Draft

Advisory Board on Radiation and Worker Health
National Institute for Occupational Safety and Health

Interim SC&A Review of the SEC Petition Evaluation Report for Petition SEC-00256: Pinellas Plant

Contract No. 75D30119C04183
Document No. SCA-TR-2023-SEC001, Revision 0

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June 16, 2023

SC&A, Inc. technical support for the Advisory Board on Radiation and Worker Health's review of NIOSH dose reconstruction program

Document title	Interim SC&A Review of the SEC Petition Evaluation Report for Petition SEC-00256: Pinellas Plant
Document number	SCA-TR-2023-SEC001
Revision number	0 (Draft)
Supersedes	NA
Effective date	June 16, 2023
Task manager	Stephen L. Ostrow, PhD [signature on file]
Project manager	Bob Barton, CHP [signature on file]
Document reviewer(s)	Bob Barton, CHP [signature on file]

Record of revisions

Revision number	Effective date	Description of revision
0 (Draft)	6/16/2023	Initial issue

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Abbreviations and Acronyms

ABRWH, Board	Advisory Board on Radiation and Worker Health
a.k.a.	also known as
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
AWLPG	Albuquerque Workload Planning Guide
C	carbon
°C	degrees Celsius
CATI	computer-assisted telephone interview
CDC	Centers for Disease Control and Prevention
Ci	curie
CFR	Code of Federal Regulations
Co	cobalt
CY	calendar year
DCAS	Division of Compensation Analysis and Support
DD	deuterium-deuterium fusion reaction
DFO	Designated Federal Official
DI	deionized
DOE	U.S. Department of Energy
DOL	U.S. Department of Labor
DOL DEEOIC SEM	DOL Division of Energy Employees Occupational Illness & Compensation Site Exposure Matrix
dpm, DPM	disintegrations per minute
DR	dose reconstruction
DT	deuterium-tritium fusion reaction
ECL	Environmental Chemistry Laboratory
EE	energy employee
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
EHS	environmental health and safety
EH&SP	Environmental Health and Safety Program
EPA	U.S. Environmental Protection Agency
ER	evaluation report

g	grams
GE	General Electric
GEND	General Electric Neutron Devices
GENDD	General Electric Neutron Devices Department
GEPP	General Electric Pinellas Plant
H	hydrogen
GEXF	General Electric X-Ray Division Florida
HP	Hewlett Packard, Health Physicist, or Health Physics (department)
HRS	Dept. of Health and Rehabilitative Services (Florida)
HTO	tritium oxide
IH	industrial hygiene
IMBA	Integrated Modules for Bioassay Analysis
keV	kiloelectron volt
Kr	krypton
LAT	lateral (x-ray)
mCi	millicurie
µCi	microcurie
µCi/L	microcurie per liter
MDC	minimum detectable concentration
MeV	mega-electron volt
mg/cm^2	milligram per square centimeter
mrem	millirem
NA	not applicable
NESHAP	National Emission Standards for Hazardous Air Pollutants
ng/ml	nanograms per milliliter
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH DCAS Claims Tracking System
NRC	Nuclear Regulatory Commission
O	oxygen
OBT	organically bound tritium
ORAUT	Oak Ridge Associated Universities Team
oz	ounces
PA	posterior-anterior

PFG	photofluorography
Pinellas	Pinellas Plant
POTW	(Cross Bayou) Publicly Owned Treatment Works
Pu	plutonium
$Pu\text{-}238O_2$, $^{238}PuO_2$	plutonium-238 dioxide
RMMA	Radioactive Materials Management Area
RTG	radioisotope thermoelectric generator
SEC	Special Exposure Cohort
SECS	Stack Effluent Control System
SMT	stable metal tritide
SNL	Sandia National Laboratories
SPR	Subcommittee for Procedure Reviews
Sr	strontium
SRDB	Site Research Database
STC	special tritium compound
TBD	technical basis document
TIB	technical information bulletin
Tl	thallium
TLD	thermoluminescent dosimeter
TRS	tritium recovery system
U	uranium
UNC	University of North Carolina at Chapel Hill
WG	work group

1 Executive Summary

The initial Special Exposure Cohort (SEC) Petition-00256 for the Pinellas Plant (Pinellas) was submitted to the National Institute for Occupational Safety and Health (NIOSH) on December 16, 2019 ([Redacted], 2019). The petitioners subsequently revised the class definition twice, on May 20, 2020 ([Redacted], 2020a), and on August 17, 2020 ([Redacted], 2020b). NIOSH qualified the latter petition for evaluation on October 20, 2020, and also modified the proposed class definition. NIOSH completed the SEC petition evaluation report ("ER" or "NIOSH SEC ER") (NIOSH, 2021a) on October 13, 2021. At its December 8, 2021, meeting (ABRWH, 2021b), the Advisory Board on Radiation and Worker Health (ABRWH, Board) requested that SC&A review the ER; this report is provided to the Board in response to this request.

