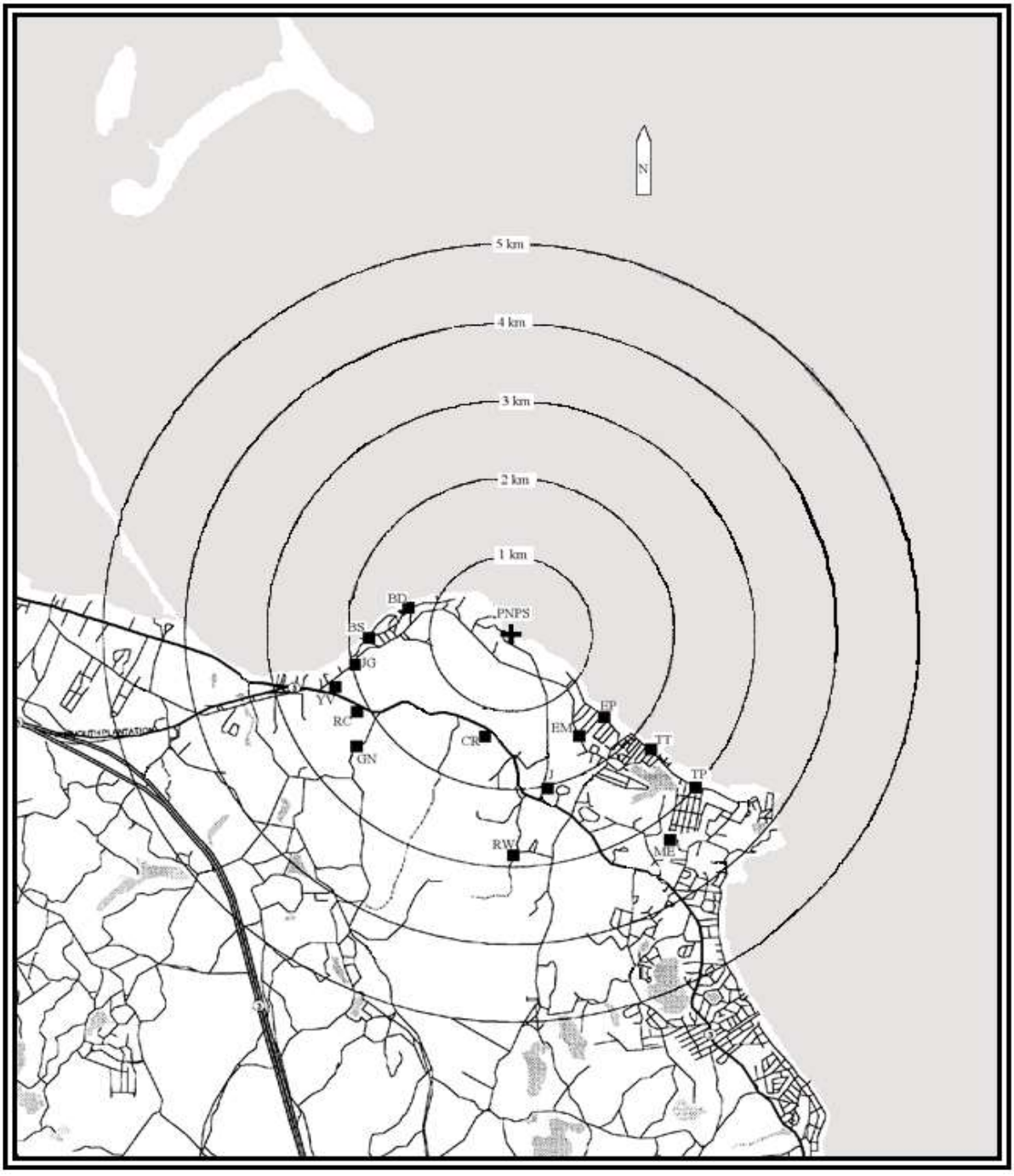


Figure 2.2-4

TLD and Air Sampling Locations: 5 to 25 Kilometers

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 4 TLDs: >15 km			EAST WEYMOUTH SUBST	EW	39.69 km NW
DIV MARINE FISH	DMF	20.97 km SSE			
EAST WEYMOUTH SUBST	EW	39.69 km NW			

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-4 (continued)

TLD and Air Sampling Locations: 5 to 25 Kilometers

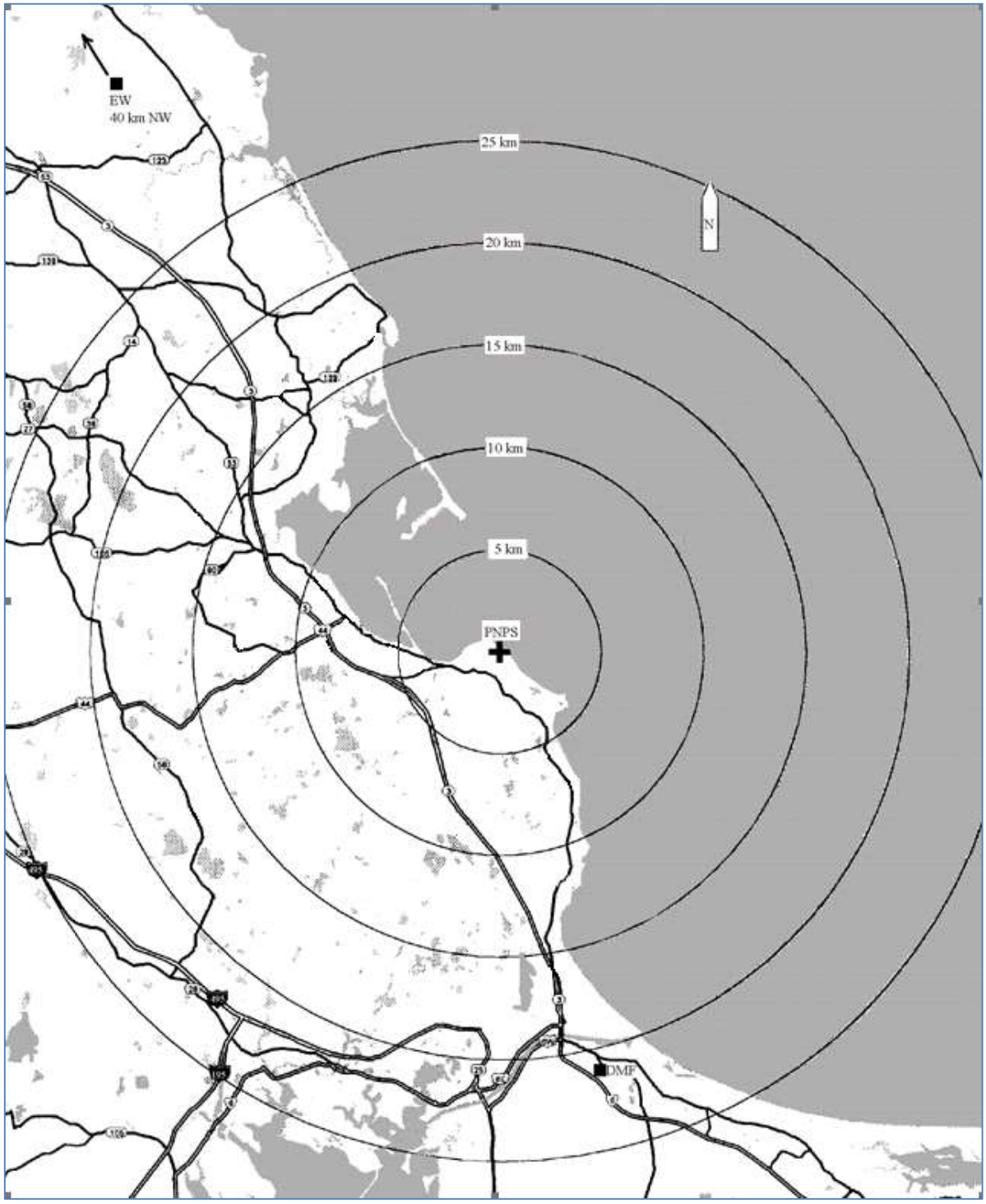


Figure 2.2-5

Marine/ Aquatic Sampling Locations

Description	Code	Distance/Direction*
SURFACE WATER		
Discharge Canal	DIS	0.2 km N
Powder Point Control	PP	13 km NNW
SEDIMENT		
Discharge Canal Outfall	DIS	0.8 km NE
Manomet Point	MP	3.3 km ESE
Plymouth Beach	PLB	4.0 km WNW
Plymouth Harbor	PLY-H	4.1 km W
Green Harbor Control	GH	16 km NNW
MUSSELS		
Discharge Canal Outfall	DIS	0.7 km NNE
Plymouth Harbor	PLY-H	4.1 km W
Green Harbor Control	GH	16 km NNW
SOFT-SHELLED CLAMS		
Plymouth Harbor	PLY-H	4.1 km W
Duxbury Bay Control	DUX-BAY	13 km NNW
LOBSTER		
Discharge Canal Outfall	DIS	0.5 km N
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Discharge Canal Outfall	DIS	0.5 km N
Cape Cod Bay Control	CC-BAY	24 km ESE
Buzzards Bay Control	BB	40 km SSW
Vineyard Sound Control	MV	64 km SSW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location.

Figure 2.2-5 (continued)

Marine/Aquatic Sampling Locations

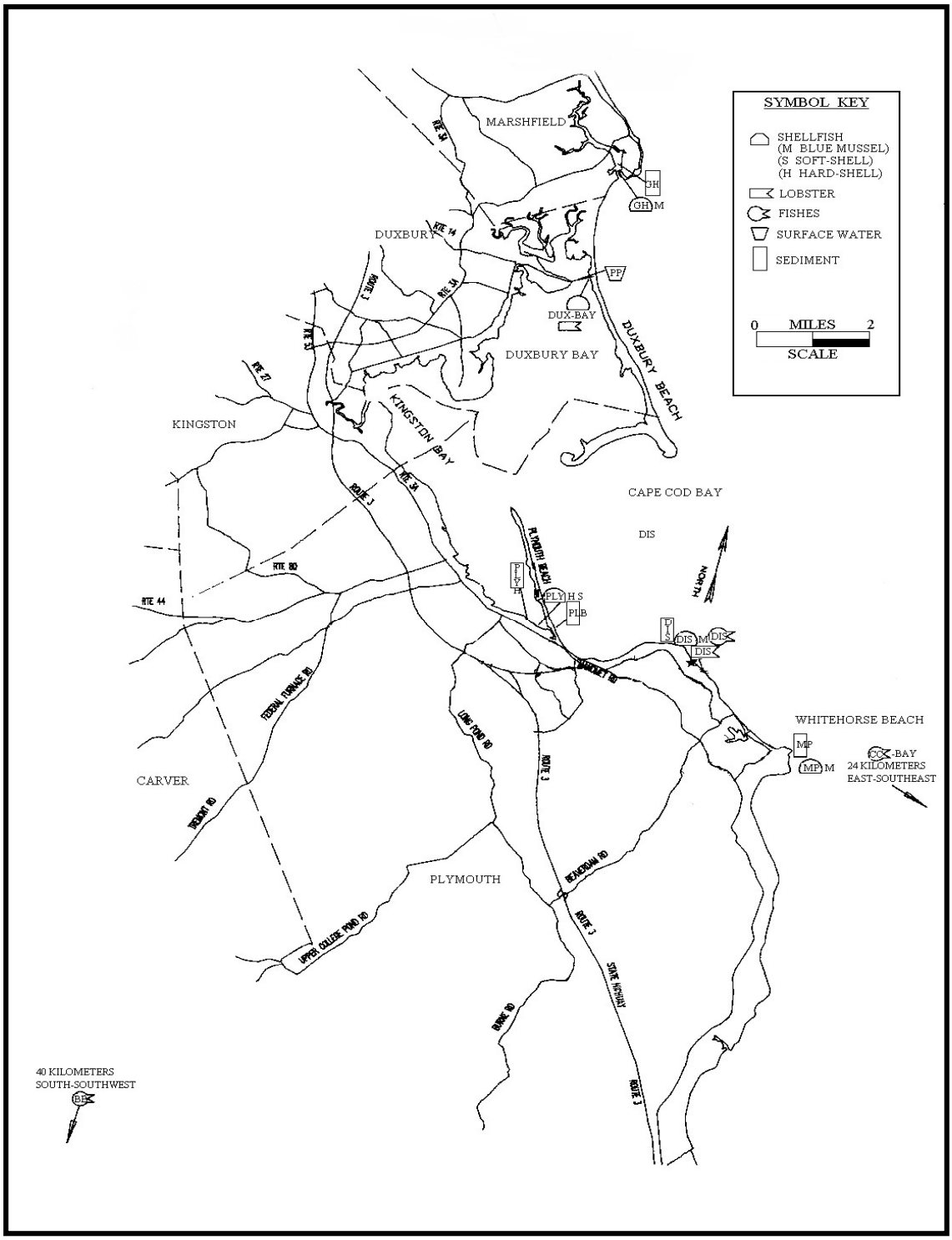


Figure 2.2-6

Environmental Sampling And Measurement Control Locations

Description	Code	Distance/Direction*
TLD (Controls)		
Div. Marine Fisheries	DMF	21 km SSE
East Weymouth Substation	EW	40 km NW
AIR SAMPLING (Control)		
East Weymouth Substation	EW	40 km NW

Description	Code	Distance/Direction*
SURFACE WATER		
Powder Point Control	PP	13 km NNW
SEDIMENT		
Green Harbor Control	GH	16 km NNW
MUSSELS		
Green Harbor Control	GH	16 km NNW
SOFT-SHELLED CLAMS		
Duxbury Bay Control	DUX-BAY	13 km NNW
LOBSTER		
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Cape Cod Bay Control	CC-BAY	24 km ESE
Buzzards Bay Control	BB	40 km SSW
Vineyard Sound Control	MV	64 km SSW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location.

Figure 2.2-6 (continued)

Environmental Sampling And Measurement Control Locations

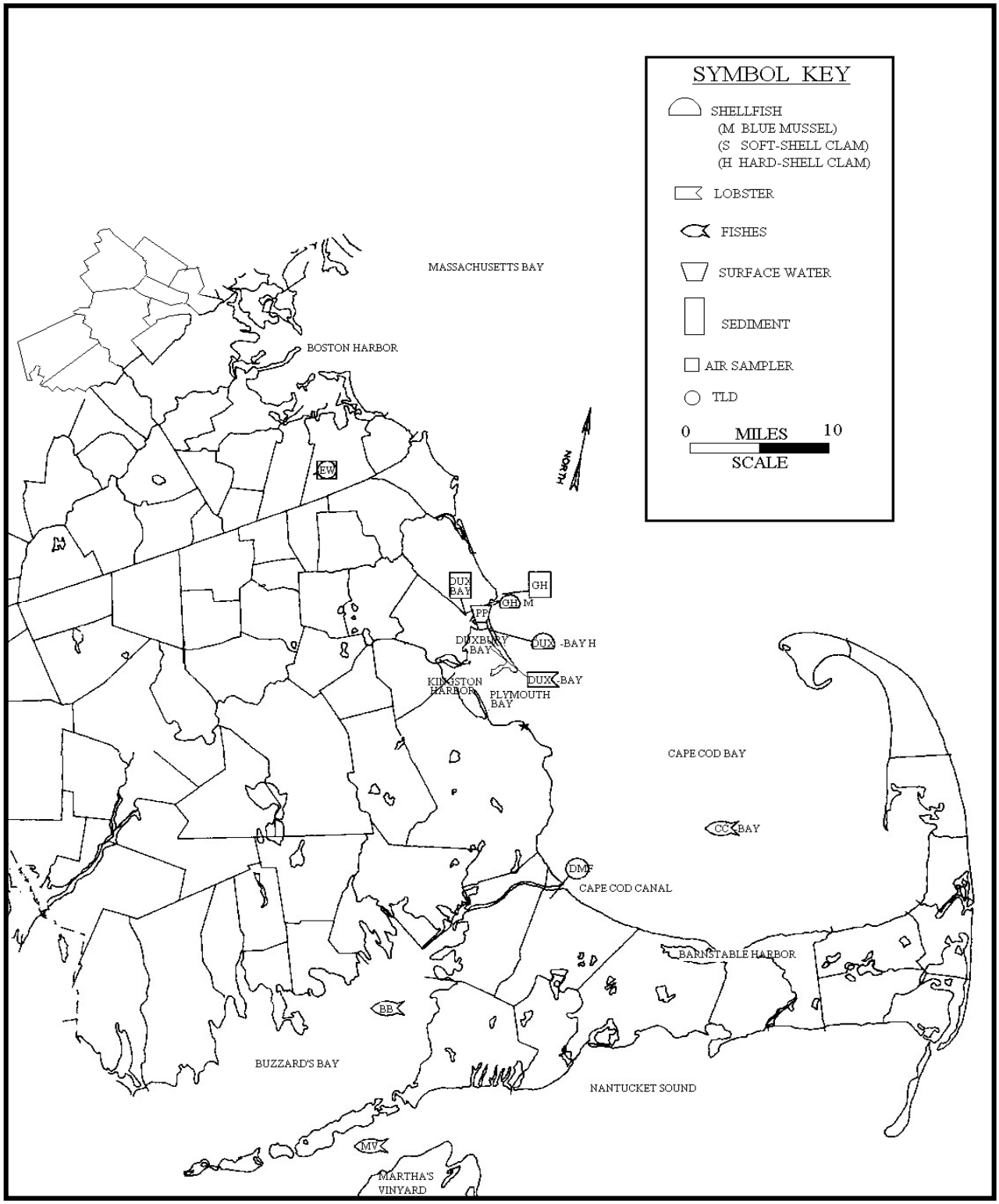


Figure 2.5-1
Airborne Gross-Beta Radioactivity Levels: Near Station Monitors

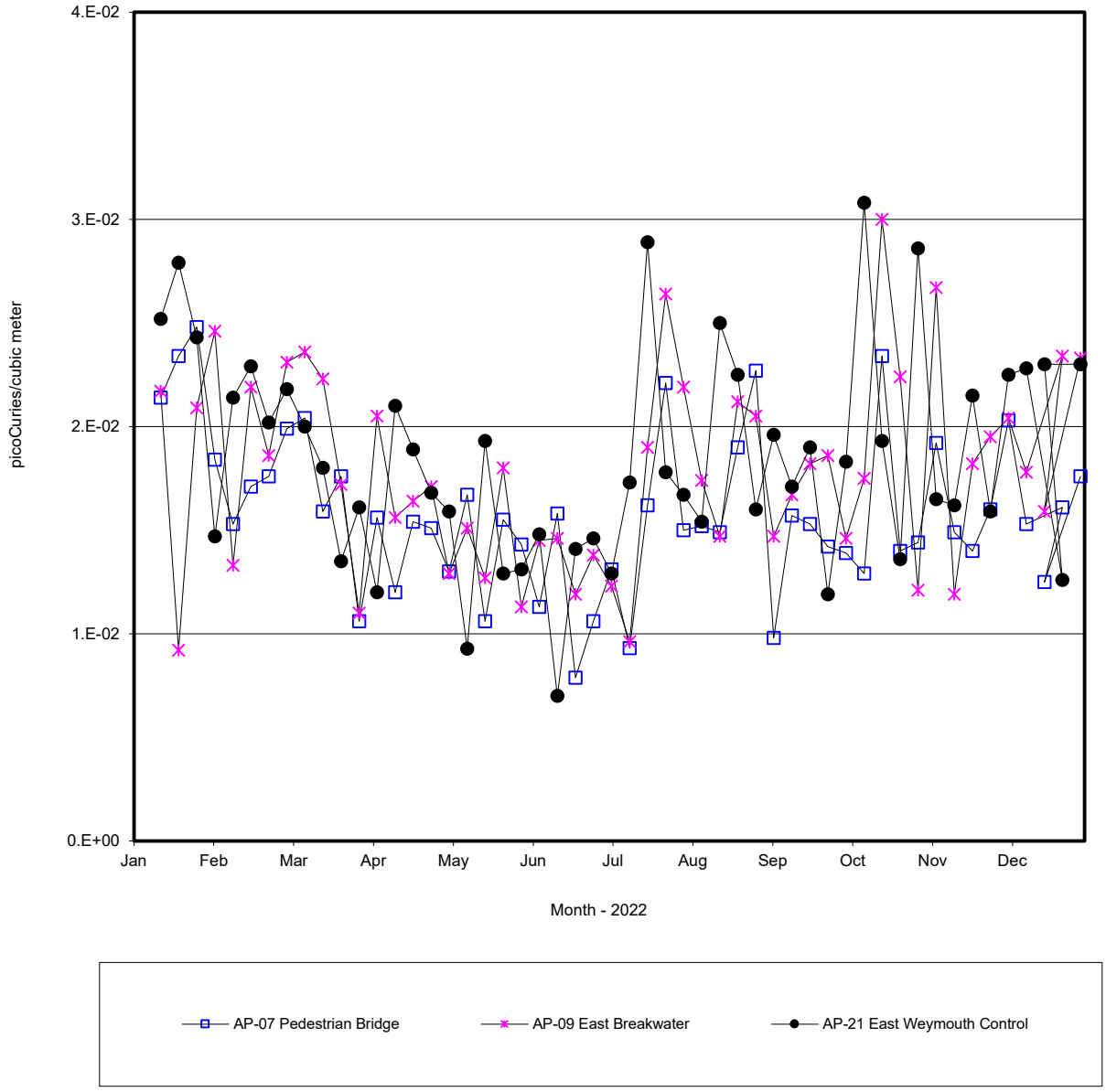


Figure 2.5-2
Airborne Gross-Beta Radioactivity Levels: Property Line Monitors

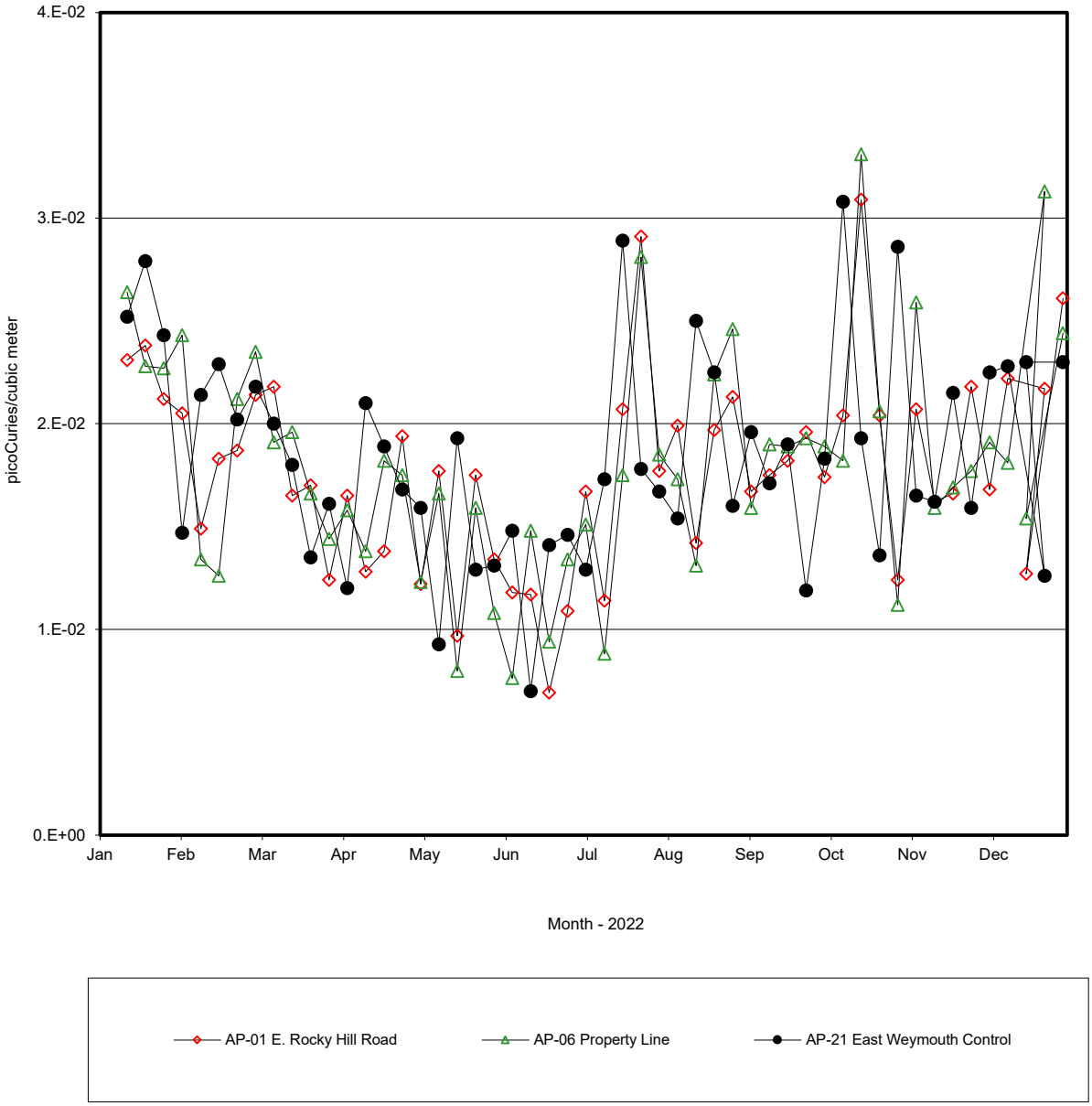
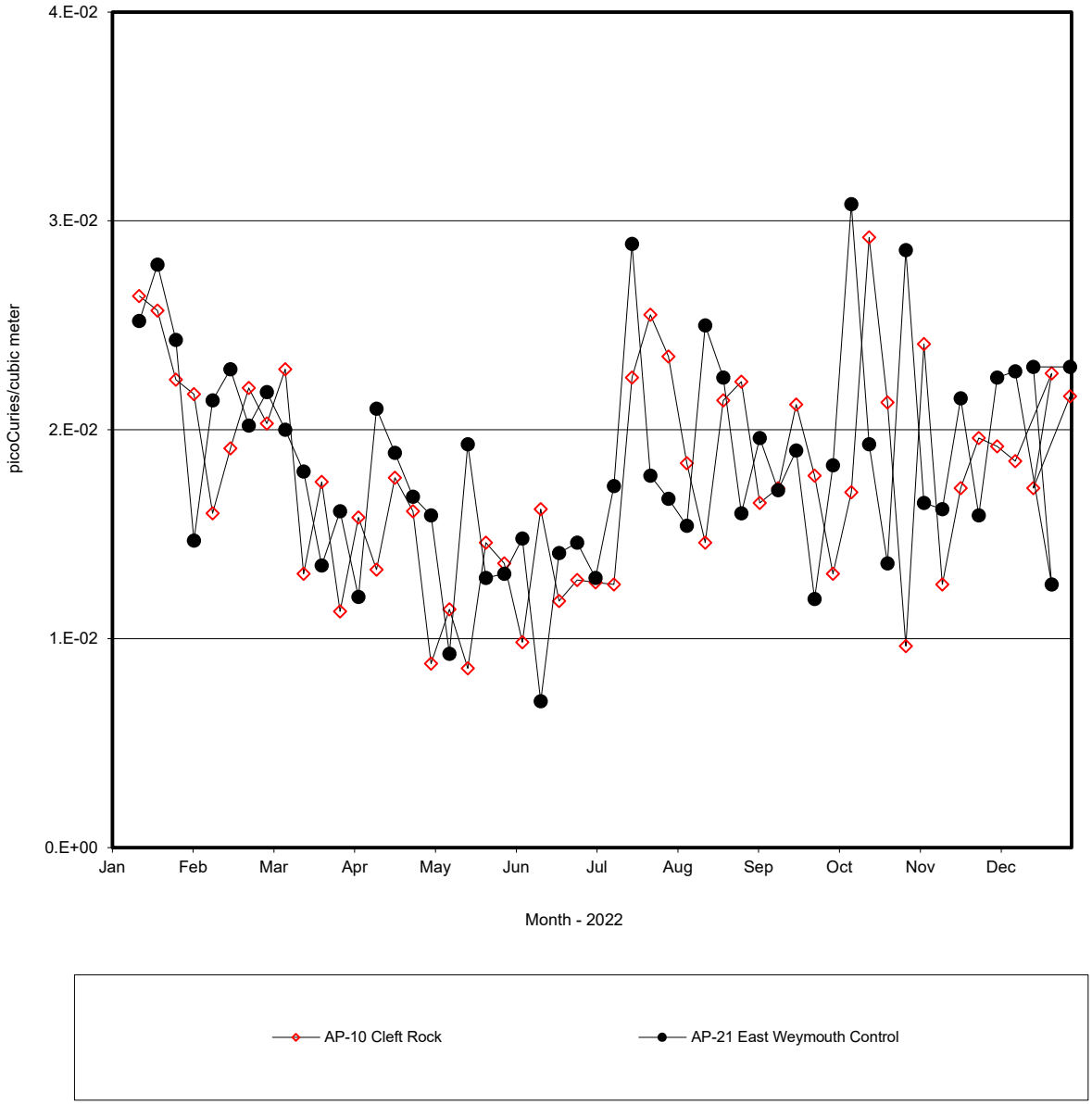


Figure 2.5-3
Airborne Gross-Beta Radioactivity Levels: Offsite Monitors



* Manomet substation collection was discontinued after the ODCM revision 15 collapsed the outer sampling ring to 3km.

3.0 SUMMARY OF RADIOLOGICAL IMPACT ON HUMANS

The radiological impact to humans from the Pilgrim Station's radioactive liquid and gaseous releases has been estimated using two methods:

- calculations based on measurements of plant effluents; and
- calculations based on measurements of environmental samples.

The first method utilizes data from the radioactive effluents (measured at the point of release) together with conservative models that calculate the dispersion and transport of radioactivity through the environment to humans (Reference 7). The second method is based on actual measurements of radioactivity in the environmental samples and on dose conversion factors recommended by the Nuclear Regulatory Commission. The measured types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during 2022 were reported to the Nuclear Regulatory Commission within the station's Annual Radiological Effluent Release Report (ARERR). The measured levels of radioactivity in the special studies environmental samples that required dose calculations are listed in Appendix A.

The maximum individual dose from liquid effluents is calculated using the following radiation exposure pathways:

- shoreline external radiation during fishing and recreation at the Pilgrim Station Shorefront; Note: there is no actual access to the shorefront allowed to a MEMBER of the PUBLIC. Recreational areas were closed to unauthorized personnel after 9/11.
- external radiation from the ocean during boating and swimming; and
- ingestion of fish and shellfish.

For gaseous effluents, the maximum individual dose was calculated using the following radiation exposure pathways:

- external radiation from cloud shine and submersion in gaseous effluents;
- inhalation of airborne radioactivity;
- external radiation from soil deposition;
- consumption of vegetables; and
- consumption of milk and meat. Note: There are no milk/ meat animals in the vicinity Pilgrim Station

The results from the dose calculations based on PNPS operations are presented in Table 3.0-1. The dose assessment data presented were taken from the "Radioactive Effluent Release Report" for the period of January 1 through December 31, 2022 (Reference 17).

Table 3.0-1

Radiation Doses from 2022 Pilgrim Station Operations

Receptor	Maximum Individual Dose From Exposure Pathway - mrem/yr			
	Gaseous Effluents*	Liquid Effluents	Ambient Radiation**	Total
Total Body	0.000068	N/A	0.16	0.16
Max. Organ	0.000070	N/A	0.16	0.16

* Gaseous effluent exposure pathway includes combined dose from particulates and tritium, calculated at the nearest residence or receptor location yielding the highest projected dose from all exposure pathways.

** Ambient radiation dose for the hypothetical maximum-exposed individual at a location beyond the PNPS owner-controlled area yielding highest ambient radiation exposure value as measured with TLDs.

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 100 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 1301, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made sources of radiation. Such radiation doses are summarized in Table 1.2-1. The typical American receives approximately 620 mrem/yr from such sources.

As can be seen from the doses resulting from Pilgrim Station decommissioning operations during 2022, all values are well within the federal limits specified by the NRC and EPA. In addition, the calculated doses from PNPS operation represent only a fraction of a percent of doses from natural and man-made radiation.

In conclusion, the radiological impact of Pilgrim Station decommissioning operations, whether based on actual environmental measurements or calculations made from effluent releases, would yield doses well within any federal dose limits set by the NRC or EPA. Such doses represent only a small percentage of the typical annual dose received from natural and man-made sources of radiation.

4.0 REFERENCES

1) United States of America, Code of Federal Regulations, Title 10, Part 50, Appendix A Criteria 64.

2) Donald T. Oakley, "Natural Radiation Exposure in the United States." U. S. Environmental Protection Agency, ORP/SID 72-1, June 1972.

3) National Council on Radiation Protection and Measurements, Report No. 93, "Ionizing Radiation Exposures of the Population of the United States," September 1987.

4) United States Nuclear Regulatory Commission, Regulatory Guide 8.29, "Instructions Concerning Risks from Occupational Radiation Exposure," Revision 0, July 1981.

5) Boston Edison Company, "Pilgrim Station" Public Information Brochure 100M, WNTHP, September 1989.

6) United States Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

7) Pilgrim Nuclear Power Station Offsite Dose Calculation Manual, Revision 15, June 2021.

8) United States of America, Code of Federal Regulations, Title 10, Part 20.1301.

9) United States of America, Code of Federal Regulations, Title 10, Part 50, Appendix I.

10) United States of America, Code of Federal Regulations, Title 40, Part 190.

11) United States Nuclear Regulatory Commission, Regulatory Guide 4.1, "Program for Monitoring Radioactivity in the Environs of Nuclear Power Plants," Revision 1, April 1975.

12) ICN/Tracerlab, "Pilgrim Nuclear Power Station Pre-operational Environmental Radiation Survey Program, Quarterly Reports," August 1968 to June 1972.

13) International Commission of Radiological Protection, Publication No. 43, "Principles of Monitoring for the Radiation Protection of the Population," May 1984.

14) United States Nuclear Regulatory Commission, NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors," April 1991.

15) United States Nuclear Regulatory Commission, Branch Technical Position, "An Acceptable Radiological Environmental Monitoring Program," Revision 1, November 1979.

16) Settlement Agreement Between Massachusetts Wildlife Federation and Boston Edison Company Relating to Offsite Radiological Monitoring - June 9, 1977.

17) Pilgrim Nuclear Power Station, “Annual Radioactive Effluent Release Report”, May 2022.

APPENDIX A

SPECIAL STUDIES

There were no environmental samples collected during 2022 that contained plant-related radioactivity. Therefore, no special studies were required to estimate dose from plant-related radioactivity.

APPENDIX B

LAND USE CENSUS RESULTS

The annual land use census requirement for gardens and milk and meat animals, as well as the broadleaf vegetation collection in the vicinity of Pilgrim Station was discontinued in 2021 with Revision 15 of the ODCM. As stated earlier in this report the broadleaf vegetation collection was in lieu of milk sampling as a type of cattle feed to account for iodine deposition. At the plant is permanently in a shutdown and decommissioned status no new iodine is produced and that which was produced has decayed away.

No new milk or meat animals were identified during the last land use census. In addition, the Town of Plymouth Animal Inspector stated that their office is not aware of any animals at locations other than the Plimoth Plantation. Although milk sampling is not performed at Plimoth Plantation, effluent dose calculations are performed for this location assuming the presence of a milk ingestion pathway, as part of the Annual Radioactive Effluent Release Report (Reference 17).

APPENDIX C

ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES

In any given year there were a number of instances in which inadvertent issues can be encountered in the collection of environmental samples. All of these issues are usually minor in nature and do not have an adverse effect on the results or integrity of the monitoring program. The PNPS TLD placement still exceeds that prescribed by NUREG-1302. Details of these various problems are given below.

Within the air sampling program, there were no instances in which continuous sampling was interrupted at airborne sampling locations during 2022. There was only one instance (01 Feb 2023) where the filter changeout had a two week run time instead of require one week due to area access issues. This event did not have any significant impact on the scope and purpose of the sampling program, and lower limits of detection (LLDs) were met for airborne particulates on all 311 filters collected. In the fourth quarter of 2019, following the permanent shutdown of the station, the use of charcoal cartridges at air sample locations was discontinued as iodine had decayed away.

Out of 312 filters 311 samples were collected and analyzed during 2022. In accordance with ODCM Table 3.5-1, offsite REMP air particulate filters are to be collected at a weekly interval. Weekly is defined as once every seven days with a one-day grace period before and after the scheduled date. occasionally samples are collected with a longer than seven day interval due to access (especially in the winter) or some other issue. It must be emphasized that the station continued to sample during the duration and no monitoring time was lost.

The configuration of air samplers that had been in use at Pilgrim Station since the early 1980s, was replaced between June and August of 2012. Both the pumps and dry gas meters were replaced, and operating experience since changing over to the new configuration has been favorable. Although the occurrence of pump failures and gas meter problems have been largely eliminated, the new configuration is still subject to trips of the ground fault interrupt circuit (GFCI). Such problems can be encountered at air samplers located at the East Breakwater and Pedestrian Bridge. Both of these locations are immediately adjacent to the shoreline and are subject to significant wind-blown salt water, and are prone to tripping of the GFCI. In 2021 the air sample station at the Pedestrian Bridge was modified to increase the capabilities of collecting a representative sample after observations during an NRC inspection of the REMP program. The following table contains a listing the discrepancies encountered with air sampling stations during 2022.

Location	Sampling Period	Sampling Hours Lost	Problem Description/Resolution
EW	2/1-2/8/22	0	Two week collection due to access issues caused by snow

Group III fishes, consisting of alewife, smelt, or striped bass are normally collected once each year in the summer from the vicinity of the Discharge Canal Outfall. Since the shut down of Pilgrim station the warm water plume of the discharge, which drew in fish species like the Striped Bass, has dissipated and is no longer present. Fish species once in such abundance to bring in harbor seals and sharks behind them are no longer found in the plant area. Repeated and concerted efforts were made to collect these species, but failed to produce all required samples. Group I (autumn) and Group III (autumn) fish could not be collected.

Issues were encountered when attempting to sample sediment and shellfish due to environmental conditions due negative tides, several unsuccessful attempts were made resulting in fewer program samples.

In summary, the various problems encountered in collecting and analyzing environmental samples during 2022 were relatively minor when viewed in the context of the entire monitoring program. These discrepancies were promptly corrected when issue was identified, where possible. None of the discrepancies resulted in an adverse impact on the overall monitoring program.

APPENDIX E

Teledyne Brown Engineering Environmental Services
Annual 2022 Quality Assurance Report

ENVIRONMENTAL DOSIMETRY COMPANY

ANNUAL QUALITY ASSURANCE STATUS REPORT

January - December 2022

Prepared By: _____ Date: 3/24/23

Approved By: _____ Date: 3/24/23

Environmental Dosimetry Company
10 Ashton Lane
Sterling, MA 01564

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

Routine quality control (QC) testing was performed for dosimeters issued by the Environmental Dosimetry Company (EDC) .

During this annual period100% (72/72) of the individual dosimeters, evaluated against the EDC internal performance acceptance criteria (high-energy photons only), met the criterion for accuracy and 100% (72/72) met the criterion for precision (Table 1). In addition, 100% (12/12) of the dosimeter sets evaluated against the internal tolerance limits met EDC acceptance criteria (Table 2) and 100% (6/6) of independent testing passed the performance criteria (Table 3). Trending graphs, which evaluate performance statistic for high-energy photon irradiations and co-located stations are given in Appendix A.

One internal assessment was performed in 2022.There were no findings.

I. INTRODUCTION

The TLD systems at the Environmental Dosimetry Company (EDC) are calibrated and operated to ensure consistent and accurate evaluation of TLDs. The quality of the dosimetric results reported to EDC clients is ensured by in-house performance testing and independent performance testing by EDC clients, and both internal and client directed program assessments.

The purpose of the dosimetry quality assurance program is to provide performance documentation of the routine processing of EDC dosimeters. Performance testing provides a statistical measure of the bias and precision of dosimetry processing against a reliable standard, which in turn points out any trends or performance changes. Two programs are used:

A. QC Program

Dosimetry quality control tests are performed on EDC Panasonic 814 Environmental dosimeters. These tests include: (1) the in-house testing program coordinated by the EDC QA Officer and (2) independent test perform by EDC clients. In-house test are performed using six pairs of 814 dosimeters, a pair is reported as an individual result and six pairs are reported as the mean result. Results of these tests are described in this report.

Excluded from this report are instrumentation checks. Although instrumentation checks represent an important aspect of the quality assurance program, they are not included as process checks in this report. Instrumentation checks represent between 5-10% of the TLDs processed.

B. QA Program

An internal assessment of dosimetry activities is conducted annually by the Quality Assurance Officer (Reference 1). The purpose of the assessment is to review procedures, results, materials or components to identify opportunities to improve or enhance processes and/or services.