SC&A recognizes that several new issues have recently been raised by the petitioners that may have SEC implications (e.g., potential uranium glass blowing operations) and that documents found in recent data captures have not yet been reviewed. However, SC&A is releasing this interim draft to inform the Board and to facilitate moving discussions forward.

The ER concludes that doses experienced by the workers covered by the SEC petition can be reconstructed with sufficient accuracy in accordance with 42 CFR 83.13(c)(1) ("Is it feasible to estimate the level of radiation doses of individual members of the class with sufficient accuracy?") and recommends denying the petition. This recommendation is based on data, methods, assumptions, and other sources of information described in the ER.

SC&A's review of the ER has two objectives:

1. Provide information for use by the Board in determining whether doses can be reconstructed with sufficient accuracy, as defined in 42 CFR Part 83, "Procedures for Designating Classes of Employees as Members of the Special Exposure Cohort Under the Energy Employees Occupational Illness Compensation Program Act of 2000."

2. Provide a technical evaluation of the scenarios, data, assumptions, models, and other information given or referenced in the ER for reconstructing doses.

From the evidence that it has examined, SC&A believes, with some caveats, that it may be possible to bound doses to workers covered by the SEC petition, in a scientifically sound and claimant-favorable manner, by application of the methodologies and data outlined in the ER and contained in supporting documents referenced in the ER or otherwise found by SC&A in the NIOSH Site Research Database (SRDB). These methods include, but are not limited to, use of one of the highest contamination survey measurements to reconstruct stable metal tritides (SMTs).

However, SC&A notes that it has yet to be demonstrated that a suitable co-exposure model can be developed for other soluble tritium compounds. This may be particularly problematic in light of the U.S. Department of Energy (DOE) Tiger Team findings noting noncompliance with the site bioassay program. Mitigating factors such as the comments made by the same Tiger Team commending the site for its radiation protection program, as well as generally low doses, may inform whether such a co-exposure can be acceptably developed (refer to section 4.4 and appendix A for a detailed account of the Tiger Team review).

This SC&A review summarizes Pinellas Plant history and site information, discusses the radiation sources and types of radiation that might have exposed personnel, and examines radiation monitoring procedures and compliance both pre- and post-issuance of the 1990 DOE Tiger Team report (DOE, 1990a). It also evaluates whether the ER (1) adequately recognizes and addresses all petitioner concerns as articulated in the petition, computer-assisted telephone interview (CATI) reports, and subsequent petitioner communications to the Board and (2) accounts for all relevant reported radiological incidents at the plant.

The Board will use this information, in part, as a basis for determining whether it finds that doses can be reconstructed with sufficient accuracy for the SEC class. SC&A has a few reservations it recommends the Board also consider, centered around compliance with bioassay program requirements before the Tiger Team assessment in 1990, which are summarized in observations 2, 4, 5, 7, and 9.

While SC&A's review had no findings, it made the following 13 observations, which may reflect either unfavorably or favorably or provide noteworthy information on the radiation-related conditions and practices at Pinellas and the conclusions of the ER.

Observation 1: Neutron generator production was fairly steady
SC&A's review of neutron generator production from 1974 through 1993 showed that it was fairly steady, with a peak in the early 1980s and a few notable dips in the late 1970s into 1980. (section 3.1)

Observation 2: Potential for tritium contamination is adequately addressed
SC&A notes that key aspect 4 of the accepted NIOSH stable metal tritide model indicates that stable metal tritide exposures would only be applied if the energy employee were also monitored via urinalysis. However, given the deficiencies noted by the Tiger Team in the performance of the bioassay program as late as 1990, relying on bioassay completeness to establish exposure potential is likely inappropriate. (section 3.3.1)

Observation 3: The ER does not reference recent special tritium compound document
The SEC evaluation report and ORAUT-TKBS-0029-5, revision 03 (the occupational internal dose technical basis document (TBD)), do not incorporate guidance for performing dose reconstruction for intakes of stable metal tritides from revision 01 of ORAUT-OTIB-0066 (2020). NIOSH should commit to reference and discuss guidance from OTIB-0066 in the next revision of the occupational internal dose TBD and evaluate whether it has any consequential effect on the SEC evaluation report conclusions. In addition, as noted in key aspect 2 of the stable metal tritide model accepted by the Board (as presented by SC&A at the August 9–10, 2016, Board meeting), sitewide air monitoring data or contamination survey data should be preferentially used over other modeling in dose reconstructions for stable metal tritides whenever available. (section 3.3.1)

Observation 4: Lack of bioassays records for 1988–1990
Despite between 129 and 201 employees reportedly monitored by bioassays from 1988 to 1990, NIOSH only has monitoring records for 3–10 claimants per year. According to the 1990 DOE

Tiger Team report, approximately 1,750 people were employed in 1989, suggesting that monitoring records are missing. (section 4.3)