II. PERFORMANCE EVALUATION CRITERIA

A. Acceptance Criteria for Internal Evaluations

1. Bias

For each dosimeter tested, the measure of bias is the percent deviation of the reported result relative to the delivered exposure. The percent deviation relative to the delivered exposure is calculated as follows:

$$\frac{\left(H_i' - H_i\right)}{H_i} 100$$

where:

H_i' = the corresponding reported exposure for the i^{th} dosimeter (i.e., the reported exposure)

H_i = the exposure delivered to the i^{th} irradiated dosimeter (i.e., the delivered exposure)

2. Mean Bias

For each group of test dosimeters, the mean bias is the average percent deviation of the reported result relative to the delivered exposure. The mean percent deviation relative to the delivered exposure is calculated as follows:

$$\sum\left(\frac{(H_i' - H_i)}{H_i}\right)100\left(\frac{1}{n}\right)$$

where:

H_i' = the corresponding reported exposure for the i^{th} dosimeter (i.e., the reported exposure)

H_i = the exposure delivered to the i^{th} irradiated test dosimeter (i.e., the delivered exposure)

n = the number of dosimeters in the test group

Precision

For a group of test dosimeters irradiated to a given exposure, the measure of precision is the percent deviation of individual results relative to the mean reported exposure. At least two values are required for the determination of precision. The measure of precision for the i^{th} dosimeter is:

$$\left(\frac{\left(H_i' - \bar{H}\right)}{\bar{H}}\right)100$$

where:

H_i' = the reported exposure for the i^{th} dosimeter (i.e., the reported exposure)

$\bar{H}$ = the mean reported exposure; i.e., $\bar{H} = \sum H_i'\left(\frac{1}{n}\right)$

n = the number of dosimeters in the test group

3. EDC Internal Tolerance Limits

All evaluation criteria are taken from the “EDC Quality System Manual,” (Reference 2). These criteria are only applied to individual test dosimeters irradiated with high-energy photons (Cs-137) and are as follows for Panasonic Environmental dosimeters: ± 15% for bias and ± 12.8% for precision.

B. QC Investigation Criteria and Result Reporting

EDC Quality System Manual (Reference 2) specifies when an investigation is required due to a QC analysis that has failed the EDC bias criteria. The criteria are as follows:

1. No investigation is necessary when an individual QC result falls outside the QC performance criteria for accuracy.

2. Investigations are initiated when the mean of a QC processing batch is outside the performance criterion for bias.

C. Reporting of Environmental Dosimetry Results to EDC Customers

1. All results are to be reported in a timely fashion.

4. If the QA Officer determines that an investigation is required for a process, the results shall be issued as normal. If the QC results prompting the investigation have a mean bias from the known of greater than ±20%, the results shall be issued with a note indicating that they may be updated in the future, pending resolution of a QA issue.

5. Environmental dosimetry results do not require updating if the investigation has shown that the mean bias between the original results and the corrected results, based on applicable correction factors from the investigation, does not exceed ±20%.

III. DATA SUMMARY FOR ISSUANCE PERIOD JANUARY-DECEMBER 2022

A. General Discussion

Results of performance tests conducted are summarized and discussed in the following sections. Summaries of the performance tests for the reporting period are given in Tables 1 through 3 and Figures 1 through 4.

Table 1 provides a summary of individual dosimeter results evaluated against the EDC internal acceptance criteria for high-energy photons only. During this period100% (72/72) of the individual dosimeters, evaluated against these criteria, met the tolerance limits for accuracy and 100% (72/72) met the criterion for precision. A graphical interpretation is provided in Figures 1 and 2.

Table 2 provides the bias and standard deviation results for each group (N=6) of dosimeters evaluated against the internal tolerance criteria. Overall,100% (12/12) of the dosimeter sets, evaluated against the internal tolerance performance criteria, met these criteria. A graphical interpretation is provided in Figure 3.

Table 3 presents the independent blind spike results for dosimeters processed during this annual period. All results passed the performance acceptance criterion. Figure 4 is a graphical interpretation of Seabrook Station blind co-located station results.

B. Result Trending

One of the main benefits of performing quality control tests on a routine basis is to identify trends or performance changes. The results of the Panasonic environmental dosimeter performance tests are presented in Appendix A. The results are evaluated against each of the performance criteria listed in Section II, namely: individual dosimeter accuracy, individual dosimeter precision, and mean bias.

All of the results presented in Appendix A are plotted sequentially by processing date.

IV. STATUS OF EDC CONDITION REPORTS (CR)

No condition reports were issued during this annual period.

V. STATUS OF AUDITS/ASSESSMENTS

1. Internal

EDC Internal Quality Assurance Assessment was conducted during the fourth quarter 2022. There were no findings identified.

2. External

None.

VI. PROCEDURES AND MANUALS REVISED DURING JANUARY - DECEMBER 2022

Two procedures were reissued with no changes as part of the 5 year review cycle.

VII. CONCLUSION AND RECOMMENDATIONS

The quality control evaluations continue to indicate the dosimetry processing programs at the EDC satisfy the criteria specified in the Quality System Manual. The EDC demonstrated the ability to meet all applicable acceptance criteria.

VIII. REFERENCES

1. EDC Quality Control and Audit Assessment Schedule, 2022.

2. EDC Manual 1, Quality System Manual, Rev. 4, September 28, 2020.

TABLE 1

PERCENTAGE OF INDIVIDUAL DOSIMETERS THAT PASSED EDC INTERNAL CRITERIA JANUARY – DECEMBER 2022[(1), (2)]

Dosimeter Type	Number Tested	% Passed Bias Criteria	% Passed Precision Criteria
Panasonic Environmental	72	100	100

[(1)]This table summarizes results of tests conducted by EDC.
[(2)]Environmental dosimeter results are free in air.

TABLE 2

MEAN DOSIMETER ANALYSES (N=6) JANUARY – DECEMBER 2022[(1), (2)]

Process Date	Exposure Level	Mean Bias %	Standard Deviation %	Tolerance Limit +/-15%
4/25/2022	43	1.2	1.8	Pass
4/27/2022	62	6.2	1.0	Pass
5/05/2022	99	2.3	0.7	Pass
7/26/2022	34	-2.6	1.2	Pass
7/27/2022	81	0.6	1.7	Pass
8/07/2022	107	-3.5	0.7	Pass
10/27/2022	52	1.8	0.9	Pass
11/02/2022	76	2.0	0.9	Pass
11/07/2022	27	7.0	0.7	Pass
01/24/2023	38	1.5	1.7	Pass
01/26/2023	115	-0.3	2.0	Pass
02/14/2023	49	2.3	4.0	Pass

[(1)]This table summarizes results of tests conducted by EDC for TLDs issued in 2022.
[(2)]Environmental dosimeter results are free in air.

TABLE 3
SUMMARY OF INDEPENDENT DOSIMETER TESTING JANUARY – DECEMBER 2022[(1), (2)]

Issuance Period	Client	Mean Bias %	Standard Deviation %	Pass / Fail
1st Qtr. 2022	Millstone	-0.6	0.6	Pass
2nd Qtr.2022	Millstone	-3.9	1.0	Pass
3rd Qtr. 2022	Millstone	0.1	0.5	Pass
4th Qtr.2022	Millstone	-2.6	1.2	Pass
4th Qtr.2022	PSEG(PNNL) 48mR	1.1	1.5	Pass
4th Qtr.2022	PSEG(PNNL) 95mR	0.7	0.3	Pass
4th Qtr.2022	PSEG(PNNL) 143mR	2.3	0.8	Pass
4th Qtr.2022	PSEG(PNNL) 190mR	1.4	0.8	Pass
4th Qtr.2022	SONGS	-5.6	1.1	Pass

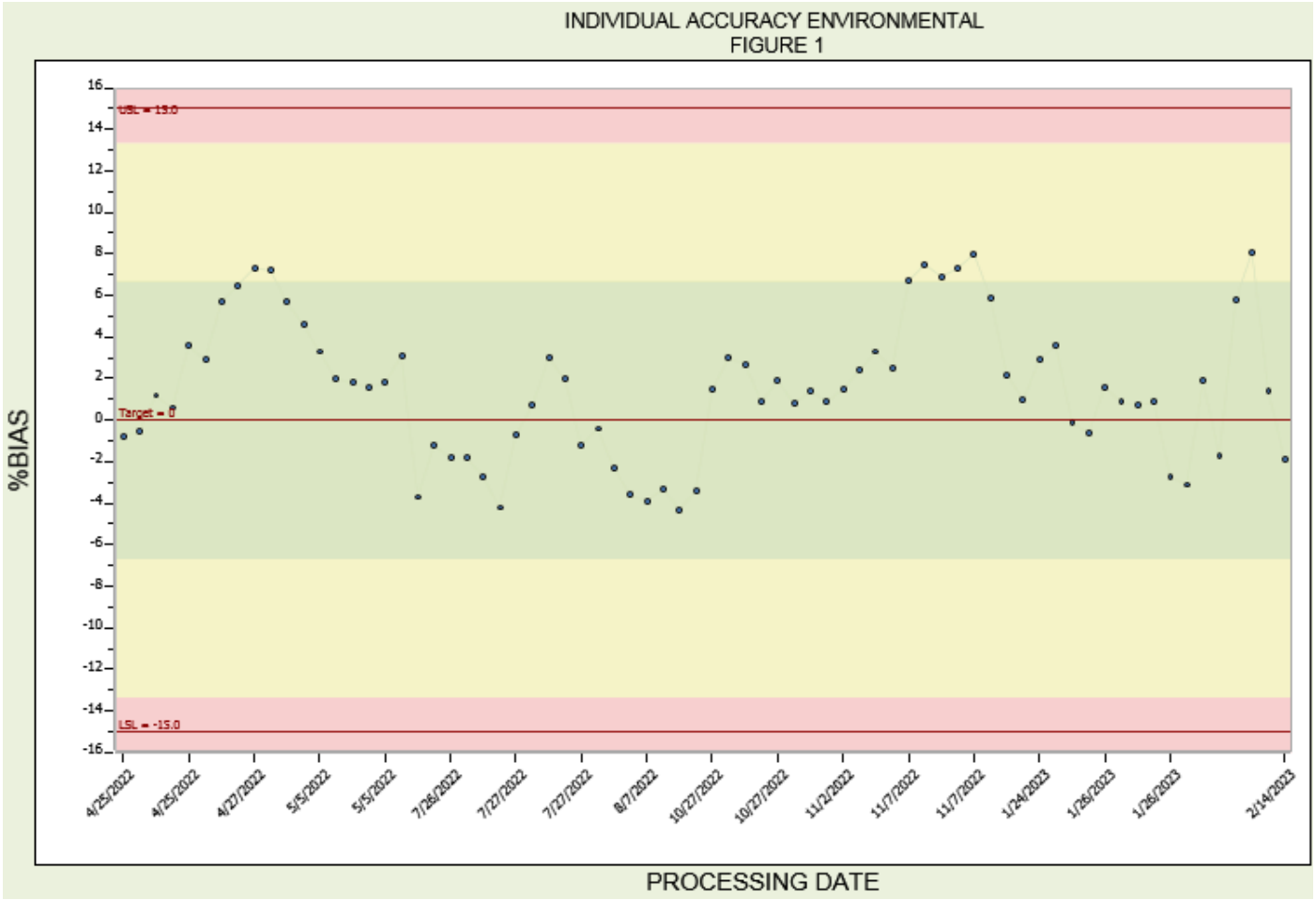
[(1)]Performance criteria are +/- 15%.
[(2)]Blind spike irradiations using Cs-137

APPENDIX A

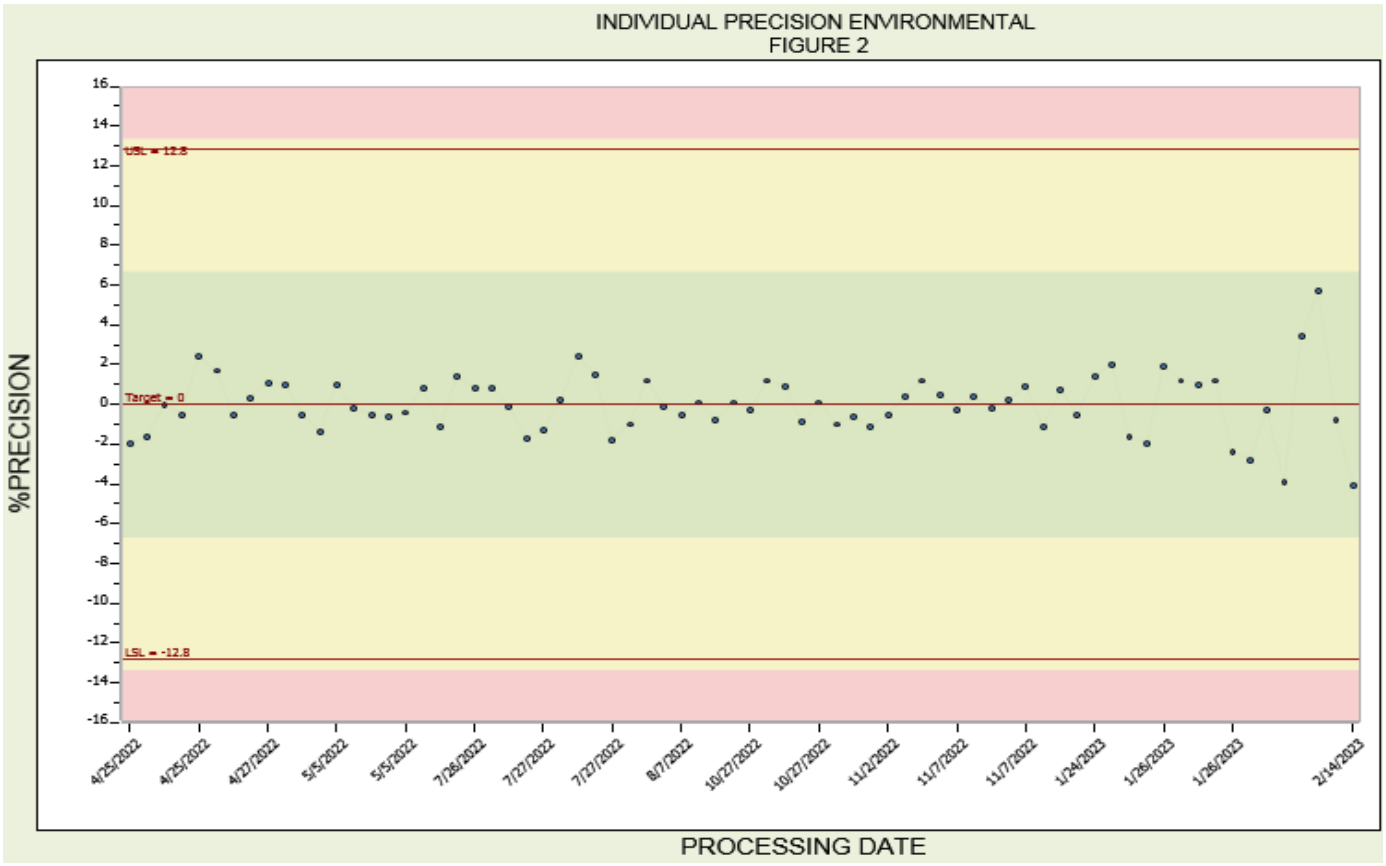
DOSIMETRY QUALITY CONTROL TRENDING GRAPHS

ISSUE PERIOD JANAURY - DECEMBER 2022

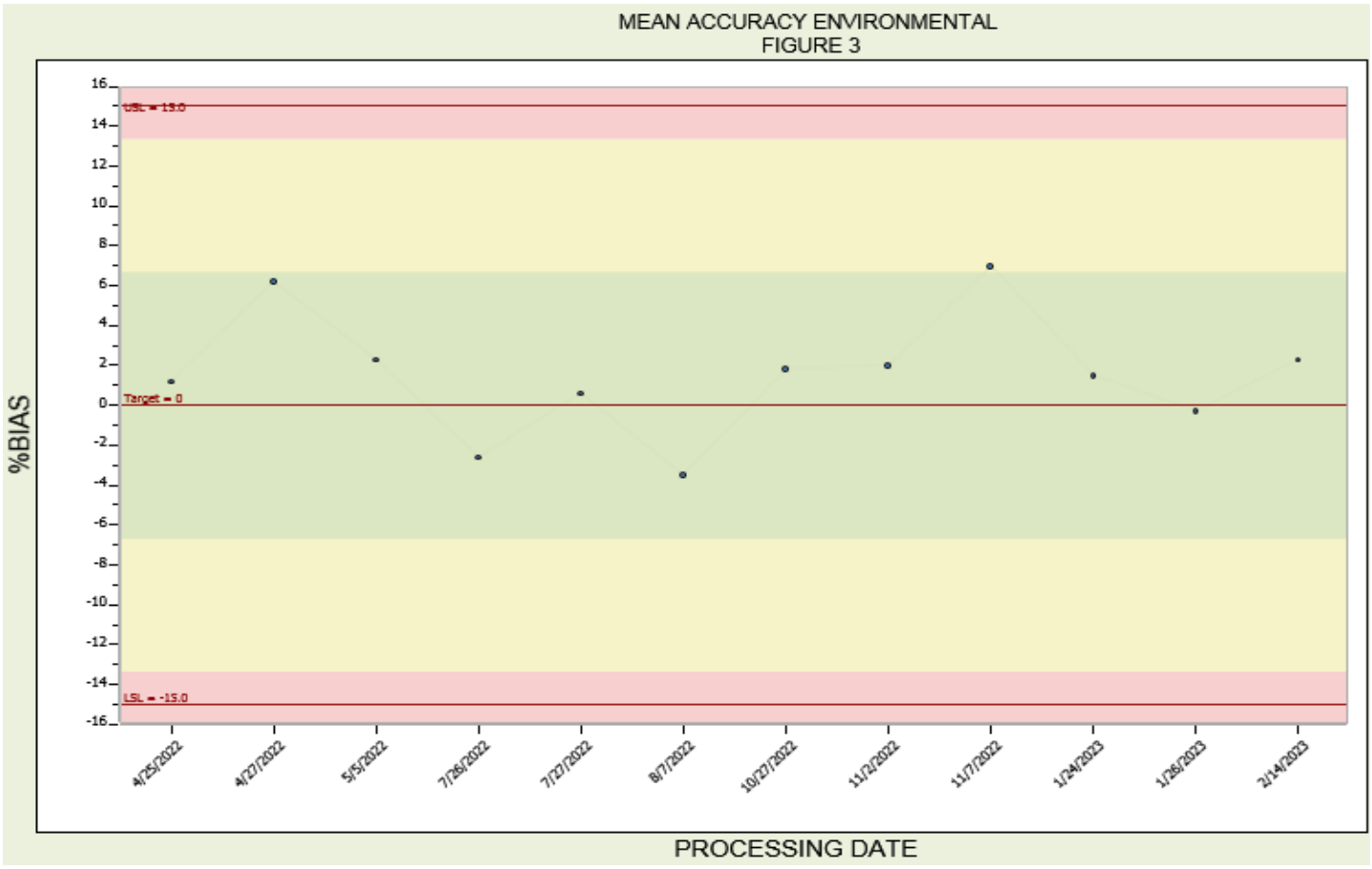
INDIVIDUAL ACCURACY ENVIRONMENTAL
FIGURE 1



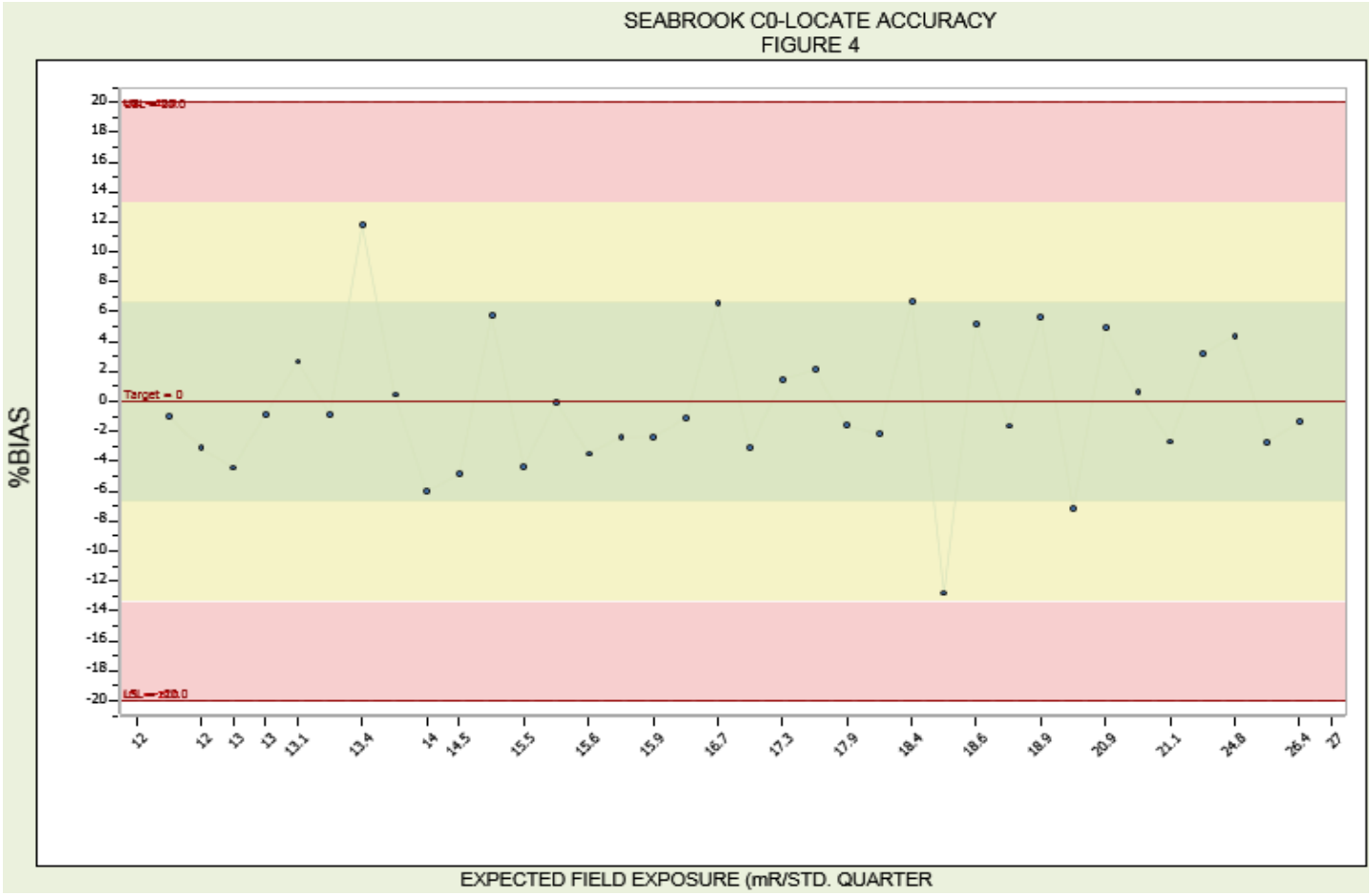
INDIVIDUAL PRECISION ENVIRONMENTAL
FIGURE 2



MEAN ACCURACY ENVIRONMENTAL
FIGURE 3



SEABROOK C0-LOCATE ACCURACY
FIGURE 4



APPENDIX D

Environmental Dosimetry Company
Annual 2022 Quality Assurance Status Report

TELEDYNE
BROWN ENGINEERING
A Teledyne Technologies Company

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

Knoxville Laboratory

4th Quarter 2022 QUALITY ASSURANCE REPORT

January – December 2022

Teledyne Brown Engineering
2508 Quality Lane
Knoxville, TN 37931-3133

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4th Quarter 2022 Quality Assurance Report

Review and Signatures

Quality Assurance Manager:
Contractual Review

Sharon L. Northcutt 01/26/23
Sharon L. Northcutt **Date**

Laboratory Operations Manager:
Technical Review

Keith O. Jeter 1/26/23
Keith O. Jeter **Date**

TABLE OF CONTENTS

I. INTRODUCTION

This report covers the Quality Assurance (QA) Program for the Analytical Services function of the Teledyne Brown Engineering Environmental Services (TBE-ES) laboratory for January through December 2022.

A. Operational Quality Control Scope

The TBE-ES Laboratory Quality Control (QC) Program is designed to monitor the quality of analytical processing associated with environmental, effluent (USNRC Regulatory Guide 4.15), bioassay, industrial process, and waste characterization (10CFR Part 61) samples.

Quality Control of radioanalyses involves an internal process control program and participation in external independent third-party programs administered by Analytics, Environmental Resource Associates (ERA) and the Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP). *The MAPEP is designed to evaluate specific analytical capabilities that are of importance for DOE analytical services. These types of performance evaluation samples may contain both radiological and non-radiological "mixed" analytes and are reflective of real-world samples seen from DOE monitoring sites. Although TBE-ES is not currently under contract to analyze samples for DOE sites, the laboratory chooses to participate in PE program because it offers a variety of matrices and nuclides that are analyzed on a routine basis (water, soil, air filters, etc.).*

1. Interlaboratory

Results for third-party process checks prepared by Analytics, ERA and MAPEP are not reported during the first quarter of the year.

Inter-laboratory cross-check samples are received and reported as follows:

- Analytics cross-check samples are analyzed by TBE two times per year, typically in April and September.
- MAPEP provides samples semi-annually in March and September with required reporting dates in May and November, respectively, following sample receipt.
- ERA cross-check samples are analyzed by TBE semi-annually in April and October with required reporting dates in May and November, respectively, following sample receipt.

2. Intralaboratory

The internal QC program is designed to include QC functions such as instrumentation checks (to ensure proper instrument response) and blank samples (to which no analyte radioactivity has been added) for contamination checks and instrumentation backgrounds. Process controls (or process checks) are actual samples analyzed in duplicate (duplicates) in order to evaluate the precision of laboratory measurements. Accuracy of analyses is measured by analyzing blank samples which have been spiked with a known quantity of a radioisotope (spikes) that are of interest to

laboratory clients. Some client samples are also spiked with a known activity of target analyte (matrix spikes) and aid in evaluating analytical method performance.

QC samples are intended to evaluate the entire radiochemical and radiometric process. Process control and qualification analyses samples seek to mimic the media type of those samples submitted for analysis by laboratory clients. The magnitude of the process control program combines both internal and external sources targeted at 10% of the routine sample analysis load. A summary of blanks, spikes and duplicates is found in Attachments B.1 and B.2.

3. Quality Assurance Program

To provide direction and consistency in administering the quality assurance program, TBE-ES has developed and follows a Quality Manual and a set of Standard Operating Procedures (SOP). The plan describes the scheduled frequency and scope of Quality Assurance and Quality Control (QA/QC) considered necessary for an adequate QA/QC program conducted throughout the year.

Internal audits are performed on an annual schedule, usually during the 4th quarter. External audits are performed by prospective and/or existing clients in accordance with contractual specifications. State audits are conducted to maintain client-specific certification requirements and for accreditation by the National Environmental Laboratory Accreditation Program (NELAP). The Nuclear Procurement Issues Corporation (NUPIC) evaluates suppliers of laboratory services to nuclear utilities. TBE-ES is audited every 33-36 months by NUPIC as a function of the utilities' Radiological Environmental Monitoring Program (REMP).

Audits have been performed by NUPIC, Perry Johnson Laboratory Accreditation (PJLA) for ISO 17025 accreditation and BWXT. Audit results are included in Attachment D.2.

B. Performance Characteristics

1. Interlaboratory Accuracy

TBE-ES has adopted a QC acceptance protocol based upon two external performance models. For the interlaboratory programs that have established performance criteria (e.g., established warning and failure limits), the laboratory uses those established criteria to evaluate QC sample results. For interlaboratory QC programs which report no pre-set acceptance (pass/fail) criteria (e.g., Analytics Cross Check Program), results are evaluated in accordance with TBE-ES internal acceptance criteria.

a) Analytics' Evaluation Criteria

Analytics' evaluation report provides a ratio of TBE's result and the Analytics known value. Since flag values are not assigned, TBE-ES

evaluates the reported ratios based on internal QC requirements, which are based on the DOE MAPEP criteria.

b) MAPEP Evaluation Criteria

MAPEP evaluation criteria found in the *Handbook for the Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP)*, MAPEP-HB-1 Rev. 2 (June 13, 2018), pp. 9-11 & 30-32 and online at https://www.id.energy.gov/resl/mapep/MAPEP-HB-1%20Rev%202.pdf contains the following information:

MAPEP's evaluation report provides a calculated relative bias for the lab's reported results, the acceptance range, and associated flag values. The relative bias places the laboratory result in one of three categories:

- *Acceptable (flag = A)* — *Bias <= 20%*
- *Acceptable with Warning (flag = W)* — *20% < Bias <=30%*
- *Not Acceptable (flag = N)* — *Bias > 30%*

Radiological results must be reported with an associated uncertainty at one standard deviation. The uncertainty associated with a result is not currently used as part of the acceptance criteria, but an uncertainty evaluation is used to flag potential areas of concern. MAPEP assigns A (Acceptable), W (Acceptable with Warning) and N (Not Acceptable) uncertainty flags based upon the relative precision (RP) ratio:

$$RP = (\text{Reported Uncertainty} / \text{Reported Result}) \times 100$$

Uncertainty flags are currently for information only, but reported total uncertainties are used to evaluate performance in false positive/ negative tests and sensitivity evaluations.

The MAPEP program uses false-positive testing in each session to identify laboratory results that indicate the presence of a particular radionuclide when, in fact, the actual activity of the radionuclide is far below the detection limit of the measurement. Not Acceptable (N) performance, and hence a false positive result, is indicated when the range encompassing the result, plus or minus the total uncertainty at three standard deviations, does not include zero (i.e. 2.5 ± 0.2; range of 1.9 –3.1). Statistically, the probability that a result can exceed the absolute value of its total uncertainty at three standard deviations by chance alone is less than 1%. MAPEP uses a three standard deviation criterion for the false positive test to ensure confidence about issuing a false-positive performance evaluation. A result that is greater than three times the total uncertainty of the measurement represents a statistically- positive detection with over 99% confidence.

Sensitivity evaluations are routinely performed to complement the false-positive tests. In a sensitivity evaluation, the radionuclide is present at or near the detection limit, and the difference between the reported result and the MAPEP reference value is compared to the propagated combined total uncertainties. The results are evaluated at three standard deviations. If the observed difference is greater than three times the combined total uncertainty, the sensitivity evaluation in "Not Acceptable". The probability that such a difference

can occur by chance alone is less than 1%. If the participant did not report a statistically positive result, a "Not Detected" is noted in the text field of the MAPEP performance report. A non-detect is potentially a false-negative result, dependent upon the laboratory's detection limit for the radionuclide.

False-negative tests are also performed in combination with the sensitivity evaluations. In this scenario, the sensitivity of the reported measurement indicates that the known specific activity of the targeted radionuclide in the performance evaluation sample should have been detected, but was not, and a "Not Acceptable" performance evaluation is issued. The uncertainty of the MAPEP reference value and of the reported result at three standard deviations is used for the false-negative test.

The false-positive/negative and sensitivity evaluation tests are conducted in a manner that assists the participants with their measurement uncertainty estimates and helps ensure they are not underestimating or over inflating their total uncertainties. If the total uncertainty is over-inflated in order to pass a false-positive test, it will result in a "Not Detected" if the test is actually a sensitivity evaluation. The opposite is true for a false-positive test. False-negatives and failed sensitivity evaluations can also result from under-estimating the total uncertainty. An accurate estimate of measurement uncertainty is required for consistent performance at the acceptable level.

c) ERA Evaluation Criteria

The ERA evaluation report provides an acceptance range for control and warning limits with associated flag values. Acceptance limits for drinking/potable water are established per The NELAC Institute's (TNI) guidance. The TNI Standard uses Fields of Proficiency Testing (FoPT) Tables to calculate upper and lower acceptance limits set at the Mean ± 2 standard deviations (SD). ERA's acceptance limits for other matrices differ based on historical data from past studies.

d) NRC Verification Test Comparison Criteria

Some laboratory clients submit double-blind 10 CFR Part 50 performance evaluation samples. The lab processes these samples as routine client samples and sends the reports to the client, who then reports the result(s) to the sample's originator. This may be via an outside vendor (i.e., Analytics) or prepared by the client. After the results are received by the client, NRC Resolution Criteria is used to determine acceptance of results using a calculated resolution number (known value / 1-sigma uncertainty) and a calculated ratio (lab result of unknown/known value). Clients may or may not share the result with the laboratory and are therefore usually not included with this report.

2. Intralaboratory Accuracy Acceptance Criteria

a) Process Controls

The measure of accuracy for a group of test measurements to a given spike level is found by calculating the recovery of the spike activity found

versus the added spike activity. The percent recovery is calculated as follows:

$$\% \text{ Recovery} = (A_m / A_s)\ 100$$

Where: A_m = the activity measured

A_s = the spiked activity

Internal Process Control sample results use acceptance criteria of 70%-130% for spike recovery. Warning limits are set from 70%-79% and 121%-130%. Results evaluated as "Warning" are assessed for trends of low or high bias and are used to detect potential problems. The laboratory's internal acceptance criteria are based on MAPEP's defined performance levels of bias greater than 30%.

Matrix spikes (MS) may be used to document the bias of a method in a sample matrix. MS acceptance criteria is 60% - 140% recovery.

b) Other Measures

Backgrounds, which represent the ambient signal response recorded by measuring instruments, are independent of radioactivity contributed by the radionuclides being measured in the sample. If possible, equivalent media for preparing laboratory processing blanks will be used.

Acceptable method blank sample results have no three-sigma statistically positive activity for the target parameters. If all sample results associated with the blank are greater than the MDC, then the blank MDC shall be less than the activity of the least active sample in the work order or it will be flagged with a qualifier in the client report with a case narrative.

Replicate/duplicate (DUP) and matrix spike duplicate (MSD) samples are produced by taking two aliquots from a single sample and assigning each aliquot a different Lab Sample Number. In cases of duplicate analyses where there are no "known" values, the analyses will be evaluated for precision only. All duplicates are carried through the complete sample preparation and analytical procedure. Precision is evaluated by calculating the Relative Percent Difference (RPD) between the two samples. Relative Percent Difference is calculated as the absolute difference between two values normalized to the average value, expressed as a percentage:

$$\% \text{ RPD} = (\text{abs}[\text{orig} - \text{dup}] / [\text{orig} + \text{dup}]/2) \times 100$$

Matrix spike duplicates are split samples spiked with identical concentrations of a target analyte and are used to evaluate precision and bias. The matrix spike duplicate recovery is expressed as a percentage:

$$\% \text{ MSD} = (\text{abs}[\text{orig activity}^* - \text{dup activity}]/\text{spike activity}) \times 100$$

**If the original activity is not detected then the activity is considered zero (0)*

For purposes of analytical reporting, each result specifies the radionuclide concentration and the *a posteriori* Minimum Detectable Concentration (MDC). TBE-ES calculates the *a posteriori* MDC using the sample's actual measurement parameters (i.e., sample volume, chemical recovery, instrument background, etc.) to demonstrate that the Nuclear Regulatory Commission's (NRC) *a priori* MDC has been met for each radionuclide/sample. By TBE-ES policy, the *a posteriori* MDC must be less than the required NRC *a priori* MDC.

3. Investigations and Nonconformance Reports

QC investigations are initiated when QC results fall outside of the QC criteria. Other investigations may arise from unanticipated situations which are not clearly defined in the procedures or bounded by pre-established performance criteria but have the potential of becoming QA-related issues. The QA investigation is the mechanism to quickly ascertain if there is "due cause" to issue a formal Non-Conformance Report (NCR).

An NCR is issued to formally document a QC investigation into the root cause of failure, the corrective action taken, and the action taken to prevent recurrence where applicable. Investigations may include review of procedures, interviews of personnel, review of laboratory and instrument logbooks, observation of analyst techniques and any other items identified as necessary to resolve the issue. For intercomparison performance evaluation samples, it is TBE's policy to issue an NCR for all unacceptable results.

II. ANALYTICAL SERVICES QUALITY CONTROL SYNOPSIS

A. Interlaboratory Cross-Check Program

During this reporting period, 27 nuclides associated with six media types (Air Filter, Charcoal [Air Iodine], Milk, Soil, Vegetation and Water) were analyzed. Samples were obtained from Analytics, the Department of Energy's (DOE) Mixed Analyte Performance Evaluation Program (MAPEP) and Environmental Resource Associates (ERA). Media types representative of client analyses performed during this reporting period were selected. The results are presented in Attachment A.

1. Analytics Environmental Cross Check Program

   Twelve nuclides were evaluated in air particulate, charcoal filter, milk and soil matrices during this reporting period. All analyses were within acceptable criteria except for one AP Ce-141 and one AP Co-60 (first failure for each). **NCRs 22-04** and **22-21** were initiated and closed. All raw and associated QC data was reviewed and found to be within acceptable limits. (See Attachment C for NCR detail)

2. DOE's MAPEP Quality Assessment Program

   Fourteen nuclides in water, air particulate (AP), soil, urine and vegetation samples were evaluated in January - December 2022. All of the environmental analyses performed were evaluated as within the acceptable/acceptable with warning criteria except for the urine U-234 & U-238 and water Tc-99 (first failure for each). **NCRs 22-05** and **22-22** were initiated and closed. (See Attachment C for NCR detail)

   NOTE: The soil Tc-99 result for 1st quarter was not within the acceptable range and is not on the ICP list. The 3rd quarter sample result was acceptable. (TBE is running this for our information only at this point.)

3. ERA Environmental Cross Check Program (RAD/MRAD)

   Eighteen nuclides were evaluated in water, soil, and air particulate samples during 2022. All analyses performed were within acceptable criteria except for the MRAD 3rd quarter AP Pu-238 and RAD 4th quarter water U Natural. **NCRs 22-19** and **22-20** were initiated and closed. All raw and associated QC data was reviewed and found to be within acceptable limits. (See Attachment C for NCR detail)

   NOTE: The soil U-238 result for 3rd quarter was not within the acceptable range and is not on the ICP list. (TBE is running this for our information only at this point.)

B. Intralaboratory Cross-Check Program

During this reporting period, 21 nuclides (and numerous other gamma nuclides) in various matrices, including air particulate, charcoal, vegetation, milk, and water were analyzed by means of the laboratory's internal process control program. A compilation of intralaboratory comparison data for this reporting period is summarized in Attachment B. *(Note: Only gamma nuclides that are typically seen in samples are included in the attachment – a complete list is available upon request).*

The TBE-ES laboratory's internal process control program evaluated 7,251 analyses during this period.

1. Blanks

   During this reporting period, 1,597/1,5999 blanks analyzed were less than the MDC. One workgroup blank for Sr-90 and one for S-35 was above the MDC. The workgroups included samples whose activity was greater than 5x the blank. Positive blank activities were reported with a case narrative.

2. Spikes

   During this reporting period, all 1,564 workgroup and matrix spikes analyzed were within the acceptance criteria.

3. Duplicates

   All of the 4,088 duplicate sets analyzed were within acceptance criteria.

C. Non-Conformance Reports (NCRs)

Twenty-two NCRs were initiated, and corrective action completed in 2022. Copies are included in Attachment C.

D. Instrumentation

TBE-ES uses the statistical principal method of evaluation for instrument quality control check data based on the mean, 2-sigma and 3-sigma set point model or uses pre-set tolerance limits. Each detector is checked prior to use for that day and the resulting data points are automatically compared to statistical baselines to determine the instrument's acceptability for counting. Control charts showing this data are available during audits or upon request. TBE-ES instrumentation includes:

1. <u>Gamma Spectroscopy</u>

   Gamma detectors are routinely monitored for energy, full width at half maximum, efficiency, and background. TBE-ES gamma detectors operated without incident during this reporting period. Occasional second runs (as allowed by our QA program) were necessary to verify acceptable operation. Some amplifier fine gain adjustments and liquid nitrogen addition to the dewars were also necessary when data trends indicate an energy drift on the detector.

2. Liquid Scintillation Counters (LSC):

   LSC instruments, used in tritium, carbon-14, nickel-63 and other low-energy beta-emitters, are monitored for background and efficiency. The reliability of these instruments is exceptional with zero instances of background or efficiency values outside of control limits.

3. Alpha/Beta Gas Flow Proportional (GFP) Counters:

   GFP detectors used for gross alpha/beta, strontium-89/90, iodine-131 (low level) and other nuclides are monitored for background and efficiency. These detectors operated without incident during this reporting period. Occasionally, second runs (primarily for alpha due to the sensitivity of source placement) were necessary to verify acceptable operation or because of low P-10 pressure. After gas change-out and purging, control check values return to control norms.

4. Alpha Spectroscopy:

   Alpha detectors are routinely monitored for energy, full width at half maximum, efficiency, and background. TBE-ES alpha detectors operated without incident during this reporting period. Occasional second runs (as allowed by our QA program) were necessary to verify acceptable operation.

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ATTACHMENT A

Interlaboratory Quality Control Program Results

A.1

Analytics Cross Check Program Results

A.1 Analytics Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value [(a)]	Ratio of TBE to Analytics Result	Evaluation [(b)]
March 2022	E13706	Milk	Sr-89	pCi/L	80.3	96.8	0.83	A
			Sr-90	pCi/L	12.7	12.6	1.01	A
	E13707	Milk	Ce-141	pCi/L	62.3	65	0.96	A
			Co-58	pCi/L	158	164	0.96	A
			Co-60	pCi/L	286	302	0.95	A
			Cr-51	pCi/L	314	339	0.93	A
			Cs-134	pCi/L	155	182	0.85	A
			Cs-137	pCi/L	210	223	0.94	A
			Fe-59	pCi/L	211	185	1.14	A
			I-131	pCi/L	88.0	96.7	0.91	A
			Mn-54	pCi/L	169	164	1.03	A
			Zn-65	pCi/L	238	246	0.97	A
	E13708	Charcoal	I-131	pCi	79.9	87.1	0.92	A
	E13709	AP	Ce-141	pCi	60.9	42.0	1.45	N[(1)]
			Co-58	pCi	118	107	1.11	A
			Co-60	pCi	218	196	1.11	A
			Cr-51	pCi	251	221	1.14	A
			Cs-134	pCi	129	118	1.09	A
			Cs-137	pCi	156	145.0	1.07	A
			Fe-59	pCi	124	120.0	1.03	A
			Mn-54	pCi	120	107	1.12	A
			Zn-65	pCi	162	160	1.01	A
	E13710	Soil	Ce-141	pCi/g	0.123	0.103	1.19	A
			Co-58	pCi/g	0.254	0.263	0.97	A
			Co-60	pCi/g	0.493	0.483	1.02	A
			Cr-51	pCi/g	0.603	0.543	1.11	A
			Cs-134	pCi/g	0.268	0.292	0.92	A
			Cs-137	pCi/g	0.399	0.431	0.93	A
			Fe-59	pCi/g	0.320	0.296	1.08	A
			Mn-54	pCi/g	0.263	0.263	1.00	A
			Zn-65	pCi/g	0.407	0.395	1.03	A
	E13711	AP	Sr-89	pCi	83.2	97.4	0.85	A
			Sr-90	pCi	12.7	12.7	1.00	A

(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) Analytics evaluation based on TBE internal QC limits:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

A.1 Analytics Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value [(a)]	Ratio of TBE to Analytics Result	Evaluation [(b)]
September 2022	E13712	Milk	Sr-89	pCi/L	71.1	89.1	0.80	A
			Sr-90	pCi/L	12.0	13.6	0.88	A
	E13713	Milk	Ce-141	pCi/L	148	161	0.92	A
			Co-58	pCi/L	178	189	0.94	A
			Co-60	pCi/L	229	260	0.88	A
			Cr-51	pCi/L	486	456	1.07	A
			Cs-134	pCi/L	220	252	0.87	A
			Cs-137	pCi/L	203	222	0.92	A
			Fe-59	pCi/L	174	173	1.01	A
			I-131	pCi/L	75.9	94.2	0.81	A
			Mn-54	pCi/L	269	282	0.95	A
			Zn-65	pCi/L	364	373	0.97	A
	E13714	Charcoal	I-131	pCi	81.4	83.6	0.97	A
	E13715	AP	Ce-141	pCi	102	91	1.12	A
			Co-58	pCi	118	107	1.11	A
			Co-60	pCi	207	147	1.41	N[(2)]
			Cr-51	pCi	310	257	1.21	W
			Cs-134	pCi	148	142	1.04	A
			Cs-137	pCi	137	125	1.10	A
			Fe-59	pCi	115	98	1.18	A
			Mn-54	pCi	168	159	1.05	A
			Zn-65	pCi	240	211	1.14	A
	E13716	Soil	Ce-141	pCi/g	0.288	0.284	1.01	A
			Co-58	pCi/g	0.320	0.334	0.96	A
			Co-60	pCi/g	0.445	0.459	0.97	A
			Cr-51	pCi/g	0.883	0.805	1.10	A
			Cs-134	pCi/g	0.410	0.446	0.92	A
			Cs-137	pCi/g	0.447	0.465	0.96	A
			Fe-59	pCi/g	0.314	0.305	1.03	A
			Mn-54	pCi/g	0.489	0.499	0.98	A
			Zn-65	pCi/g	0.666	0.660	1.01	A
	E13717	AP	Sr-89	pCi	87.5	98.3	0.89	A
			Sr-90	pCi	12.6	15.0	0.84	A

(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) Analytics evaluation based on TBE internal QC limits:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

A.2

MAPEP Quality Assessment Program Results

A.2 DOE's Mixed Analyte Performance Evaluation Program (MAPEP)
Teledyne Brown Engineering Environmental Services

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value [a]	Acceptance Range	Evaluation [b]
February 2022	22-GrF46	AP	Gross Alpha	Bq/sample	0.402	1.20	0.36 - 2.04	A
			Gross Beta	Bq/sample	0.669	0.68	0.341 - 1.022	A
	22-MaS46	Soil	Ni-63	Bq/kg	645	780	546 - 1014	A
			Tc-99	Bq/kg	526	778	545 - 1011	N(3)
	22-MaSU46	Urine	Cs-134	Bq/L	1.67	1.77	1.24 - 2.30	A
			Cs-137	Bq/L	1.50	1.56	1.09 - 2.03	A
			Co-57	Bq/L	4.93	5.39	3.77 - 7.01	A
			Co-60	Bq/L	2.13	2.06	1.44 - 2.68	A
			Mn-54	Bq/L	4.83	5.08	3.56 - 6.60	A
			U-234	Bq/L	0.142	0.0074	0.0052 - 0.0096	N(4)
			U-238	Bq/L	0.0254	0.0103	0.0072 - 0.0134	N(4)
			Zn-65	Bq/L	4.71	4.48	3.14 - 5.82	A
	22-MaW46	Water	Ni-63	Bq/L	28.6	34.0	23.8 - 44.2	A
			Tc-99	Bq/L	8.59	7.90	5.5 - 10.3	A
	22-RdV46	Vegetation	Cs-134	Bq/sample	6.61	7.61	5.33 - 9.89	A
			Cs-137	Bq/sample	1.50	1.52	1.06 - 1.98	A
			Co-57	Bq/sample	5.11	5.09	3.56 - 6.62	A
			Co-60	Bq/sample	0.0162		*(1)*	A
			Mn-54	Bq/sample	2.42	2.59	1.81 - 3.37	A
			Sr-90	Bq/sample	0.684	0.789	0.552 - 1.026	A
			Zn-65	Bq/sample	1.44	1.47	1.03 - 1.91	A
August 2022	22-MaS47	Soil	Ni-63	Bq/kg	14.6		*(1)*	A
			Tc-99	Bq/kg	994	1000	700 - 1300	A
	22-MaW47	Water	Ni-63	Bq/L	24.4	32.9	23.0 - 42.8	A
			Tc-99	Bq/L	1.9		*(1)*	N(5)
	25-RdV47	Vegetation	Cs-134	Bq/sample	0.032		*(1)*	A
			Cs-137	Bq/sample	0.891	1.08	0.758 - 1.408	A
			Co-57	Bq/sample	0.006		*(1)*	A
			Co-60	Bq/sample	4.04	4.62	3.23 - 6.01	A
			Mn-54	Bq/sample	2.01	2.43	1.70 - 3.16	A
			Sr-90	Bq/sample	1.25	1.60	1.12 - 2.08	W
			Zn-65	Bq/sample	6.16	7.49	5.24 - 9.74	A

(a) The MAPEP known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) DOE/MAPEP evaluation:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

(1) False positive test

(2) Sensitivity evaluation

(3) Tc-99 soil cross-checks done for TBE information only - not required

*(4) See **NCR 22-05***

A.3

ERA Cross Check Program Results

A.3 ERA Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value [a]	Acceptance Limits	Evaluation [b]
March 2022	MRAD-36	Water	Am-241	pCi/L	68.3	74.6	51.2 - 95.4	A
			Fe-55	pCi/L	797	1140	670 - 1660	A
			Pu-238	pCi/L	146	147	88.4 - 190	A
			Pu-239	pCi/L	69.9	71.9	44.5 - 88.6	A
		Soil	Sr-90	pCi/kg	8050	6720	2090 - 10500	A
		AP	Fe-55	pCi/filter	148	127	46.4 - 203	A
			Pu-238	pCi/filter	29.9	29.6	22.3 - 36.4	A
			Pu-239	pCi/filter	51.6	49.7	37.2 - 60.0	A
			U-234	pCi/filter	59.9	67.3	49.9 - 78.9	A
			U-238	pCi/filter	59.0	66.7	50.4 - 79.6	A
			GR-A	pCi/filter	95.6	94.2	49.2 - 155	A
			GR-B	pCi/filter	71.2	66.8	40.5 - 101	A
April 2022	RAD-129	Water	Ba-133	pCi/L	61.7	62.9	52.3 - 69.2	A
			Cs-134	pCi/L	80.9	81.6	68.8 - 89.8	A
			Cs-137	pCi/L	37.4	36.6	32.1 - 43.3	A
			Co-60	pCi/L	103	97.4	87.7 - 109	A
			Zn-65	pCi/L	318	302	272 - 353	A
			GR-A	pCi/L	26.9	20.8	10.4 - 28.3	A
			GR-B	pCi/L	49.7	51.0	34.7 - 58.1	A
			U-Nat	pCi/L	56.3	68.9	56.3 - 75.8	A
			H-3	pCi/L	17,000	18,100	15,800 - 19,000	A
			Sr-89	pCi/L	65.3	67.9	55.3 - 76.1	A
			Sr-90	pCi/L	42.1	42.7	31.5 - 49.0	A
			I-131	pCi/L	25.7	26.2	21.8 - 30.9	A
September 2022	MRAD-37	Water	Am-241	pCi/L	111	96.2	66.0 - 123	A
			Fe-55	pCi/L	850	926	544 - 1350	A
			Pu-238	pCi/L	62.1	52.6	31.6 - 68.2	A
			Pu-239	pCi/L	139.5	117	72.5 - 144	A
		Soil	Sr-90	pCi/kg	3350	6270	1950 - 9770	A
			U-234	pCi/kg	1684	3350	1570 - 4390	A
			U-238	pCi/kg	1658	3320	1820 - 4460	N(2)
		AP	Fe-55	pCi/filter	71.9	122	44.5 - 195	A
			Pu-238	pCi/filter	38.8	29.9	22.6 - 36.7	N(1)
			Pu-239	pCi/filter	14.5	13.0	9.73 - 15.7	A
			U-234	pCi/filter	78.0	71.5	53.0 - 83.8	A
			U-238	pCi/filter	79.7	70.9	53.5 - 84.6	A
			GR-A	pCi/filter	62.8	55.5	29.0 - 91.4	A
			GR-B	pCi/filter	70.9	64.8	39.3 - 97.9	A
October 2022	RAD-131	Water	Ba-133	pCi/L	76.2	79.4	66.6 - 87.3	A
			Cs-134	pCi/L	28.0	30.5	23.9 - 33.6	A
			Cs-137	pCi/L	202	212	191 - 235	A
			Co-60	pCi/L	52.4	51.4	46.3 - 59.1	A
			Zn-65	pCi/L	216	216	194 - 253	A
			GR-A	pCi/L	19.7	16.9	8.28 - 23.7	A
			GR-B	pCi/L	49.8	53.0	36.1 - 60.0	A
			U-Nat	pCi/L	10.54	8.53	6.60 - 9.88	N(3)
			H-3	pCi/L	13,900	15,100	13,200 - 16,600	A
			Sr-89	pCi/L	59.7	64.5	52.3 - 72.5	A
			Sr-90	pCi/L	32.9	37.3	27.4 - 43.0	A
			I-131	pCi/L	26.9	24.4	20.2 - 28.9	A

(a) The ERA known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.

(b) ERA evaluation:
A = Acceptable - Reported value falls within the Acceptance Limits
N = Not Acceptable - Reported value falls outside of the Acceptance Limits

*(1) See **NCR 22-19***

(2) U soil cross-checks done for TBE information only - not required

*(3) See **NCR 22-20***

A.4

Formal Interlaboratory Quality Control Program Results

Eckert & Ziegler

Analytics

1380 Seaboard Industrial Blvd.
Atlanta, Georgia 30318 U.S.A.

Tel 404-352-8677
Fax 404-352-2837

ANAB ACCREDITED ISO/IEC 17043 PROFICIENCY TESTING PROVIDER

RESULTS OF ENVIRONMENTAL CROSS CHECK PROGRAM

TELEDYNE BROWN ENGINEERING

1st QUARTER 2022

(Ref. Date 10 Mar 2022, Rev. 0)

L. Tk

19 May 2022

Levan Tkavadze , Nuclear Metrologist

Sample	Analysis	ENGINEERING Value, pCi/L	EZA Value, pCi/L	Ratio ENGINEERING: EZA
E13706 Milk	Sr-89	8.03E+01	9.68E+01	0.83
	Sr-90	1.27E+01	1.26E+01	1.01

Sample	Analysis	ENGINEERING Value, pCi/L	EZA Value, pCi/L	Ratio ENGINEERING: EZA
E13707 Milk	Ce-141	6.23E+01	6.46E+01	0.96
	Co-58	1.58E+02	1.64E+02	0.96
	Co-60	2.86E+02	3.02E+02	0.95
	Cr-51	3.14E+02	3.39E+02	0.93
	Cs-134	1.55E+02	1.82E+02	0.85
	Cs-137	2.10E+02	2.23E+02	0.94
	Fe-59	2.11E+02	1.85E+02	1.14
	I-131	8.80E+01	9.67E+01	0.91
	K-40	1.43E+03	Not Measured	---
	Mn-54	1.69E+02	1.64E+02	1.03
	Zn-65	2.38E+02	2.46E+02	0.97

Sample	Analysis	ENGINEERING Value, pCi	EZA Value, pCi	Ratio ENGINEERING: EZA
E13708 Cartridge	I-131	7.99E+01	8.71E+01	0.92

Sample	Analysis	ENGINEERING Value, pCi	EZA Value, pCi	Ratio ENGINEERING: EZA
E13709 Filter	Ce-141	6.09E+01	4.20E+01	1.45
	Co-58	1.18E+02	1.07E+02	1.11
	Co-60	2.18E+02	1.96E+02	1.11
	Cr-51	2.51E+02	2.21E+02	1.14
	Cs-134	1.29E+02	1.18E+02	1.09
	Cs-137	1.56E+02	1.45E+02	1.07
	Fe-59	1.24E+02	1.20E+02	1.03
	Mn-54	1.20E+02	1.07E+02	1.12
	Zn-65	1.62E+02	1.60E+02	1.01

Sample	Analysis	ENGINEERING Value, pCi/g	EZA Value, pCi/g	Ratio ENGINEERING: EZA
E13710 Soil	Ce-141	1.23E-01	1.03E-01	1.19
	Co-58	2.54E-01	2.63E-01	0.97
	Co-60	4.93E-01	4.83E-01	1.02
	Cr-51	6.03E-01	5.43E-01	1.11
	Cs-134	2.68E-01	2.92E-01	0.92
	Cs-137	3.99E-01	4.31E-01	0.93
	Fe-59	3.20E-01	2.96E-01	1.08
	K-40	9.55E-01	Not Measured	---
	Mn-54	2.63E-01	2.63E-01	1.00
	Zn-65	4.07E-01	3.95E-01	1.03

Sample	Analysis	ENGINEERING Value, pCi	EZA Value, pCi	Ratio ENGINEERING: EZA
E13711 Filter	Sr-89	8.32E+01	9.74E+01	0.85
	Sr-90	1.27E+01	1.27E+01	1.00

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ANAB ACCREDITED ISO/IEC 17043 PROFICIENCY TESTING PROVIDER

RESULTS OF ENVIRONMENTAL CROSS CHECK PROGRAM

TELEDYNE BROWN ENGINEERING

3rd QUARTER 2022

(Ref. Date 15 Sep 2022, Rev. 0)

L. Tk 01 Dec 2022

Levan Tkavadze , Nuclear Metrologist

Sample	Analysis	ENGINEERING Value, pCi/L	EZA Value, pCi/L	Ratio ENGINEERING: EZA
E13712 Milk	Sr-89	7.11E+01	8.91E+01	0.80
	Sr-90	1.20E+01	1.36E+01	0.88

Sample	Analysis	ENGINEERING Value, pCi/L	EZA Value, pCi/L	Ratio ENGINEERING: EZA
E13713 Milk	Ce-141	1.48E+02	1.61E+02	0.92
	Co-58	1.78E+02	1.89E+02	0.94
	Co-60	2.29E+02	2.60E+02	0.88
	Cr-51	4.86E+02	4.56E+02	1.07
	Cs-134	2.20E+02	2.52E+02	0.87
	Cs-137	2.03E+02	2.22E+02	0.92
	Fe-59	1.74E+02	1.73E+02	1.01
	I-131	7.59E+01	9.42E+01	0.81
	K-40	1.33E+03	Not Measured	---
	Mn-54	2.69E+02	2.82E+02	0.95
	Zn-65	3.64E+02	3.73E+02	0.97

Sample	Analysis	ENGINEERING Value, pCi	EZA Value, pCi	Ratio ENGINEERING: EZA
E13714 Cartridge	I-131	8.14E+01	8.36E+01	0.97

Sample	Analysis	ENGINEERING Value, pCi	EZA Value, pCi	Ratio ENGINEERING: EZA
E13715 Filter	Ce-141	1.02E+02	9.07E+01	1.12
	Co-58	1.18E+02	1.07E+02	1.11
	Co-60	2.07E+02	1.47E+02	1.41
	Cr-51	3.10E+02	2.57E+02	1.21
	Cs-134	1.48E+02	1.42E+02	1.04
	Cs-137	1.37E+02	1.25E+02	1.10
	Fe-59	1.15E+02	9.75E+01	1.18
	Mn-54	1.68E+02	1.59E+02	1.05
	Zn-65	2.40E+02	2.11E+02	1.14

Sample	Analysis	ENGINEERING Value, pCi/g	EZA Value, pCi/g	Ratio ENGINEERING: EZA
E13716 Soil	Ce-141	2.88E-01	2.84E-01	1.01
	Co-58	3.20E-01	3.34E-01	0.96
	Co-60	4.45E-01	4.59E-01	0.97
	Cr-51	8.83E-01	8.05E-01	1.10
	Cs-134	4.10E-01	4.46E-01	0.92
	Cs-137	4.47E-01	4.65E-01	0.96
	Fe-59	3.14E-01	3.05E-01	1.03
	Mn-54	4.89E-01	4.99E-01	0.98
	Zn-65	6.66E-01	6.60E-01	1.01

Sample	Analysis	ENGINEERING Value, pCi	EZA Value, pCi	Ratio ENGINEERING: EZA
E13717 Filter	Sr-89	8.75E+01	9.83E+01	0.89
	Sr-90	1.26E+01	1.50E+01	0.84

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP Series 46
(TELE01) Teledyne Brown Engineering - Environmental Services
2508 Quality Lane
Knoxville, TN 37931-6819

MAPEP-22-GrF46: Gross alpha/beta air filter

Radiological — Units: (Bq/sample)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Gross alpha	.402	1.20	A		-66.5	0.36 - 2.04	.0497	A
Gross beta	.669	0.681	A		-1.8	0.341 - 1.022	.0521	A

Radiological Reference Date: February 1, 2022

MAPEP-22-MaS46: Radiological and inorganic combined soil standard

Inorganic — Units: (mg/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Antimony	NR	0.16				Sensitivity Evaluation		
Arsenic	NR	35.2				24.6 - 45.8		
Barium	NR	341				239 - 443		
Beryllium	NR	59.1				41.4 - 76.8		
Cadmium	NR	11.7				8.2 - 15.2		
Chromium	NR	110				77 - 143		
Cobalt	NR	245				172 - 319		
Copper	NR	195				137 - 254		
Lead	NR	72.8				51.0 - 94.6		
Mercury	NR	0.322				0.225 - 0.419		
Nickel	NR	347				243 - 451		
Selenium	NR	0.36				Sensitivity Evaluation		
Silver	NR	10.6				7.4 - 13.8		
Technetium-99	NR	0.00123				0.00086 - 0.00160		
Thallium	NR	75.0				52.5 - 97.5		
Uranium-235	NR	0.0330				0.0231 - 0.0429		
Uranium-238	NR	9.9				6.9 - 12.9		
Uranium-Total	NR	9.9				6.9 - 12.9		
Vanadium	NR	215				151 - 280		
Zinc	NR	288				202 - 374		

Radiological — Units: (Bq/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	72.0				50.4 - 93.6		
Cesium-134	NR	890				623 - 1157		
Cesium-137	NR	365				256 - 475		

Radiological								Units: (Bq/kg)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Cobalt-57	NR	1400				980 - 1820		
Cobalt-60	NR	443				310 - 576		
Iron-55	NR	1100				770 - 1430		
Manganese-54	NR	1140				798 - 1482		
Nickel-63	645	780	A		-17.3	546 - 1014	44.6	A
Plutonium-238	NR	56.0				39.2 - 72.8		
Plutonium-239/240	NR	41.0				28.7 - 53.3		
Potassium-40	NR	596				417 - 775		
Strontium-90	NR	677				474 - 880		
Technetium-99	526	778	N		-32.4	545 - 1011	49.2	A
Thorium-228	NR	43				30 - 56		
Thorium-230	NR	38				27 - 49		
Thorium-232	NR	42				29 - 55		
Uranium-234	NR	44.0				30.8 - 57.2		
Uranium-238	NR	123				86 - 160		
Zinc-65	NR					False Positive Test		

Radiological Reference Date: February 1, 2022

MAPEP-22-MaSU46: Radiological urine standard

Mass								Units: (ng/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-235	NR	4.14				2.90 - 5.38		
Uranium-238	NR	828				580 - 1076		
Uranium-Total	NR	832				582 - 1082		

Radiological								Units: (Bq/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	0.0018				Sensitivity Evaluation		
Cesium-134	1.67	1.77	A		-5.7	1.24 - 2.30	.172	A
Cesium-137	1.5	1.56	A		-3.8	1.09 - 2.03	.298	W
Cobalt-57	4.93	5.39	A		-8.5	3.77 - 7.01	.239	A
Cobalt-60	2.13	2.06	A		3.4	1.44 - 2.68	.203	A
Curium-244	NR					False Positive Test		
Manganese-54	4.83	5.08	A		-4.9	3.56 - 6.60	.288	A
Nickel-63	NR	6.44				4.51 - 8.37		
Plutonium-238	NR	0.0042				Sensitivity Evaluation		
Plutonium-239/240	NR	0.291				0.204 - 0.378		
Strontium-90	NR	1.26				0.88 - 1.64		
Technetium-99	NR					False Positive Test		
Uranium-234	.142	0.0074	N		1818.9	0.0052 - 0.0096	.0177	A
Uranium-238	.0254	0.0103	N		146.6	0.0072 - 0.0134	.00697	W
Zinc-65	4.71	4.48	A		5.1	3.14 - 5.82	.56	A

Radiological Reference Date: February 1, 2022

MAPEP-22-MaW46: Radiological and inorganic combined water standard

Inorganic

Units: (mg/L)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Antimony	NR	10.22				7.15 - 13.29		
Arsenic	NR	3.37				2.36 - 4.38		
Barium	NR	0.041				Sensitivity Evaluation		
Beryllium	NR	1.95				1.37 - 2.54		
Cadmium	NR					False Positive Test		
Chromium	NR	3.29				2.30 - 4.28		
Cobalt	NR	12.5				8.8 - 16.3		
Copper	NR	15.3				10.7 - 19.9		
Lead	NR	1.57				1.10 - 2.04		
Mercury	NR	0.152				0.106 - 0.198		
Nickel	NR	8.22				5.75 - 10.69		
Selenium	NR	0.81				0.57 - 1.05		
Technetium-99	NR	1.26E-5				8.80E-6 - 1.64E-5		
Thallium	NR	1.04				0.73 - 1.35		
Uranium-235	NR	9.1E-4				6.37E-4 - 1.18E-3		
Uranium-238	NR	0.124				0.087 - 0.161		
Uranium-Total	NR	0.125				0.088 - 0.163		
Vanadium	NR	4.9				3.4 - 6.4		
Zinc	NR	10.2				7.1 - 13.3		

Radiological

Units: (Bq/L)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	0.355				0.249 - 0.462		
Cesium-134	NR					False Positive Test		
Cesium-137	NR	7.64				5.35 - 9.93		
Cobalt-57	NR	36.0				25.2 - 46.8		
Cobalt-60	NR	9.3				6.5 - 12.1		
Hydrogen-3	NR	300				210 - 390		
Iron-55	NR	15.2				10.6 - 19.8		
Manganese-54	NR	18.9				13.2 - 24.6		
Nickel-63	28.6	34.0	A		-15.9	23.8 - 44.2	.481	N
Plutonium-238	NR	1.07				0.75 - 1.39		
Plutonium-239/240	NR	1.19				0.83 - 1.55		
Potassium-40	NR					False Positive Test		
Radium-226	NR	0.8				0.6 - 1.0		
Strontium-90	NR	12.9				9.0 - 16.8		
Technetium-99	8.59	7.9	A		8.7	5.5 - 10.3	1.52	W
Uranium-234	NR	1.5				1.1 - 2.0		
Uranium-238	NR	1.54				1.08 - 2.00		
Zinc-65	NR	26.2				18.3 - 34.1		

Radiological Reference Date: February 1, 2022

MAPEP-22-RdV46: Radiological vegetation

Inorganic

Units: (ug/sample)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-235	NR	0.0434				0.0304 - 0.0564		
Uranium-238	NR	5.95				4.17 - 7.74		
Uranium-Total	NR	5.99				4.19 - 7.79		

Radiological

Units: (Bq/sample)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	0.101				0.071 - 0.131		
Cesium-134	6.61	7.61	A		-13.1	5.33 - 9.89	.267	A
Cesium-137	1.5	1.52	A		-1.3	1.06 - 1.98	.148	A
Cobalt-57	5.11	5.09	A		0.4	3.56 - 6.62	.188	A
Cobalt-60	.0162		A			False Positive Test	.0775	
Manganese-54	2.42	2.59	A		-6.6	1.81 - 3.37	.235	A
Plutonium-238	NR	0.027				0.019 - 0.035		
Plutonium-239/240	NR	0.0594				0.0416 - 0.0772		
Strontium-90	.684	0.789	A		-13.3	0.552 - 1.026	.0229	A
Uranium-234	NR	0.071				0.050 - 0.092		
Uranium-238	NR	0.074				0.052 - 0.096		
Zinc-65	1.44	1.47	A		-2.0	1.03 - 1.91	.344	W

Radiological Reference Date: February 1, 2022

MAPEP Mixed Analyte Performance Evaluation Program
Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP Series 47
(TELE01) Teledyne Brown Engineering - Environmental Services
2508 Quality Lane
Knoxville, TN 37931-6819

MAPEP-22-MaS47: Radiological and inorganic combined soil standard

Inorganic

Units: (mg/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Antimony	NR	7.8				5.5 - 10.1		
Arsenic	NR	13.9				9.7 - 18.1		
Barium	NR	280				196 - 364		
Beryllium	NR	8.78				6.15 - 11.41		
Cadmium	NR	10.0				7.0 - 13.0		
Chromium	NR	49.1				34.4 - 63.8		
Cobalt	NR	60.0				42.0 - 78.0		
Copper	NR	59.0				41.3 - 76.7		
Lead	NR	51.0				35.7 - 66.3		
Mercury	NR	0.235				0.165 - 0.306		
Nickel	NR	194				136 - 252		
Selenium	NR	11.1				7.8 - 14.4		
Silver	NR	52.9				37.0 - 68.8		
Technetium-99	NR	0.00158				0.00111 - 0.00205		
Thallium	NR	64.4				45.1 - 83.7		
Uranium-235	NR	0.0389				0.0272 - 0.0506		
Uranium-238	NR	12.6				8.8 - 16.4		
Uranium-Total	NR	12.7				8.9 - 16.5		
Vanadium	NR	122				85 - 159		
Zinc	NR	127				89 - 165		

Radiological

Units: (Bq/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	99.2				69.4 - 129.0		
Cesium-134	NR	627				439 - 815		
Cesium-137	NR					False Positive Test		
Cobalt-57	NR	786				550 - 1022		
Cobalt-60	NR					False Positive Test		
Iron-55	NR	740				518 - 962		
Manganese-54	NR	841				589 - 1093		
Nickel-63	14.6		A			False Positive Test	17.5	
Plutonium-238	NR	0.56				Sensitivity Evaluation		
Plutonium-239/240	NR	113				79 - 147		
Plutonium-241	NR	26.8				Sensitivity Evaluation		
Potassium-40	NR	537				376 - 698		

Radiological — Units: (Bq/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Strontium-90	NR	852				596 - 1108		
Technetium-99	994	1000	A		-0.6	700 - 1300	85.4	A
Thorium-228	NR	49				34 - 64		
Thorium-230	NR	43				30 - 56		
Thorium-232	NR	47				33 - 61		
Uranium-234	NR	50.8				35.6 - 66.0		
Uranium-238	NR	157				110 - 204		
Zinc-65	NR	1140				798 - 1482		

Radiological Reference Date: August 1, 2022

MAPEP-22-MaW47: Radiological and inorganic combined water standard

Inorganic — Units: (mg/L)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Antimony	NR	4.77				3.34 - 6.20		
Arsenic	NR	1.53				1.07 - 1.99		
Barium	NR	2.34				1.64 - 3.04		
Beryllium	NR	3.27				2.29 - 4.25		
Cadmium	NR	0.634				0.444 - 0.824		
Chromium	NR	3.49				2.44 - 4.54		
Cobalt	NR	6.01				4.21 - 7.81		
Copper	NR	6.72				4.70 - 8.74		
Lead	NR	2.11				1.48 - 2.74		
Mercury	NR	0.124				0.087 - 0.161		
Nickel	NR	4.02				2.81 - 5.23		
Selenium	NR					False Positive Test		
Technetium-99	NR					False Positive Test		
Thallium	NR	0.000017				Sensitivity Evaluation		
Uranium-235	NR	5.05E-4				3.54E-4 - 6.57E-4		
Uranium-238	NR	0.068				0.048 - 0.088		
Uranium-Total	NR	0.068				0.048 - 0.088		
Vanadium	NR	3.37				2.36 - 4.38		
Zinc	NR	3.62				2.53 - 4.71		

Radiological — Units: (Bq/L)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	0.327				0.229 - 0.425		
Cesium-134	NR	17.1				12.0 - 22.2		
Cesium-137	NR	16.8				11.8 - 21.8		
Cobalt-57	NR	30.0				21.0 - 39.0		
Cobalt-60	NR	17.0				11.9 - 22.1		
Hydrogen-3	NR	395				277 - 514		
Iron-55	NR	27.8				19.5 - 36.1		
Manganese-54	NR					False Positive Test		
Nickel-63	24.4	32.9	W		-25.8	23.0 - 42.8	1.17	A

Radiological								Units: (Bq/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Plutonium-238	NR	0.985				0.690 - 1.281		
Plutonium-239/240	NR	1.070				0.749 - 1.391		
Potassium-40	NR					False Positive Test		
Radium-226	NR	0.511				0.358 - 0.664		
Strontium-90	NR	7.73				5.41 - 10.05		
Technetium-99	1.86		N	(1)		False Positive Test	.414	
Uranium-234	NR	1.37				0.96 - 1.78		
Uranium-238	NR	0.84				0.59 - 1.09		
Zinc-65	NR	11.3				7.9 - 14.7		

Radiological Reference Date: August 1, 2022

MAPEP-22-RdV47: Radiological vegetation

Inorganic								Units: (ug/sample)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-235	NR	0.076				0.053 - 0.099		
Uranium-238	NR	10.5				7.4 - 13.7		
Uranium-Total	NR	10.5				7.4 - 13.7		

Radiological								Units: (Bq/sample)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	NR	0.189				0.132 - 0.246		
Cesium-134	.0321		A			False Positive Test	0.1058	
Cesium-137	0.891	1.083	A		-17.7	0.758 - 1.408	0.169	W
Cobalt-57	0.005817		A			False Positive Test	0.0543	
Cobalt-60	4.04	4.62	A		-12.6	3.23 - 6.01	0.189	A
Manganese-54	2.01	2.43	A		-17.3	1.70 - 3.16	0.245	A
Plutonium-238	NR	0.156				0.109 - 0.203		
Plutonium-239/240	NR	0.162				0.113 - 0.211		
Strontium-90	1.25	1.60	W		-21.9	1.12 - 2.08	0.0413	A
Uranium-234	NR	0.126				0.088 - 0.164		
Uranium-238	NR	0.130				0.091 - 0.169		
Zinc-65	6.16	7.49	A		-17.8	5.24 - 9.74	0.549	A

Radiological Reference Date: August 1, 2022

Notes:

(1) = False Positive

MRAD-36 Final Evaluation Report

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(865) 934-0374

EPA ID: TN11387
ERA Customer Number: T200801
Report Issued: 05/24/2022
Study Dates: 03/21/2022 - 05/20/2022

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
MRAD Soil Radionuclides (cat# 802, lot# A036-608)												
2706	Actinium-228	pCi/kg		1670	1100 - 2100	Not Reported				1550	186	
2732	Americium-241	pCi/kg		1310	707 - 1850	Not Reported				1420	418	
2710	Bismuth-212	pCi/kg		1840	527 - 2740	Not Reported				1700	356	
2713	Bismuth-214	pCi/kg		790	379 - 1180	Not Reported				790	132	
2868	Cesium-134	pCi/kg		6620	4530 - 7910	Not Reported				6030	907	
2801	Cesium-137	pCi/kg		6760	5110 - 8550	Not Reported				6840	1020	
2815	Cobalt-60	pCi/kg		2820	2220 - 3480	Not Reported				2830	418	
2982	Lead-212	pCi/kg		1630	1140 - 2060	Not Reported				1620	195	
2983	Lead-214	pCi/kg		838	352 - 1320	Not Reported				838	164	
2990	Manganese-54	pCi/kg		< 555	0.00 - 555	Not Reported						
2994	Plutonium-238	pCi/kg		289	144 - 439	Not Reported				382	123	
2996	Plutonium-239	pCi/kg		1180	643 - 1700	Not Reported				1250	377	
2946	Potassium-40	pCi/kg		37900	26100 - 45300	Not Reported				40400	2780	
3005	Strontium-90	pCi/kg	8050	6720	2090 - 10500	Acceptable	HASL 300 Sr-03 28th ED 1997	5/3/2022	0.396	7510	1350	
3028	Thorium-234	pCi/kg		3390	1280 - 5810	Not Reported				3840	692	
3036	Uranium-234	pCi/kg		3410	1600 - 4470	Not Reported				3460	408	
3038	Uranium-238	pCi/kg		3390	1860 - 4550	Not Reported				3540	274	
3055	Uranium-Total	pCi/kg		6960	3860 - 9000	Not Reported				6840	346	
1184	Uranium (mass)	µg/kg		10100	4560 - 13600	Not Reported				10100	1520	
3070	Zinc-65	pCi/kg		5070	4050 - 6920	Not Reported				5330	929	

MRAD-36 Final Evaluation Report

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ERA Customer Number: **T200801**
Report Issued: **05/24/2022**
Study Dates: **03/21/2022 - 05/20/2022**

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
MRAD Air Filter Radionuclides (cat# 800, lot# A036-606)												
2755	Americium-241	pCi/Filter		21.0	15.0 - 28.0	Not Reported				21.2	0.926	
2800	Cesium-134	pCi/Filter		549	356 - 673	Not Reported				486	31.0	
2805	Cesium-137	pCi/Filter		1320	1080 - 1730	Not Reported				1390	97.9	
2815	Cobalt-60	pCi/Filter		885	752 - 1120	Not Reported				922	66.4	
2885	Iron-55	pCi/Filter	148	127	46.4 - 203	Acceptable	TBE Proprietary	4/21/2022	0.688	126	31.6	
2905	Manganese-54	pCi/Filter		< 35.0	0.00 - 35.0	Not Reported						
2990	Plutonium-238	pCi/Filter	29.9	29.6	22.3 - 36.4	Acceptable	TBE Proprietary	4/14/2022	1.36	28.5	0.995	
2995	Plutonium-239	pCi/Filter	51.6	49.7	37.2 - 60.0	Acceptable	TBE Proprietary	4/14/2022	1.59	47.2	2.75	
3080	Strontium-90	pCi/Filter		31.1	19.7 - 42.3	Not Reported				32.3	3.99	
3085	Uranium-234	pCi/Filter	59.9	67.3	49.9 - 78.9	Acceptable	TBE Proprietary	4/19/2022	-1.29	64.9	3.90	
3090	Uranium-238	pCi/Filter	59.0	66.7	50.4 - 79.6	Acceptable	TBE Proprietary	4/19/2022	-1.61	64.1	3.18	
3095	Uranium-Total	pCi/Filter		137	100 - 162	Not Reported				133	5.01	
11144	Uranium (mass)	µg/Filter		200	160 - 234	Not Reported				193	7.68	
3070	Zinc-65	pCi/Filter		671	550 - 1030	Not Reported				756	59.1	
MRAD Air Filter Gross Alpha/Beta (cat# 801, lot# A036-607)												
2830	Gross Alpha	pCi/Filter	95.6	94.2	49.2 - 155	Acceptable	EPA 900.0 1980	4/27/2022	0.678	87.2	12.4	
2840	Gross Beta	pCi/Filter	71.2	66.8	40.5 - 101	Acceptable	EPA 900.0 1980	4/27/2022	0.225	68.9	10.4	

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A Waters Company

MRAD-36 Final Evaluation Report

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EPA ID: TN11387
ERA Customer Number: T200801
Report Issued: 05/24/2022
Study Dates: 03/21/2022 - 05/20/2022

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
MRAD Water Radionuclides (cat# 804, lot# A036-617)												
2755	Americium-241	pCi/L	68.3	74.6	51.2 - 95.4	Acceptable	HASL 300 Am-03 28th ED 1997	4/21/2022	-0.327	70.7	7.32	
2800	Cesium-134	pCi/L		1720	1300 - 1890	Not Reported				1590	101	
2805	Cesium-137	pCi/L		1120	959 - 1270	Not Reported				1120	35.4	
2815	Cobalt-60	pCi/L		2710	2340 - 3110	Not Reported				2770	90.7	
2885	Iron-55	pCi/L	797	1140	670 - 1660	Acceptable	TBE Proprietary	4/21/2022	-0.334	938	422	
2905	Manganese-54	pCi/L		< 71.0	0.00 - 71.0	Not Reported						
2930	Plutonium-238	pCi/L	146	147	88.4 - 190	Acceptable	HASL 300 Pu-10 28th ED 1997	4/14/2022	1.12	130	14.6	
2932	Plutonium-239	pCi/L	69.9	71.9	44.5 - 88.6	Acceptable	HASL 300 Pu-10 28th ED 1997	4/14/2022	0.994	63.7	6.23	
3005	Strontium-90	pCi/L		628	452 - 776	Not Reported				624	34.0	
3036	Uranium-234	pCi/L		44.1	33.6 - 50.4	Not Reported				41.9	2.79	
3038	Uranium-238	pCi/L		43.7	33.9 - 51.4	Not Reported				41.9	1.83	
3035	Uranium-Total	pCi/L		89.8	70.0 - 102	Not Reported				85.0	3.52	
1184	Uranium (mass)	µg/L		131	106 - 149	Not Reported				123	5.69	
3070	Zinc-65	pCi/L		1220	1090 - 1540	Not Reported				1290	51.9	

RAD-129 Final Evaluation Report

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EPA ID: **TN11387**
ERA Customer Number: **T200801**
Report Issued: **05/23/2022**
Study Dates: **04/04/2022 - 05/19/2022**

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
RAD Gamma EmitterS™ (cat# 808, lot# R129-758)												
2765	Barium-133	pCi/L	61.7	62.9	52.3 - 69.2	Acceptable	EPA 901.1 1980	4/11/2022	0.152	61.1	3.66	
2800	Cesium-134	pCi/L	80.9	81.6	66.8 - 89.8	Acceptable	EPA 901.1 1980	4/11/2022	-0.191	82.0	5.69	
2805	Cesium-137	pCi/L	37.4	36.6	32.1 - 43.3	Acceptable	EPA 901.1 1980	4/11/2022	-0.272	38.0	2.35	
2810	Cobalt-60	pCi/L	103	97.4	87.7 - 109	Acceptable	EPA 901.1 1980	4/11/2022	0.739	100	3.47	
3070	Zinc-65	pCi/L	318	302	272 - 353	Acceptable	EPA 901.1 1980	4/11/2022	0.435	313	11.7	
RAD GroSS™ Alpha/Beta (cat# 809, lot# R129-759)												
2880	Gross Alpha	pCi/L	26.9	20.8	10.4 - 28.3	Acceptable	EPA 900.0 (GPC) 1 2018	4/14/2022	3.69	17.6	2.53	
2885	Gross Beta	pCi/L	49.7	51.0	34.7 - 58.1	Acceptable	EPA 900.0 (GPC) 1 2018	4/20/2022	1.00	45.0	4.67	
RAD NaturalS™ (cat# 811, lot# R129-751)												
2990	Radium-226	pCi/L		9.46	7.09 - 11.1	Not Reported				9.55	1.13	
2975	Radium-228	pCi/L		3.18	1.71 - 4.63	Not Reported				3.17	0.678	
3055	Uranium (Nat)	pCi/L	56.3	68.9	56.3 - 75.8	Acceptable	EPA 908.0 1980	4/27/2022	-5.11	66.0	1.89	
11124	Uranium (mass)	µg/L		101	82.5 - 111	Not Reported				96.4	4.24	
RAD TritiuM™ (cat# 812, lot# R129-752)												
3030	Tritium	pCi/L	17000	18100	15800 - 19900	Acceptable	EPA 906.0 1980	4/8/2022	-0.713	17700	988	
RAD Strontium-89/90 (cat# 807, lot# R129-757)												
2995	Strontium-89	pCi/L	65.3	67.9	55.3 - 76.1	Acceptable	EPA 905.0 1980	5/3/2022	-0.792	71.3	7.53	
3005	Strontium-90	pCi/L	42.1	42.7	31.5 - 49.0	Acceptable	EPA 905.0 1980	5/4/2022	0.187	41.3	4.41	
RAD Iodine-131 (cat# 810, lot# R129-750)												
2875	Iodine-131	pCi/L	25.7	26.2	21.8 - 30.9	Acceptable	SM 7500-I C (GPC)-2000 2000	4/14/2022	-0.638	26.7	1.63	