Observation 5: Bioassay schedule noncompliance by the plant
One of the principal Tiger Team findings relevant to the SEC petition was noncompliance with the plant's own requirements for termination, monthly, and weekly bioassays. Appropriate bioassay compliance (data completeness levels) in general is a subjective judgment to be made by the Board. In addition, the level of compliance with the bioassay program is unknown before the findings of the Tiger Team. It is SC&A's opinion that at a minimum, NIOSH should demonstrate that an appropriate co-exposure model can be constructed to address apparent incompleteness in the tritium bioassay program (likely throughout its relevant operating history). Despite concerted efforts by the site to rectify the compliance issues, nearly one-fifth of worker bioassay requirements were still not met. Bounding co-exposure values would certainly appear warranted during this latter period (1991–1997). (section 4.3)

The following five additional observations (6 through 10) are taken from SC&A's review of the 1990 DOE Tiger Team report (DOE, 1990a) (refer to section 4.4 of this SC&A review).

Observation 6: Radiological protection program commended by Tiger Team
On a positive note, commending the radiological protection program, section 4.4.11.1 (p. 4-90) of the 1990 DOE Tiger Team report states, "The overall assessment is that all levels of the GEND [General Electric Neutron Devices, another name for the Pinellas Plant] organization are receiving adequate radiological protection. This is primarily due to a GEND staff that appears willing to accept line responsibility for radiological safety along with a technically strong health physics staff providing direction."

Observation 7: Bioassay sampling frequency requirements not followed as noted by Tiger Team
Section 4.5.11.1 (p. 4-90) of the 1990 DOE Tiger Team report compliments the plant for maintaining low overall internal dose exposures but also makes an important finding on noncompliance issues related to the plant not following bioassay sampling frequency requirements. This is one of the bases cited in the SEC petition: "Occupational internal exposures are low compared to other DOE sites. This accomplishment results from a conservative approach to working with tritium and through extensive use of engineering controls. However, compliance with the rules on providing bioassay samples at specified frequencies has not been satisfactory."

Observation 8: Contamination controls found generally good by Tiger Team
Section 4.5.11.1 (p. 4-91) of the 1990 DOE Tiger Team report discusses the effectiveness of contamination controls at Pinellas and notes that while it is generally good, there are instances when it is not: "Contamination controls are generally good. Contamination levels within the work areas are kept low and generally confined to the source. Indications were found that proper contamination control techniques are not always being followed, in some areas causing contamination spread to the general areas of the facility."

Section 4.5.11.2 (p. 4-101) continues the discussion of contamination controls with a negative statement: "Proper contamination control techniques are not being followed by personnel when working in and exiting from Contaminated Areas." The report (p. 4-102) notes that a contractor disagreed that workers were inadequately protected given the extremely low contamination levels detected and that "radiation exposures from these contamination levels are not measurable, as supported by bioassay sampling."

Observation 9: Bioassay sampling program implementation inadequacies noted by the Tiger Team

Section 4.5.11.2 (p. 4-98 ff.) of the 1990 DOE Tiger Team report contains several radiological protection findings and concerns related to internal dosimetry that are relevant here. Of particular importance, finding RP.7 (p. 4-98) claims that "Procedural requirements have not been established for an employee's termination bioassay, nor a system developed to identify and address those individuals who fail to provide a bioassay sample." Additionally, "GEND estimated that 20 percent of the personnel that terminated in 1988 did not provide a termination bioassay," and that "Individual workers, their supervisors, and management are not ensuring that required bioassay samples are provided. In 1989, bioassay samples were not submitted in accordance with GEND procedures. Seventy percent of the required monthly samples and 35 percent of the required weekly samples were not submitted." NIOSH cited these Tiger Team findings as sufficient to qualify the SEC petition for further evaluation.

Observation 10: Tiger Team assessment of deficiency root causes: emphasis on production and mindset that Pinellas poses no unusual radiological risks

Section 5.7 (p. 5-33) of the 1990 DOE Tiger Team report covers management assessments. It opines the following on the probable root causes of some of its deficiency findings and lists the following two: "First, emphasis on production has traditionally overshadowed interest in fully complying with environment, safety and health requirements"; and "Second, there is a wideset mindset that the Pinellas Plant poses no unusual or unique risks."

Observation 11: Transition Year of 1990 after Tiger Team assessment led to overall reduced exposures

The Tiger Team assessment took place in January and February 1990, and the Pinellas Plant initiated corrective action during fiscal year 1990 (October 1, 1989, through September 30, 1990). While data indicate a significant decrease for external doses from 1990 to 1991, there was an increase in internal doses from tritium from 1990 to 1991, then a gradual decreasing trend during the years 1992–1995. The number of workers bioassayed for tritium remained reasonably consistent during the period 1986–1995, and the number of workers monitored for external exposure gradually decreased during the period 1985–1995. According to the "1991 Annual ALARA Program Report for Ionizing Radiation," the increase in internal dose was due to the "T" box incident and recovery operations in Area 182C conducted in late December 1991. To date, SC&A has not found indications that there are issues with exposure records that would prevent DR feasibility for the SEC period 1957–1990, nor for the period 1991–1997. (section 4.5)

Observation 12: ER is consistent with interview records

SC&A reviewed all available documented communication (i.e., interview) records. The interviews reflect the full date range of work at Pinellas and encompass a broad range of professions. From the interviews, it is clear that site employees had a different experience with the health and safety policies at the site based on their role and job function. In general, the interviewed workers in physics, engineering, chemistry, and lab-related professions had experience with the site internal and external monitoring program. The recollections reported in the interviews, in general, are consistent with the NIOSH SEC evaluation report. (section 5.4)

Observation 13: Pinellas plant diligent in following up on contamination-related incidents and personnel exposures

Based on its review of the available incident information, SC&A concurs with NIOSH's conclusion that Pinellas Plant was diligent about following up on contamination-related incidents and personnel exposures. The reports show investigations into the causes of various incidents, and most (1) indicate that followup monitoring was performed for employees involved in the incidents and (2) provide recommendations to prevent the incidents from reoccurring. However, given the lack of bioassay records for the years 1988–1990 described in observation 4 (section 4.3) and the issues surrounding bioassay noncompliance described in observation 5 (section 4.3), observation 7 (section 4.4), and observation 9 (section 4.4), it is possible that the program may not have captured all the internal exposures related to contamination incidents. (section 6.2.2)

2 Introduction and Background

The revised SEC petition, submitted to NIOSH on August 17, 2020 ([Redacted], 2020b, p. 4), proposed, in part, the following class definition:

> Employees of the Department of Energy (DOE), DOE contractors and/or subcontractors who were employed by General Electric Neutron Devices including all names of the company listed in Part C, Martin Marietta Specialty Components, and/or Lockheed Martin Specialty Components, Inc. (a.k.a. the *Pinellas Plant*) during the period from **January 1957 through December 1997**.

NIOSH reviewed the petition and supporting information and determined that the petition qualified for evaluation under the F.4 basis (i.e., scientific or technical report issued by a government agency or peer reviewed journal that identifies dosimetry information is unavailable). The petitioners had quoted from the 1990 DOE Tiger Team report on Pinellas (DOE, 1990a) in support of their petition, and, after review of the report, NIOSH found it provided sufficient information to allow the petition to qualify for further evaluation. Per section 3.1 of the NIOSH SEC ER (NIOSH, 2021a, p. 20):

> The [Tiger Team] report states "... compliance with the rule on providing bioassay samples at specified frequencies has not been satisfactory" (DOE 1990a, PDF p. 216) and "... In 1989, bioassay samples were not submitted in accordance with GEND [General Electric Neutron Devices] procedures. Seventy percent of the required monthly samples were not submitted" [DOE 1990a, PDF p. 224].

NIOSH expanded upon this in its December 8, 2021, presentation to the Board (NIOSH, 2021b, slide 13), where it deemed the following two statements from the Tiger Team report sufficient to qualify for an SEC evaluation (section 4.4 and appendix A of this SC&A review discuss the Tiger Team observations and findings):

- "GEND estimated that 20 percent of the personnel that terminated in 1988 did not provide a termination bioassay." [DOE 1990a, PDF p. 224]

- "Seventy percent of the required monthly samples and 35% of the required weekly samples were not submitted." [DOE 1990a, PDF p. 224]

Since the 1990 Tiger Team report assessed plant conditions in 1988 and 1989, NIOSH determined that it was not directly applicable to the time period that followed it because Pinellas had adequately and promptly addressed the bioassay compliance issues raised in the report by the end of 1990. Consequently, NIOSH terminated the SEC class definition period on December 31, 1990, rather than on December 31, 1997, as proposed in the petition. This truncated cutoff date is discussed further in section 4.2 of this SC&A review. However, SC&A notes that the Tiger Team finding of noncompliance may be applicable to the period preceding the Tiger Team's review (refer to section 4.1 of this report).

NIOSH (2021a, p. 20) qualified the final revised petition for evaluation on October 20, 2020, but modified the class definition to:

> All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked at the Pinellas Plant in Clearwater, Florida for the period from January 1, 1957 through December 31, 1990.

NIOSH submitted its SEC ER on October 13, 2021 (NIOSH, 2021a), and presented it to the ABRWH at its December 8, 2021 (NIOSH, 2021b), meeting.

The NIOSH SEC ER concludes the following about the Pinellas facility:

> NIOSH concludes that it has access to sufficient information to estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could be incurred in plausible circumstances by any member of the class under evaluation. Therefore, NIOSH does not recommend adding the NIOSH-evaluated class to the SEC. [NIOSH, 2021a, p. 21]

Following discussions of the NIOSH SEC ER at the December 8, 2021, ABRWH meeting, the Board tasked SC&A with reviewing it. This review report presents the results of SC&A's investigation.