ERA
A Waters Company

Final Evaluation Report

Study: **MRAD-37**

ERA Customer Number: **T200801**

Laboratory Name: **Teledyne Brown Engineering**

RAD Results

MRAD-37 Final Evaluation Report

A Waters Company

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EPA ID: TN11387
ERA Customer Number: T200801
Report Issued: 11/21/2022
Study Dates: 09/19/2022 - 11/18/2022

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
MRAD Soil Radionuclides (cat# 802, lot# A037-608)												
2700	Actinium-228	pCi/kg		1670	1100 - 2100	Not Reported				1660	157	
2755	Americium-241	pCi/kg		147	79.4 - 208	Not Reported				158	42.6	
2772	Bismuth-212	pCi/kg		1670	478 - 2490	Not Reported				1550	437	
2773	Bismuth-214	pCi/kg		790	379 - 1180	Not Reported				764	131	
2800	Cesium-134	pCi/kg		9600	6560 - 11500	Not Reported				8810	1320	
2805	Cesium-137	pCi/kg		7890	5970 - 9980	Not Reported				7960	1140	
2815	Cobalt-60	pCi/kg		1500	1180 - 1850	Not Reported				1520	239	
2902	Lead-212	pCi/kg		1630	1140 - 2060	Not Reported				1690	141	
2903	Lead-214	pCi/kg		838	352 - 1320	Not Reported				830	127	
2905	Manganese-54	pCi/kg		< 555	0.00 - 555	Not Reported						
2930	Plutonium-238	pCi/kg		1100	549 - 1670	Not Reported				1080	361	
2932	Plutonium-239	pCi/kg		967	527 - 1390	Not Reported				914	174	
2946	Potassium-40	pCi/kg		43100	29700 - 51500	Not Reported				43100	3600	
3005	Strontium-90	pCi/kg	3350	6270	1950 - 9770	Acceptable	HASL 300 Sr-03 28th ED 1997	11/18/2022	-1.63	6120	1700	Shannon Cooper
3028	Thorium-234	pCi/kg		3320	1250 - 5690	Not Reported				3640	779	
3036	Uranium-234	pCi/kg	1684	3350	1570 - 4390	Acceptable	HASL 300 U-02 28th ED 1997	11/17/2022	-1.56	3080	898	Shannon Cooper
3038	Uranium-238	pCi/kg	1658	3320	1820 - 4460	Not Acceptable	HASL 300 U-02 28th ED 1997	11/17/2022	-2.37	3410	742	Shannon Cooper
3055	Uranium-Total	pCi/kg		6830	3790 - 8830	Not Reported				6990	1030	
1184	Uranium (mass)	µg/kg		9960	4490 - 13400	Not Reported				10200	1440	
3070	Zinc-65	pCi/kg		3990	3190 - 5440	Not Reported				4150	571	

MRAD-37 Final Evaluation Report

A Waters Company

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EPA ID: **TN11387**
ERA Customer Number: **T200801**
Report Issued: **11/21/2022**
Study Dates: **09/19/2022 - 11/18/2022**

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
MRAD Air Filter Radionuclides (cat# 800, lot# A037-606)												
2755	Americium-241	pCi/Filter		38.8	27.7 - 51.7	Not Reported				40.4	4.99	
2800	Cesium-134	pCi/Filter		325	211 - 399	Not Reported				275	33.7	
2805	Cesium-137	pCi/Filter		795	653 - 1040	Not Reported				781	67.4	
2815	Cobalt-60	pCi/Filter		191	162 - 243	Not Reported				198	12.8	
2885	Iron-55	pCi/Filter	71.9	122	44.5 - 195	Acceptable	TBE Proprietary	11/18/2022	-1.14	93.3	18.8	Shannon Cooper
2905	Manganese-54	pCi/Filter		< 35.0	0.00 - 35.0	Not Reported						
2930	Plutonium-238	pCi/Filter	38.8	29.9	22.6 - 36.7	Not Acceptable	TBE Proprietary	11/16/2022	5.21	29.9	1.71	Shannon Cooper
2932	Plutonium-239	pCi/Filter	14.5	13.0	9.73 - 15.7	Acceptable	TBE Proprietary	11/16/2022	1.31	13.0	1.13	Shannon Cooper
3005	Strontium-90	pCi/Filter		133	84.1 - 181	Not Reported				129	1.15	
3036	Uranium-234	pCi/Filter	78.0	71.5	53.0 - 83.8	Acceptable	TBE Proprietary	11/17/2022	4.80	67.7	2.15	Shannon Cooper
3038	Uranium-238	pCi/Filter	79.7	70.9	53.5 - 84.6	Acceptable	TBE Proprietary	11/17/2022	1.49	65.0	9.84	Shannon Cooper
3055	Uranium-Total	pCi/Filter		146	107 - 173	Not Reported				137	4.14	
3184	Uranium (mass)	µg/Filter		212	170 - 248	Not Reported				213	10.5	
3070	Zinc-65	pCi/Filter		120	98.4 - 183	Not Reported				132	12.2	
MRAD Air Filter Gross Alpha/Beta (cat# 801, lot# A037-607)												
2830	Gross Alpha	pCi/Filter	62.8	55.5	29.0 - 91.4	Acceptable	EMSL-LV p. 1 1979	10/25/2022	0.964	53.8	9.33	Susan Ogletree
2840	Gross Beta	pCi/Filter	70.9	64.8	39.3 - 97.9	Acceptable	EMSL-LV p. 1 1979	10/25/2022	0.329	68.4	7.49	Susan Ogletree

MRAD-37 Final Evaluation Report

ERA
A Waters Company

Sharon Northcutt
QA Manager
Teledyne Brown Engineering
2508 Quality Ln.
Knoxville, TN 37931
(865) 934-0374

EPA ID: TN11387
ERA Customer Number: T200801
Report Issued: 11/21/2022
Study Dates: 09/19/2022 - 11/18/2022

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
MRAD Water Radionuclides (cat# 804, lot# A037-617)												
2755	Americium-241	pCi/L	111	96.2	66.0 - 123	Acceptable	HASL 300 Am-03 28th ED 1997	11/17/2022	2.41	96.7	5.91	Shannon Cooper
2800	Cesium-134	pCi/L		483	365 - 531	Not Reported				457	27.1	
2805	Cesium-137	pCi/L		1250	1070 - 1420	Not Reported				1230	44.3	
2815	Cobalt-60	pCi/L		1420	1220 - 1630	Not Reported				1450	71.1	
2885	Iron-55	pCi/L	850	926	544 - 1350	Acceptable	TBE Proprietary	11/18/2022	0.948	778	75.8	Shannon Cooper
2905	Manganese-54	pCi/L		< 71.0	0.00 - 71.0	Not Reported						
2930	Plutonium-238	pCi/L	62.1	52.6	31.6 - 68.2	Acceptable	HASL 300 Pu-10 28th ED 1997	11/16/2022	1.60	52.6	5.95	Shannon Cooper
2932	Plutonium-239	pCi/L	139.5	117	72.5 - 144	Acceptable	HASL 300 Pu-10 28th ED 1997	11/16/2022	1.56	117	14.3	Shannon Cooper
3005	Strontium-90	pCi/L		224	161 - 277	Not Reported				225	23.2	
3036	Uranium-234	pCi/L		153	116 - 175	Not Reported				141	7.74	
3038	Uranium-238	pCi/L		152	118 - 179	Not Reported				146	8.51	
3055	Uranium-Total	pCi/L		312	243 - 356	Not Reported				289	15.2	
1184	Uranium (mass)	µg/L		455	369 - 516	Not Reported				297	210	
3070	Zinc-65	pCi/L		122	109 - 154	Not Reported				137	14.7	

RAD-131 Final Evaluation Report

A Waters Company

Sharon Northcutt
QA Manager
Teledyne Brown Engineering
2508 Quality Ln.
Knoxville, TN 37931
(865) 934-0374

EPA ID: **TN11387**
ERA Customer Number: **T200801**
Report Issued: **11/23/2022**
Study Dates: **10/07/2022 - 11/21/2022**

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
RAD Gamma EmitterS™ (cat# 808, lot# R131-758)												
2765	Barium-133	pCi/L	76.2	79.4	66.6 - 87.3	Acceptable	EPA 901.1 1980	10/14/2022	0.747	74.4	2.45	Shannon Cooper
2800	Cesium-134	pCi/L	28.0	30.5	23.9 - 33.6	Acceptable	EPA 901.1 1980	10/14/2022	-0.337	28.6	1.92	Shannon Cooper
2805	Cesium-137	pCi/L	202	212	191 - 235	Acceptable	EPA 901.1 1980	10/14/2022	-1.06	208	6.13	Shannon Cooper
2815	Cobalt-60	pCi/L	52.4	51.4	46.3 - 59.1	Acceptable	EPA 901.1 1980	10/14/2022	-0.192	52.7	1.60	Shannon Cooper
2070	Zinc-65	pCi/L	216	216	194 - 253	Acceptable	EPA 901.1 1980	10/14/2022	-0.792	225	11.1	Shannon Cooper
RAD GroSS™ Alpha/Beta (cat# 809, lot# R131-759)												
2830	Gross Alpha	pCi/L	19.7	16.9	8.28 - 23.7	Acceptable	EMSL-LV p. 1 1979	11/8/2022	2.13	14.7	2.33	Susan Ogletree
2840	Gross Beta	pCi/L	49.8	53.0	36.1 - 60.0	Acceptable	EMSL-LV p. 1 1979	11/8/2022	0.395	47.8	5.04	Susan Ogletree
RAD NaturalS™ (cat# 811, lot# R131-751)												
2965	Radium-226	pCi/L		19.0	14.1 - 21.7	Not Reported				18.6	2.00	
2970	Radium-228	pCi/L		2.33	1.11 - 3.65	Not Reported				2.47	0.505	
2055	Uranium (Nat)	pCi/L	10.54	8.53	6.60 - 9.88	Not Acceptable	EPA 908.0 1980	11/17/2022	5.11	8.21	0.457	Shannon Cooper
2184	Uranium (mass)	µg/L		12.4	9.58 - 14.4	Not Reported				12.0	0.667	
RAD TritiuM™ (cat# 812, lot# R131-752)												
3030	Tritium	pCi/L	13900	15100	13200 - 16600	Acceptable	EPA 906.0 1980	10/27/2022	-1.39	15000	755	Susan Ogletree
RAD Strontium-89/90 (cat# 807, lot# R131-757)												
2995	Strontium-89	pCi/L	59.7	64.5	52.3 - 72.5	Acceptable	EPA 905.0 1980	11/20/2022	-0.504	61.6	3.83	Shannon Cooper
3005	Strontium-90	pCi/L	32.9	37.3	27.4 - 43.0	Acceptable	EPA 905.0 1980	11/20/2022	-1.32	37.4	3.38	Shannon Cooper
RAD Iodine-131 (cat# 810, lot# R131-750)												
2875	Iodine-131	pCi/L	26.9	24.4	20.2 - 28.9	Acceptable	SM 7500-I C (GPC)-2000 2000	10/18/2022	1.88	25.2	0.919	Shannon Cooper

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ATTACHMENT B

Intralaboratory Quality Control Program Results

B.1 Blanks, Spikes and Matrix Spikes

ATTACHMENT B.1
TBE - ES QC Program
In-House Water Blanks and Spikes

Nuclide	# of Samples Analyzed	Blank Results	Spike Recovery % (Range*)	% of Samples Within 20% of Known Value
Am-241	35	All < MDC	78.9 - 102	91.4
C-14	96	All < MDC	71.5 - 121	70.5
Ce-144 (RAD)	32	All < MDC	NA	
Cs-137	18	All < MDC	72.9 - 109	94.4
Co-60 (Direct)	3	All < MDC	96.8 - 99.4	100
Fe-55	116	All < MDC	72.6 - 125	87.1
Gross Alpha	145	All < MDC	70.5 - 114	62.8
Gross Beta	107	All < MDC	74.0 - 129	87.9
H-3	342	All < MDC	70.1 - 129	88.6
I-129/131	99	All < MDC	74.2 - 124	89.0
Ni-63	115	All < MDC	72.5 - 124	93.9
P-32	19	All < MDC	NA	
Pu-239/240	36	All < MDC	79.5 - 122	94.4
S-35 (RAD)	6	All < MDC[1]	NA	
Sr-89	139	All < MDC	80.5 - 130	87.8
Sr-90	175	All < MDC[1]	80.2 - 129	89.7
Tc-99	49	All < MDC	74.7 - 105	91.8
Th-230	19	All < MDC	78.5 - 115	89
U-238	45	All < MDC	83.3 - 119	100

[1] *One blank failure: Sample activity > 5x blank activity (reported with case narrative)*

**Internal Process Control results use TBE-ES acceptance criteria of 70 -130% recovery*

Matrix Spikes

Nuclide	Count Date	Sample Result (pCi/L)	Spiked Result (pCi/L)	Spike Value (pCi/L)	% Recovery**
Fe-55	02/10/22	<186	1252	1470	85.3
Fe-55	05/18/22	<115	1183	1320	89.4
Fe-55	08/25/22	<94.0	1068	1240	86.1
Fe-55	12/29/22	<76.60	1200	1160	103.2
Gr-A	02/02/22	4.23	50.8	52.2	89.2
Gr-A	05/05/22	1.65	46.7	52.2	86.3
Gr-A	08/15/22	2.71	41.6	52.2	74.5
Gr-A	12/27/22	2.22	40.1	42.8	88.6
Gr-B	01/31/22	22.5	58.4	55.8	64.4
Gr-B	05/04/22	8.45	58.4	55.2	90.4
Gr-B	08/11/22	9.70	49.0	54.9	71.6
Gr-B	12/20/23	11.60	71.1	54.6	109.0
H-3	01/26/22	<293	4000	3920	102
H-3	05/09/22	<273	5600	7670	73.0
H-3	08/16/22	<282	4150	3780	109.8
H-3	12/20/23	<285	5130	3730	137.7
Ni-63	02/09/22	<4.50	1020	1300	78.4
Ni-63	05/20/22	5.75	877	865	100.8
Ni-63	08/24/22	<4.17	800	863	92.7
Ni-63	12/30/23	<4.87	899	862	104.3
Sr-89	03/10/22	< 8.25	1180	1220	96.6
Sr-89	05/17/22	<7.3	179	163	109.8
Sr-89	09/08/22	<6.56	63.1	45.5	138.7
Sr-89	12/28/23	<7.52	230	327	70.4
Sr-90	03/10/22	<0.85	51.3	54.3	94.5
Sr-90	05/17/22	<0.997	68.6	53.8	127.5
Sr-90	09/08/23	<0.724	70.3	53.5	131.4
Sr-90	12/28/23	<0.807	52.8	53.1	99.4

**Internal Process Control results use TBE-ES acceptance criteria of 70 -130% recovery*

B.2 Duplicates

ATTACHMENT B.2

TBE - ES QC Program In-House Duplicates*

Matrix	Nuclide	# of Dups Analyzed	# Samples Evaluated for RPD**	RPD Range	RPD Upper Limit
Air Particulates	Be-7 (Gamma)	45	9	2.3 - 17.9	30
	Gross Alpha	66	13	0.0 - 25.5	30
	Gross Beta	505	289	0.0 - 29.5	30
	Sr-89	74	2	11.8 - 17.0	30
	Sr-90	76	1	16.3	30
Animals	Be-7 (Gamma)	2	0		50
	K-40 (Gamma)	2	2	0.2 - 0.4	50
Charcoal	I-131 (Gamma)	393	2	1.8 - 1.9	50
Feed/Food/Grass/Veg	Be-7 (Gamma)	52	12	0.7 - 23.9	50
	K-40 (Gamma)	57	56	0.2 - 21.4	50
Fish/Shellfish	Be-7 (Gamma)	4	0		50
	K-40 (Gamma)	4	2	0.7 - 12.9	50
Milk	K-40 (Gamma)	116	116	0.1 - 27.9	30
Sediment/Soil/Solid	C-14 (RAD)	4	0		50
	H-3	3	0		50
	K-40 (Gamma)	13	5	3.9 - 15.8	50
Water/Liquid	Fe-55	6	1	4.4	30
	Gross Alpha	31	1	16.7	30
	Gross Beta	37	4	0.0 - 21.7	30
	H-3	249	37	0.0 - 27.1	30
	K-40 (Gamma)	33	3	0.1 - 27.6	30
	Ni-63	5	1	2.5	30
	Sr-89	18	2	2.9 - 4.5	30
	Sr-90	22	2	1.4 - 4.8	30
LO/LR	C-14 (RAD)	9	0		30
	H-3	34	7	0.6 - 10.0	30
LCSD's	Am-241 (AS)	31	31	0.2 - 21.7	30
	C-14 (RAD)	66	66	0.0 - 19.5	30
	Co-60 (Direct)	3	3	3.5 - 4.5	30
	Cs-137	18	18	0.0 - 25.8	30
	Fe-55	100	98	0.2 - 29.7	30
	Gross Alpha	42	42	0.0 - 27.2	30
	Gross Beta	44	44	0.0 - 23.9	30
	H-3	54	54	0.0 - 26.5	30
	I-129	66	66	0.4 - 27.1	30
	Ni-63	101	101	0.0 - 21.0	30
	Pu-239/240 (AS)	32	32	0.7 - 23.1	30
	Sr-89	38	38	0.7 - 27.9	30
	Sr-90	46	46	0.7 - 22.5	30
	Tc-99	41	41	0.3 - 24.5	30
	Th-230 (AS)	18	18	0.5 - 27.7	30
	U-238 (AS)	39	39	0.3 - 22.4	30
MSD's	Th-230 (AS)	2	2	2.49 - 3.3	50
	U-234 (AS)	2	2	16.7 - 17.6	50
	U-235 (AS)	2	2	28.9 - 41.2	50
	U-238 (AS)	2	2	5.7 - 10.2	50

**NOTE: Duplicates for Gamma analyses on this form are only for nuclides reported for QC data packages (All Gamma nuclides are duplicated at the time of analysis)*

Precision is not evaluated if results are < 5x MDC* ***or *if both results are non-detect*

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ATTACHMENT C

Non-Conformance Reports

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

1. NCR No.: 22-01

2. Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
3. Laboratory Area: Project Management	4. Client/Project Affected: N/A
5. Requirement Reference: QA Manual; TBE-1014	6. Affected Data: N/A
7. NCR Description: Audit Deficiency - incomplete contract reviews	
8. Client Notification: ☐ YES ☒ NO	9. Associated CC #: N/A
10. Prepared By: Sharon Northcutt	11. Date: 02/10/22

PART 2. TO BE COMPLETED BY NCR INVESTIGATOR	
12. Root Cause, Corrective/Preventative Action: See attached Supplemental Sheet	
13. Planned Completion Date(s) for Actions(s): 03/10/22	
14. Prepared By: Sharon L Northcutt	15. Date: 02/10/22
16. Approved By: Keith Jete	17: Date: 2/10/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
18. Review and Verification of Corrective Action (where applicable) ☐ Accepted ☐ Rejected ☑ Follow-up Needed — KQA-12 Form — Training	
19. Prepared By: Sharon L Northcutt	20. Date: 02/15/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
21. Client Follow-Up Notification: ☐ YES ☒ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 02/15/22

C.1

Supplemental Sheet

NCR No: 22-01

Description of Nonconformance:

NUPIC audit deficiency due to not meeting the following requirement from the TNI Standard Module 2, Section 4.4.2 & ISO 17025 Section 7.1.8 which state that records of reviews, including any significant changes, shall be maintained/retained.

No records were available to indicate performance of reviews for 2 contracts. Interviews with staff indicated that signatures on the final contract indicated the necessary review had been completed.

Root Cause:

Misunderstanding in terminology for "recorded contract review" which resulted in insufficient training for the QA Manager, Project Managers and Operations Manager.

Corrective Action to Prevent Recurrence:

Immediate Corrective Action: Thoroughly review contracts to ensure that no specification is incorrect or unclear between TBE and clients. Contact the contract issuer to make necessary changes on existing contracts where appropriate.

TBE will prevent recurrence by issuing a Contract Review Form for each new contract on which will be recorded the name and date of reviewers along with any notes, comments or changes that were discussed and/or agreed upon prior to final signature of the Lab Operations Manager (or designee).

Keith Jeter — 2/10/22

Department Manager or Designee — Date

Quality Assurance Manager or Designee — 02/10/22 — Date

Entergy	CONDITION REPORT (Draft)	VN-CAR-2021-00xxx Finding 1

Originator:		**Originator Phone:**	
Originator Site Group:	Entergy Supplier QA	**Operability Required:**	No
Supervisor Name:		**Reportability Required:**	No
Discovered Date:		**Initiated Date:**	

Condition Description:

The process for documenting the review of customer contracts has not been developed. Two (2) examples of requirements in accepted customer contracts that have not been recognized or implemented include:

1) **It was noted that 15 of 37 analytical procedures were revised in 2021, but no evidence that these changes were submitted to NPPD as required by Contract 4200003328 issued on 1/30/20. In addition, no evidence that the program for interlaboratory cross-check has been submitted for approval also as required by the same contract.**

2) **Contract 10641231 from Entergy on 1/1/21 was incorrectly classified by Entergy as safety related and imposed 10CFR21. This should have been discovered and exception taken by Teledyne Brown during contract review. The Teledyne Brown QA Program does not support safety related / 10CFR21 work.**

Requirement:

Teledyne Brown QA Manual K-QAM-1, Appendix A Regulatory References, states in Section 7.1 "Review of Requests, Tenders, and Contracts", that "Records of reviews, including any significant changes, shall be maintained."

Requirement Not Met:

Contrary to the above, records are not available to support performance of the RFP and Contract Reviews as described in QA Manual Section 7.1 and implementing procedure TBE-1014. Interviews with those involved stated that signature on the contract by the TBE Lab Manager indicated to them that all the necessary reviews had been completed.

Impact on past, present, and future procurements:

Without correction, more significant errors are possible on future procurements.

Immediate Action Description: Correct the examples provided.

Suggested Action Description: Develop a method of documenting contract reviews that provides objective evidence of compliance and, where necessary, action to resolve clarifications and exceptions.

C.1

Entergy requests the following:

a) An initial response to Entergy within 30 days;

b) The reason for the nonconformance;

c) Your corrective actions to prevent recurrence;

d) A schedule for completion of proposed corrective actions;

e) An evaluation of the extent of condition on products and services.

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

1. NCR No.: 22-02

2. Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
3. Laboratory Area: Count Toom	4. Client/Project Affected: N/A
5. Requirement Reference: QA Manual; TBE-4019	6. Affected Data: N/A
7. NCR Description: Audit Deficiency - Gamma calibration standard dilution calculation spreadsheet not appropriately validated	
8. Client Notification: ☐ YES ☒ NO	9. Associated CC #: N/A
10. Prepared By: Sharon Northcutt	11. Date: 02/10/22

PART 2. TO BE COMPLETED BY NCR INVESTIGATOR	
12. Root Cause, Corrective/Preventative Action: See attached Supplemental Sheet	
13. Planned Completion Date(s) for Actions(s): 03/10/22	
14. Prepared By: Sharon L Northcutt	15. Date: 02/10/22
16. Approved By: Keith Jete	17: Date: 2/10/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
18. Review and Verification of Corrective Action (where applicable) ☑ Accepted ☐ Rejected ☑ Follow-up Needed — Secondary Calc Sheet	
19. Prepared By: Sharon L Northcutt	20. Date:

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
21. Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 02/10/22

Supplemental Sheet

NCR No: 22-02

Description of Nonconformance:

NUPIC audit deficiency due to the gamma calibration standard dilution calculation spreadsheet not being appropriately validated.

Root Cause:

The Lab Operations Manager had created the spreadsheet to verify hand-calculated values for gamma calibration standard dilutions. The spreadsheet calculations were not verified in an appropriate and systematic manner. During the audit, the calculations were confirmed by the auditor to be accurate.

Corrective Action to Prevent Recurrence:

An additional Excel spreadsheet for standard dilutions will be employed to verify the original dilution calculation(s) as a secondary review. A copy of both sheets will be kept in the QA Manager's office along with the standard calibration certificate and a backup of the spreadsheet stored on the TBE network.

Keith Jeter — 2/10/22

Department Manager or Designee — Date

Shawn L Northcutt — 02/10/22

Quality Assurance Manager or Designee — Date

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

1. NCR No.: 22-03

2. Responsible Manager: Kim Thurman

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
3. Laboratory Area: Environmental Lab	4. Client/Project Affected: PSEG
5. Requirement Reference:	6. Affected Data: L#95584-1
7. NCR Description: Data calculated for H-3 using the incorrect sample count.	
8. Client Notification: [x] YES [ ] NO	9. Associated CC #: 22-05
10. Prepared By: Kim Thurman	11. Date: 04/08/22

PART 2. TO BE COMPLETED BY NCR INVESTIGATOR	
12. Root Cause, Corrective/Preventative Action: See Attached Supplemental Sheet	
13. Planned Completion Date(s) for Action(s): 05/08/22	
14. Prepared By: Sharon Labrecque	15. Date: 05/02/22
16. Approved By: Keith Jeter	17: Date: 5/3/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
18. Review and Verification of Corrective Action (where applicable) [✓] Accepted [ ] Rejected [ ] Follow-up Needed	
19. Prepared By: Sharon Labrecque	20. Date: 05/03/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
21. Client Follow-Up Notification: [✓] YES [ ] NO Description:	22. Date: 6/15/22
23. Prepared By: Kimberly Thurman	24. Date: 6/15/22

Supplemental Sheet

NCR No: 22-03

Description of Nonconformance:

After the H-3 result for L95584 was reported, the client questioned the result for Well BJ as it was 10x lower than usual at 236 pCi/L. A corrected result concurred with historical results at 2530 pCi/L.

Root Cause:

The data was reviewed and it was found a transcription error by the technician when transferring the sample number from the LSC counter to the data file calculation. The sample was recalculated and a revised report was issued.

Corrective Action to Prevent Recurrence:

This error was due to human error. The technician has been made aware of the issue and the Project Manager will be more diligent during data review. The QA Manager will monitor this issue for trending.

Keith Jete 5/3/22

Department Manager or Designee Date

Quality Assurance Manager or Designee 05/03/22

Date

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

1. NCR No.: 22-04

2. Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
3. Laboratory Area: Count Room	4. Client/Project Affected: TBE XCHK
5. Requirement Reference: TBE-4006	6. Affected Data: L#95401
7. NCR Description: Failed cross-check for AP Ce-141 (high)	
8. Client Notification: ☐ YES ☒ NO	9. Associated CC #: N/a
10. Prepared By: Sharon Northcutt	11. Date: 05/19/22

PART 2. TO BE COMPLETED BY NCR INVESTIGATOR	
12. Root Cause, Corrective/Preventative Action: See attached supplemental sheet	
13. Planned Completion Date(s) for Action(s): N/A - 05/19/22	
14. Prepared By: Sharon L Northcutt	15. Date: 05/19/22
16. Approved By: Keith Jobe	17: Date: 5/19/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
18. Review and Verification of Corrective Action (where applicable) ☑ Accepted ☐ Rejected ☐ Follow-up Needed	
19. Prepared By: Sharon L Northcutt	20. Date: 05/19/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
21. Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 05/19/22 SN

C.4

Supplemental Sheet

NCR No: 22-04

Description of Nonconformance:

The 1Q22 Analytics result for AP Ce-144 was above the TBE upper acceptable range of 130%. The reported result was 60.9 pCi and the known was 42.0 pCi. TBE's acceptance range based upon the known result would be 29.4 - 54.6 pCi.

Root Cause:

The reported result with error was 60.9 +/- 19.73 and counted on TBE06. Taking the error into consideration, the result would be in the acceptable range. The workgroup duplicate result was 45.68 +/- 2.08 (counted on TBE14), which was 109% of the known. The sample was counted on TBE07 with a result of 50.98 +/- 16.41 or 121% of the known.

Corrective Action to Prevent Recurrence:

This is the first failure for AP Ce-141 and taking all of the results into consideration, no corrective action is needed at this time.

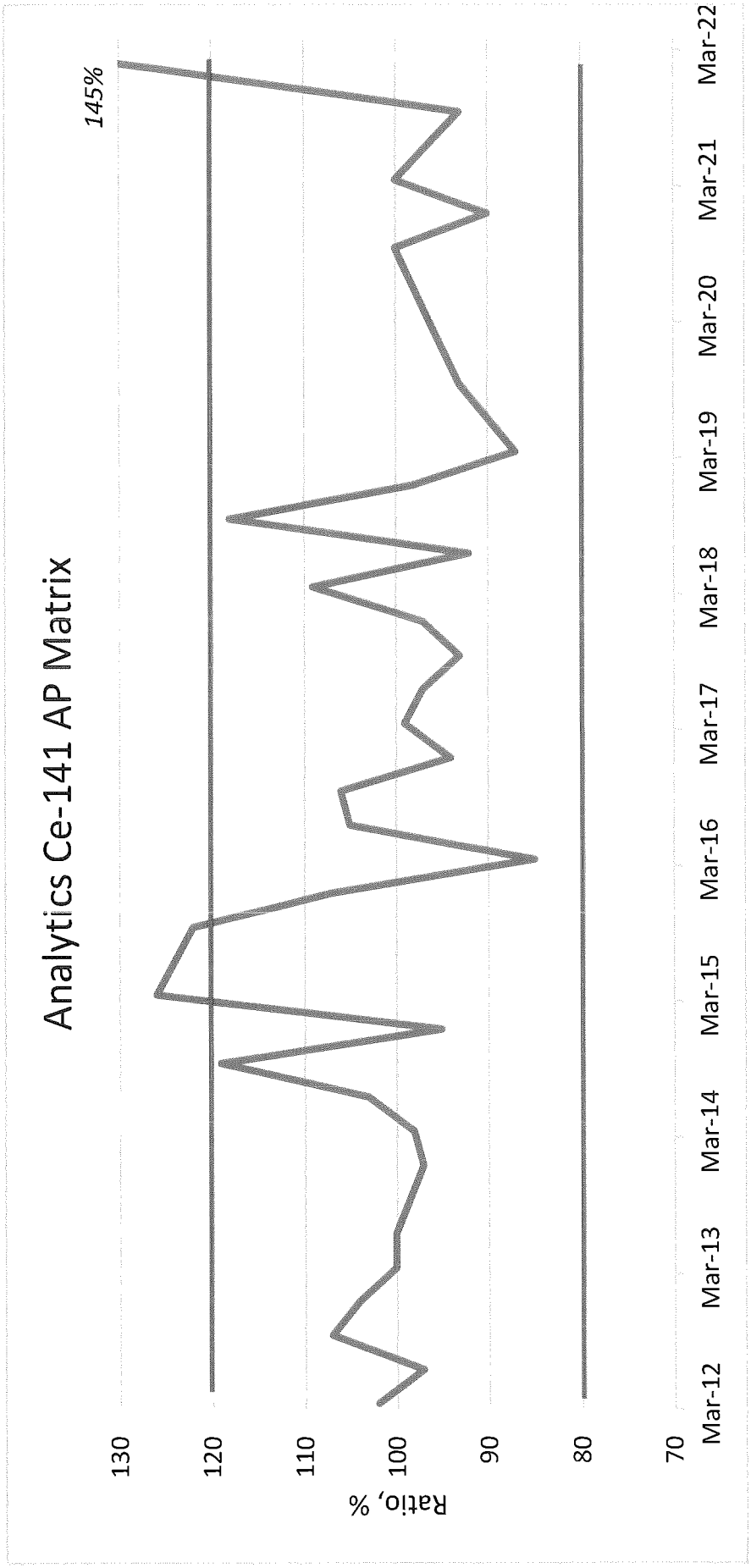
Keith Foster 5/19/22

Department Manager or Designee Date

Sharon L Northcutt 05/19/22

Quality Assurance Manager or Designee Date

Sample	Analysis	ENGINEERING Value, pCi	Uncertainty (1 Sigma)	EZA Value, pCi	Uncertainty (1 Sigma)	Ratio ENGINEERING: EZA
E13709 Filter	Ce-141	6.09E+01	1.97E+01	4.20E+01	7.02E-01	1.45
	Co-58	1.18E+02	1.39E+01	1.07E+02	1.78E+00	1.11
	Co-60	2.18E+02	1.21E+01	1.96E+02	3.28E+00	1.11
	Cr-51	2.51E+02	1.67E+01	2.21E+02	3.69E+00	1.14
	Cs-134	1.29E+02	1.58E+01	1.18E+02	1.98E+00	1.09
	Cs-137	1.56E+02	1.59E+01	1.45E+02	2.43E+00	1.07
	Fe-59	1.24E+02	1.99E+01	1.20E+02	2.01E+00	1.03
	Mn-54	1.20E+02	1.66E+01	1.07E+02	1.78E+00	1.12
	Zn-65	1.62E+02	2.84E+01	1.60E+02	2.68E+00	1.01



TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-05

Responsible Manager: Sharon Northcutt

PART 1.	TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☑ XCHK Failure ☐ Staff Observation		
Process Area: QA - Env. Lab	Client/Project Affected: TBE MAPEP	
Requirement Reference: TBE-4006	Affected Data: L# 95402	
NCR Description: Failed XCHK for U-234, U-238 (Urine matrix)		
Client Notification Needed: ☐ YES ☑ NO	Associated CAR or CC #: ~~N/A~~ SN CAR-22-10	
Prepared By: Sharon L Northcutt	Date: 06/13/22	

PART 2.	TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: Low spiked sample (see supplemental sheet)		
Corrective Action Plan: Flag urine samples from MAPEP for aliquot volume and counting time in LIMS		
Planned Completion Date(s) for Actions(s): 10/10/22		
Prepared By: Sharon L Northcutt	Date: 10/10/22	
Approved By: Keith Jete	Date: 10/10/22	

PART 3.	TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected		
☐ Follow-up Needed (describe) ☐ Completed		
Prepared By: Sharon L Northcutt	Date: 10/10/22	

PART 4.	TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO (QA Report) Description:	22. Date:	
23. Prepared By: Sharon L Northcutt	24. Date: 10/10/22	

Supplemental Sheet

NCR No: 22-05

Description of Nonconformance:

The 1Q22 MAPEP result for Urine U-234 & U-238 was above the upper acceptable limit of 0.0096 and 0.0134 respectively. The reported result for U-234 was 0.142 Bq/Land U-238 was 0.0254 Bq/L. The known was 0.0074 Bq/L (U-234) and 0.0103 Bq/L (U-238).

Investigation:

The original sample was prepped using 100 ml aliquot and counted for 48 hours. After receiving the results, the sample was re-prepped using a larger sample aliquot (200 ml) and counted for 60 hours. Using a larger aliquot volume and additional counting time, results were well within the acceptable range. The U-238 result was 0.00732 Bq/L (acceptable range 0.0052 - 0.0096) and the U-234 result was 0.0119 Bq/L (acceptable range 0.0072 - 0.0134).

Root Cause:

The MAPEP cross-check sample was spiked below TBE's typical MDC for urine U-234 and U-238 client samples. This was the 3rd cross-check sample analyzed by our lab and we did not anticipate results at such a low level. Previous count times were 16.7 - 48 hours (consistent with client sample count times). The directions that came with the sample merely stated that results would be <2000 Bq/L.

Corrective Action to Prevent Recurrence:

This is the first failure for U U-234 & U-238. Previous results were passing at 123% & 115% (U-234) and 111% & 113% (U-238). Going forward, we will use a 200-ml aliquot and count for at least 48 hours for MAPEP samples.

Keith Jeter 10/10/22

Department Manager or Designee Date

Shawn L Northcutt 10/10/22

Quality Assurance Manager or Designee Date

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-06

Responsible Manager: Kimberly Thurman

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☑ XCHK Failure ☐ Staff Observation	
Process Area: QA - In-Plant Lab	Client/Project Affected: PSEG Salem
Requirement Reference: TBE-4006	Affected Data: L#96492
NCR Description: Failed XCHK for Ni-63 (AP matrix)	
Client Notification Needed: ☑ YES ☐ NO	Associated CAR or CC #: NA
Prepared By: Kimberly Thurman	Date: 07/05/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: (See attached Supplemental Sheet)	
Corrective Action Plan: Update TBE-2013 Section 9.3.3	
Planned Completion Date(s) for Actions(s): 08/05/22	
Prepared By: Sharon L Northcutt	Date: 08/02/22
Approved By: Keith Jeter	Date: 8/2/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected	
☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 08/02/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☑ YES ☐ NO	22. Date: 08/14/22
Description: NCR copy sent to client	
23. Prepared By: Kimberly Thurman	24. Date: 08/14/22

Supplemental Sheet

NCR No: 22-06

Description of Nonconformance:

The client cross-check result for AP Ni-63 failed (low) at 51.3% recovery. The reported result was 6.11E-04 µCi and the known was 1.19E-03 µCi/mL. This was the first failure for AP Ni-63.

Investigation:

The initial sample result used a 10% aliquot and had a 55% recovery and was re-analyzed. The R1 sample aliquot was increased to 50% and had a more acceptable yield of 100.4%. All other workgroup QC was acceptable. After the client notified TBE that the reported result was a failure, it was logged for re-analysis. A 40% aliquot was used and the tracer was added prior to digestion and there was little difference in the chemical yield (98.9%). The R2 result was 1.09E-3 µCi (91.6% agreement with known value). No other AP matrix samples were included in the original, R1 or R2 workgroups.

Root Cause:

There appears to have been some loss in the analytical process during digestion of the AP filter. Initially, the carrier was added after digestion and no loss was detected.

Corrective Action to Prevent Recurrence:

The procedure will be modified to move the carrier addition prior to digestion of AP samples. Also, for cross-check samples, no less than a 40% aliquot should be used.

Keith Pete 8/2/22

Department Manager or Designee Date

Shawn L Matthews 08/02/22

Quality Assurance Manager or Designee Date

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-07

Responsible Manager: Karli Arterburn

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☐ XCHK Failure ☒ Staff Observation	
Process Area: Sample Receiving	Client/Project Affected: Exelon Clinton
Requirement Reference:	Affected Data: L# L97508
NCR Description: AP samples came in contact cleaning agent (scrubbing bubbles)	
Client Notification Needed: ☑ YES ☐ NO	Associated CAR or CC #: CAR 22-16
Prepared By: Karli Arterburn	Date:09/08/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: Samples were not labeled and put away before the cleaning agent was on the countertop.	
Corrective Action Plan: Cleaning supplies will be put away until all samples are removed from counters.	
Planned Completion Date(s) for Actions(s): Immediately	
Prepared By: Karli Arterburn	Date:09/20/22
Approved By: Keith Jete	Date: 9/20/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected	
☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/20/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☑ YES ☐ NO Description: Phone call with client to explain event. Final report to be sent out by 9/25/22.	22. Date:9/20/22
23. Prepared By: Karli Arterburn	24. 9/29/22

C.7

Supplemental Sheet

NCR No: 22-07

Description of Nonconformance:

Three air particulate samples inadvertently came in contact with a cleaning agent (scrubbing bubbles) on the counter leading to inaccurate results.

Root Cause:

Samples were not labeled and put away before a cleaning agent was used on the countertops.

Corrective Action to Prevent Recurrence:

Cleaning supplies must be stored in a cabinet or on a shelf until all samples are labeled and moved to the appropriate storage area. (See CAR 22-16)

Department Manager or Designee — Date 9/29/22

Quality Assurance Manager or Designee — Date 09/30/22

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-08

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Sample Receiving/Login	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 V1M2 5.8.4(c)	Affected Data: N/A
NCR Description: Audit Finding NCR 1 - Sample coolers not being screened for radiation on all surfaces	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #:
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: Incomplete verbiage in procedures.	
Corrective Action Plan: Update TBE-4003 & TBE-7001; training	
Planned Completion Date(s) for Actions(s): 11/01/23	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Gete	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO N/A Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

Supplemental Sheet

NCR No: 22-08

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 1 - Sample coolers are not screened for radiation on all surfaces upon receipt. This finding is accordance with the requirements stated in the DOE QSM 5.4 V1M2 5.8.4(c).

Root Cause:

Neither TBE-4003 "Sample Receipt and Control" nor TBE-7001 "Receiving Packaged Radioactive Materials" state specifically to screen ALL surfaces upon receipt. They both merely state to "survey incoming packages". During the audit demonstration, the technician surveyed around all sides (inside/out) except for the bottom of the cooler.

Corrective Action to Prevent Recurrence:

Procedures TBE-4003 and TBE-7001 will be updated to state "survey ALL sides of containers". All staff qualified for login/receiving will be trained to the updated procedures.