Since the NIOSH SEC ER and SC&A's review rely, in part, on the information in the technical basis documents (TBDs) comprising the site profile, a brief summary of the history and status of the site profile is in order. SC&A had reviewed the original site profile TBDs produced by NIOSH in 2005 and 2006 (ORAUT, 2005a, 2005b, 2005c, 2005d, 2005e, 2006) and submitted its assessment to the Board in 2006 (SC&A, 2006). That assessment identified 11 primary and eight secondary issues.

Responding to SC&A's assessment and several technical exchanges between NIOSH, SC&A, and the Board's Pinellas Plant Work Group (WG), NIOSH revised the TBDs beginning in 2011 (ORAUT, 2011a, 2011b, 2011c, 2011d, 2016, 2017). After further reviews and discussions, SC&A presented the final status of the issues at the August 9, 2016, Board meeting (SC&A, 2016b) and stated that "SC&A and the Pinellas Work Group agree that all of the primary and secondary issues raised in SC&A's site profile review have been adequately addressed and resolved" (slide 3). However, "Primary Issue 2" concerning stable metal tritides was "in abeyance until NIOSH delivers a revision of the internal dose TBD" (SC&A, 2016b, slide 3), which is still pending. (Section 3.3.1 of this review discusses the issue of SMTs in detail.) The result of these TBD discussions is that the basis for many of NIOSH's assertions and methods in the SEC ER have already been reviewed and approved by both SC&A and the Board through the site profile review process and, therefore, have not been revisited here in great depth.

2.1 Site information

Information on the Pinellas Plant is found in the current site profile TBDs (ORAUT, 2011a, 2011b, 2011c, 2011d, 2016, 2017). Details of the history, building and equipment layout, manufacturing and other processes, radioactive source types and locations, and potential for personnel exposure are primarily in the site description TBD, ORAUT-TKBS-0029-2, revision 02 (ORAUT, 2011b), with parts repeated as appropriate in the other TBDs.

The plant, located on a 100-acre site in Clearwater, FL, was constructed in 1956 by the General Electric Company to manufacture neutron generators for the U.S. nuclear weapons program and expanded after 10 years of operation to include other specialized electronic and support components. Prominent among them from a radiological standpoint were radioisotope thermoelectric generators (RTGs). There was one large building, Building 100, which contained many areas designated for manufacturing, engineering, and administrative functions, and 17 smaller, surrounding buildings and structures. Figure 5-1 of the ER shows a Pinellas Plant site map for reference. At peak operations, the plant employed approximately 2,000 people (GENDD, 1986).[1] The plant operated from 1957 through September 1994, with subsequent decontamination and decommissioning activities from October 1994 through 1997 and remediation activities in 1999, 2008, and 2009. Pope (2007) provides further information on the plant's closing, which was prompted by DOE's efforts in the late 1980s to reduce its overall budget by closing several Nuclear Weapons Complex plants and transferring their essential functions to other plants. As part of that process, fabrication of neutron generators passed from Pinellas to Sandia National Laboratories (SNL).

Over the plant's long history, Pinellas has gone by many names, including, but not limited to, the 908 Plant, GE X-ray Division Florida (GEXF), GE Neutron Devices Department (GENDD), GE Neutron Devices (GEND), GE Pinellas Plant (GEPP), General Electric Temporary Plant, GE Aerospace Neutron Generators, and Pinellas Peninsula Plant. These names occur throughout the literature and employee statements but are generally understood to refer to the same facility. Throughout this review, the plant is referred to as Pinellas, the Pinellas Plant, or the plant.

2.2 History of Board activities

Table 1 summarizes the long history of Board activities, beginning in 2004, concerning Pinellas. Additionally, current evidence suggests that NIOSH conducted interviews with at least 16 former workers and/or subject matter experts in November 2007, 2013, 2020, and 2021.

Table 1. Summary of Advisory Board meetings and activities

Meeting date	Meeting group/purpose
September 2, 2004	NIOSH worker outreach
November 2, 2005	NIOSH worker outreach
May 27–29, 2006	SC&A conducted worker interviews
February 28–29, 2008	NIOSH outreach on SEC petitioning process
June 11, 2008	Work Group on Pinellas Plant
June 11, 2009	Work Group on Pinellas Plant
October 13, 2011	Work Group on Pinellas Plant
November 19, 2012	Work Group on Pinellas Plant
February 11, 2016	Work Group on Pinellas Plant
March 10, 2016	Work Group on Pinellas Plant

[1] Table 6-8 of ORAUT-TKBS-0029-6, revision 02 (ORAUT, 2017), shows Pinellas employees per year for 1960–1973 ranging from about 1,300 to 1,600, peaking at 1,597 in 1963. The total number of employees for years 1974–1985 are listed as "not available." However, GENDD (1986) states that the maximum was about 2,000 but does not give the corresponding year or basis for its statement.

Meeting date	Meeting group/purpose
March 23, 2016	ABRWH meeting, SC&A status report
August 9, 2016	ABRWH meeting, SC&A final status report
December 8, 2021	ABRWH Meeting, NIOSH SEC presentation
December 8, 2022	ABRWH Meeting, SC&A ER review update presentation

3 Sources of Exposure

The ER draws from the Pinellas site description TBD (ORAUT, 2011b), documents referenced therein, and other documents, such as those found in data capture activities, to describe the sources of radiation at the plant that might have exposed personnel through various pathways. The following sections discuss radiation sources and potential internal and external exposure sources.

3.1 Radiation sources

Section 2.4 of the Pinellas site description TBD (ORAUT, 2011b), which is echoed in the ER, discusses the radiation sources at the plant and categorizes them as either radioactive materials that continuously emit radiation through radioactive decay, or radiation-generating devices that produce radiation only when they are operating. In the radioactive materials category, the TBD lists several products containing radionuclides, such as:

- miniature linear accelerator-type neutron generators (containing tritium targets) used to initiate nuclear fission reactions
- RTGs containing plutonium oxide heat sources that arrived at the plant as triply encapsulated units
- borosilicate glass structures containing uranium
- leak-testing systems containing krypton (Kr)-85
- tritium storage systems
- instrumentation and dosimeter calibration and check sources
- analytical standards for laboratory analyses

The TBD asserts that, "With the exception of radionuclides used as analytical standards, tritium (^{3}H), ^{14}C [carbon-14], and ^{85}Kr [krypton-85] were the only dispersible radionuclides normally encountered at the Pinellas Plant. All other radionuclides at the Plant were in nondispersible forms (plated sources, containerized sources, encapsulated sources, solid metal sources, etc.)" (ORAUT, 2011b, p. 14).

Tritium (a low-energy beta emitter with 5.7 kiloelectron volt (keV) average energy, 18.5 keV maximum energy, and a 12.32-year half-life) appeared at Pinellas in four forms: tritiated water (tritium oxide or HTO), tritium gas, organically bound tritium (OBT), and metal tritides.[2] Plutonium (Pu) (as Pu-238, 87.7-year half-life, and Pu-239, 24,110 year half-life) is an alpha and x-ray emitter but may also produce neutrons and gamma rays from spontaneous fission. Plutonium fission products, in turn, also emit radiation as they decay. Kr-85 (10.756-year half-life) is a beta-emitting noble gas. Natural and depleted uranium isotopes were also present. The uranium (U) isotopes (U-234, U-235, and U-238) emit alpha particles and x-rays when they undergo radioactive decay, and some of their decay chain progeny also emit alpha and beta

[2] A note on nomenclature: Metal tritides also go by alternate names, including stable metal tritides (SMTs), insoluble metal tritides, and insoluble tritium compounds; it is assumed here that all refer to the same forms.

particles and gamma rays as they, in turn, decay. The depleted uranium (lower U-235 isotopic percentage than in natural uranium), in a containerized configuration, was primarily used to store tritium in storage beds (depleted uranium hydrogen getter). Natural uranium was used as a dopant in borosilicate glass structures that were received by the Pinellas Plant in a sealed form. Nickel-63 (101-year half-life), used in krytrons (sealed, gas-filled glass tubes that were used as very high-speed switches in nuclear weapons), is a beta emitter. C-14 (5,730-year half-life) is a beta-emitting radionuclide, used in small amounts in the plant as a radioactive label in some laboratory solvents.[3]

In addition to the radioactive materials, which always emit radiation, certain devices also generated radiation only when they were operating. The primary product of the plant was neutron generators (containing very small linear accelerators enclosed in vacuum tubes) used in the triggering mechanism of nuclear weapons, which accelerate deuterons into either a tritium target or deuterium target resulting in the emission of either 14 mega-electron volts (MeV) or 2.5 MeV neutrons, respectively, from the nuclear fusion reactions. Ion accelerators were used for ion implantation and target assessment, materials analysis, and other purposes. Table 2-1 of the Pinellas site description TBD (ORAUT, 2011b) lists radiation-generating devices with their quantities and types. Finally, the plant conducted onsite personnel occupational medical x-ray examinations.

SC&A thought it valuable to examine production of radioactive source-containing materials or radiation-producing devices over time in the Pinellas Plant to both understand the magnitude of the operations and find out if reported measured dose values correlate with production. Section 2.6.1 of the site description TBD (ORAUT, 2011b) notes that Area 108 of Building 100 handled the most tritium at Pinellas, and that "Overall tritium use at Pinellas was generally low, with an average yearly inventory of approximately 15 g (0.53 oz)"; this is equivalent to about 144,600 curies (Ci) activity.