Keith Pete — 9/23/22

Department Manager or Designee — Date

Sharon L Montano — 09/23/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

ASSESSMENT INFORMATION		
Number	**Type**	**Date(s)**
A2022-01554	Accreditation	September 19-21, 2022
Standard(s):	ISO/IEC 17025:2017 /Option A Testing /DOD ELAP DOECAP QSM V5.4	
Team: (LA, TA, TE)	Albert Ellis (Lead)	
CONFORMITY ASSESSMENT BODY (CAB)		
Name	**Location(s)**	
Teledyne Brown Engineering	2508 Quality Ln Knoxville, TN 37931	

TOTALS			
Repeat	**Major**	**Minor**	**Observation(s)**
0	N/A	11	1

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
OBS 01	**Finding** - The laboratory's documented Quality Management System (QMS) has not been updated to reflect the current version of the standard (QSM V5.4). Since the QMS is compliant to QSM V5.3, and the only change to V5.4 was the addition of Appendix B Table B-24 for EPA 1633, this is identified as an observation to monitor the status. **Objective Evidence** – Interview of QA manager	**DOD/DOE QSM V1M2 5.4 V1M2 4.2.1** - The laboratory shall establish, implement, and maintain a management system appropriate to the scope of its activities. The laboratory shall document its policies, systems, programs, procedures, and instructions to the extent necessary to assure the quality of the test and/or calibration results. The system's documentation shall be communicated to, understood by, available to, and implemented by the appropriate personnel.
NCR 1 - Minor ☐ Repeat? [a]	**Finding** – Sample coolers are not screened for radiation on all surfaces upon receipt. **Objective Evidence** – Interview and witnessing of Sample Intake procedures.	**DOE QSM 5.4 V1M2 5.8.4(c)** Containers are to be opened in a manner to prevent worker exposure
NCR 2 - Minor ☐ Repeat? [a]	**Finding** – There are multiple forms throughout the laboratory that are uncontrolled. **Objective Evidence** – Prep sheets; Annual Data Integrity Training Agenda, etc.	**DOE QSM 5.4 V1M2 4.3.2.3** - management system documents generated by the laboratory shall be uniquely identified. This identification shall include the date of issue and/or revision identification, page numbering, the total number of pages or a mark to signify the end of the document and the issuing authority(ies).
NCR 3 - Minor ☐ Repeat? [a]	**Finding** –Technical SOPs are not reviewed annually and updated where necessary. **Objective Evidence** - Interview of QA manager	**DOD/DOE QSM 5.4 V1M2 4.2.8.5(g), DOD/DOE QSM 5.4 V1M2 4.3.2.2(b)** - All technical SOPs (e.g., sample preparation, analytical procedures, sample storage, or sample receipt) shall be reviewed for accuracy and adequacy at least annually and updated if necessary. Documents shall be periodically reviewed and, where necessary, revised to ensure continuing suitability and compliance with applicable requirements
NCR 4 - Minor ☐ Repeat? [a]	**Finding** – The management review did not address all aspects as required. Also, it did not include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions **Objective Evidence** – 2021 Management Review conducted October 23, 2021	**DOD/DOE QSM 5.4 v1M2 4.15 Grey Box 18** The inputs to management review include information related to the following. Management reviews whall also include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions, where applicable

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-09

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Quality Assurance	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 V1M2 4.3.2.3	Affected Data: N/A
NCR Description: Audit Finding NCR 2 - Multiple forms in the lab that are uncontrolled - see supplement pg	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #:
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: Misunderstanding of description by QA Manager	
Corrective Action Plan: Review all forms/documents used by lab and uniquely identify/control them.	
Planned Completion Date(s) for Actions(s): 11/01/22	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Jete	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO N/A Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

PJLA

NONCONFORMANCE REPORT

ASSESSMENT INFORMATION		
Number	**Type**	**Date(s)**
A2022-01554	Accreditation	September 19-21, 2022
Standard(s):	ISO/IEC 17025:2017 /Option A Testing /DOD ELAP DOECAP QSM V5.4	
Team: (LA, TA, TE)	Albert Ellis (Lead)	

CONFORMITY ASSESSMENT BODY (CAB)	
Name	**Location(s)**
Teledyne Brown Engineering	2508 Quality Ln Knoxville, TN 37931

TOTALS			
Repeat	**Major**	**Minor**	**Observation(s)**
0	N/A	11	1

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
OBS 01	**Finding** - The laboratory's documented Quality Management System (QMS) has not been updated to reflect the current version of the standard (QSM V5.4). Since the QMS is compliant to QSM V5.3, and the only change to V5.4 was the addition of Appendix B Table B-24 for EPA 1633, this is identified as an observation to monitor the status. **Objective Evidence** – Interview of QA manager	**DOD/DOE QSM V1M2 5.4 V1M2 4.2.1** - The laboratory shall establish, implement, and maintain a management system appropriate to the scope of its activities. The laboratory shall document its policies, systems, programs, procedures, and instructions to the extent necessary to assure the quality of the test and/or calibration results. The system's documentation shall be communicated to, understood by, available to, and implemented by the appropriate personnel.
NCR 1 - Minor ☐ Repeat?[a]	**Finding** – Sample coolers are not screened for radiation on all surfaces upon receipt. **Objective Evidence** – Interview and witnessing of Sample Intake procedures.	**DOE QSM 5.4 V1M2 5.8.4©** Containers are to be opened in a manner to prevent worker exposure
NCR 2 - Minor ☐ Repeat?[a]	**Finding** – There are multiple forms throughout the laboratory that are uncontrolled. **Objective Evidence** – Prep sheets; Annual Data Integrity Training Agenda, etc.	**DOE QSM 5.4 V1M2 4.3.2.3** - management system documents generated by the laboratory shall be uniquely identified. This identification shall include the date of issue and/or revision identification, page numbering, the total number of pages or a mark to signify the end of the document and the issuing authority(ies).
NCR 3 - Minor ☐ Repeat?[a]	**Finding** –Technical SOPs are not reviewed annually and updated where necessary. **Objective Evidence** - Interview of QA manager	**DOD/DOE QSM 5.4 V1M2 4.2.8.5(g), DOD/DOE QSM 5.4 V1M2 4.3.2.2(b)** - All technical SOPs (e.g., sample preparation, analytical procedures, sample storage, or sample receipt) shall be reviewed for accuracy and adequacy at least annually and updated if necessary. Documents shall be periodically reviewed and, where necessary, revised to ensure continuing suitability and compliance with applicable requirements
NCR 4 - Minor ☐ Repeat?[a]	**Finding** – The management review did not address all aspects as required. Also, it did not include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions **Objective Evidence** – 2021 Management Review conducted October 23, 2021	**DOD/DOE QSM 5.4 v1M2 4.15 Grey Box 18** The inputs to management review include information related to the following. Management reviews whall also include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions, where applicable

TBE QUALITY ASSURANCE
LIST OF CURRENT FORMS

Form #	Rev #	Date	Title	Procedure Reference
KQA-1	3	10/01/21	TBE-ES Analyst Training Record	TBE-1007
KQA-2	6	08/31/20	Approved Vendor Qualifications	TBE-1015
KQA-4	0	10/20/04	Chain of Custody	TBE-4003
KQA-5	1	10/07/05	Computer Software Validation	TBE-1001
KQA-6	5	06/04/19	Demonstration of Capability	TBE-1007
KQA-8	3	09/02/13	Group Training Record	TBE-1007
KQA-9	6	12/29/21	Nonconformance Report Form	TBE-1018
KQA-10	3	02/15/18	Nonconformance Report Log	TBE-1018
KQA-13	3	02/15/20	Self Read Training Record	TBE-1007
KQA-15	1	05/26/19	Fume Hood Velocity Form	TBE-5001
KQA-16	0	10/26/04	TBE Internal Chain of Custody Form	TBE-4003
KQA-17	2	12/01/21	TBE Procedure Modification Record	TBE-1008
KQA-18	1	07/01/21	Initial Training (New Employee)	TBE-1007
KQA-19	0	05/26/06	Investigation Documentation Record	TBE-1018
KQA-20	9	03/21/22	New Employee Orientation	TBE-1007
KQA-20a	1	12/29/21	New Employee Orientation - Clerical Only	TBE-1007
KQA-21	0	11/1818	Preventative Action Form	TBE-1013
KQA-22	3	05/05/20	Customer Complaint Form	TBE-1016
KQA-26	2	07/28/18	Supplier Qualification Annual Verification	TBE-1015
KQA-31	2	05/13/20	Approved Supplier List	TBE-1015
KQA-32	2	09/22/20	Calibration Schedule	TBE-1009
KQA-33	1	04/17/19	Method Procedure Surveillance Form	TBE-1013
KQA-34	1	08/15/21	LIMS User Authorization Request Form	TBE-6010
KQA-35	1	08/15/21	LIMS User Access Initial Instructions	TBE-6010
KQA-36	0	12/28/17	Data Integrity Ethics Certification	TBE-1005
KQA-38	0	02/28/19	TBE Internal Audit Checklist	TBE-1013
KQA-39	1	10/15/22	TBE Supplier Information Form F-380	TBE-1015
KQA-40	0	12/29/21	Corrective Action Request Form	TBE-1018
KQA-41	0	12/28/21	TBE-ES Client Survey	TBE-1016
KQA-42	0	0210/22	Contract Review Form	TBE-1014
KQA-43	0	05/18/22	Management of Change	TBE-8005
KQA-44	1	09/22/22	Safety Shower/Eyewash Station Check	Safety Man 5.4
KQA-45	0	09/22/22	Staff Meeting Attendance Sheet	QA Man 8.2
KQA-46	1	09/22/22	Rad Control Tech Qualification Record	TBE-7005
KQA-47	0	09/22/22	Toluene Usage Form	TBE-5003
KQA-48	1	09/22/22	Daily Response Check	TBE-7005
KQA-49	0	10/10/22	Rad Survey Plan and Maps	TBE-7003
KQA-50	0	09/22/22	Weekly Waste Container Inspection Checklist	TBE-7003
KQA-51	0	09/22/22	Labs End of Day Checklist	TBE-8007

Regulatory Reference Documents:
US NRC Reg. Guide 4.15 QA for Radiological Monitoring Programs
TNI Standard 2016/ISO 17025
ANSI N42.23 QA for Radioassay Laboratories
DoD/DOE QSM 5.4

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-10

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Quality Assurance	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1 M2 4.2.8.5 & 4.2.2	Affected Data: N/A
NCR Description: Audit Finding NCR 3 - Technical SOPs not reviewed annually and updated where necessary - see supplement page	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-20
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New requirement for DOE accreditation	
Corrective Action Plan: Update review schedule for technical SOPs to annually	
Planned Completion Date(s) for Actions(s): 10/07/22	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Jett	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO N/A Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

C.10

Supplemental Sheet

NCR No: 22-10

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 3 - ALL technical SOPs are not reviewed annually and updated where necessary. This finding is accordance with the requirements stated in the DOE QSM 5.4 V1M2 4.2.8.5(g) and 4.2.2(b).

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4.

Corrective Action to Prevent Recurrence:

The review schedule for all technical SOP's will be updated from every three years to annually beginning in 2023.

Keith Jete 9/23/22

Department Manager or Designee Date

Quality Assurance Manager or Designee 09/23/22

Date

PJLA

NONCONFORMANCE REPORT

ASSESSMENT INFORMATION		
Number	**Type**	**Date(s)**
A2022-01554	Accreditation	September 19-21, 2022
Standard(s):	ISO/IEC 17025:2017 /Option A Testing /DOD ELAP DOECAP QSM V5.4	
Team: (LA, TA, TE)	Albert Ellis (Lead)	

CONFORMITY ASSESSMENT BODY (CAB)	
Name	**Location(s)**
Teledyne Brown Engineering	2508 Quality Ln Knoxville, TN 37931

TOTALS			
Repeat	**Major**	**Minor**	**Observation(s)**
0	N/A	11	1

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
OBS 01	**Finding** - The laboratory's documented Quality Management System (QMS) has not been updated to reflect the current version of the standard (QSM V5.4). Since the QMS is compliant to QSM V5.3, and the only change to V5.4 was the addition of Appendix B Table B-24 for EPA 1633, this is identified as an observation to monitor the status. **Objective Evidence** – Interview of QA manager	**DOD/DOE QSM V1M2 5.4 V1M2 4.2.1** - The laboratory shall establish, implement, and maintain a management system appropriate to the scope of its activities. The laboratory shall document its policies, systems, programs, procedures, and instructions to the extent necessary to assure the quality of the test and/or calibration results. The system's documentation shall be communicated to, understood by, available to, and implemented by the appropriate personnel.
NCR 1 - Minor ☐ Repeat? [a]	**Finding** – Sample coolers are not screened for radiation on all surfaces upon receipt. **Objective Evidence** – Interview and witnessing of Sample Intake procedures.	**DOE QSM 5.4 V1M2 5.8.4©** Containers are to be opened in a manner to prevent worker exposure
NCR 2 - Minor ☐ Repeat? [a]	**Finding** – There are multiple forms throughout the laboratory that are uncontrolled. **Objective Evidence** – Prep sheets; Annual Data Integrity Training Agenda, etc.	**DOE QSM 5.4 V1M2 4.3.2.3** - management system documents generated by the laboratory shall be uniquely identified. This identification shall include the date of issue and/or revision identification, page numbering, the total number of pages or a mark to signify the end of the document and the issuing authority(ies).
NCR 3 - Minor ☐ Repeat? [a]	**Finding** –Technical SOPs are not reviewed annually and updated where necessary. **Objective Evidence** - Interview of QA manager	**DOD/DOE QSM 5.4 V1M2 4.2.8.5(g), DOD/DOE QSM 5.4 V1M2 4.3.2.2(b)** - All technical SOPs (e.g., sample preparation, analytical procedures, sample storage, or sample receipt) shall be reviewed for accuracy and adequacy at least annually and updated if necessary. Documents shall be periodically reviewed and, where necessary, revised to ensure continuing suitability and compliance with applicable requirements
NCR 4 - Minor ☐ Repeat? [a]	**Finding** – The management review did not address all aspects as required. Also, it did not include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions **Objective Evidence** – 2021 Management Review conducted October 23, 2021	**DOD/DOE QSM 5.4 v1M2 4.15 Grey Box 18** The inputs to management review include information related to the following. Management reviews whall also include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions, where applicable

Procedure	Number: Active Procedures TOC	Revision:
	Issue Date: 03/02/2004	Revision Date: 11/01/2022
Responsible Individual:	Quality Assurance Manager	Next Review Date: N/A
Subject:	Table of Contents, Record of Revisions & Review Schedule	

Table of Contents and Record of Revisions

Procedure	Number: Active Procedures TOC	Revision:
	Issue Date: 03/02/2004	Revision Date: 11/01/2022
Responsible Individual:	Quality Assurance Manager	Next Review Date: N/A
Subject:	Table of Contents, Record of Revisions & Review Schedule	

Procedure	Number: Active Procedures TOC	Revision:
	Issue Date: 03/02/2004	Revision Date: 11/01/2022
Responsible Individual:	Quality Assurance Manager	Next Review Date: N/A
Subject:	Table of Contents, Record of Revisions & Review Schedule	

Procedure	Number: Active Procedures TOC	Revision:
	Issue Date: 03/02/2004	Revision Date: 11/01/2022
Responsible Individual:	Quality Assurance Manager	Next Review Date: N/A
Subject:	Table of Contents, Record of Revisions & Review Schedule	

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-11

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: QA Manual	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2.4.15 grey box	Affected Data: N/A
NCR Description: Audit Finding NCR 4 - Annual management review did not address all required items - see supplement page	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-21
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New requirement for DOE accreditation	
Corrective Action Plan: Add Radioactive waste/materials management and rad health/safety to Annual Management Report	
Planned Completion Date(s) for Actions(s): 02/15/23	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Gete	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected	
☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO N/A Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

Supplemental Sheet

NCR No: 22-11

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 5 - The management review did not address all aspects as required. Also, it did not include laboratory radiation health and safety, radioactive hazardous waste and radioactive materials management functions. This finding is accordance with the requirements stated in the DOE QSM 5.4 V1M2 4.15 Grey Box 18.

Section 4.15.1 states that *management reviews shall also include laboratory radiation health and safety, radioactive hazardous waste and radioactive materials management functions where applicable.*

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4.

Corrective Action to Prevent Recurrence:

Beginning with the 2022 Management Review, health/safety and radioactive hazardous waste/materials management will be included in the report.

Keith Jole 9/23/22

Department Manager or Designee Date

Sharon L Westcott 09/23/22

Quality Assurance Manager or Designee Date

PJLA

NONCONFORMANCE REPORT

ASSESSMENT INFORMATION		
Number	**Type**	**Date(s)**
A2022-01554	Accreditation	September 19-21, 2022
Standard(s):	ISO/IEC 17025:2017 /Option A Testing /DOD ELAP DOECAP QSM V5.4	
Team: (LA, TA, TE)	Albert Ellis (Lead)	

CONFORMITY ASSESSMENT BODY (CAB)	
Name	**Location(s)**
Teledyne Brown Engineering	2508 Quality Ln Knoxville, TN 37931

TOTALS			
Repeat	**Major**	**Minor**	**Observation(s)**
0	N/A	11	1

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
OBS 01	**Finding** - The laboratory's documented Quality Management System (QMS) has not been updated to reflect the current version of the standard (QSM V5.4). Since the QMS is compliant to QSM V5.3, and the only change to V5.4 was the addition of Appendix B Table B-24 for EPA 1633, this is identified as an observation to monitor the status. **Objective Evidence** – Interview of QA manager	**DOD/DOE QSM V1M2 5.4 V1M2 4.2.1** - The laboratory shall establish, implement, and maintain a management system appropriate to the scope of its activities. The laboratory shall document its policies, systems, programs, procedures, and instructions to the extent necessary to assure the quality of the test and/or calibration results. The system's documentation shall be communicated to, understood by, available to, and implemented by the appropriate personnel.
NCR 1 - Minor ☐ Repeat? [a]	**Finding** – Sample coolers are not screened for radiation on all surfaces upon receipt. **Objective Evidence** – Interview and witnessing of Sample Intake procedures.	**DOE QSM 5.4 V1M2 5.8.4©** Containers are to be opened in a manner to prevent worker exposure
NCR 2 - Minor ☐ Repeat? [a]	**Finding** – There are multiple forms throughout the laboratory that are uncontrolled. **Objective Evidence** – Prep sheets; Annual Data Integrity Training Agenda, etc.	**DOE QSM 5.4 V1M2 4.3.2.3** - management system documents generated by the laboratory shall be uniquely identified. This identification shall include the date of issue and/or revision identification, page numbering, the total number of pages or a mark to signify the end of the document and the issuing authority(ies).
NCR 3 - Minor ☐ Repeat? [a]	**Finding** –Technical SOPs are not reviewed annually and updated where necessary. **Objective Evidence** - Interview of QA manager	**DOD/DOE QSM 5.4 V1M2 4.2.8.5(g), DOD/DOE QSM 5.4 V1M2 4.3.2.2(b)** - All technical SOPs (e.g., sample preparation, analytical procedures, sample storage, or sample receipt) shall be reviewed for accuracy and adequacy at least annually and updated if necessary. Documents shall be periodically reviewed and, where necessary, revised to ensure continuing suitability and compliance with applicable requirements
NCR 4 - Minor ☐ Repeat? [a]	**Finding** – The management review did not address all aspects as required. Also, it did not include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions **Objective Evidence** – 2021 Management Review conducted October 23, 2021	**DOD/DOE QSM 5.4 v1M2 4.15 Grey Box 18** The inputs to management review include information related to the following. Management reviews whall also include laboratory radiation health and safety, radioactive hazardous waste, and radioactive materials management functions, where applicable

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-12

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Radiation/Safety Program	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2.6.1.1.2	Affected Data: N/A
NCR Description: Audit Finding NCR 5 - Radiation Protection Program has not been reviewed since 2018 - see supplement page	
Client Notification Needed: ☐ YES ☒ X NO	Associated CAR or CC #:
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: Miscommunication during the audit.	
Corrective Action Plan: 2021 RSO RPP assessment uploaded to PJLA website on 09/21/22	
Planned Completion Date(s) for Actions(s): 09/23/22	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Gete	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

C.12

Supplemental Sheet

NCR No: 22-12

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 5 - The radiation protection program has not been reviewed since 2018. This finding is accordance with the requirements stated in the DOE QSM 5.4 V1M2 6.1.1.2.

NOTE: This audit finding was in error, as the Lab Operations Manager/Safety/Rad Officer was not interviewed. The QA Manager is not responsible for the Radiation Program and could only give a copy of the radiation program manual to the auditor. A copy of the 2021 RSO RPP Annual Assessment was uploaded to the PJLA website (under Assessment Reports folder) on 09/21/22.

Root Cause:

Miscommunication during the audit.

This is a new requirement for TBE to be in compliance with QSM 5.4.

Corrective Action to Prevent Recurrence:

Please see the attached 2021 RSO RPP Annual Assessment.

Keith Jete — 9/23/22

Department Manager or Designee — Date

Shannon L Northcutt — 09/23/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 5 - Minor ☐ Repeat? [a]	**Finding** – The radiation protection program has not been reviewed since 2018 **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.1.1.2** The laboratory shall review, at least annually, the radiation protection program content and implementation. The records of audits, reviews, and inspections for the last five years maintained and readily available for review.
NCR 6 - Minor ☐ Repeat? [a]	**Finding** – The survey equipment used in the sample receipt, there is not a battery check. **Objective Evidence** - Interview of QA manager	**DOE QSM 5.4 V1M2 5.4 6.1.5.2** Prior to performing radiological surveys, is the radiological survey instrumentation checked for operational performance using a radiological source, a battery check, and a measurement of the nominal background is measured
NCR 7 - Minor ☐ Repeat? [a]	**Finding** –There is not a HAZWOPER trained person on staff. **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.3.17** The laboratory shall have a Hazardous Waste Operator and Emergency Response (HAZWOPER) trained person on staff. Also, Backup personnel with appropriate training for the Emergency Response (HAZWOPER) trained personnel.
NCR 8 - Minor ☐ Repeat? [a]	**Finding** – Various instruments have not been verified **Objective Evidence** – 1. Mechanical volumetric pipette (pipette 19) 2. Volumetric labware (plastic graduated cylinders and beakers used throughout the laboratory)	**DOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1: Mechanical volumetric pipette** Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on minimum of 3 replicate measurements) [Note: for variable volume pipettes, verify at the volume of use or using two volumes that bracket the range of use]
NCR 9 - Minor ☐ Repeat? [a]	**Finding** – the waste brokering provider has not been evaluated within the last three years **Objective Evidence** – Interview of QA manager	**DOD QSM 5.4 V1M2 6.2.2.3** Waste brokering and TSDF evaluation shall be based upon the results of a site visit to the waste facility or a desktop review that includes information from audits of the facilities conducted by state or federal agencies. The evaluation shall include liability coverage, financial stability, any Notices of Violations (NOVs) from the last three years, relevant permits and licenses to accept the waste, and other relevant information.
NCR 10 - Minor ☐ Repeat? [a]	**Finding** – There is not a record of the weekly monitoring of the waste disposal area not is there any secondary containment of for the drums in the area. **Objective Evidence** – Visual inspection of was storage area.	**DOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** The waste storage area shall provide secondary containment of sufficient capacity for the waste expected to be stored in the areas. Waste storage areas, and containers of waste shall be monitored weekly by an operator or someone knowledgeable in waste operations specific to this facility.

Corporate RSO Radiation Protection Program Assessment
November 2021 TBE Lab Knoxville, TN

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
I **FACILITY POSTING & RADIOACTIVE MATERIAL MARKINGS**	TBE-7004				
The following areas are Radioactive Materials Storage Areas posted "CAUTION – RADIOACTIVE MATERIALS": ❑ In-Plant/Reactor Chemistry Lab (2doors – Room 112) ❑ In-Plant/Reactor Chemistry Storage and Evaporation (1 door - Room113) ❑ Sample Receipt and Storage (3 doors - Room 110) ❑ Counting Room 2 source storage cabinets (Room 134) ❑ Rad Chem & Alpha Lab source storage cabinets (2 source usage areas and 1 cabinet – Room 101) ❑ Rad Waste Storage (Room 116) ❑ Standard Prep Lab (Room104) – 3 cabinets		X			Postings on doors/cabinets/source usage areas – Visual Inspection
Radioactive Waste collection drums, located in the following rooms, are marked "CAUTION – RADIOACTIVE MATERIALS" and lids are placed on drum: ❑ In-Plant Lab(112/113/116)	TBE-7009	X			In-Plant Lab – Drums are marked appropriately, and lids are on drums.
TN DRH Prenatal Exposure Notice posted in a frequented location.	TN SRPAR	X			Posted on bulletin board in lobby.
Last TN DRH Audit posted until item completed	TN SRPAR	X			The last audit was performed on August 31, 2020. There were no findings.
TN DRH "Notice to Employees" posted in a frequented location.	TN SRPAR	X			Posted on bulletin board in lobby.
II **RADIATION EXPOSURE CONTROL PROGRAM**	TBE-7003				
Environmental TLDs exchanged 1st month of the Semi-annual exchange requirement.		X			
Personnel TLDs exchanged Semi-annually.		X			Reviewed 1/1/2020 – 6/30/2020 and 7/1/20-12/31/20

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
Exposure history requested for all new employees. RHS 8-1H or equivalent.		X			One new employee with no radiation history. – Abbygail Ochs Observation: The RSO RPP Assessment dated April 19, 2021, Section II, 6) – states that there were two new radiation workers hired in 2020 but only one was recorded in the Quarterly Assessments for 2020.
Individuals assigned duties primarily in the radiological restricted areas are assigned TLDs.		X			
Individuals assigned duties primarily in the radiological restricted areas are qualified as Radiation Workers, by one of the following methods: ❑ Completion of the TBE Radiation Worker training, or ❑ Confirmation in writing, by the TBE RSO, that the individual's previous training satisfies the TBE requirements and that the RSO has briefed the individual.		X			Training provided : Abbygail Ochs – 6/12/20
All women (new hires) received specific training IAW TN SRPAR, concerning embryo exposure. All have received written guidance and certified that they understand the recommended program.		X			Abbygail Ochs – 6/12/20
Bioassay samples provided by all Radiation Workers during the 1st month of the semi-annual cycle.		X			Confirmed: In files
TLDs stored at the employee "in-box" location when employees leave for the day.		X			Visual Inspection
Three (3) TLD controls located for background subtraction. 1) North end of bldg. 2) SE end of bldg. 3) Office Supply Room		X			Visual Inspection

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
A report generated by the RSO is available detailing the employee exposures for both internal and external sources. (semi-annual)		X			Occupational Radiation Exposure Report Report# 18576 for 1st Semi-Annual 2020 and Report #18939 for the 2nd Semi-Annual 2020 in RSO office files.
A report generated by the RSO is available detailing the environmental TLD doses. (semi-annual)		X			Located in RSO file cabinet.
Exposures no more than 150 mRem/qtr (average) or 600 mRem/yr.		x			All employees under 150mRem/qtr (January – December 2020)
No exposures greater than 100 mRem/yr (above BKGD) at building exterior TLD locations.		x			No exposure>100mRem/yr (January – December 2020)
III RADIOACTIVE WASTE GENERATION & CONTROL	TBE-7009				
Radioactive Waste collection drums, located in the In-Plant Lab, Bioassay Prep, Sample Prep rooms, have the following information on sheets attached to the collection container: ❑ Radiation reading, in microR/hr, and ❑ Description of contents placed in the container, and ❑ Date filled		X			Visual inspection of drums.
Once collected, radioactive waste is not stored for greater than 365 days.	TBE-7007	X			No containers of radioactive waste stored over 365 days.
If a broker is used to ship radioactive waste from the TBE facility, then the Broker must have: ❑ A state of TN issued "license for delivery", and ❑ Certify that they brokers agent (shipper) has been trained IAW 49 CFR subpart H to ship radioactive materials.	TBE-7009	X			Chase Environmental Group, Inc. License T-KY003-L20 Expires: December 31,2020 Observation: Please have Janet Baker send certifications for 49CFR 172 subpart H for the individuals that picked up the waste .
TBE retains copies of the transfer documentation for any radioactive waste picked up by a broker.		X			12/2/20 Form 540.

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
TBE has a copy of receipt documentation (broker and final processor or disposal facility) that matches each shipment of radioactive waste from the facility.		X			Letter attached with broker signature for 12/2/20 Form 540. Toxco (TSDF) letter January 7, 2020. Observation: The letter from Toxco should be dated January 7, 2021. Please request corrected date from Janet Baker.
TBE confirmed that the consignee of a shipment of TBE radioactive waste has a license that allows for the receipt and processing of the materials. A copy of the license must be retained by TBE.		X			TOXCO Expires: 10/31/2026 License #: R-01037-J26
If a TBE employee signs the radioactive shipment documentation, that individual must have been trained IAW 49 CFR 172 subpart H for the preparation and shipment of radioactive materials.		X			Keith Jeter – Advanced Mixed Waste Shipper – 49CFR, Part 172, Subpart H November 20, 2020 – November 20, 2023.
IV FACILITY INSPECTION					
Environmental TLDs, both inside and outside are properly posted in designated locations.	TBE-7003	X			Visual Inspection
By visual inspection of non-radioactive storage areas, verify that no radioactive samples are in non-radioactive storage.		X			No radioactive samples were present in non-radioactive storage.
Employees are wearing appropriate PPE in the laboratories: ❑ Lab coats, ❑ Gloves, ❑ Eye protection, as required	H&S Manual	X			Visual Inspection
Employees remove gloves before leaving labs and lab coats before leaving the radiological controlled areas.		X			Visual Inspection
Lab Hood "Sashes" are not higher than the specified height.			X		Visual Inspection Finding: One sash was found above the specified height.

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
Individuals leaving the In-Plant Lab frisk properly before exiting.		X			Visual Inspection
Radioactive materials are opened and handled in designated hoods or in designated areas on laboratory counters.		X			Visual Inspection
Radioactive waste collection containers have the lids placed on the top of the container. Lids do not have to be secured with the locking ring until the drum is moved from the laboratory.	TBE-7009	X			Visual Inspection Observation: There is an open 55gallon poly drum in Rm 113. The drum needs to be labeled and the container should be closed when no one is adding solutions. There is also a cardboard 55 gallon drum that is not labeled in Rm 112.
VI CONTAMINATION AND RADIATION SURVEY INSTRUMENTATION	**TBE-7005**				
All "in use" portable contamination and radiation instrumentation calibrated within last 12 months. ❑ Review calibration certifications to assure all are accounted for		X			Visual Inspection
All "in use" portable contamination and radiation instrumentation calibrated within last 12 months. ❑ All instruments have calibration sticker showing either last calibration date (within 12 months), or ❑ Due date that is in the future		X			Visual Inspection
All instruments not in calibration or taken out-of-service are tagged "Do Not Use"		X			Visual Inspection – Tags attached with "Do Not Use" (Located in room #134)
Inspect all in use portable instrumentation to assure they are in the proper location and in suitable operating condition.		X			Visual Inspection

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
Review instrument response logs ❑ Assure daily checks are performed, or ❑ Checks were performed for days the instrument was used to record required data		X			Daily checks recorded on side of instrument
VII **RADIATION PROTECTION PROGRAM RECORDS**					
Verify: ❑ For packages with greater than 500 µR/h the RSO was notified, and ❑ For packages greater than 20 cpm alpha or 100 cpm beta-gamma the RSO was notified ❑ For packages that contain isotopes greater than 1mCi the RSO was notified.	TBE-7001	X			Note: Log information is in LIM system. Shipping and Receiving notifies RSO
For New Employees, the following records are available: ❑ Exposure (dose) for current year for former employer(s), ❑ If current exposure is not available, copy of letter requesting dose records, ❑ TBE Radiation Worker Qualification record, or RSO evaluation that past Radiation Worker training is satisfactory, ❑ Initial Bioassay results ❑ Prenatal embryo exposure training and employee certification (For Women only)	TBE-7003	X			Reviewed the following record: Abbygail Ochs did not have a previous radiation exposure history All other records are on-file.
TLD results in employee records.	TBE-7003	X			Located in RSO's files

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
Bioassay results in employee records.	TBE-7003	X			Located in RSO's files
RSO evaluation of personnel TLD and Bioassay results in file.	TBE-7003	X			Located in RSO's files
Review records of review of visitor TLD results.	TBE-7008			X	Observation: On the quarterly assessments for 2020 it was noted that Visitor TLDs were issued to contactor employees. After speaking with the RSO he stated this was a typo. There have been no visitors.
Environmental TLD results in Env TLD records.	TBE-7003	X			Located in RSO's files
RSO evaluation of Environmental TLD results in file.	TBE-7003	X			Located in RSO's files
Annual RSO RPP Assessment completed for previous year. This should include 4 completed quarterly assessment checklists.	TBE-7003 & TBE-7007	X			Reviewed Quarterly Assessments for 2020. RSO will correct assessments noted above for visitor TLD results.
Current facility floor plan or procedure designating all potential Radiation Areas and Radioactive Materials storage areas noted on file.	TBE-7004	X			Posted on the hallway walls/bulletin boards.
Any areas added to the original established radiation and radioactive material storage areas designated in writing.	TBE-7004	X			None per RSO
All weekly surveys completed since last assessment and filed for ease in review that they have been completed.	TBE-7005 3.2.1	X			Yes – Located in RSO's files.

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
All monthly surveys completed since last assessment and filed for ease in review that they have been completed.	TBE-7005 3.2.2	X			Yes – Located in RSO's files. Reviewed Jan-Dec 2020
All quarterly surveys completed since last assessment and filed for ease in review that they have been completed.	TBE-7005 3.2.3	X			Yes – Located in RSO's files.
RSO retains completed survey/calibration and daily source-response checks for at least three years.	TBE-7005	X			Retained in RSO's office. Verified 2017-2020
Review Survey Technician Training records to assure that training has been completed in the last 3 years.	TBE-7005	X			Radiation Control Tech Qualification Record: Donna Webb 1/20/20 (good for 3 yrs)
Review and file inventory reports of all radioactive materials available for State of Tennessee review. Shall include the following materials and data: ❑ Sources ❑ Samples ❑ Radioactive Waste ❑ Activity of each radionuclide ❑ Listed in a format that can easily be compared with the license limits ❑ Generation date (filled and transferred to storage) of all radioactive waste	Radioactive Materials License	X			License on file in RSO office.
Review file to assure that management audits of the RPP are retained.	TBE-7007	X			Retained in RSO's files.
Review file to assure that State of Tennessee audits of the RPP are retained.	TBE-7007	X			8/31/2020 audit retained in RSO's office.

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
Radioactive Waste "Broker" information is current and on file. ❑ DOT HAZMAT training certification for the broker's shipper, and ❑ Radioactive material licenses for the consignee that the broker ships to, and ❑ "License for Delivery" issued by the State of Tennessee (Current –issued each year)	TBE-7009	X			Need 49CFR172, Subpart H for individuals that picked up the waste. Broker: Chase Environmental Group, Inc. TN Rad Waste License for Delivery License Number: T-KY003-L20 Expires: December 31, 2020
Review that all shipment manifests (with attached information) and acknowledgement receipts are available for the last 4 months. These records are retained for the life of the facility.	TBE-7007	X			
VIII SOURCE CONTROL	TBE-7006				
Review file of Seal Source inventories. 2 should be conducted annually. Records shall be retained for at least 3 years.				X	None
Review file of Seal Source leak tests. 2 should be conducted annually. Records shall be retained for at least 3 years.				X	
Review records to assure individuals performing Sealed Source leak tests have been trained IAW TBE requirements.				X	
Sources numbered and included on last inventory.				X	
Records for disposal of non-exempt sources are retained for review.				X	
IX TRAINING					
Performance of "sealed" source leak tests	TBD			X	
Respiratory wearer training	TBD			X	

COMPLIANCE ISSUE	REFERENCE	STATUS			COMMENTS
		SAT	UNSAT	NA	
Initial and annual Radiation Worker Training. Confirm New employees trained prior to working with radioactive materials.		X			Abbygail Ochs trained 6/2020.
Individuals preparing and shipping packages with radioactive materials are trained in accordance with 49 CFR subpart H.	49 CFR subpart H "Training"	X			Kenny Cooper trained in basic 49 CFR 172, Subpart H Sep.17,2021-Sep. 27, 2024 Keith Jeter and Karli Arterburn were certified in Advanced Mixed Waste Transportation 49CFR 172, Subpart H Nov 20, 2020 – Nov 20, 2023.
Individuals checking in package have been trained to properly survey, document and report radiological problems relative to the received packages.	TBE-7001	X			Kenny Cooper trained to TBE 7001

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-13

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Radiation/Safety Program	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2 5.4.6.4.5.2	Affected Data: N/A
NCR Description: Audit Finding NCR 6 - No battery check record for rad survey equipment - see supplement page	
Client Notification Needed: ☐ YES ☒ X NO	Associated CAR or CC #:
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New Requirement for DOE Accreditation	
Corrective Action Plan: Add "Battery Check" column to Daily Response Check Form	
Planned Completion Date(s) for Actions(s): 09/23/22	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Jete	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO N/A Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

Supplemental Sheet

NCR No: 22-13

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 6 - No record of battery check for the survey equipment used at sample receipt. This finding is accordance with the requirements stated in the DOE QSM 5.4 V1M2 5.4.6.1.5.2.

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4.

The battery check is performed on radiation survey instruments prior to use but it was not previously recorded.

Corrective Action to Prevent Recurrence:

The battery check for radiation survey instruments will be included and recorded on TBE Form KQA 48 Daily Response Check. (see attached form)

Keith Jete — 9/23/22

Department Manager or Designee — Date

Shawn L Norment — 09/23/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 5 - Minor ☐ Repeat? [a]	**Finding** – The radiation protection program has not been reviewed since 2018 **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.1.1.2** The laboratory shall review, at least annually, the radiation protection program content and implementation. The records of audits, reviews, and inspections for the last five years maintained and readily available for review.
NCR 6 - Minor ☐ Repeat? [a]	**Finding** – The survey equipment used in the sample receipt, there is not a battery check. **Objective Evidence** - Interview of QA manager	**DOE QSM 5.4 V1M2 5.4 6.1.5.2** Prior to performing radiological surveys, is the radiological survey instrumentation checked for operational performance using a radiological source, a battery check, and a measurement of the nominal background is measured
NCR 7 - Minor ☐ Repeat? [a]	**Finding** –There is not a HAZWOPER trained person on staff. **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.3.17** The laboratory shall have a Hazardous Waste Operator and Emergency Response (HAZWOPER) trained person on staff. Also, Backup personnel with appropriate training for the Emergency Response (HAZWOPER) trained personnel.
NCR 8 - Minor ☐ Repeat? [a]	**Finding** – Various instruments have not been verified **Objective Evidence** – 1. Mechanical volumetric pipette (pipette 19) 2. Volumetric labware (plastic graduated cylinders and beakers used throughout the laboratory)	**DOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1: Mechanical volumetric pipette** Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on minimum of 3 replicate measurements) [Note: for variable volume pipettes, verify at the volume of use or using two volumes that bracket the range of use]
NCR 9 - Minor ☐ Repeat? [a]	**Finding** – the waste brokering provider has not been evaluated within the last three years **Objective Evidence** – Interview of QA manager	**DOD QSM 5.4 V1M2 6.2.2.3** Waste brokering and TSDF evaluation shall be based upon the results of a site visit to the waste facility or a desktop review that includes information from audits of the facilities conducted by state or federal agencies. The evaluation shall include liability coverage, financial stability, any Notices of Violations (NOVs) from the last three years, relevant permits and licenses to accept the waste, and other relevant information.
NCR 10 - Minor ☐ Repeat? [a]	**Finding** – There is not a record of the weekly monitoring of the waste disposal area not is there any secondary containment of for the drums in the area. **Objective Evidence** – Visual inspection of was storage area.	**DOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** The waste storage area shall provide secondary containment of sufficient capacity for the waste expected to be stored in the areas. Waste storage areas, and containers of waste shall be monitored weekly by an operator or someone knowledgeable in waste operations specific to this facility.

TBE-ES Daily Response Check

Inst. Model		Ludlum 3		Ludlum 2221		Bicron		Lud 177 (H1)		Lud 177 (H2)		Lud 177 (F1)		Lud 177 (F2)		Lud 177 (F3)		Ludlum 3		Ludlum 3		Ludlum 3		Battery Check (each model) ✓	Initials
Ser. No.		303316		97815		C315G		155773		155773		155773		155773		155773		142277		142277		81105			
Probe Model		44-9		43-90		N/A		44-25		44-25		44-26		44-26		44-26		44-9		44-38		44-9			
Ser. No.		PR184648		PR145796		N/A		PR155835		PR155835		PR158430		PR158430		PR158430		PR030982		PR037763		PR184595			
Source		Sr-90, Y-90		Th-230		Cs-137		Sr-90, Y-90		Sr-90,Y-90		Sr-90,Y-90		Sr-90, Y-90		Sr-90,Y-90		Sr-90, Y-90		Sr-90, Y-90		Sr-90, Y-90			
Ser. No.		95SR2200464		95TH2200529		1 MICRO CI		95SR2200464		95SR2200464		95SR2200464		95SR2200464		95SR2200464		95SR2200464		95SR2200464		95SR2200464			
Avg																									
20%																									
+ 20%			Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		Sat (Y or N)		
- 20%																									
Date	Day	kcpm		kcpm		µR/hr		kcpm		kcpm		kcpm		kcpm		kcpm		Kcpm		mR/hr		kcpm			

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-14

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Radiation/Safety Program	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2 6.3.17	Affected Data: N/A
NCR Description: Audit Finding NCR 7 - No trained HAZWOPER on staff - see supplement page	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-24
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New Requirement for DOE accreditation	
Corrective Action Plan: Lab Operations Mgr & Lab Supervisor to complete training course ASAP	
Planned Completion Date(s) for Actions(s): 12/01/22	
Prepared By: Keith Jeter	Date: 9/23/22
Approved By: Sharon L Northcutt	Date: 09/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 10/28/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 10/28/22

Supplemental Sheet

NCR No: 22-14

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 7 - There is no HAZWOPER trained person on staff. This finding is in accordance with the requirements stated in the DOE QSM 5.4 V1M2 6.3.17.