To date, SC&A found only one document, "Pinellas Plant Overview" (DOL, c1994[4]), that contains some of the desired information related to device production. It presents some relevant information in two unnumbered charts, both titled "Pinellas Plant Products." The data in the charts are "based on 1989 AWLPG"; SC&A determined that this acronym stands for "Albuquerque Workload Planning Guide." The first chart (reproduced here as figure 1) compares, in stacked bar format, the number of types produced per year of 10 different products for fiscal years 1974 through 1993. The second chart (reproduced here as figure 2) displays in a similar format the number of shipped units by year for each of the products. Two products of interest to this analysis are neutron generators ("Generators"), which contain tritium and produce neutrons and associated radiation, and RTGs, which contain plutonium.

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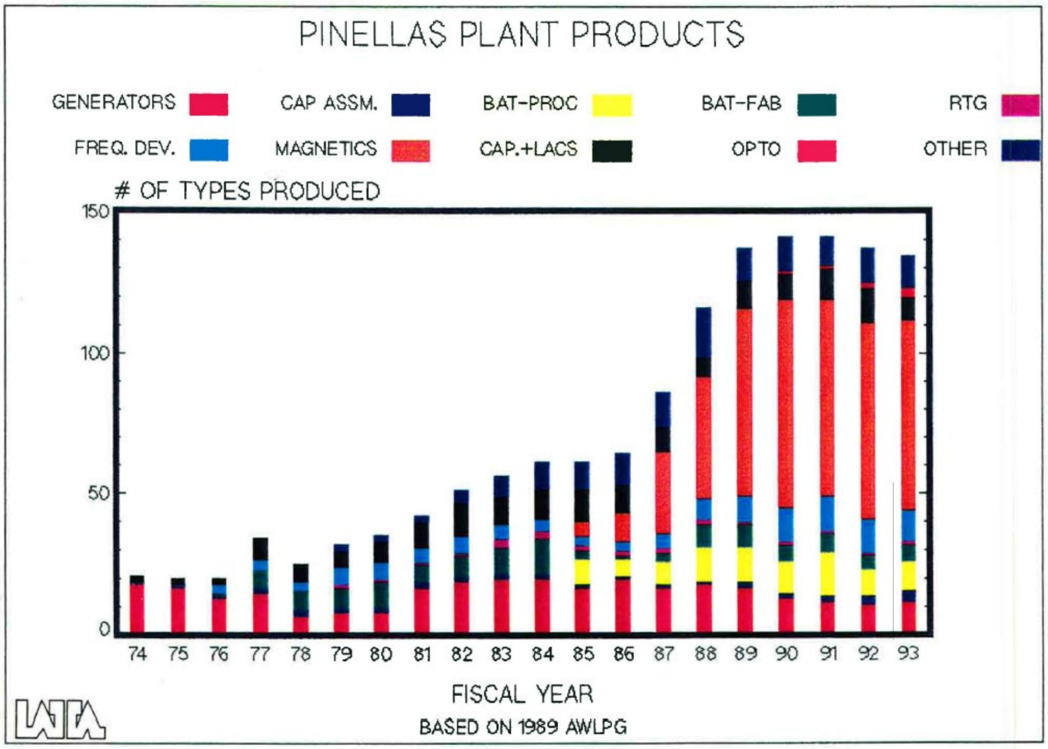
[3] ORAUT (2011b) notes that "A 1983 environmental assessment indicated that small quantities of ^{14}C labeled solvents were used in a laboratory testing operation (DOE 1983). No other documentation was found to indicate other uses of ^{14}C" (p. 16).

[4] The U.S. Department of Labor (DOL) presentation is undated, but since the last year of the charts is 1993, SC&A assumes that the presentation was prepared soon thereafter.