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4.

Corrective Action to Prevent Recurrence:

The Lab Operations Manager and Lab Supervisor will complete HAZWOPER training ASAP.

Keith Jete — 9/23/22

Department Manager or Designee — Date

Sharon L Northcutt — 09/23/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 5 - Minor ☐ Repeat? [a]	**Finding** – The radiation protection program has not been reviewed since 2018 **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.1.1.2** The laboratory shall review, at least annually, the radiation protection program content and implementation. The records of audits, reviews, and inspections for the last five years maintained and readily available for review.
NCR 6 - Minor ☐ Repeat? [a]	**Finding** – The survey equipment used in the sample receipt, there is not a battery check. **Objective Evidence** - Interview of QA manager	**DOE QSM 5.4 V1M2 5.4 6.1.5.2** Prior to performing radiological surveys, is the radiological survey instrumentation checked for operational performance using a radiological source, a battery check, and a measurement of the nominal background is measured
NCR 7 - Minor ☐ Repeat? [a]	**Finding** –There is not a HAZWOPER trained person on staff. **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.3.17** The laboratory shall have a Hazardous Waste Operator and Emergency Response (HAZWOPER) trained person on staff. Also, Backup personnel with appropriate training for the Emergency Response (HAZWOPER) trained personnel.
NCR 8 - Minor ☐ Repeat? [a]	**Finding** – Various instruments have not been verified **Objective Evidence** – 1. Mechanical volumetric pipette (pipette 19) 2. Volumetric labware (plastic graduated cylinders and beakers used throughout the laboratory)	**DOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1: Mechanical volumetric pipette** Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on minimum of 3 replicate measurements) [Note: for variable volume pipettes, verify at the volume of use or using two volumes that bracket the range of use]
NCR 9 - Minor ☐ Repeat? [a]	**Finding** – the waste brokering provider has not been evaluated within the last three years **Objective Evidence** – Interview of QA manager	**DOD QSM 5.4 V1M2 6.2.2.3** Waste brokering and TSDF evaluation shall be based upon the results of a site visit to the waste facility or a desktop review that includes information from audits of the facilities conducted by state or federal agencies. The evaluation shall include liability coverage, financial stability, any Notices of Violations (NOVs) from the last three years, relevant permits and licenses to accept the waste, and other relevant information.
NCR 10 - Minor ☐ Repeat? [a]	**Finding** – There is not a record of the weekly monitoring of the waste disposal area not is there any secondary containment of for the drums in the area. **Objective Evidence** – Visual inspection of was storage area.	**DOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** The waste storage area shall provide secondary containment of sufficient capacity for the waste expected to be stored in the areas. Waste storage areas, and containers of waste shall be monitored weekly by an operator or someone knowledgeable in waste operations specific to this facility.

C.14

We recommend you print this page. Print

Dear Karli Arterburn,

Thank you for shopping at 365 Training and Certification. We received your order 15776308. If you have any questions or concerns about your order, you can contact us by e-mail at support@360training.com or by phone at 1-877-881-2235. Thanks again for shopping at 365 Training and Certification

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Order Details

Order Number: 15776308
Order date: October 28, 2022

Account Information

To access your course(s):

HAZWOPER 40 Hour Plus GHS Hazardous Communication

Use the following login information:

Login:	Click here to begin your courses
Username:	karterburn
Forgot Password:	Click here to reset your password
Email:	Karli.Arterburn@Teledyne.com
Phone:	(423) 284-0413
Address:	2508 Quality Lane Knoxville TN United States 37931

Product	Qty	Each	Total
HAZWOPER 40 Hour Plus GHS Hazardous Communication SKU: HAZWOPER40GHS	2	$255.00	$510.00

Karli Arterburn

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-15

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Both Environmental & In-Plant Labs	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2 5.5.13.1(f)	Affected Data: N/A
NCR Description: Audit Finding NCR 8 - Various instruments have not been verified - see supplement page	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-15
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New Requirement for DOE accreditation	
Corrective Action Plan: a) QA Mgr to verify labware used in DoE workgroups b) LIMS programming to increase pipette verification from 1 to 3 replicates.	
Planned Completion Date(s) for Actions(s): 12/01/22	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Gale	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☒ Accepted ☐ Rejected	
☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO NA	22. Date:
Description:	
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

Supplemental Sheet

NCR No: 22-15

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 8 - Various instruments have not been verified according to the requirements stated in the DOE QSM 5.4 V1M2 5.5.3.1(f) Table 5-1.

Non-volumetric (not Class A or B) labware must be verified by lot before first use and upon evidence of deterioration. Bias specs: mean within 3% of nominal volume; Precision specs: RSD ≤ 3% of nominal volume (based on 10 replicate measurements).

Mechanical volumetric pipettes must be verified daily before use. Bias specs: mean within ± 2% of nominal volume; Precision specs: RSD ≤ 1% of nominal volume (based on a minimum of 3 replicate measurements). *For variable volume pipettes, verify using two volumes that bracket the range of use.*

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4.

Thile TBE's lab equipment is verified according to TNI Standard required specifications, the DOE QSM is more stringent.

Corrective Action to Prevent Recurrence:

Non-volumetric labware including beakers, graduated cylinders and centrifuge tubes will be verified prior to use for all DOE workgroup samples.

LIMS programming to record pipette verification using 3 replicate measurements. The precision and bias in LIMS is currently 1%, unless directed otherwise by manufacturer specs.

Keith Gete — 9/23/22

Department Manager or Designee — Date

Shawn L Nesbitt — 09/23/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 5 - Minor ☐ Repeat? [a]	**Finding** – The radiation protection program has not been reviewed since 2018 **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.1.1.2** The laboratory shall review, at least annually, the radiation protection program content and implementation. The records of audits, reviews, and inspections for the last five years maintained and readily available for review.
NCR 6 - Minor ☐ Repeat? [a]	**Finding** – The survey equipment used in the sample receipt, there is not a battery check. **Objective Evidence** - Interview of QA manager	**DOE QSM 5.4 V1M2 5.4 6.1.5.2** Prior to performing radiological surveys, is the radiological survey instrumentation checked for operational performance using a radiological source, a battery check, and a measurement of the nominal background is measured
NCR 7 - Minor ☐ Repeat? [a]	**Finding** –There is not a HAZWOPER trained person on staff. **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.3.17** The laboratory shall have a Hazardous Waste Operator and Emergency Response (HAZWOPER) trained person on staff. Also, Backup personnel with appropriate training for the Emergency Response (HAZWOPER) trained personnel.
NCR 8 - Minor ☐ Repeat? [a]	**Finding** – Various instruments have not been verified **Objective Evidence** – 1. Mechanical volumetric pipette (pipette 19) 2. Volumetric labware (plastic graduated cylinders and beakers used throughout the laboratory)	**DOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1: Mechanical volumetric pipette** Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on minimum of 3 replicate measurements) [Note: for variable volume pipettes, verify at the volume of use or using two volumes that bracket the range of use]
NCR 9 - Minor ☐ Repeat? [a]	**Finding** – the waste brokering provider has not been evaluated within the last three years **Objective Evidence** – Interview of QA manager	**DOD QSM 5.4 V1M2 6.2.2.3** Waste brokering and TSDF evaluation shall be based upon the results of a site visit to the waste facility or a desktop review that includes information from audits of the facilities conducted by state or federal agencies. The evaluation shall include liability coverage, financial stability, any Notices of Violations (NOVs) from the last three years, relevant permits and licenses to accept the waste, and other relevant information.
NCR 10 - Minor ☐ Repeat? [a]	**Finding** – There is not a record of the weekly monitoring of the waste disposal area not is there any secondary containment of for the drums in the area. **Objective Evidence** – Visual inspection of was storage area.	**DOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** The waste storage area shall provide secondary containment of sufficient capacity for the waste expected to be stored in the areas. Waste storage areas, and containers of waste shall be monitored weekly by an operator or someone knowledgeable in waste operations specific to this facility.

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-16

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Rad Waste Program	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2 6.2.2.3	Affected Data: N/A
NCR Description: Audit Finding NCR 9 - Waste brokering provider not evaluated in the past 3 years	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-24
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New Requirement for DoE accreditation	
Corrective Action Plan: Evaluate Waste broker for Approved Supplier list adding to	
Planned Completion Date(s) for Actions(s): 12/01/22	
Prepared By: Sharon L Northcutt	Date: 09/23/22
Approved By: Keith Jeter	Date: 9/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected	
☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 09/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 09/23/22

C.16

Supplemental Sheet

NCR No: 22-16

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 9 - The waste brokering provider has not been evaluated within the last three years. This finding is in accordance with the requirements stated in the DOE QSM 5.4 V1M2 6.2.2.3.

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4. The last annual evaluation found was from March, 2018 completed by the former ES&H Manager.

Corrective Action to Prevent Recurrence:

Complete evaluation of Chase Environmental Group ASAP (by 12/01/22).

Keith Gotte 9/23/22

Department Manager or Designee Date

Shawn L Nostrant 09/23/22

Quality Assurance Manager or Designee Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 5 - Minor ☐ Repeat? [a]	**Finding** – The radiation protection program has not been reviewed since 2018 **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.1.1.2** The laboratory shall review, at least annually, the radiation protection program content and implementation. The records of audits, reviews, and inspections for the last five years maintained and readily available for review.
NCR 6 - Minor ☐ Repeat? [a]	**Finding** – The survey equipment used in the sample receipt, there is not a battery check. **Objective Evidence** - Interview of QA manager	**DOE QSM 5.4 V1M2 5.4 6.1.5.2** Prior to performing radiological surveys, is the radiological survey instrumentation checked for operational performance using a radiological source, a battery check, and a measurement of the nominal background is measured
NCR 7 - Minor ☐ Repeat? [a]	**Finding** –There is not a HAZWOPER trained person on staff. **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.3.17** The laboratory shall have a Hazardous Waste Operator and Emergency Response (HAZWOPER) trained person on staff. Also, Backup personnel with appropriate training for the Emergency Response (HAZWOPER) trained personnel.
NCR 8 - Minor ☐ Repeat? [a]	**Finding** – Various instruments have not been verified **Objective Evidence** – 1. Mechanical volumetric pipette (pipette 19) 2. Volumetric labware (plastic graduated cylinders and beakers used throughout the laboratory)	**DOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1: Mechanical volumetric pipette** Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on minimum of 3 replicate measurements) [Note: for variable volume pipettes, verify at the volume of use or using two volumes that bracket the range of use]
NCR 9 - Minor ☐ Repeat? [a]	**Finding** – the waste brokering provider has not been evaluated within the last three years **Objective Evidence** – Interview of QA manager	**DOD QSM 5.4 V1M2 6.2.2.3** Waste brokering and TSDF evaluation shall be based upon the results of a site visit to the waste facility or a desktop review that includes information from audits of the facilities conducted by state or federal agencies. The evaluation shall include liability coverage, financial stability, any Notices of Violations (NOVs) from the last three years, relevant permits and licenses to accept the waste, and other relevant information.
NCR 10 - Minor ☐ Repeat? [a]	**Finding** – There is not a record of the weekly monitoring of the waste disposal area not is there any secondary containment of for the drums in the area. **Objective Evidence** – Visual inspection of was storage area.	**DOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** The waste storage area shall provide secondary containment of sufficient capacity for the waste expected to be stored in the areas. Waste storage areas, and containers of waste shall be monitored weekly by an operator or someone knowledgeable in waste operations specific to this facility.

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-17

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☒ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Rad Waste Program	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2 6.2.3.3 & .7	Affected Data: N/A
NCR Description: Audit Finding NCR 10 - No record of weekly monitoring of waste disposal area; no secondary containment of drums in the area - see attached supplement	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-27
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: NEW Requirement for DOE accreditation	
Corrective Action Plan: New form KQA-50; Purchase Containment Pallets.	
Planned Completion Date(s) for Actions(s): 12/01/22	
Prepared By: Sharon L Northcutt	Date: 10/10/22
Approved By: Keith Gete	Date: 10/10/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 10/10/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 10/10/22

C.17

Supplemental Sheet

NCR No: 22-17

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 10 - There is no record of the weekly monitoring of the waste disposal area and there is no secondary containment of sufficient capacity for the waste expected to be stored in the area. This finding is in accordance with the requirements stated in the DOE QSM 5.4 V1M2 6.2.2.3.

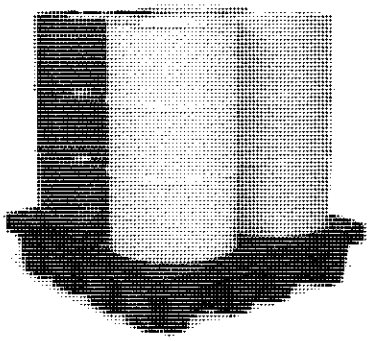
Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4. Weekly inspections were being done, but there was no record.

Corrective Action to Prevent Recurrence:

Weekly monitoring will be recorded on TBE Form KQA 49 (see attached for example).

For secondary containment of sufficient capacity for waste drum storage, the lab will purchase containment pallets ASAP.



Keith Gete — 10/10/22

Department Manager or Designee — Date

Sharon L Noonan — 10/10/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 5 - Minor ☐ Repeat? [a]	**Finding** – The radiation protection program has not been reviewed since 2018 **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.1.1.2** The laboratory shall review, at least annually, the radiation protection program content and implementation. The records of audits, reviews, and inspections for the last five years maintained and readily available for review.
NCR 6 - Minor ☐ Repeat? [a]	**Finding** – The survey equipment used in the sample receipt, there is not a battery check. **Objective Evidence** - Interview of QA manager	**DOE QSM 5.4 V1M2 5.4 6.1.5.2** Prior to performing radiological surveys, is the radiological survey instrumentation checked for operational performance using a radiological source, a battery check, and a measurement of the nominal background is measured
NCR 7 - Minor ☐ Repeat? [a]	**Finding** –There is not a HAZWOPER trained person on staff. **Objective Evidence** – Interview of QA manager	**DOE QSM 5.4 V1M2 6.3.17** The laboratory shall have a Hazardous Waste Operator and Emergency Response (HAZWOPER) trained person on staff. Also, Backup personnel with appropriate training for the Emergency Response (HAZWOPER) trained personnel.
NCR 8 - Minor ☐ Repeat? [a]	**Finding** – Various instruments have not been verified **Objective Evidence** – 1. Mechanical volumetric pipette (pipette 19) 2. Volumetric labware (plastic graduated cylinders and beakers used throughout the laboratory)	**DOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1: Mechanical volumetric pipette** Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on minimum of 3 replicate measurements) [Note: for variable volume pipettes, verify at the volume of use or using two volumes that bracket the range of use]
NCR 9 - Minor ☐ Repeat? [a]	**Finding** – the waste brokering provider has not been evaluated within the last three years **Objective Evidence** – Interview of QA manager	**DOD QSM 5.4 V1M2 6.2.2.3** Waste brokering and TSDF evaluation shall be based upon the results of a site visit to the waste facility or a desktop review that includes information from audits of the facilities conducted by state or federal agencies. The evaluation shall include liability coverage, financial stability, any Notices of Violations (NOVs) from the last three years, relevant permits and licenses to accept the waste, and other relevant information.
NCR 10 - Minor ☐ Repeat? [a]	**Finding** – There is not a record of the weekly monitoring of the waste disposal area not is there any secondary containment of for the drums in the area. **Objective Evidence** – Visual inspection of was storage area.	**DOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** The waste storage area shall provide secondary containment of sufficient capacity for the waste expected to be stored in the areas. Waste storage areas, and containers of waste shall be monitored weekly by an operator or someone knowledgeable in waste operations specific to this facility.

TBE Weekly Hazardous Waste Container Inspection Checklist

Inspection Date	Inspection Time	Inspector Name

Number of Containers Inspected	Location of Container(s)

Evaluation and Action

**All "YES" responses mean no issues found. A "NO" response means a discrepancy exists that requires immediate corrective action. Notify the Lab Operations Manager and/or RSO/Safety Manager and record action(s) taken below.

Inspection Checklist	YES / NO
Are containers properly and clearly labeled and dated?	
Are containers tightly closed?	
Are there any signs of leaks, stains or spills?	
Are containers free of dents, bulging and/or corrosion (no evidence of deterioration)?	
Are spaces between containers clear of debris?	
Are wastes stored in compatible containers?	
Are drums securely & safely stacked?	
Are incompatible wastes properly segregated?	
Is the ECO funnel properly secured & latched?	
Does each container have adequate secondary containment for its volume?	
Are flammable wastes properly stored and grounded/bonded?	
Are "Hazardous Waste" signs in place and clearly visible?	
Are all waste containers stored inside the waste storage area?	
Is the total volume of wastes stored beow the facility's generator status?	
Is an eyewash station and operational?	
Is emergency communication/warning device information posted and properly working?	
Is spill response equipment adequate and accessible?	

Corrective Action Taken

Description:

Manager Name (print)	Manager Signature	Date

Inspection Checklist Reviewed by:

Name (print)	Signature	Date

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-18

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☐ XCHK Failure ☐ Staff Observation	
Process Area: Safety & Radiation Program	Client/Project Affected: N/A
Requirement Reference: QSM 5.4 v1M2 6.1.3.1-.2	Affected Data: N/A
NCR Description: Audit Finding NCR 11 - No alternate or backup RSO on staff - see attached supplement	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-28
Prepared By: Sharon Northcutt	Date: 09/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: New Requirement for DOE Accreditation	
Corrective Action Plan: Lab Supervisor attend training ASAP; Temporary RSO alternate from Teledyne Oak Ridge facility	
Planned Completion Date(s) for Actions(s): 12/16/22	
Prepared By: Keith Otto	Date: 10/20/22
Approved By: Sharon L Northcutt	Date: 10/20/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action ☑ Accepted ☐ Rejected	
☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 10/20/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description:	22. Date:
23. Prepared By: Sharon L Northcutt	24. Date: 10/20/22

C.18

Supplemental Sheet

NCR No: 22-18

Description of Nonconformance:

ISO 17025 DoD/DOE Audit finding NCR 11 - The laboratory does not have an alternate or backup RSO with the necessary training and experience to perform the duties of the RSO in the event that the RSO is not available. This finding is in accordance with the requirements stated in the DOE QSM 5.4 V1M2 6.1.3.1-.2.

Root Cause:

This is a new requirement for TBE to be in compliance with QSM 5.4

A vacancy was created due to the former RSO separating from TBE. The replacement staff member is in internal training but has not completed all aspects as of the initial ISO 17025 September 2022 audit.

Corrective Action to Prevent Recurrence:

The Lab Supervisor has registered for the next available RSO course available (December 12-16). In the interim, the RSO for the Teledyne Oak Ridge Facility has agreed to be the designated backup.

Keith Gete — 10/20/22

Department Manager or Designee — Date

Sharon L Northcutt — 10/20/22

Quality Assurance Manager or Designee — Date

PJLA

NONCONFORMANCE REPORT

NUMBER & TYPE (Major, Minor or Observation)	FINDING & OBJECTIVE EVIDENCE	REQUIREMENT
NCR 11 - Minor ☐ Repeat? [a]	**Finding** – The laboratory does not have an alternate or backup RSO with the necessary training and experience to perform the duties of the RSO in the event that the RSO is not available. **Objective Evidence** – Interview of RSO..	**DOE QSM 5.4 V1M2 6.1.3.1; DOE QSM 5.4 V1M2 6.1.3.2** The laboratory shall have an alternate or backup RSO with the necessary training and experience to perform the duties of the RSO, in the event that the RSO is not available. Initial and refresher training of the RSO and the alternate RSO will be identified and completed on an established frequency.

[a] an Identify assessment Number and NCR# in the objective evidence discussion.

Note: Corrective Action Responses shall be submitted **within 60 days** on the organization's internal corrective form in accordance with the standard. Corrective Actions should be sent to CA@pjlabs.com.

SUBMITTED BY ASSESSOR:

Name: Albert Ellis Signature: _____ Date: 9/21/2022

ACCEPTED BY CAB:

Name: _____ Signature: _____ Date: _____

ASSESSOR CORRECTIVE ACTION ACCEPTANCE: (with receipt of evidence of corrective actions)

Assessor Signature: _____ Date: _____

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-19

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☒ XCHK Failure ☐ Staff Observation	
Process Area: Environmental Laboratory	Client/Project Affected: TBE XCHK
Requirement Reference: TBE-4006	Affected Data: L#97815
NCR Description: Failed cross-check for AP Pu-238	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-33
Prepared By: Sharon Northcutt	Date: 11/22/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: See attached Supplemental Sheet	
Corrective Action Plan: CAR 22-33 – digest AP entirely before aliquotting and prep.	
Planned Completion Date(s) for Actions(s): 12/01/22 (next XCHK in 2023)	
Prepared By: Keith Jete	Date: 12/1/22
Approved By: Sharon L Northcutt	Date: 12/01/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action: ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 12/01/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO (QA Rept) Description:	Date:
Prepared By: Sharon L Northcutt	Date: 12/01/22

Supplemental Sheet

NCR No: 22-19

Description of Nonconformance:

The 3Q22 ERA MRAD result for AP Pu-238 was above the upper acceptable limit. The reported result was 38.8 pCi and the known was 29.9 pCi (acceptable range of 22.6 - 36.7).

Investigation:

All steps of the sample prep and counting were done according to the procedure. The only slight difference for this sample was that the original AP sample that was received was cut in half prior to digestion, as Fe-55 and U were also analyzed from this sample. All QC was satisfactory and there was no impact on any other samples in the workgroup. The remaining sample was reprepped with a similar result (higher than the upper limit).

Root Cause:

The AP crosscheck was mistakenly cut in half prior to digestion. We feel that there may have been just enough more of the spike on the half that was used for the analysis that pushed the result a bit higher.

Corrective Action to Prevent Recurrence:

This is the first failure for AP Pu-238 since starting these in 2021. Prior results were within 98-101% of the known. Going forward, AP cross check samples will be digested entirely prior to prep and then aliquots taken for individual analyses.

Keith Jete 12/1/22

Department Manager or Designee Date

Sharon L Northcutt 12/01/22

Quality Assurance Manager or Designee Date

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-20

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☒ XCHK Failure ☐ Staff Observation	
Process Area: Environmental Lab	Client/Project Affected: TBE
Requirement Reference: TBE-4006	Affected Data: L#98038
NCR Description: Failed cross-check for Total U (water)	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: N/A
Prepared By: Sharon Northcutt	Date:11/23/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: See Supplemental Sheet attached	
Corrective Action Plan: No corrective action needed at this time.	
Planned Completion Date(s) for Actions(s): 11/23/22	
Prepared By: Sharon Northcutt	Date:11/23/22
Approved By: Keith Jett	Date: 11/23/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action: ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 11/23/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description: (Qtrly QA Report)	Date:
Prepared By: Sharon L Northcutt	Date: 11/23/22

C.20

Supplemental Sheet

NCR No: 22-20

Description of Nonconformance:

The 4Q22 ERA RAD result for Water Uranium (total) was above the upper acceptable range. The reported result was 10.54 pCi/L and the known was 8.53 pCi/L (124% recovery). The known range was 6.60 – 9.88 pCi/L.

Root Cause:

The result with associated error was 10.54 pCi/L +/- 3.18, which would be in the acceptable range (with error). This sample was also used as the workgroup duplicate and counted on a different detector. Its result with error was 8.20 pCi/L +/- 2.9 (96.1% recovery). The reported result was chosen because the yield was slightly higher than the WG duplicate's yield. Both results (with error) are in the acceptable range. Both results are within TBE's acceptable QC range of 70% - 130%.

Corrective Action to Prevent Recurrence:

No corrective action is needed at this time, as the reported result was within the acceptable range (with associated error) and was within TBE's acceptable range for QC results.

Keith Jete — 11/23/22

Department Manager or Designee — Date

Sharon L Northcutt — 11/23/22

Quality Assurance Manager or Designee — Date

TELEDYNE
BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-21

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☒ XCHK Failure ☐ Staff Observation	
Process Area: Environmental Laboratory	Client/Project Affected: TBE XCHK
Requirement Reference: TBE-4006	Affected Data: L#97722
NCR Description: Failed cross-check for AP Co-60	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: N/A
Prepared By: Sharon Northcutt	Date:12/01/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: The reported result was 207 pCi and the known was 147 pCi (141% ratio). This sample was used as the workgroup duplicate and counted on a different detector with a result of 167 pCi (114%). Historical results for AP Co-60 have ranged from 91%-141% with a mean of 91%.	
Corrective Action Plan: No corrective action needed at this time as it's the first failure for this nuclide for AP.	
Planned Completion Date(s) for Actions(s):	
Prepared By: Sharon L Northcutt	Date: 12/01/22
Approved By: Keith Gete	Date: 12/01/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action: ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 12/01/22

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO QA Rept Description:	Date:
Prepared By: Sharon L Northcutt	Date: 12/01/22

TELEDYNE BROWN ENGINEERING

NONCONFORMANCE REPORT (NCR) FORM

NCR No.: 22-22

Responsible Manager: Sharon Northcutt

PART 1. TO BE COMPLETED BY ORIGINATOR OF NCR	
Initiated due to: ☐ Customer Complaint ☐ Audit/Mgmt Rept ☒ XCHK Failure ☐ Staff Observation	
Process Area: Environmental Laboratory	Client/Project Affected: TBE XCHK
Requirement Reference: TBE-4006	Affected Data: L#97595
NCR Description: Failed cross-check for WO Tc-99	
Client Notification Needed: ☐ YES ☒ NO	Associated CAR or CC #: CAR 22-34
Prepared By: Sharon Northcutt	Date: 12/15/22

PART 2. TO BE COMPLETED BY ROOT CAUSE INVESTIGATOR	
Root Cause: See attached Supplemental Sheet	
Corrective Action Plan: N/A	
Planned Completion Date(s) for Actions(s): 01/05/23	
Prepared By: Sharon L Northcutt	Date: 12/29/22
Approved By: Keith Gite	Date: 12/29/22

PART 3. TO BE COMPLETED BY QUALITY ASSURANCE MANAGER	
Review and Verification of Corrective Action: ☑ Accepted ☐ Rejected ☐ Follow-up Needed (describe) ☐ Completed	
Prepared By: Sharon L Northcutt	Date: 01/05/23

PART 4. TO BE COMPLETED BY RESPONSIBLE MANAGER	
Client Follow-Up Notification: ☐ YES ☑ NO Description:	Date:
Prepared By: Sharon L Northcutt	Date: 01/05/23

Supplemental Sheet

NCR No: 22-22

Description of Nonconformance:

The 3Q22 MAPEP result for Water Tc-99 was not acceptable. The reported result was 1.86 +/- 0.414 Bq/L and the known was a "false positive".

Root Cause:

According to the MAPEP handbook, "Not Acceptable (N) performance, and hence a false positive result, is indicated when the range encompassing the result, plus or minus the total uncertainty at three standard deviations, does not include zero (e.g., 2.5 +/- 0.2; range of 1.9 to 3.1). A result greater than three times the total uncertainty of the measurement represents a statistically positive detection with over 99% confidence."

TBE's reported result with 3 times the uncertainty resulted in a slightly positive net result (0.62 Bq/L). This sample was used as the workgroup duplicate with a result of 0.88 +/- 0.374 Bq/L. Using the MAPEP logic, this result would have been acceptable.

Corrective Action to Prevent Recurrence:

No corrective action is needed at this time, as the workgroup duplicate would have been acceptable, and this was the first unacceptable result since TBE resumed reporting water Tc-99 in the 3rd quarter of 2020. Since that time, results have ranged between 94-109% of the known.

Keith Jeter 11/5/23

Department Manager or Designee Date

Shawn L Northcutt 01/05/23

Quality Assurance Manager or Designee Date

ATTACHMENT D

Audit Reports

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D.1

INTERNAL AUDITS

TELEDYNE BROWN ENGINEERING
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INTERNAL AUDIT REPORT

Audit Plan

Auditor: Charles Hurst (Lead), Joy White	Audit Date: 14-16 November 2022	Audit No.: 2022-029
Auditee(s): Sharon Northcutt, TBE Knox Lab	Methods: Review of objective evidence, documentation, and through interview of personnel	
Scope: TBE Knoxville Lab Operations Criteria: TBE Knoxville Quality Manual	Tools: AS9100D Aerospace Standard (or other standard as noted in Scope & Criteria), K-QAM-1 Rev 35, Process Specifications, Internal Audit Checklists, associated forms, and other tools as needed	

Date	Time	Area / Department / Process / Function	Key Contact
14-16 Nov	Various	TBE Knoxville Lab Quality program and lab operations	Keith Jeter, Sharon Northcutt, Casey Dearcop, Tyler Cavin, Donna Webb, Hillary Wellnitz

Process Effectiveness Assessment Report (PEAR)

Process Name: TBE Knoxville Quality System and Operations

Process details, including associated process interfaces:

Personnel training, Contracts management, method verification, handling of tests, results reporting, nonconformances, corrective actions.

Applicable AS9100 clause(s): N/A. This annual internal audit is conducted for the purpose of assessing TBE Knoxville Lab's quality system as documented in the Quality Assurance Manual for Teledyne Brown Engineering Environmental Services, Document K-QAM-1, Rev 35, effective August 15, 2022, and associated implementing Procedures. A specific checklist was developed and used for this audit. The completed checklist is attached to this form.

Organization's method for determining process effectiveness:

- Audit results
- NCRs generated
- Other external audits
- Customer Complaints

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INTERNAL AUDIT REPORT

Auditor observations and comments supporting process effectiveness determination:

The quality program and lab operations of TBE Lab Knoxville were well documented, organized and implemented. All required information was readily available, and all involved in the audit were very helpful and knowledgeable.

Statement of Effectiveness Level:

The process is:

☐ 1. Not implemented; planned results are not achieved.

☐ 2. Implemented; planned results are not achieved, and appropriate actions not taken.

☐ 3. Implemented; planned results are not achieved, but appropriate actions being taken.

☒ 4. Implemented; planned results are achieved.

Auditor Name(s): Charles Hurst (Lead), Joy White	Auditee Representative Acknowledgement Name: Sharon Northcutt

Audit Summary

The results of this audit are documented in the attached checklist.

There were zero (0) findings noted during the course of this audit with three (3) Opportunities for Improvement recommended

Based on the results of this audit, TBE Knoxville Lab QA program and operations are determined to be effectively implemented.

Note: The 2023 internal audit of the Knoxville Lab will be shifted to earlier in the calendar year to correspond to the ISO 17025 external audit. The internal will be conducted 1-2 months prior to the external and will be based on the ISO 17025 checklist.

Previous Year's Finding

REF	Requirements	Observation, Comments, Objective Evidence	ACC	REJ
	NONE			

Current Year Audit Findings and Opportunities for Improvement (OFI's)

REF	Requirements	Observation, Comments, Objective Evidence	ACC	REJ
		Three (3) OFIs as noted in the attached checklist	X	

Checklist – See Attached Checklist

REF	Requirements	Observation, Comments, Objective Evidence	ACC	REJ

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
	Section 6.2 Personnel		
6.2.1	The QA Manager maintains the training matrix for the lab and ensures that procedure update or annual quality and/or safety-related training is complete	**SAT**	2022 Training matrix was reviewed and found to provide extensive coverage of procedures/methods. The following records were reviewed and found to be current to the training matrix: - Kenny Cooper - Tyler Cavin - Donna Webb - Casey Dearcop
6.2.2	Job descriptions that include duties and responsibilities for all staff are available for review.	**SAT**	Reviewed job descriptions for the following positions: 1) PM, 2) Lab Technician, 3) Sample Receiving/Login Technician All included the following elements: - Position Summary and Responsibilities - Minimum Education/Experience Requirements - Job Advancement Opportunity
6.2.4	Analysts must be recertified if: a) not enough QC data has been generated to support annual requirement or b) there are significant changes to a procedure	**SAT**	Training record reviews indicated process for managing this requirement is in place and appears affective. Procedure revision training was indicated by training records reviews as noted elsewhere in this checklist. In the case of insufficient QC data to support annual requirements, this is managed by the QA Manager through standard reporting generated b y LIMS that identifies the qualities of materials works by analysts. Any that fall short of the annual requirements are identified and reported to the lab manager so workload can be adjusted, when possible, to allow sufficient data to justify annual recertification per the QAM.
6.2.5	Staff Responsibilities & Authorities *NOTE: Some positions may be filled as a dual role with another position*	**SAT**	The TBE Knox lab org chart is maintained on the TBE website and was accessed to evaluate this section. The list was easily accessible and contains extensive information for each employee to include position, contact information, and years of service.

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
6.2.5.1	Lab Operations Manager a. directing all aspects of normal business operations, including strategic planning, staff management and meeting TBE profitability objectives; b. supervising the establishment of client programs and ensuring review of proposals, contracts, and purchase orders to determine adequate personnel, equipment, training and procedure needs to meet referenced requirements; c. monitoring the validity of analyses performed and data generated in the laboratory to assure reliable data, as well as reviewing results for accuracy and signing final client reports (*Reports may be signed by the QA Manager or other qualified designee if needed)*; d. ensuring that clients are contacted regarding non-standard or out-of-spec results (c*lient contact may be performed by a qualified designee)*; e. defining qualifications, experience and skills necessary for each staff position and verifying that lab technicians demonstrate initial and continuing proficiency in their assigned procedures;	**SAT**	Position has been filled by the incumbent for several years. As demonstrated throughout the audit, the person is very knowledgeable in the requirements for running this lab and satisfies all the requirements as detailed in this section of the manual

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
6.2.5.3	Quality Assurance Manager g. conducting or arranging for periodic internal audits and management reviews, as well as coordinating external audits;	**SAT**	The QAM exercises a wide breadth of control and engagement with all aspects of lab operations. She conducts extensive internal audits of the multitude of procedures, generates managements review documentation, coordinates numerous external audits, and maintains document control of training records, forms and procedures. Two surveillances have been conducted in 2022: • 3/17/22 TBE-2020 Rev 5 • 8/19/22 TBE-2014 Rev 8 Multiple internal audits were conducted in 2022. The following were reviewed and found to be complete: • TBE-1001 Rev 6 • TBE-1013 Rev 7 • TBE-1018 Rev O
6.2.5.4	Project Managers (PMs) b. entering and maintaining client information for contacts, reporting, billing, and technical specifications into the LIMS h. documenting and investigating client complaints j. maintaining a storage system for lab reports and other documents required to be kept for a specified time period	**SAT**	Engagements with PMs in other sections of this checklist demonstrated a high level of professionalism and quality among their team. They were knowledgeable, helpful, and diligent in their job performance and in meeting the requirements of the QAM. The following customer complaints were reviewed and found to be in compliance with this manual: • CC-22-01, Client = WCS • CC-22-03, Client = Entergy RBS • CC-22-07, Client = Exelon Limerick

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
6.2.5.5	Sample Custodian b. thoroughly reviewing paperwork and containers received with shipped packages and noting inconsistencies or damage and informing the Project Manager Immediately	**SAT**	The sample custodian receives in all samples, reviews all paperwork and verifies that the samples received match the associated paperwork. Any discrepancies are documented on a copy of the chain of custody as well as the variance report and the PM is also notified. Reviewed L98349 (LIMS ID for samples), some of the glass sample bottles arrived broken and this was documented on the variance report and a copy of the chain of custody. The PM was notified immediately. A very recent higher, and auditing engagement with this position demonstrated a job level of job knowledge and performance. Training record reviews documented a high level of initial training and indoctrination for the position.
6.2.5.6	Laboratory Technicians d. identifying potential sources of error and correcting problems that could affect data quality	**SAT**	Laboratory technicians are identified on the org chart and were directly engaged during the audit demonstrated knowledge and capability for the position. Corrective Action documentation reviewed indicated awareness of opportunities/requirements to identify improvements/concerns in correcting errors. During interview with Lab Technician, it was noted the lab technicians feel that they can bring forth any ideas or improvements when needed.

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
6.2.5.9	Health & Safety Officer c. performing safety checks and audits	**SAT**	Reviewed reports with facility Health & Safety Officer. Items reviewed/notes: - AFTAC Program Weekly Safety Walk-through indicated regular weekly inspections are being conducted as required - AFTAC Monthly Environmental Safety Report also indicated regular assessment and documentation as required - AFTAC Fire Extinguisher Monthly reports reviewed were found to be current and well documented - TBE Huntsville conducts annual, informal Health and Safety visits - Teledyne Corporate conducts formal inspections every 2-3 years. Last conducted was 2021.
6.2.5.10	Radiation Safety Officer (RSO) b. coordinating scheduled radiological surveys and administer personal dosimetry and sealed radioactive source leak test programs	**SAT**	The RSO RPP Annual Assessment was just completed by TBE Huntsville Environmental, Health & Safety representatives on 10 November 2022. No findings were issued, and one observation was noted. In reviewing the audit checklist, it appears the TBE Knox lab was in good compliance with all aspects of the RSO program.
	Section 7.0 Process Requirements **7.1 Review of Requests, Tenders and Contracts**		
7.1.1	Review of Requests, Tenders and Contracts Initial requests for quote or for additional analytical work are assigned a project manager who verifies that the scope of work is clearly defined and reviews the request against current laboratory procedures and capabilities.	**SAT**	Reviewed Quote (Q713) for soil samples, it was assigned to Karli (PM) and the scope was asking for nuclide testing with given tolerance ranges on the soil samples. The PM has an excel sheet which list the labs testing capabilities and all required nuclides were listed on the sheet when verified.
7.1.2	The response to request will include lab procedure and/or analytical method with appropriate accreditation information (where needed).	**SAT**	The response to request typically does not include the lab procedure or method in any of the quote process unless required by the customer. The final report lists SOPs (test methods) next to the nuclide that was tested. Reviewed Project ID VE705-3EFINALSUR-22, final report, listed SOP TBE-2000 next to the respective nuclide.

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
	Section 7.0 Process Requirements **7.4 Handling of Test Items**		
7.4.2	Sample Acceptance Upon receipt, a log is kept documenting each shipping container received	**SAT**	When sample boxes/containers are received, the appropriate bar code is scanned in the Knox Lab database as well as the bar code for the type of box received. Verified that the 32 boxes received from Riverrun were received in appropriately.
7.4.3	Identification Once approved, each sample is given a LIMS-generated unique laboratory ID (L#). Information associated with each sample is carried through the entire analytical process included: sample ID, collection date and/or time, receipt date/time, requested analysis, results of sample inspection. All sample containers are given a durable label using indelible ink that indicates the project ID, L#, the number of containers and the storage locations(s).	**SAT**	Once the samples have been matched against the chain of custody paperwork and have been verified to be in acceptable condition the samples are logged into the LIMS database. The LIMS database assigns a UID to each sample. Observed L98515 being created as L98515-1, L98515-2, L98515-3. The sample label is printed and attached to each sample with the following information: LIMS IUD, date, and numbers of containers. ***Note:*** *The sample label currently does not have the project ID listed as described per the QMS but the folder that contains all the paperwork/data for the samples has its own label which does have the project ID. This was addressed during the audit.*
7.4.4	Sample Storage Samples are stored away from standards, reagents, and food for human consumption.	**SAT**	Samples are stored away from standards, reagents, and food. The sample are stored in the stockroom, freezers, refrigerators, or bins.
	Section 7.0 Process Requirements **7.5 Technical Records**		
7.5.1	The laboratory maintains a documentation system for quality records of the analytical process.	**SAT**	The QA Manager maintains all the quality documents and keeps the originals in fireproof cabinets. The LIMS database maintains all records of the testing data and is maintained by the LIMS administrator.

Item	Line of Inquiry	Status	Summary of Observations/Objective Evidence, Reviewed/Audit Notes
7.5.2	Amendments to original records are signified by a single stroke through the incorrect information with a brief explanation (unless obvious). The person making the change initials and dates the change.	**SAT**	Everyone receives training on the QMS manual which describes this correction process. This is also noted in SOP methods such as TBE-2011, page 11, section 10.3 Corrections.
7.5.3	Quality records retention is based upon several factors, including client contract or regulatory requirement. Physical records are retained onsite for 2-3 years and then logged and shipped to the TBE Huntsville storage facility. All records are kept at a minimum of 7 years, unless classified as "permanent' (kept for the life of the project or facility). Electronic records are kept indefinitely. *(TBE-1003 Control and Retention of Quality Assurance Records, TBE-1008 Documents and Document Control, TBE-6001 LIMS Raw Data Processing, Reporting and Backup)*	**SAT**	The LIMS database will store all data points indefinitely. Unless each contract specifies record retention, the labs standard timeframe is 2/3 years and then the documents are sent offsite to storage.
	Section 7.0 Process Requirements **7.6 Evaluation of Measurement Uncertainty**		
7.6.3	TBE includes a 1- or 2-sigma combined standard uncertainty (CSU) [aka Total Propagated Uncertainty (TPU)] value with all analytical results, depending on client request.	**SAT**	TBE lab includes a 1- or 2-sigma combined standard uncertainty value with all analytical results. If the client requests the final report to not include the SCU then it is not in the final report but is present in the LIMS report.

	Section 7.0 Process Requirements **7.7 Ensuring the Validity of Results**		
7.7.3	Analytical Batches The Lab's analytical system is shown to be in control using batch and sample-specific QC. All samples must be placed in a workgroup batch and processed with appropriate QC. Batch size is dependent upon the method, but generally consists of one (1) to twenty (20) samples plus QC. All batch samples are processed together in the same manner (preparation, analysis, data reduction and reporting). Batch samples are not required to be analyzed concurrently on the same detection system. The lab does not systematically or preferentially use specific detectors, equipment, or glassware for analyzing QC samples. Two types of batches in the radiochemical lab are: a. Preparation Batch - samples require physical or chemical processing that affect the outcome of the analysis. Samples are prepared with the same process, personnel and lot(s) of reagents, with a maximum time between the start of processing of the first and last sample to be 24 hours. b. Radiation Measurements Batch (RMB) - samples require no physical or chemical processing that could affect the outcome of the test. Examples are: non-destructive gamma spectrometry, air filters for alpha/beta counting, or swipes on gas proportional detectors. Samples may be processed within fourteen (14) calendar days (start of the first sample to the last sample).	**SAT**	All samples are assigned a workgroup using the LIMS database. Once assigned a workgroup, the samples have a workgroup ID. a. Preparation batches, observed WG40667, Tritium 2011 (H-3) in LIMS being selected for analysis. The workgroup contained 20 samples plus one blank, one spike and one duplicate preparation for a total of 23. The LIMS software generated the list of required reagents for the analysis, NaOH pellets and $KMnO_4$. All workgroup samples are prepared together using the same method(s), reagents, and diluent(s). Once prepared the samples are given to the lab technicians in the count room for sample analysis. The maximum time between the start of processing of the first and last sample is 24 hours. Lab technician calibrated balance #13, C033887187 before use (last cal. 3/25/22 next due 3/31/23 follows TBE-3006) and the data is stored in LIMS. Tolerance was 1% and LIMS will flag an alert if outside the tolerance. Used weight set #2, S/N 15721 (last cal. 3/28/20 and cal due. 3/20/25) Lab technician verified pipette ENV #6 before use (last cal. 10/3/22 and cal. due 1/1/23) and the data is stored in LIMS. Pipettes are calibrated once every quarter by QA Manager. b. RMB samples received in for non-destructive gamma spectrometry are placed on their respective instruments and then the testing begins. The samples requiring gamma are tested as soon as possible upon receipt due to the short half-life of Iodine. Samples are processed within 14 days of receipt.

7.7.4	QC Samples Process control checks demonstrate consistent lab quality. These checks that include QC and proficiency samples, constitute 10% of the annual processing workload for lab analytes and methods.	**SAT**	Reviewed data from LIMS indicating that 10% of samples tested/processed are QC proficiency samples. OE: P-32, 21% were QC proficiency samples.
7.7.5	Interlaboratory and Client Proficiency Testing To further ensure the validity of results, TBE regularly participates in various proficiency testing (PT) studies during the year. These external performance checks (aka cross-checks) are samples with an unknown amount of analyte added. Internal PT samples are obtained from and reported to accredited proficiency testing providers. Some clients also routinely send their own cross-check samples. All PT samples are received, analyzed, and processed in the same manner as routine samples. Internal PT results are reported directly to the PT provider and the results sent back to the lab and its accrediting body (where applicable). Clients report their cross-checks to the PT provider directly and final evaluations are not always shared with the lab. Although all radionuclide or matrix combinations are not available for proficiency testing. TBE makes every effort to analyze PT samples that are representative of routine client samples. Cross-check results that are not within the provider's acceptance criteria are documented with a root cause investigation, corrective action (where merited) and a non-conformance report (NCR). (TBE-4006 "Interlaboratory Performance Evaluation Programs")	**SAT**	TBE performs proficiency testing regularly by either purchasing samples or testing samples received from clients. TBE does is unaware of the level of spike added to the samples. The samples are received in and processed the same as the non-proficiency samples. If the results obtained by TBE are not comparable to the expected results, then a RCCA and NCR are initiated. If the client does not give TBE the expected results, the results obtained are still given to the client no additional work is required. There have not been any recent NCRs for this issue. Reviewed RAD 129 report for samples which were purchased for proficiency testing through ERA. The study dates were 4/04/22-5/19/22 and the report was issued on 5/23/22. All results reported were acceptable. This type of testing is performed every 6 months.

	Section 7.0 Process Requirements **7.8 Reporting of Results**		
7.8.2	Required Items Sample results are compiled into a report and contain the following items: a. title (Report of Analysis or ROA) b. name and address of the laboratory (where analyses are performed) c. unique identification that correlates individual pages to the entirety of the report d. contact name/address of the client e. sample description information (ID, collection date/time) and lab ID information f. sample receipt date, condition and any sample acceptance criteria variance g. TBE Procedure (SOP) ID h. test result (activity) directly as obtained with appropriate number of significant figures, measurement uncertainty estimation, detection limit (MDC), measurement units, reference date, count date/time, and flagged values (results outside of technical specifications) i. notation for method changes (if applicable) j. name, title and signature of the person(s) authorizing the report k. statement that results relate only to the items tested l. statement that the report shall not be reproduced, except in full without approval of the laboratory m. clear identification of any subcontracted analyses and results	**SAT**	Reviewed sample report for SORA-2-02-007-F-S a) Report of Analysis for C of C b) TBE 2508 Quality Lane Knoxville, TN 37931 c) L98014 d) Gerald Wood, Vernon VT e) Collection date time varies but all were listed, SORA-2-02-007-F-S f) 10/10/22, variance report was accepted with no discrepancies g) Yes, each SOP was listed next to the test performed h) Yes, all information was listed i) N/A j) Report authorized by Keith k) Yes l) Yes No subcontracted analyses for this report

	Section 7.0 Process Requirements **7.9 Client Complaints**		
7.9.2	Complaint Resolution Process a. Staff receives and documents complaint on TBE KQA-22 Complaint Detail Form. b. Complaint is investigated promptly and if warranted a Non-Conformance Report that includes a root cause evaluation and corrective action is initiated. (Section 7.10) c. A decision is made regarding the complaint resolution such that all parties involved are in agreement and are satisfied with the outcome (client notification and approval). d. Suitable response is taken by the lab to prevent recurrence (where applicable).	**SAT**	a) Reviewed Customer Complaint CC 22-09. Documented on form KQA-22, Rev. 3, 5/15/20 Samples L96852 b) The complaint was investigated, and a CAR was initiated, CAR 22-13. The technician selected the wrong geometry when setting up the instrument parameters. The data was able to be re-processed. c) Once the investigation was completed the report was revised and re-distributed to the client. At this time the client had not responded back yet with the new report results, so it is assumed to be in agreement with the client. d) Because this was the first time this issue had happened the corrective action was to verbally discuss with the technicians to be more diligent when setting up these parameters.
	Section 7.0 Process Requirements **7.10 Nonconforming Work, Corrective and Preventative Actions**		
7.10.3	When a nonconformity is discovered, the following steps are taken: a. Nonconformance is initiated by the responsible staff and documented on form KQA-9 Nonconformance Report (NCR) Form. The nonconformance is given a unique identifier, added to the NCR log, and a brief summary including requested completion date recorded on the form. b. The NCR is relinquished to the appropriate manager for evaluation of significance, including work stoppage where appropriate. The manager conducts a root cause investigation to determine the source of the departure	**SAT**	a.) Reviewed NCR 22-07, (form KQA-9 Rev. 6), it was added to the NCR log which is maintained by the QA Manager, and it had a summary which included a requested completion date of immediately. Samples were contaminated by a cleaning agent before they were logged in and placed in their storage location. b.) The NCR 22-07 was relinquished to the appropriate manager who conducted a root cause. c.) CAR 22-16 was initiated after the root cause analysis was completed (form KQA-40 Rev. 0). The client was notified by the PM who wrote a Case Narrative which is generated out of LIMS. d.) The QA Manager closed the CAR and stated that it would be re-evaluated in 6 months from 9/29/22. The training record was

	from the standard. The manager will also update the parties involved as to the progress towards resolution. c. After the root cause analysis is completed, a corrective action plan is developed with the Operations Manager (or other involved staff). The Operations Manager or designee determines the acceptability of nonconforming work and where necessary, the client may be notified, and the work recalled. d. The Operations Manager or designee authorizes the resumption of work (where necessary). The QA Manager tracks the progress of the NCR through closure and evaluates the effectiveness. (Section 8.7). The target date from NCR initiation to corrective action plan is 30 days. Note: More complex issues may require more time.		attached (KQA-8 Rev. 3) which included anyone who has permission to log in samples.
	Section 7.0 Process Requirements **7.11 Control of Data and Information Management**		
7.11.2	Any changes to the LIMS software configuration or modifications to commercial software are authorized, documented and validated before use.	**SAT**	Any changes to the LIMS software that will affect the results has to be approved by the Operations Manager. Any changes to LIMS that do not affect the results are permitted acceptable and the LIMS administrator can proceed with the requested change. Reviewed a request from a PM to enhance LIMS so that the SAMPLE volume would show when added later. The LIMS administrator verified that it would work and then dated the day that he completed the request. Any major changes to LIMS software require validation which is performed by the LIMS administrator using tables and conversions.
7.11.3	TBE-ES LIMS is only accessible by trained staff with assigned security levels based upon job function. Changes to LIMS programming are documented and can only be accessed by the LIMS Manager.	**SAT**	Each staff member is assigned a role in LIMS which is based upon their job function and which permissions they need daily. When a new person is hired, they are added to LIMS and then assigned a role such as lab technician or PM. All changes to LIMS programming are documented and retained by the LIMS administrator.
7.11.6	Only the most current document revisions are available on the shared network drive. This includes TBE procedures as well as the Safety and QA Manuals. All staff have access at all times to these documents.	**SAT**	All revisions on the shared network drive are the most current. Verified TBE-2003 Rev. 6 (5/28/21) matched online and in the original book in the QA Managers office. All staff have computer access with access to the shared network.

	Section 8.0 Quality Management System (Option A) **8.2 Management System Documentation**		
8.2.3	The QMS allows only qualified personnel to review/update/perform specific procedures. It encourages integrity, impartiality and consistency in daily lab operations at all levels.	**SAT**	All documents reviewed where signed/authorized by qualified personnel. Training records were sampled to document completeness of training to include: - Kenny Cooper - Casey Deacop - Tyler Cavin - Donna Webb
	Section 8.0 Quality Management System (Option A) **8.3 Control of Management System Documents**		
8.3.1	TBE-ES maintains control of documents that relate to the QMS, including training, procedures, audits, corrective actions, management reviews, forms, and the QA Manual. (TBE-1008 "Documents and Document Control")	**SAT**	Current document revisions were observed throughout. Only current document revisions are maintained on the QAM controlled SharePoint site, while original, hardcopy documentation is maintained in file cabinets in the QAM's office. All appear to be maintained IAW the requirements of this manual and TBE-1008
8.3.2	Controlled documents are periodically reviewed and updated as necessary. Only authorized personnel can approve and issue controlled documents. All staff whose work is affected by changes are notified and trained to the revision.	**SAT**	All controlled documents reviewed showed review within the 3 years currently required by procedure. Based on the pursuit of ISO 17025 certification, that requirement will revert to an ANNUAL review of all technical procedures and documents IAW the requirements of IS 17025. That certification is currently pending based on a recently completed external audit and will likely be implemented in 2023.
8.3.4	Original signed QMS documents are stored in the QA Manager's office and/or stored electronically on TBE's shared computer network drive. Only current pdf copies of QMS documents are available for access and distribution and include the disclaimer "DOWNLOADED or PRINTED copies are UNCONTROLLED".	**SAT**	Access to documents is maintained as stated here. Documents reviewed in the QAM storage area/online included: - Training records - Position descriptions - Procedure revisions - Audit & surveillance schedules and results

	Section 8.0 Quality Management System (Option A) **8.4 Control of Records**		
8.4.1	Quality and technical records are maintained in accordance with TBE Procedures TBE-1003 "Control and Retention of Quality Assurance Records" and TBE-1008 "Documents and Document Control".	**SAT**	See sections 8.3.1 – 8.3.4 of this checklist
	Section 8.0 Quality Management System (Option A) **8.6 Improvement**		
8.6.2	Actions are taken in response to trends signifying deterioration in lab performance indicators such as quality data, repeated audit findings or turnaround times.	**SAT**	Trending, or other, issues are raised throughout the year and addressed via Corrective Actions. All employees, not just the Quality Manager, are encouraged to identify areas of concern and document them via the Corrective Action program where they are reviewed and work for potential process improvements.
8.6.3	Audits are performed to identify trends and offer suggestions for improvement.	**SAT**	An extensive list of procedure and process audits were observed to be conducted annually. These are all tracked via spreadsheet and a reviewed indicated all audits planned through October '22 had been conducted. Audit reports existed for each of the completed audits.
8.6.3.4	Lab quality performance is reviewed and summarized in a quarterly QA Report. Audits and nonconformance/corrective actions are also included in the report. This report is distributed to TBE management and is also available for clients. A summary of this report is included with the Annual Management Report.	**SAT**	The Q2 2022 QA Report, the most recent completed, was signed 11/4/22. Review of this report demonstrated a good, overall assessment of the state of the lab's quality performance. The most recent Annual Management report was reviewed and found to be mostly conforming to the requirements of this manual. The report was issued on 15 April 2022 for CY22. This represents a significant improvement in timeliness from previous years when the annual reports were not completed until halfway into the proceeding year. ***Opportunity for improvement (#1)****: Since the generation of the CY21 Management report, the Quality Manual has been revised to now include requirements for reporting and assessing Risks and Opportunities periodically. A good way to begin meeting this would be to address these areas in the upcoming CY 22 Management report.*

	Section 8.0 Quality Management System (Option A) **8.7 Corrective Actions**		
8.7.1	Corrective action is taken as the result of a departure from specifications imposed by client contract, regulatory requirement or TBE stated policy or procedure. It is a measure taken to discover the source of a deviation and to avoid similar issues going forward. Corrective action is taken promptly and to a degree appropriate to the magnitude and risk of the issue. Conditions adverse to quality are documented and tracked with proposed and actual completion dates. (*TBE-1018 "Corrective/Preventative Action and Nonconformity Control"*)	**SAT**	Numerous Corrective Actions were reviewed. These included: • CC-02 • CD-05 • CC-06 • CC-15 • CC-15 All were found to be fairly well documented and demonstrated a highly engaged team effort to identify and mitigate potential quality issues: ***Opportunity for improvement (#2)****: The corrective action program could be improved by focusing additional effort in the following areas:* 1. *Do not close out Corrective Actions until sufficient time has passed to accurately assess the effectivity of any corrective actions made as a result of the Root Cause Corrective Action (RCCA). A few reports (22-06, 22-13, 22-16, 22-19 among others) were observed to have been initiated an closed in a very short period of time that likely did not allow sufficient time to properly evaluate actions taken.* 2. *Include more detailed information in section 3 of the CA report to more thoroughly detail actions taken as a result of the RCCA. The same applies for the closure section of the RCCA to provide supporting information for the effectiveness determination*
8.7.2	Nonconformities are documented on a Non-Conformance Report (NCR) Form. After investigation and analysis is complete, appropriate corrective action is taken and consequences are determined (where applicable). A target completion date is set for 30 days from initiation to corrective action plan. This date may be adjusted as deemed necessary due to the complexity of the	**SAT**	Nonconformances are documented and hardcopies retained in the Quality Manager's office. The following NCRs were reviewed and found to be in conformance with this manual: • CC-01 • CC-02 • CC-06

	nonconforming issue. Where analytical results are involved, data is monitored carefully until the issue is fully resolved. Notification is made to appropriate parties (where applicable). All NCR's are included with the quarterly/annual QA Report.		
8.7.3	Corrective action effectiveness is evaluated periodically to verify that measures put into place have been successful and/or to ensure that any nonconforming issue has not been repeated. A summary evaluation of corrective action of effectiveness is included in the annual management report.	**SAT**	Corrective Action effectiveness is evaluated on the CA forms during the process of closure and summaries are included in the annual report. As noted in the summary for 8.7.1 above, additional information could be included in the CA closure box to better substantiate the determination of effectiveness.
8.7.4	Risks and opportunities based on corrective actions taken are evaluated periodically by management. Changes to the management system may be made to limit vulnerability or exposure to potential risk or to promote more efficient lab operation.	**SAT**	***As noted in 8.6.3.4 above –*** ***Opportunity for improvement (#1)****: Since the generation of the CY21 Management report, the Quality Manual has been revised to now include requirements for reporting and assessing Risks and Opportunities periodically. A good way to begin meeting this would be to address these areas in the upcoming CY 22 Management report.*
	Section 8.0 Quality Management System (Option A) **8.8 Internal Audits**		
8.8.1	In order to detect actual or potential nonconformities before data quality could be affected, internal audits are planned and conducted. These audits verify conformance of lab operations and the management system to regulatory and accreditation requirements, and to the lab's own policies and procedures. (TBE-1013 "Audits and Management Review")	**SAT**	The Quality Manager develops and maintains a tracking spreadsheet with all CY internal audits listed. A review of the CY 22 audit scheduled demonstrated these audits are being conducted per the schedule and complete documentation is being maintained.

8.8.2	An internal audit plan is generated annually and includes the procedures and surveillances that are planned during the year. The goal is to review each area of the lab in some fashion. The plan is maintained by the QA Manager, but audits may be performed by other staff. Auditors are trained in performing audits, have some technical background in the subject matter, and are independent of the activity to be audited (not directly involved or have supervisory responsibility).	**SAT**	A review of the CY22 internal audit scheduled demonstrated all checks scheduled through Oct '22 have been completed and documentation of such is on-hand. 13 checks remain for CY22 and there is no reason to suspect those will not be completed as scheduled. Internal audit reports for the following were reviewed: • TBE-1015, completed 7/29/22 • TBE-2023, completed 11/2/22 • TBE-2027, completed 11/1/22 • TBE-3003, completed 10/13/22 • TBE-4019, completed 1/14 and 6/30 • TBE-1018, completed 11/11/22
8.8.4	An analytical procedure surveillance is scheduled to observe analysts as they perform a method to verify that it is being done as written and to note any changes that may need to be made to the written procedure. The results of the QC workgroup are included to show that the results are within control limits. All audit results are evaluated by the Operations Manager and any necessary changes are made where needed.	**SAT**	Method surveillance status is being actively tracked by the Quality Manager. For CY 22, two surveillances were completed: • TBE-2020 Rev 5 on 3/17/22 • TBE-2014 Rev 8 on 8/19/22 ***Opportunity for improvement (#3)****: With only 2 surveillances completed in CY22, a greater focus on this requirement should be made. The Quality Manager has had many competing priorities in CY22 with several major external audits being conduct. This resulted in a lesser than normal completion rate for surveillances. Expanding the number of persons qualified to perform such surveillances would be one possible way to level out this workload, expand the reach of the surveillance program and enhance professional development of the rest of the staff.*
8.8.6	Audit findings of nonconformances are documented and timely corrective action is taken, tracked to closure, and evaluated for effectiveness. An audit response including corrective action is sent to the auditor, (and to the Director of Quality Management Systems for the annual Quality System audit). Any findings that could cast doubt on the validity of results are disclosed in writing to the	**SAT**	Multiple external audit nonconformances were identified, documented and worked to resolution. A large number of internal audits were conducted that yielded no findings but several observations. The Quality Manager and Operations Manager are encouraged to assess the rigor of the internal

	affected client(s) within 7 days. The QA Manager (or designee) verifies that the client was contacted properly.		audits being conducted to ensure sufficient evaluation of their systems to more completely identify potential nonconformances.
	Section 8.0 Quality Management System (Option A) **8.9 Management Reviews**		
8.9.1	In conjunction with the Internal Audits (Section 8.9 above), the laboratory conducts an annual management review to ensure continuing suitability, adequacy, and effectiveness of stated policies and objectives in this Quality Manual. (TBE-1013 "Audits and Management Review")	**SAT**	The Management Review for CY21 was reviewed. The report was signed out on 4/22/12 which represents a significant improvement in timeliness of report completion which, in the past, could lag by 6 months from the end of the year. Timeliness is very important to accurately and effectively assess prior year performance to implement in required improvements.

8.9.2	The review includes: • a summary of any changes to the QA program from the previous year • adequacy of staff and equipment resources • a list of staff specialty training certificates with expiration dates • highlights from the 4th Qtr (annual) QA Report (QC sample and proficiency results • and audits) • an analysis of QA results (indication of analytical bias) • internal/external audit results and associated investigations and corrective actions • commentary on effectiveness of corrective actions • a listing of current accreditations and/or plans for any changes • comparisons of sample volume and turnaround times to previous years • client feedback not included with the QA Report • observations by staff for improvements • results of risk identification • any changes/updates to methodology • radiological health/safety, waste and management functions • a statement of management system effectiveness and fulfillment of objectives	**SAT**	All the elements noted in this section were found to be included in the CY21 Management Report with two exceptions: - results of risk identification - radiological health/safety, waste and management functions Both of these elements are being included in the CY22 report based upon CY22 audit results and other observations.
8.9.3	Upon completion of the draft review, the information is submitted to and signed by the Operations Manager and then signed by the QA Manager. Action items are assigned to designated responsible staff with an agreed-upon schedule for completion. The QA Manager ensures that actions are documented and completed. A copy of the signed report is sent electronically to the Sr VP of Energy & Environment and to the Director of Quality Management Systems (both TBE Huntsville management).	**SAT**	The CY21 Management Report was signed out and transmitted via email to the Sr VP of Energy and the Director of Quality.

D.2

EXTERNAL AUDITS

EA 22-01 NUPIC AUDIT

February 7 - 10, 2022

March 8, 2022

Ms. Sharon L. Northcutt
QA Manager
Teledyne Brown Engineering – Environmental Services (TBE-ES)
2508 Quality Lane
Knoxville, TN 37931-3133

Subject: Entergy Audit Report Number WT-WTHQN-2021-00564/
NUPIC Audit Report Number 25265

CEXO2022-00020

Dear Ms. Northcutt:

Enclosed is the audit report for Entergy Audit WT-WTHQN-2021-00564 conducted at the TBE-ES facility located in Knoxville, TN from February 7-10, 2022. The audit was performed to assess the implementation and effectiveness of the company's quality assurance program for providing radiochemical analysis of environmental samples, providing radiochemical analysis of radioactive waste samples, providing bioassays, and providing laboratory services.

The audit team concluded TBE-ES is effectively implementing its quality assurance program consistent with the applicable requirements of U.S. Nuclear Regulatory Guide 4.15. TBE-ES will be maintained on the Entergy Qualified Suppliers List (QSL).

While there were no program findings identified during the audit there were, however, two program deficiencies identified during the audit. These deficiencies were entered into your internal corrective action program. No written response is required to be sent to Entergy for the deficiencies. The actions you take for these deficiencies will be evaluated during the next NUPIC audit. Since there are no follow up actions required, this audit is closed based upon issuance of this report.

We would like to thank you as well as the entire TBE-ES staff for your cooperation and the courtesies extended to the team during the audit. Should you have any questions or require additional information, please contact Joseph Walker at 601-368-5542 or via email at jwalk15@entergy.com

Sincerely,

Alisha Johnson-Thomas

Digitally signed by Alisha Johnson-Thomas
Date: 2022.03.08 14:29:30 -06'00'

Alisha Johnson-Thomas
Supervisor, Supplier QA

AJT/JCW/jcw

Attachments:
1. Audit Report WT-WTHQN-2021-00564
2. Audit Checklist (Not to addressee)
3. PBSA Worksheet (Not to addressee)
4. Technical Specialist Resume/ Audit Team Orientation (Not to addressee)

Cc: Corporate File [75], w/a

Attachment 1

Audit Report WT-WTHQN-2021-00564

Audit Number: WT-WTHQN-2021-00564

Date(s) of Audit: February 07-10, 2022

Organization/Address: Teledyne Brown Engineering – Environmental Services
2508 Quality Lane
Knoxville, TN 37931-3133

Organization Contact: Sharon L. Northcutt, Quality Assurance Manager

Phone Number: (865) 934-0374

Supplier Product/Service:

Radiochemical analysis of environmental samples, providing radiochemical analysis of radioactive waste samples, providing bioassays, and providing laboratory services.

Audit Scope:

To evaluate the adequacy and implementation of the TBE-ES quality program for the product/service scope identified above. A performance-based auditing approach was used to evaluate the effectiveness and implementation of the TBE-ES quality assurance program as it relates to the referenced documents listed. The audit was performed using the part 1 of the NUPIC radiological audit checklist, revision 1.

Reference Documents:

QA Manual K-QAM-1, Rev. 34, Dated: 04/15/2021
Revision 1 to part 1 of the NUPIC radiological audit checklist

QA Program Requirements:

The TBE-ES QA Manual references both revision 1 and revision 2 to Regulatory Guide 4.15 due to variations in client contract language, as some utilities use revision 1 while others use revision 2 of Regulatory Guide 4.15. Typically, Regulatory Guide 4.15 Rev 2 (2007) provides additional details and descriptions with more current references to regulatory documents than revision 1 (1979). Specifically, Regulatory Guide 4.15 revision 2 changed the following elements:

- Section 8 from “Review and Analysis of Data” to V/V (data and software)
- Section 9 “Audits” was split into Assessments & Audits and Preventative & Corrective Actions (added Section 10)

In summary, the two revisions to regulatory guide 4.15 do not have conflicting guidance but provide greater detail with the actual references being provided in the different sections clarifying justifications for the requirements.

- Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs, Effluent Streams, and the Environment, Revisions 1, & 2

Compliance with 10CFR Part 21: ( ) YES (X) NO

Executive Summary and Program Effectiveness:

The results of the audit showed that for the orders reviewed TBE-ES is effectively implementing their quality assurance program in accordance with Regulatory Guide 4.15 to the extent that it is applied except for the 2 deficiencies noted in the report. In addition, the audit team concluded that the identified deficiencies have no adverse impact to the quality of the products and services previously or currently

being provided by TBE-ES. Based on this conclusion, TBE-ES will be re-qualified on the Entergy qualified suppliers list (QSL) to provide radiochemical analysis of environmental samples, radiochemical analysis of radioactive waste samples, bioassay analysis results, and laboratory services.

Audit Summary:

This re-qualification audit was performed and reported in accordance with applicable Entergy procedures utilizing revision 1 to part 1 of the NUPIC radiological audit checklist. During the audit, the team evaluated to the extent possible the implementation and adequacy of the TBE-ES QA program relative to Regulatory Guide 4.15. The audit scope included the following as defined in the Part 1 of the NUPIC radiological audit checklist:

Contract/Purchase Order Review
Organizational Structure and Personnel Responsibilities
Qualification of Personnel
Operating Procedures and Instructions
Records
Quality Control in the Radioanalytical Laboratory
Data and Computer Software Verification and Validation
Assessments and Audits
Preventive and Corrective Actions

TBE-ES's quality program implementation was verified through review of records, review of procedures, observations of laboratory testing/analysis activities, and interviews with personnel.

In addition to providing radiochemical analysis of environmental samples, bioassay analysis results, and laboratory services, TBE-ES also performs radiochemical analyses for utility plant site radioactive waste samples which fall under 10CFR61. For the radiochemical analyses performed for the utility plant site radioactive waste samples there are isotopes included that are in addition to the isotopes analyzed in the environmental samples. For waste samples, additional isotopes such as $^{89}_{38}$Sr, $^{90}_{38}$Sr, $^{63}_{28}$Ni ,$^{55}_{26}$Fe, $^{129}_{53}$I, $^{14}_{6}$C, $^{99}_{43}$Tc, $^{238}_{94}$Pu, $^{239}_{94}$Pu, $^{241}_{95}$Am, $^{243}_{96}$Cm, $^{244}_{96}$Cm, and $^{242}_{96}$Cm (i.e., isotopes of Strontium-89, Strontium-90, Nickel-63 Iron-55, Iodine-129, Carbon-14, Technetium-99, Plutonium-238, Plutonium-239, Americium-241, Curium-243, Curium-244, and Curium-242) are analyzed with the testing results being provided solely by TBE-ES as testing/analysis of these isotopes are not typically performed by the utilities. Since the utilities do not perform testing/analyses for these additional isotopes, the utilities do not perform a comparison of their testing/analysis results to the TBE-ES test results for waste samples for the purpose of assuring that the correct samples were submitted by the utility to TBE-ES. The utilities classify and characterize radioactive wastes using the test results provided by TBE-ES prior to contacting suppliers of waste disposal services for arrangement of shipments to the disposal sites. However, when classifying and characterizing radioactive wastes, some utilities may rely solely on TBE-ES test results, or some combination of their own analysis results and use TBE-ES test results only for those isotopes they are unable to test for or analyze at the utility plant site. Entergy uses TBE-ES results for characterization as well as classification of radioactive wastes. In addition, Entergy compares their own site testing/analysis results for environmental/bioassay samples to the TBE-ES test results for these environmental/bioassay samples to ensure that the correct environmental/bioassay test samples were shipped to TBE-ES.

The radioactive waste samples are handled in a separate part of the TBE-ES Knoxville, TN facility due to the potential for contamination and because the radioactivity levels of the waste samples are typically higher. There were no testing activities in process within the waste sample analysis area of the facility that could be observed during the audit. However, the audit team performed a walk-through of the laboratory area where the 10CFR Part 61 testing/analysis of waste samples is performed that allowed the audit team to verify laboratory conditions and laboratory equipment is suitably controlled. Also, the audit team verified that assigned personnel performing testing/analyses in the waste sampling laboratory were adequately qualified. In addition, the audit team observed the sample storage areas where the audit

team visually verified that waste samples are uniquely identified and stored in appropriately labeled locations allowing for easy retrieval.

The waste sample laboratory and the environmental sample laboratory are very similar with testing methods being similar or in some cases nearly identical. Based on these similarities and in the interest of efficiency, all the audit information was documented in part 1 the NUPIC radiological audit checklist with the applicable sections in part 4 of the radiological audit checklist not being used.

Audit Team:

Joseph C. Walker	Audit Team Leader	Entergy (ENT)
James L. Jones	Auditor	Entergy (ENT)
Brenda Mills	Auditor (in-training)	Entergy (ENT)
Alejandro Ramírez	Auditor	Comision Federal de Electricidad (CFE)
Evan Humes	Auditor	PSEG Nuclear LLC (PSE)
John S. Larson	Auditor	Nebraska Public Power District (NPPD)
Steve Lusk	Auditor	Tennessee Valley Authority (TVA)
James Reese	Technical Specialist	Entergy (ENT)

Personnel Contacted During the Audit:

Name	Title	A*	B*	C*
Arterburn, Karli	Project Manager	—	☒	☒
Cooper, Kenneth	Sample Receipt Custodian	☐	☒	—
Culston, Kristen	Laboratory Technician	—	⧖	—
Jeter, Keith	Laboratory Operations Manager	☒	☒	☒
McKanney, Kelly	Laboratory Technician	☐	☒	☐
Newton, John	Quality Management Systems Director	☐	☒	☒
Northcutt, Sharon	Quality Manager	⧖	☒	⧖
Thurman, Kim	Project Manager	☐	☒	⧖
Webb, Donna	Laboratory Technician	☐	☒	☐
Wright, Jim	Information Technology	☐	☒	☐

***A = Pre audit conference**
***B = During audit**
***C = Post audit conference**

Audit Finding(s) Summary:

No audit findings were issued during this audit.

Audit Deficiency Summary:

There were two deficiencies issued during the audit. The details of these deficiencies can be found in the checklist.

Technical Specialists Evaluation Summary:

TBE-ES provides analytical services for nuclear utility customers. Primary services offered by TBE-ES include the analysis for radiological effluents, environmental samples, 10CFR61 radioactive waste stream samples, and personnel bioassay samples. Areas reviewed included:

1. Sample Receipt Process Control
2. Laboratory Controls
3. Quality Control
4. Participation in a Laboratory Inter-Comparison Program

The assessment of processes consisted of direct observations of work activities, interviews of applicable personnel, the review of records, and the review of procedures.

The audit produced satisfactory results with one deficiency being noted for gamma spectroscopy calibrations. The current process does not require appropriate validation and verification of Excel spreadsheets used to over check hand calculated gamma radioactivity levels for diluted secondary calibration standards made using the primary NIST-traceable mixed gamma standard. While no errors in spreadsheet calculations were identified during the audit, not applying independent validation and verification (V&V) process controls, which are required for other software and hand calculations related to sampling analysis reporting allows an opportunity for spreadsheet programming logic errors to reduce the precision in the calibration of gamma detectors, thereby leading to inaccuracies for data produced during analysis of the samples. Post calibration checks would potentially not detect these errors because it is traditional industry practice for gamma radioactivity analyses to process the same diluted calibration standards and compare results to NIST certified values for each nuclide in the mixed gamma standard. As a result, inaccuracies for calibration of the gamma detectors would not necessarily reveal itself through analysis of the same standard. Depending on the magnitude of the error, daily quality control (QC) checks may possibly not detect the inaccuracies in the test data during calibration activities. Application of the independent V&V process for this spreadsheet would ensure precision of calibration for the detectors (See NCR 22-02 for additional details). Because this was an isolated event, and because no errors were identified this issue was a programmatic deficiency as there was no impact to quality.

Observations of personnel performance showed individuals were proficient in their assigned roles and they performed job assignments as required. The Laboratory Information Management System (LIMS) is used by TBE-ES to manage as well as store nearly all information related to receipt of customer samples, tracking of the analyses for these samples, calibration information for measuring and testing equipment (M&TE), and all other relevant information. The LIMS is a database management system that optimizes the TBE-ES business model which is to say that TBE-ES operates as a high-capacity production analytical lab. The LIMS ensures that traceability information is accurate and unique which allows ease of tracking for customer samples along with the associated analytical results. The LIMS also reduces the potential for human error during data entry when performing laboratory activities through use of laser scan man readable bar-coded labels facilitating the transfer of information into the LIMS and interchangeably between instruments integrated into the LIMS.

The results of the audit were satisfactory.

1. Sample Receipt Process Control

This section reviewed the processes related to sample receipt and inspection, sample storage, preparation and processing for analysis, analysis of samples, and reporting of results to the customer.

References:

TBE-2007 “Gamma Emitting Radioisotope Analysis”, Revision 10, 12/28/2019

TBE-2010 “Beta Activity by Liquid Scintillation (Direct Prep)”, Revision 6, 07/15/2020
TBE-2012 “Radioiodine in Various Matrices”, Revision 11, 06/15/2021
TBE-4003 “Sample Receipt and Control”, Revision 14, 06/05/2021
TBE-4009 “Detection Levels”, Revision 3, 01/09/2020
TBE-6010 “Laboratory Information Management Systems (LIMS)”, Original Version, 06/05/2019
TBE-7001 “Receiving Packaged Radioactive Materials”, Revision 12, 06/05/2019

Sample Receipt, Identification, Control, and Storage

Receipt inspection for four milk samples from the Susquehanna Steam Electric Station (SSES) was observed. The customer requested analyses for gamma-emitting radionuclides (γ) and the iodine 131 isotope ($^{131}_{52}$I). The customer’s chain of custody form was included with the shipment and was also electronically transmitted in a Microsoft WORD format to TBE-ES prior to sample arrival. The chain of custody WORD file is imported into the LIMS which minimizes the potential for human performance errors during data entry into the LIMS. The information for each sample was verified against the chain of custody form and a receipt checklist was completed to document that no discrepancies were noted. The LIMS generated a unique sample number along with computer-generated man readable bar-coded labels for each of the sample components. The individual labels containing the unique sample number was applied to each customer container. Samples were stored within the location identified by the location identifier which is also on the labels. The location identifier was also written on the outer refrigerator label for ease in locating samples for retrieval during analysis or disposal. The resulting receipt package was taken to the project manager for review and approval. Observations of the receiving inspection process was considered adequate and was effectively implemented.

The project manager for the environmental sample program performed a peer-check of the paperwork and documented approval electronically in the LIMS. This electronic approval is one of the numerous process overchecks ensuring the accuracy of sample information and that all specified analyses will be performed as required. These in-process inspections are a key part of TBE-ES quality controls. Approval by the project manager within the LIMS makes the data available to lab personnel when they query their work assignments for the day. The review/approval processes performed by project managers is adequate for assurance of accuracy in the LIMS information and was effectively implemented.

TBE-ES processes have minimal data entry relying primarily on file transfers for testing/analysis data as well as transfers of quality reviews by personnel. These largely automated processes for the LIMS minimize introduction of human performance errors in the system.

This process is unchanged from the previous audit. TBE-ES has established adequate measures for receipt of samples, identification of samples, control of samples, as well as storage of samples and is effectively implementing these measures.

Sample Preparation and Analysis

The four milk samples received from Susquehanna were observed during preparation for γ and $^{131}_{52}$I analyses. The γ analysis was completed first because this is considered a non-destructive examination in that none of the sample is consumed in the performance of this analysis. Preparation for performance of the $^{131}_{52}$I analysis required consumption of a large portion of the sample, so this analysis is performed last. Performance of the analyses in this order reduces the volume of sample required from the customer.

The milk samples had already been retrieved from the storage location identified in the LIMS prior to the observations of the analyses in the laboratory. The technician performing γ analysis queried the approved samples from the LIMS and printed sample labels for each of the 3.5-liter Marinelli beakers. After beakers were labeled and the samples were transferred to the beakers, the beakers were weighed on a digital scale and the sample weights were electronically transferred into the LIMS. Sample analyses were then performed using the γ spectroscopy detector system housed in thick shielding.

At completion of the γ analyses, the γ isotopic report was reviewed by the technician to verify sample identity, analysis parameters, and to ensure the required lower level of detection (LLD) values were met. Analysis results were forwarded to the laboratory operations manager for review. Upon completion of the review by the laboratory operations manager, the analysis results were transferred into the LIMS.

Even though no unidentified energy peaks were listed on the analysis report, the technician and laboratory operations manager were questioned about how unidentified energy peaks would be handled. This was a deficiency identified in the previous audit, although in the instances reported the unidentified energy peaks were secondary energy levels of radionuclides already identified as present in the samples (Previous NUPIC audit deficiency SR-2019-14-1 and TBE-ES NCR 19-09). In response to that audit, TBE-ES created and implemented a job aid where secondary gamma energies of radionuclides commonly identified in the samples are posted in the laboratory. These energy lines are not included in the γ spectroscopy libraries used by the software for radionuclide identification and quantification because their probability (yield) is too low for accurate quantification of activity level. However, these energy peaks may be detected and listed in the results as unidentified energy peaks. The job aid is used to determine if these energy peaks are secondary peaks of radionuclides already identified and quantified in the sample results. For unknown energy peaks not listed on the job aid, the laboratory operations manager would assist the technician in identifying the radionuclide(s) using the γ energy reference produced by TBE-ES, commonly known as the "Kocher" reference, calculating the resulting γ activity level, and updating the analysis report accordingly. This solution is satisfactory to ensure all radionuclides present in the sample are identified during analysis.

Following the γ analysis, the milk samples were prepared for $^{131}_{53}$I analyses. This is a more complex analysis that requires isolating $^{131}_{53}$I in the sample matrix using a combination of an anion resin, the addition of a stable iodine carrier, and the addition of binding agents as well as extraction chemicals to reduce the total iodine present to a palladium iodide ($_{46}$Pd-$_{53}$I) precipitate, which is filtered, dried, and weighed to determine chemical yield that will be used in the analytical calculations. Sample preparation steps using 4 liters for each sample were observed, but time constraints did not allow observation of the entire analysis. The analyst was questioned about the purpose of various portions of the sample preparation and was knowledgeable of the process. This complex extraction process produces the most consistent results if the analyst performs the analysis activities on a regular basis. Through personnel workflows and qualifications, TBE-ES ensures that each analysis is performed by a primary technician with backup technicians available if needed. This practice ensures the technician remains familiar with the complex analysis techniques thereby providing for consistent and accurate analytical results.

Sample results were provided for review by the laboratory operations manager after the analysis was completed. The laboratory operations manager must review/approve of the data before it is transferred to the LIMS. This independent review of the data ensures the required $^{131}_{53}$I LLD values are met. Sample analysis reports generated in the LIMS are reviewed and approved by a project manager before results are provided to the customer.

Samples are returned to storage following analysis and held for a period after sample test results have been provided to the customer. If the customer questions analysis results, the sample can be pulled for reanalysis assuming that enough sample remains in unaltered form.

The area of sample preparation and analysis is unchanged from the previous audit, apart from the addition of the job aid for unknown gamma energy peaks. This area is adequately controlled and effectively implemented.

2. Laboratory Controls

This section reviewed the controls of radionuclides, cleanliness, handling, and NIST traceability.

References:

TBE-2007 “Gamma Emitting Radioisotope Analysis”, Revision 10, 12/28/2019
TBE-2012 “Radioiodine in Various Matrices”, Revision 11, 06/15/2021
TBE-4002 “Quality Control Checking of Analytical Data”, Revision 6, 12/20/2019
TBE-4019 “Radioactive Reference Standard Solutions and Records”, Revision 7, 06/08/2021
TBE-ES Radiation Protection Program Manual, Revision 6

Control of Radionuclides

Radioactive source inventory and accountability is tracked in the LIMS. Tennessee Radioactive Materials License Number R-47173-G23 has an expiration date of 07/31/2028 and is unchanged since the previous audit. A random check of sources used in various areas of the laboratory indicated proper source identification and radiological markings. Most sources are maintained in common storage areas for adequate source control, but some sources such as tritium isotopes ($^{3}_{1}H$) and the carbon-14 isotopes ($^{14}_{6}C$) are required to be dark adapted prior to analysis due to the adverse effect laboratory lighting can have on these sources, which requires that these isotopes be maintained within the analytical instruments. This is a common practice for these sensitive, low-level sources.

Established controls for radionuclides are considered adequate and are being effectively implemented.

Cleanliness and Handling

Sample preparations for potentially radioactive samples was observed in multiple areas of the laboratory. Personnel demonstrated good radiological control practices and wore proper personal protective equipment. All samples were clearly marked with radioactive stickers where applicable. Radioactive waste receptacles were properly marked, and waste levels were not excessive. Personnel contamination monitoring instruments were properly maintained and in good condition and were also observed to be source checked as required. All personnel wore dosimetry as required when working with radioactive samples and materials.

There were no 10 CFR Part 61 waste samples received or analyzed during the audit, but the laboratory operations manager explained the process and how it differs from the environmental samples typically analyzed by the laboratory. Separate labs are used for analysis of these typically high activity samples where higher levels of personnel protection and radiological controls are required. The remaining portions of the Part 61 waste samples are typically not returned to the customer. Storage areas for waste samples is in an isolated portion of the facility that provides required shielding for dose reduction to personnel.

The laboratory areas and associated analytical measuring and testing equipment (M&TE) used for environmental sample analyses was observed to be clean and well maintained. It could be seen from observations of personnel cleaning up their work areas at the conclusion of their assigned activities each day that these activities were being performed as required. Review of inspection documentation for laboratory fume hoods and safety showers located within this area of the laboratory showed that inspections were being performed as required. Laboratory fire extinguishers were properly charged and mounted appropriately for quick access. Laboratory counter space was observed to be clean with fresh counter paper applied. Anti-fatigue padded floor mats were used throughout the laboratory areas to aid technicians who often stand for long periods of time performing assigned analysis activities.

Controls for cleanliness and handling were considered adequate as well as effectively implemented.

NIST Traceability

The γ spectroscopy detector calibration records were reviewed, along with the respective radionuclide source certificates providing objective evidence that NIST-traceable radionuclide sources are used in the calibration of M&TE. Primary liquid radionuclide source standards are used to make secondary radionuclide source standards in various sample geometries. Spreadsheets are used for sample dilution calculations. Documentation of the radionuclide source standard serial number for primary radionuclide sources was included on the printed spreadsheet pages contained in calibration records for the various sample geometries reviewed. This provided traceability to the primary radionuclide source standards. Several certificates for sealed radionuclide sources such as $^{3}_{1}H$ and $^{14}_{6}C$ were also provided for review showing there is clear traceability of instrument calibrations to the NIST traceable radionuclide source standards. The NIST traceable radionuclide source standard certificates are maintained along with instrument calibration records in fireproof cabinets. Certificates for the NIST traceable radionuclide source standards are also available from the various radionuclide source standard vendors upon request if the lab copy is damaged or lost. Controls which provide evidence of traceability for radionuclide source standards to NIST were considered adequate and noted to be effectively implemented.

3. Quality Controls

This section reviewed the instrument reference standards, calibration records and QC samples and trends.

References:

TBE-1009 “Calibration Systems”, Revision 7, 10/15/2021
TBE-3001 “Calibration and Control of Gamma-Ray Spectrometers”, Revision 8, 6/20/2021
TBE-3006 “Balance Calibration and Check”, Revision 4, 11/02/2018
TBE-3009 “Calibration, Use, and Maintenance of Pipettes and Pipettors”, Revision 4, 02/01/2019
TBE-4002 “Quality Control Checking of Analytical Data”, Revision 6, 12/20/2019
TBE-4005 “Quality Control Samples – Blanks, Spikes and Duplicates”, Revision 7, 8/31/2021
TBE-4011 “Quality Calculations and Charting”, Revision 3, 12/04/2019
TBE-4019 “Radioactive Reference Standard Solutions and Records”, Revision 7, 06/08/2021

A review of calibration records for several γ spectroscopy detectors, liquid scintillation detectors, and gas flow proportional counters was conducted as no calibrations were performed by the technicians during the audit. Quality control charts are typically maintained internally by the instrument software. When an instrument fails the QC checks, the technician removes the instrument from service and places an “Out of Service” sign on the instrument to prevent further use of the instrument until the problem is identified and resolved.

Instrument calibrations are performed only when required and are driven by QC check results. Some instruments haven’t required recalibration in more than 10 years which is a testament to the stability of the instrumentation and laboratory environmental conditions.

Observations during the audit indicated that adequate and accurate calibrations were performed for γ spectroscopy equipment. Part of the calibration process is the use of Excel spreadsheets to verify hand calculations of the γ radioactivity levels for secondary working radionuclide source standards made from NIST traceable primary radionuclide source standards. The audit identified that while current processes require validation and verification (V&V) of Excel spreadsheets used to calculate activity levels for the diluted secondary radionuclide source standards or spike standards, it was noted that the laboratory operations manager had created the spreadsheet to verify hand-calculated values for γ calibration radionuclide source standard dilutions. While this spreadsheet was initially validated and verified by the laboratory operations manager prior to use, it was not independently verified and validated by the QA manager. This was discussed with the laboratory operations manager where nonconformance report

(NCR) number NCR 22-02 was initiated since the spreadsheet calculations were not verified in an appropriate and systematic manner. Per NCR 22-02, an additional Excel spreadsheet for radionuclide source standard dilutions will be employed to verify the original dilution calculation(s) as a secondary review. A copy of both sheets will be kept in the QA Manager's office along with the standard calibration certificate and a backup of the spreadsheet stored on the TBE network. The QA manager is the only individual with access to the calculation verification spreadsheets, so no modifications can be made to the spreadsheets by anyone other than the QA manager.

During the audit, the spreadsheet used for calculating γ radioactivity levels of diluted secondary radionuclide source calibration standards was verified to have no errors and be producing accurate results. This spreadsheet was initially validated and verified by the laboratory operations manager prior to use. Creating the additional Excel spreadsheet for calculating the γ radioactivity levels for the purpose of appropriately verifying and validating calculations as a secondary review provides an additional barrier to ensure that no software errors are inadvertently overlooked that could potentially produce errors in the sample results. Because this was an isolated event, and because no errors were identified this issue was considered a deficiency with no impact to quality.

Except for the minor deficiency, quality controls are considered adequate and observed to be effectively implemented.

4. Participation in Lab Inter-Comparison Program

The 2021 results for the Inter-Laboratory Performance Evaluation Program were reviewed for the three inter-laboratory programs in which TBE-ES participates covering multiple analytes in matrices approximating normal laboratory samples. The QA manager was interviewed to answer questions related to cross-check failures and discuss results of the cross-check program investigations.

References:

TBE-4005 "Quality Control Samples – Blanks, Spikes and Duplicates", Revision 7, 08/31/2021
TBE-4006 "Inter-Laboratory Performance Evaluation Programs", Revision 11, 11/07/2018

Interlaboratory Cross-Check Program:

TBE-ES participates in three inter-laboratory programs. Two programs are commercial – **E**nvironmental **R**esource **A**ssociates (ERA) and Eckert and Ziegler Analytics, and one program is government – Department of Energy **M**ixed **A**nalyte **P**erformance **E**valuation **P**rogram (MAPEP). In each program unknown samples with unknown activity levels are received by the cross-check laboratories for analytes of interest in matrices like those received from clients. The QA manager selects the analytes, matrices, and frequency of samples from those offered by each program. Samples are received, logged in, and analyzed per TBE-ES procedures. Analysis results are submitted to the test lab for evaluation, and the test lab provides a report flagging any results that exceed the respective program's specified warning and failure limits. Warnings or failures are investigated internally by TBE-ES and reports on failures are provided to the respective test labs. The samples provided by Analytics are assessed by criteria within the TBE-ES quality program.

Analytics Cross-Check Program Results:

Six samples were analyzed in March 2021. These were two milk samples, two activation product samples, one charcoal sample, and one soil sample. All sample results were evaluated as "Acceptable".

Six samples were analyzed in September 2021. These were two milk samples, two activation product samples, one charcoal sample, and one soil sample. Out of 33 total analytes, three were evaluated as "Acceptable with Warning".

The controls for the analytics cross-check program were considered adequate and were observed to be effectively implemented.

ERA Cross-Check Program Results:

Nine samples were analyzed throughout 2021, including five water samples, two soil samples, and two activation product samples.

In March 2021, the $^{55}_{26}$Fe in water sample MRAD-34 was evaluated as “Not Acceptable”. The reported value was higher than acceptance limits (NCR 21-01). The investigation revealed an unexpected loss of sample during the plating process which caused an unusually low yield resulting in artificially high values for the sample test data. Re-analysis of a duplicate sample produced results that were evaluated as “Acceptable”. To prevent recurrence, lab technicians were instructed to conduct closer examinations of analysis plates for detection of possible sample loss and to automatically reprocess samples where a loss of sample is indicated or suspected.

In October 2021, the gross beta (β) activity analysis for water sample RAD-127 was evaluated as “Not Acceptable”. The test data indicated a value that was slightly higher than the acceptance limits (NCR 21-10). The investigation failed to determine the cause of the deviation but did note the ERA acceptance limit was significantly tighter than the TBE-ES QC acceptance criteria for the instrument at the upper limit. The reported result was well within the TBE-ES limit for QC results. $^{3}_{1}$H was also evaluated as “Not Acceptable” on this sample. The test data showed the value was lower than the acceptance limits (NCR 21-11). The investigation failed to determine the cause of the deviation but noted the ERA acceptance limit was significantly tighter than the TBE-ES limit for QC results on the instrument.

A “Quick Response” ERA sample was ordered following the gross beta and $^{3}_{1}$H failures. This sample was analyzed in December 2021 with the $^{3}_{1}$H result being evaluated as “Acceptable”. However, the gross β was once again slightly above the acceptance limit. The investigation failed to determine the cause of the deviation. Again, the ERA acceptance limits were significantly tighter than the TBE-ES limits for QC results on the instrument. TBE-ES determined no corrective action was necessary since both $^{3}_{1}$H values were only slightly outside the acceptance range but well within the TBE-ES acceptable QC range for the instrument.

The controls for the ERA cross-check program were considered adequate and noted to be effectively implemented.

DOE MAPEP Cross-Check Program Results:

Five samples were analyzed in February 2021. These samples consisted of activation products, soil, urine, water, and vegetation samples. Gross alpha (α) on activation product sample 21-GrF44 was evaluated as “Not Acceptable”. The reported value was lower than the acceptance range (NCR 21-02). The investigation revealed a possible mispositioning of the filter in the sample container by the vendor. The MAPEP instructions stated the “spiked” side of the filter is placed in the packet facing up toward the label. The filters are not marked, so the analyst must maintain correct orientation of the filter when transferring from the packet to the instrument for analysis. The technician utilized a practice of placing a small “dot” on the outer edge of the spiked side of the filter immediately upon opening the filter packet to ensure the correct filter orientation could be maintained without question. Since the filter itself will shield α activity from the detector, correct orientation is critical for accurate results. The sample was reanalyzed with the same orientation as the initial count and again with the filter flipped. It was noted that the analysis with the filter flipped so the spiked side was facing away from the detector yielded results that were “Acceptable”.

TBE-ES requested the vendor mark the filter in a similar way to ensure the filter orientation is maintained correct for analysis. Until the vendor adopts this practice, TBE-ES lab technicians will mark the filter as described above to ensure the correct orientation is maintained. The investigation resulted in no further

corrective actions since it is suspected the vendor oriented the filter incorrectly in the packet. It should be noted that normal air filter samples give clear indication of the correct side to face the detector due to the large volume of air filtered that discolors the filter on the inlet side. The dot technique is not necessary for correct positioning of customer air samples.

On the same sample set, the nickel-63 isotope ($^{63}_{28}$Ni) on soil sample 21-MaS44 was evaluated as "Not Acceptable". The reported value was lower than the acceptance range (NCR 21-03). The investigation noted the MAPEP soil sample is spiked with radionuclides known to interfere with the $^{63}_{28}$Ni analysis. These interferences were evaluated as not completely removed in the TBE-ES precipitation and separation process used in the analysis. The TBE-ES process is sufficient for customer soil samples because they do not contain the interfering radionuclides added to the cross-check sample. The procedure for soils analysis has been re-evaluated against national standards and rewritten to provide better removal of known interferences to ensure lower loss of $^{63}_{28}$Ni in the sample preparation process.

Five samples were analyzed in August 2021. Samples consisted of activation products, soil, urine, water, and vegetation samples. $^{63}_{28}$Ni and technetium-99 isotope ($^{99}_{43}$Tc) on soil sample 21-MaS45 were evaluated as "Not Acceptable". The $^{99}_{43}$Tc analysis was not required and was performed for TBE-ES information only. The $^{63}_{28}$Ni result was lower than the acceptance range (NCR 21-13). The investigation again noted the presence of interfering radionuclides that are not typically present in customer soil samples. Further investigation into a revised sample preparation continues, and until a more definitive solution is found for analyzing the MAPEP soil cross-check samples, a matrix spike will be added to all $^{63}_{28}$Ni soil and sediment samples to ensure quality analysis results are achieved.

The controls for the DOE MAPEP cross-check program were considered adequate and noted to be effectively implemented.

Technical Specialist Conclusion:
It was concluded that TBE-ES is employing processes that ensure control of sample receipt, laboratory processes, measuring and testing equipment calibration, and the laboratory inter-comparison program. All performance-based audit attributes, for activities observed during this assessment, were determined to be implemented satisfactorily.

Conclusions

The TBE-ES Quality Program is adequately documented. Except for the two deficiencies, TBE-ES is effectively implementing these established measures. TBE-ES will be maintained on the Entergy qualified suppliers list with no procurement requirements.

Previous Audit Findings/ Deficiencies:

(Ref. NUPIC Audit 24791 / EXL SR-2019-14)
No findings were identified during the last NUPIC audit. One deficiency was identified during the previous audit. Through observations it was verified that adequate corrective actions continue to be effectively implemented.

Review of Previously Identified Industry Issues and/or NRC Information:

Review of the INPO OE database and the NUPIC database was conducted which resulted in no industry related issues associated with TBE-ES.

TBE-ES Nuclear has not had any NRC Inspections since the previous audit.

Unique Order Entry:

There are no unique order entry requirements. Contracts and/or purchase orders should be submitted to the Knoxville, TN office to the following address:

Teledyne Brown Engineering – Environmental Services
2508 Quality Lane
Knoxville, TN 37931-3133

Approved Shipping Location:

TBE-ES provides testing services and does not ship manufactured items. TBE-ES typically disposes of samples and does not return anything to the utility. However, when samples are returned to the utility this happens when the sample is mixed waste, both radioactive and hazardous. Normally this only occurs 1-2 times per year. If shipping was required, the shipments would be from:

Teledyne Brown Engineering – Environmental Services
2508 Quality Lane
Knoxville, TN 37931-3133

Report Approvals:

Joseph C. Walker
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Audit Team Leader **Date**

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Technical Specialist **Date**

Guy Robinson
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Date: 2022.03.07 11:42:15 -06'00'

NUPIC Representative **Date**

Alisha Johnson-Thomas
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Date: 2022.03.08 15:24:58 -06'00'

Supervisor, Supplier QA **Date**

Confidentiality Statement

This audit report, including any attachments, contains or may contain confidential and privileged information solely for the use of the individual and/or supplier to whom they are addressed. Suppliers receiving a copy of the joint utility audit report directly from the lead utility are to consider the documents confidential and proprietary and shall consider the document for information only and may not disclose in whole or in part, by any means, to any third party without the written consent of the lead utility. Also note that this joint utility audit does not constitute nor imply any industry-wide endorsement, certification, approval or disapproval of your Quality Assurance Program and the results shall not be used in any supplier advertising material.

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EA 22-02

Perry Johnson Laboratory Accreditation (PJLA) ISO 17025

September 19-21, 2022

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ASSESSMENT		
Number	**Type**	**Date(s)**
A2022-01554	Accreditation	September 19-21, 2022
Standard(s): ISO/IEC 17025:2017 / Option A Testing / DOECAP Quality Systems Manual V5.4		
Team: Albert Ellis (Lead)		
CONFORMITY ASSESSMENT BODY (CAB) ORGANIZATION		
Name	**Location(s)**	
Teledyne Brown Engineering	2508 Quality Ln Knoxville, TN 37931	

ASSESSMENT INFORMATION	
☐ PRELIMINARY ☒ INITIAL ☐ SURVEILLANCE ☐ REACCREDITATION ☐ SCOPE EXPANSION ☐ SCOPE UPGRADE ☐ REVISIT ☐ OTHER (e.g., ownership/location change)	
OTHER CAB ORGANIZATION INFORMATION	
MAIN CONTACT(S)	**OTHER ADDRESS(ES) ASSESSED** (List Headquarters first, attach separate sheet if needed)
Sharon Northcutt	

SUMMARY REPORT

SCOPE(S): Environmental Testing as detailed in supplement(s)

SCOPE(S) VERIFIED DURING THIS ASSESSMENT Ā$$#"!

☒ An Opening Meeting was held with personnel as detailed on a separate attendance sheet (LF-06).
☒ Documentation and activities related to the above scope were assessed.
☒ All relevant observations were recorded on a separate form (LF-56 Supp).
☒ Identified nonconformities were discussed with personnel.
☒ The Nonconformance(s)/Observation(s) detailed in the LF-08 report are summarized below.
☒ A Closing Meeting was held with personnel, as detailed on a separate attendance sheet (LF-06).

CONCLUSIONS

An effective conformity body system was found to be implemented
☐ without any OR ☒ without serious nonconformances, as detailed in the LF-08 report.
For surveillance assessments, when evidence of satisfactory corrective actions to the nonconformance(s) detailed in the LF-08 report has been received by PJLA, recommendation for continuation of accreditation can be made.

☐ An insufficient conformity body system was found to facilitate a recommendation for accreditation or continued accreditation, as detailed in the LF-08 report and in this report.

☐ The conformity body system was not fully assessed as detailed in this report.

A follow-up visit ☒ is not required **OR** ☐ is required and the date arranged is: _____

SUMMARY OF NONCONFORMANCE / OBSERVATION REPORTS ISSUED (*Note: The absence of reported nonconformances cannot be taken to mean that none exist.)*
Nonconformance Key: MAJOR: A total absence of a required system element or a group of minor nonconformances within an element. MINOR: A single lapse in discipline or control. OBSERVATION: Where, in the opinion of the assessor, clarification or improvement is appropriate.
Below is a brief summary of the nonconformance(s) and observation(s) issued. Nonconformances and observations are detailed in the LF-08 report. **MAJOR:** # **0** General areas of nonconformance:
MINOR: # **11** General areas of nonconformance: **1.ĀDOE QSM 5.4 V1M2 5.8.4©** **2.ĀDOE QSM 5.4 V1M2 4.3.2.3** **3.ĀDOD/DOE QSM 5.4 V1M2 4.2.8.5(g), DOD/DOE QSM 5.4 V1M2 4.3.2.2(b)** **4.ĀDOD/DOE QSM 5.4 v1M2 4.15 Grey Box 18** **5.ĀDOE QSM 5.4 V1M2 6.1.1.2** **6.ĀDOE QSM 5.4 6.1.5.2** **7.ĀDOE QSM 5.4 V1M2 6.3.17** **8.ĀDOD QSM 5.4 V1M2 5.5.13.1(f) Table 5-1** **9.ĀDOD QSM 5.4 V1M2 6.2.2.3** **10.ĀDOE QSM 5.4 V1M2 6.2.3.7 - DOE QSM 5.4 V1M2 6.2.3.3** **11.ĀDOE QSM 5.4 V1M2 6.1.3.1; DOE QSM 5.4 V1M2 6.1.3.2**
OBSERVATIONS: # **1** General areas for observation: 1.Ā**DOE QSM V1M2 5.4 V1M2 4.2.1**
TOTAL NUMBER OF NONCONFORMANCES: 11 **TOTAL NUMBER OF OBSERVATIONS: 1**

ASSESSMENT ACTIVITIES
☐ A checklist other than the LF-56 or LF-56 Supplement series was used and is listed below:
Description of activities witnessed during assessment: Alpha Spectroscopy (TBE-2001); Liquid Spectrometry (TBE-2001); Gamma-LEPS (TBE-2006); Gamma Spectrometry (EPA 901.1); Alpha Beta GPC (EPA 900.0, SM7110B, EPA 9310, EPA 300 BE-01-R); Liquid Scintillation (HASL-300-BA-01-R); Beta GPC (EPA 905.0, DOE-HASL-300, Sr-01 &Sc-03, HASL-300-BA-01-R); Sample Intake
Description of activities verified during assessment: (Not applicable for ISO/IEC 17020 assessments) Alpha Spectroscopy (TBE-2001); Liquid Spectrometry (TBE-2001); Gamma-LEPS (TBE-2006); Gamma Spectrometry (EPA 901.1); Alpha Beta GPC (EPA 900.0, SM7110B, EPA 9310, EPA 300 BE-01-R); Liquid Scintillation (HASL-300-BA-01-R); Beta GPC (EPA 905.0, DOE-HASL-300, Sr-01 &Sc-03, HASL-300-BA-01-R); Sample Intake
PROFICIENCY TESTING PROGRAM
Type of Proficiency Test Program assessed: (e.g., ISO/IEC 17043 Third-Party, Intra-Laboratory) Third Party. 1.ĀL95402 TELE01_MAPEP_Series46 2.ĀEckert and Ziegler 3.ĀERA - MRAD 35 and MRAD 36 and RAD-129 and 120121Y
The proficiency-testing program was appropriate (source, frequencies): ☒ Yes ☐ No *If no, comment why it was not appropriate.*
The results of the PTs were acceptable (initial/continuing, number, failures): ☒ Yes ☐ No *If no, comment why they were not acceptable and include the corrective action(s) taken by the CAB.* Corrective actions completed and provided
The (CAB's) PJLA approved 4-year PT plan was followed: ☐ Yes ☐ No *If no, comment what was not followed and include the (CAB's) reasoning.* Submitted at assessment

CONTINUED DETAILS
Quality Manual (if applicable) and/or QMS Documentation (Issue Date/Revision): K-QAM-1 Rev 35 eff 8/15/22 Details of other documentation: SOPS, training records, COAs, etc.
Results of evaluation from previous assessment's NCRs: Total #: 0 ("0" if none) Not applicable
Scope Changes: ☐ Yes ☐ No ☒ Not Applicable *If yes, provide a brief summary in the details section of this report.*

Other assessment details: Include CAB system changes, scope changes, improvements, areas of concern, follow-up activities or recommendations for next visit.

This was an initial assessment for accreditation for adherence to DOD/DOE QSM 5.4. Teledyne Brown Engineering - Environmental Services (TBE-ES) is located in Knoxville, TN and is the sole environmental analytical laboratory within Teledyne Technologies International (TDY).

The laboratory was scheduled for DOD accreditation only, however the application was modified at the assessment to also include the evaluation of adherence to the DOE guidelines outlined in QSM 5.4. Due to time limitations during the on-site assessment, the assessment also included off-site review of documents provided at the assessment.

The laboratory is currently accredited by the following organizations;

1.Ā Louisiana LA002 12/31/22
2.Ā Montana CERT0108 01/01/23
3.Ā New Jersey TN003 06/30/23
4.Ā New York 11698 04/01/23
5.Ā North Dakota R-225 04/30/23
6.Ā Tennessee 02047 07/27/25
7.Ā Texas T104704469 08/31/23
8.Ā Utah (NELAP Primacy) TN11387 04/30/23
9.Ā Washington C787 03/28/23

The laboratory is in the process of implementing an enhanced tracking system to provide improved traceability of reagents, standards and spiking materials. This tacking system is incorporated into their current LIMS system and was in use and demonstrated to the assessor during the witnessing of one of the prep methods. The training and full implementation of this system throughout the remaining departments in the lab is scheduled to be completed by the end of October 2022.

The laboratory personnel were very helpful in providing the documentation necessary to conduct this assessment. They were very well prepared and very responsive with providing all requested information.

ASSESSOR'S ACCREDITATION RECOMMENDATION
☒ Yes ☐ No (provide explanation): Recommend accreditation/continued accreditation/scope expansion/upgrade/address change/name change as identified above to the standard(s) identified above with receipt of acceptable corrective actions to nonconformities identified in the LF-08 report (when applicable). ☐ Yes ☐ No ☐ NA: Proceed with initial accreditation assessment (if preliminary assessment).
Offsite Surveillance Considerations: ☐ Next assessment is a 1 year surveillance (offsite not an option). ☐ Offsite recommended. ☒ Offsite **not** recommended (provide explanation). 1st years surveillance
Notes for next assessment ("None" if none) (e.g., forecasted organizational/facility/LIMS changes, areas requiring attention or additional time (e.g., LIMS upgrades, 2nd-shifts, Major/Repeat NCRs): LIMS upgrades,
Ownership of this report lies with PJLA and CAB. A third party can only obtain right of perusal after permission from the CAB. Distribution: PJLA, CAB and as required by program/state specific (e.g., DOECAP-AP, DoD-ELAP, TNI) requirements. Additional reports may be distributed as necessary upon permission of the laboratory and as required by program specific requirements and/or by the state requirements. Report reviews: If an additional or revised report is required as a result of PJLA Headquarters or program/state review, one will be issued within 30 days from the receipt of this report, upon final review by PJLA. Acknowledgment: PJLA wishes to thank the CAB for their assistance and cooperation during this assessment.
Signed: _____ Date: September 21, 2022 (Lead Assessor) Amended report (if yes, provide summary of changes) ☐ Yes Date: _____

EA 22-03

BWXT

September 19-21, 2022

2022

BWXT

BWX Technologies, Inc.

BWXT NOG-L
Supplier Quality Audit Report

TELEDYNE BROWN ENGINEERING | KNOXVILLE, TN

ADMINISTRATIVE REVIEW

NAME Doug Mapes DATE 1/24/2023

BWXT Audit Report Number	EA-2022-95
Audit Date(s)	December 5th – December 6th, 2022

Supplier

Teledyne Brown Engineering
2508 Quality Lane
Knoxville, TN 37931

Purpose

The purpose of this audit was to evaluate the Teledyne Brown Engineering (TBE) Knoxville facility's procedures and determine, on a sample basis, if the facility is meeting the minimum requirements invoked by those procedures and BWXT technical requirements.

Scope of Supply

Radiobioassay Laboratory Services

Audit Team

Kerry S. Johnson	BWXT	Quality Engineering Lead Auditor (Team Lead)
Lynn M. Smith	BWXT	Health Physicist (Subject Matter Expert)

Requirement Documents

- Purchase Order 4700047512
- BWXT-3081, Terms and Conditions (11-2021)
- Teledyne Brown Engineering Procedures

Quality System Elements Evaluated

1. Control of Documents
2. Control of Records
3. Qualification and Training
4. Identification and Traceability of Samples (Chain of Custody)
5. Control and Maintenance of Calibration Standards
6. Inspection and Testing of Materials and Equipment
7. Procurement of Materials
8. Corrective and Preventive Action
9. Organization and Management Responsibilities
10. Prevention of Deliberate Malpractice (Fraud and Falsification)
11. Independent Verification of Results
12. Documentation of Statistical Parameters
13. Inter-Laboratory / Intra-Laboratory Comparisons
14. Follow-Up from 2019 Audit

Audit Summary

The quality evaluation of Teledyne Brown Engineering (TBE) began Monday, December 5, 2022 with a brief opening meeting followed by a tour of the facility. The audit concluded with a closing meeting held Tuesday, December 6, 2022. The audit elements previously listed were evaluated as they relate to BWXT product. The quality evaluation resulted in no supplier corrective action reports (SCARs).

The following best practices were noted by the BWXT Audit Team:

- The locations of safety equipment, such as fire extinguishers, were marked with tape on the floor to make finding them easy. Red and white striped tape marked the floor under fire extinguishers. Green and white striped tape marked the floor under eye wash stations and emergency showers.
- Safe areas within laboratories were easy to find with black and yellow striped tape marking the floor. Safety glasses were optional in these areas of the different laboratories.
- Personnel contacted were knowledgeable and helpful when auditors approached them with questions.

TBE's quality program is based on ANSI/HPS N13.30-2011, Revision 2017 (Performance Criteria for Radiobioassay). The results of this audit conclude that TBE is compliant with their stated Quality Plan and BWXT requirements.

The contents of this report are considered by BWXT to be within the contractual scope of existing contracts and, therefore, do not involve or authorize any delay in delivery or cost to BWXT, either direct or indirect.

The auditors conducted the audit on a sample basis. The sample may not have uncovered all nonconformities existing in an area audited. It is up to TBE management to perform a full investigation to determine the extent of nonconformities in an audited area.

TBE agrees that this report may be distributed to the Contracting Agencies, GQAR and other BWXT divisions based upon "Need-to-Know" as deemed appropriate by BWXT NOG-L.

Personnel Contacted During Audit

Name	Title
Keith Jeter	Laboratory Operations Manager
Sharon Northcutt	Quality Assurance Manager
Karli Arterburn	Project Manager/Lab Supervisor
Casey Dearcop	Project Manager
Jim Wright, II	LIMS Programmer/Software Engineer
Kenny Cooper	Sample Receipt Control Technician and Gamma Prep Technician
Belinda Crouse	Laboratory Technician
Cindy Eidson	Laboratory Technician
Blake Gildner	Laboratory Technician
Susan Ogletree	Laboratory Technician
Donna Webb	Laboratory Technician

Supplier Corrective Action Reports

SCAR Number	Level	Requirement	Nonconformity/Observation
NONE			

Lead Auditor: Kerry S. Johnson Date: 1/18/23
Kerry Johnson

Supplier Quality Unit Manager: David Fort Date: 1-23-23
Daniel Fort

Methods of Evaluation

Document Control

Control of Documents

- Verified all staff had access to procedures, the Quality Manual, and any other documentation or instructions applicable to assigned job responsibilities through a corporate electronic share drive.
- Confirmed only authorized personnel could approve and issue controlled documents.
- Verified Quality Assurance (QA) ensured lab technicians worked to the most current revision of a procedure by making only the current revision available on the lab computers.
- Confirmed obsolete procedures were removed from the corporate share drive after being identified as obsolete and were archived electronically in a folder that only QA, IT, and the Laboratory Operations Manager could access.
- Verified by a review of a sample of procedures that each procedure contained a header page with the following:
    - An identifying code or number,
    - Date of issue and/or revision,
    - Approval signature (and date signed) of appropriate manager, QA Manager, and Lab Operations Manager, and
    - Page numbering and total number of pages.
- Confirmed the Quality Manual was reviewed annually.
- Verified QA maintained due dates for the review of procedures.

Control of Quality Records

Control of Records

- Confirmed the Project Managers reviewed data for accuracy and historical consistency and then generated and delivered client reports.
- Verified the Laboratory Operations Manager approved and signed off on the final client reports.
- Reviewed data packages and confirmed all original observations, calculations, derived data, calibration data, and test reports were included in the data packages.
- Verified project managers maintained analysis report files both physically in hard copy form and in electronic form organized by sample number. Hard copies were maintained in fire-rated filing cabinets.
- Confirmed records on computer were backed up incrementally daily with a full back up of the system performed each week. Recent electronic copies were backed up to a file server in Huntsville, Alabama; a third party electronic storage company maintained older electronic files.
- Verified version control was exercised through a log of all programs changes. This log separated the different types of programs and included the following:
    - Program name,
    - Date of change,
    - Requestor,
    - Reason for change, and
    - Person making the change.

- Confirmed documents were available to demonstrate the validity of software used in the Laboratory Information Management System (LIMS) and included:
  - Software description and functional requirements,
  - Listing of algorithms and formulas,
  - Testing and quality assurance documentation, and
  - Installation, operation, and maintenance records.
- Verified the software historical files of all versions of software programs were maintained and included dates that software was placed into and removed from production.

Training

Qualification and Training

- Observed the QA Manager maintained a training matrix on the computer indicating the training status of all personnel.
- Verified the QA Manager updated the training matrix when personnel changed assignments.
- Confirmed the QA Manager reviewed training and certifications annually.
- Reviewed employee training records to verify all employees received training annually in quality, general safety, and radiological safety.
- Confirmed job descriptions included duties and responsibilities and were available for review in the Quality Manual.
- Observed the QA Manager maintained records of training subjects, contents, attendees, instructors, and certifications.
- Verified the QA Manager ensured that all staff whose work was affected by procedural changes were notified of the changes and trained to the revision.
- Reviewed records to confirm personnel performing specific tasks were qualified on the basis of appropriate education, training, experience, and/or demonstrated skills.
- Reviewed forms KQA-1 and KQA-6 to verify individual Demonstration of Capability certifications.

Product Identification and Traceability

Identification and Traceability of Samples (Chain of Custody)

- Confirmed incoming samples were inspected for damage during shipment and then checked against client-provided paperwork to verify sufficient sample volume, correct preservative and/or holding time, and requested analysis.
- Confirmed that, if the incoming samples were acceptable, the sample information was entered into LIMS; LIMS generated barcoded labels for attachment to the samples for identification and traceability.
- Verified project managers planned work and ensured that LIMS contained any special instructions to the analysts.
- Verified unacceptable samples were entered into the LIMS with a variance report to notify a project manager of the nonconforming condition.
- Confirmed the LIMS-assigned numbers on the barcoded labels were used for identification through all operations to record data and maintain Chain of Custody.

- Verified data was entered into LIMS, logbooks, or equipment data systems (depending on the analysis) to record data; this combination of LIMS, logbooks, and equipment data systems provided the Chain of Custody data and documented all actions taken on samples.
- Confirmed TBE management ensured Chain of Custody criteria by maintaining the following security conditions:
    - Access to the laboratory was through a reception area; other access doors to the laboratory were kept locked,
    - Visitors signed in at reception and were escorted in the laboratory,
    - Sample storage areas were within the secure area,
    - Samples remained in sample storage until removed for preparation or analysis, and
    - When out of storage, the analyst handling samples had responsibility for them and returned any sample residuals to the storage area.
- Verified samples were stored for 90 days after the issuance of the laboratory report (or reanalysis report) in case another analysis was required.
- Observed disposal information for each project was stored in LIMS and included storage period, disposal or return requirements, and notification requirements.

Control of Inspection, Measuring, and Test Equipment

Control and Maintenance of Calibration Standards

- Verified standards used for calibrations were traceable to the National Institute for Standards and Technology (NIST).
- Review Certificates of Calibration for weight sets. ISO 17025 accreditation allowed for weight standards to be traceable to the International System of Units (SI).
- Observed management had a written calibration schedule established and it was followed.
- Reviewed records confirming the maintenance of calibration records.
- Verified that a list of Approved Suppliers for equipment and calibration and maintenance services was maintained.
- Confirmed corrective actions were initiated when equipment was found to be out of tolerance.
- Observed records verifying radionuclide standards were traceable to NIST.
- Verified reagents and standards that were in use in the lab were labeled with current calibration and recalibration dates.
- Verified dilutions of chemicals were marked with expiration dates.
- Verified standard expiration dates were maintained in LIMS.
- Verified all balances were calibrated annually.
- Observed balances were labeled with TBE ID number and manufacturer serial number and calibration date.
- Confirmed certificates of service and calibration were issued for each unit and labeled properly.
- Verified all nonfunctioning equipment was labeled as such and was not accessible to the process in LIMS (programmatically locked out).
- Confirmed each standard bore a unique identifier and expiration date.

- Observed bioassay glassware was cleaned and stored in a separate area from other laboratory glassware.
- Confirmed activity of radioactive sources were verified with a minimum of three trials.
- Observed each balance had a certificate of service.

Inspection and Testing of Materials and Equipment

- Reviewed LIMS Report #L97822 for BWXT sample analysis dated 09/26/22 to confirm the tracer for uranium isotope U-232 was added as required by the procedure.
- Verified the LIMS system had the following security features:
  - Operating system privileges and file access safeguards were implemented to restrict the use of LIMS data to users with authorized access,
  - Monitoring of system events such as log on failures or break-in attempts,
  - Incorporation of application-specific safeguards,
  - Protection against the introduction of computer viruses, and
  - Application of security measures to limit physical access.
- Confirmed the server hosting the LIMS system was located in a temperature-controlled environment.
- Confirmed different users had different permissions assigned for the LIMS system.
- Verified checks and balances had been written into the LIMS programming to ensure data did not get overwritten.
- Observed that to correct aliquot information, a program manager was notified in order to open the codes to allow correction.
- Observed that when a correction was made, a reason for the correction was entered into LIMS before the correction can be saved.
- Confirmed sampling data was recorded in LIMS.
- Verified re-analysis was required for an entire analytical batch if any batch control sample failed laboratory-established quality control criteria or failed to meet specific customer contract requirements.

Purchasing

Procurement of Materials

- Verified the QA Manager maintained an Approved Supplier List (ASL) and records of evaluations and audits performed on those suppliers.
- Confirmed new vendors were qualified by the QA Manager based upon ISO/IEC accreditation or by on-site audit and were maintained on the Approved Supplier List.
- Verified suppliers on the ASL were re-evaluated periodically; re-approval entailed meeting the same requirements for initial approval or by evidence of continued acceptable performance.
- Confirmed the laboratory procured reagents, processing chemicals, laboratory glassware, consumables, and other catalog items from nationally-known vendors and to applicable laboratory grades, purities, concentrations, and accuracy levels.
- Verified vendors of typical lab consumables, such as plastic/glassware or chemicals, were selected based upon applicable laboratory grade, purity, or other relevant specifications, and were ordered form nationally recognized vendors.
- Confirmed requisitions for procured goods and services were initiated at TBE-ES but controlled and administered through TBE's home office in Huntsville, Alabama.

- Verified the Laboratory Operations Manager and the QA Manager reviewed and approved requisitions for new equipment and software programs affecting the quality system.
- Confirmed the QA Manager reviewed requisitions for radioactive standards or services related to the calibration of equipment.
- Verified support equipment and analytical instruments were given an identifying name or number and were calibrated before being put into service.
- Reviewed a Form KQA-39, Supplier Information Form, for a new vendor to confirm all required information on the new vendor was filled in as required.

Corrective and Preventive Action

Corrective and Preventive Action

- Verified through a document review that customer complaints were documented on Form KQA-22, Customer Complaint Detail Form, and tracked to closure.
- Confirmed through the document review that project managers handled most of the customer complaints and were responsible for:
  - Logging the complaint,
  - Ordering retests for verification, and
  - Providing documented results to the customer.
- Verified the KQA-22 forms included the following required information:
  - The complaint number,
  - The date the complaint was received and the person handling it, and
  - Client contact, company name, associated sample number, workgroup number, and nonconformance report number (if applicable).
- Reviewed a sample of Form KQA-9, Nonconformance Reports (NCR) Form, to confirm failures or non-agreement of inter-comparison analyses (cross-checks) were documented as required.
- Confirmed the Laboratory Operations Manager and the QA Manager (or their designees) were required to verify the adequacy of corrective and preventive actions.
- Reviewed both the annual report to management for 2021 and the quarterly reports for 2022 to verify the reports included a discussion of completed NCRs.

Management Responsibility

Organization and Management Responsibilities

- Verified the QA Manager prepared quarterly management reports and annual management reports.
- Reviewed annual management reports from 2021 and 2020 to confirm these reports summarized accreditations, audits and surveillances, results of internal and external audits, nonconformances, and provided an evaluation for the status and effectiveness of the QA program.
- Reviewed the Customer Complaint Log and verified appropriate documentation had been filled out for each customer complaint.
- Confirmed customer feedback, both positive and negative, was encouraged through an online survey.

Contract Review

Fraud and Falsification

- Confirmed the Fraud and Falsification statement was present on company documents such as the Report of Analysis and the Certificate of Conformance.
- Verified personnel who worked on BWXT product were informed in writing of the Fraud and Falsification statement.
- Reviewed employee training records to confirm employees received training annually on data integrity in recording test results.

Inspection and Testing

Independent Verification of Results

- Confirmed results obtained from analytical efforts were reviewed by the Project Managers and the Laboratory Operations Manager.
- Verified on LIMS Report L97822 for BWXT samples that Project Managers added case narratives to the final report.
- Verified personnel using LIMS were trained in its use and operation.
- Verified changes made in LIMS had a documented reason, date of change, and evidence that a change was made.
- Confirmed data forms had data integrity validation routines built into the forms.
- Verified LIMS sent an email notification to project managers, the operations manager, the lab production manager, the QA manager, and IT when data submitted was outside of contract-approved specifications and when the cause of the error was corrected.

Statistical Techniques

Documentation of Statistical Parameters

- Verified there had been no significant change in the test method for analysis of isotopic uranium and therefore no requirement to recalculate the minimum detectable amount (MDA).
- Verified the MDA for the analysis of urine had been optimized appropriately.
- Confirmed the Canberra alpha spectroscopy software performed the verification and validation of the MDA for the method.

Special Processes

Inter-Laboratory / Intra-Laboratory Comparisons

- Verified TBE participated in the Inter-Laboratory Performance Evaluation Program.
- Verified documentation of Inter-Laboratory comparison result failures in NCRs and that the reports included investigations of reasons for the failures.
- Confirmed the QA Manager maintained documentation of crosscheck analyses and any necessary investigations.
- Reviewed LIMS Report L97822 for BWXT bioassay samples to confirm the use of blank samples and blank spiked samples for each group of bioassay samples.
- Verified the QC samples were prepared and counted in the same manner as the samples submitted for analysis.
- Confirmed the uranium standard used to prepare the laboratory control sample was independent of the laboratory standard used for instrument calibration.

- Verified the lab control sample spike solution was of appropriate activity for bioassay samples.
- Confirmed blank and blank spiked samples were used with each sample group for bioassay samples.

Follow-Up from Last Audit

- Confirmed TBE completed the corrective actions for the nonconformities from the 2019 BWXT audit.

END OF DOCUMENT