Figure 1. Number of different types of different products produced per year

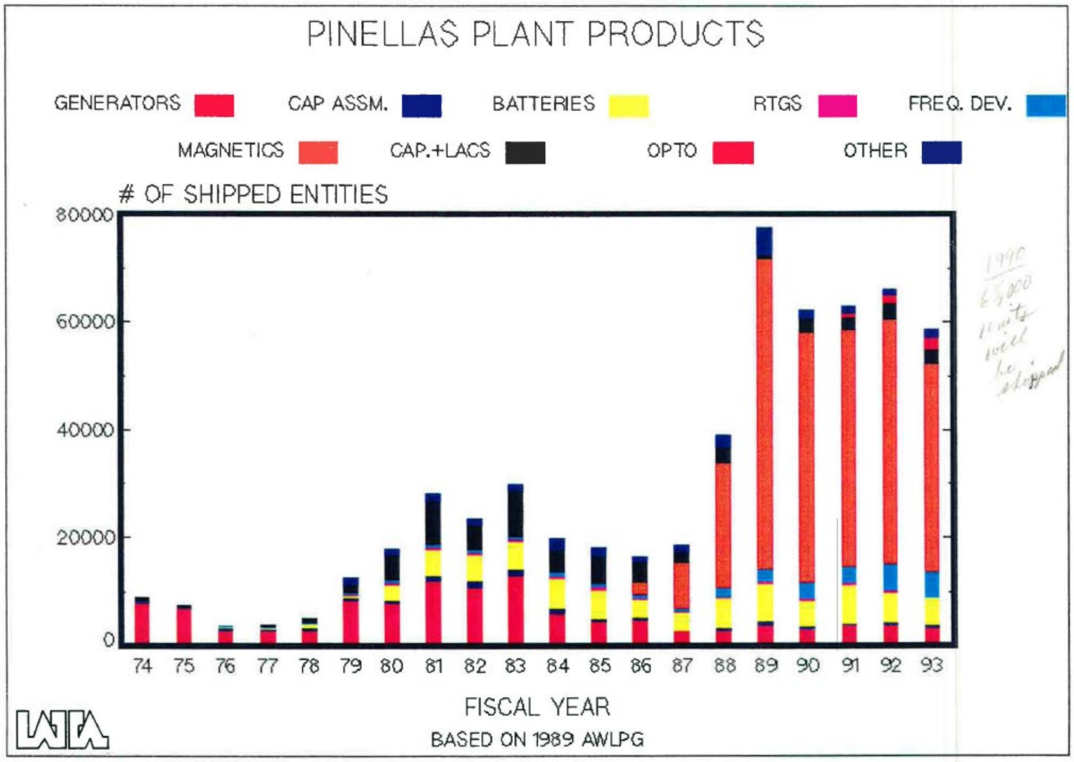
DOL-06-02424



Source: DOL (c1994).

Figure 2. Number of units of different products shipped per year

DOL-06-02424



Source: DOL (c1994).

It is not feasible to read actual numbers from the charts, but some trends can be discerned. Neutron generator production was ongoing at the start of the chart in 1974, with about 20 different types and about 8,000 shipped, and ending in 1993 (the plant ceased operations in 1994) with 15 different types produced and 2,000 shipped. The trend in number of different types by year is fairly steady, with some dips in the late 1970s and 1980. The trend in number shipped is as high as over 10,000 units in 1983 and as low as about 1,000 units in several years, particularly from 1987 through 1993.

It is not clear from the available copy of the presentation which of the colored stacks represents RTGs, since several products were given similar reddish colors, but, assuming the stacks are ordered in the same way as the 10 different products listed with corresponding colors in the legends above the charts, RTGs would be the fifth up from the bottom of each bar (neutron generators would be the lowest). The number of different types of RTGs appears to be no more than a few throughout all the years. SC&A could not draw any definitive conclusions about the amount shipped per year on that chart since not all of the reddish-colored bars appear each year. Therefore, SC&A has one observation about neutron generator production.

Observation 1: Neutron generator production was fairly steady

SC&A's review of neutron generator production from 1974 through 1993 showed that it was fairly steady, with a peak in the early 1980s and a few notable dips in the late 1970s into 1980.

3.2 External exposures

Section 5.3 of the ER addresses external radiation exposure sources at the Pinellas Plant. This information also appears in the occupational external dose TBD, ORAUT-TKBS-0029-6, revision 02 (ORAUT, 2017), which was reviewed by SC&A and the Pinellas WG with all issues resolved (refer to section 2 of this report). ER section 5.3 begins by summarizing what NIOSH considers to be the potential for external occupational exposures:

> The activities with a potential for external radiation exposure at the Pinellas Plant included testing the neutron tubes and neutron generators, working near the plutonium oxide heat sources, using other radiation-generating devices, and in rare instances, external exposure to Kr-85 gas leaks. The radiological materials with potential for external exposure included Kr-85, carbon-14, and plutonium. The depleted uranium used in the tritium storage beds presented no significant external radiation hazard due to the low specific-activity and the non-penetrating radiation emitted. [NIOSH, 2021a, p. 37]

Other radionuclides were also present at Pinellas, but they were mostly sealed check sources and other low-activity sources that would not make significant contributions to sitewide external dose. The introductory paragraph of ER section 5.3 concludes:

> While radioactive materials and radiation-generating devices were necessary to the product manufacturing, the majority of the work performed at the Pinellas Plant did not involve exposures to external sources of radiation. **This lack of external radiation exposure potential is why the Pinellas Plant did not monitor many workers for external doses.** [NIOSH, 2021a, p. 37; emphasis added]

The last sentence of this quotation is the primary justification given for more workers not being monitored for external radiation. The following subsections discuss the different types and sources of external radiation considered in the ER: photon, beta (electron), and neutron.

3.2.1 Photon radiation

Section 5.3.1 of the ER discusses potential photon exposure sources in several plant areas:

- Neutron Generator Production Areas: The main source of photon exposure would have been from testing neutron tubes and neutron generators.
- RTG Production Areas: According to a 1991 as low as reasonably achievable (ALARA) report for 1990 (Harder, 1991, p. 1), the plutonium-238 dioxide (Pu-238O_2 or $^{238}PuO_2$) heat sources produced gamma radiation that amounted to an estimated 67 percent of the plant's photon dose in 1990.
- Ion Implanter Accelerator: This Model 200 Hewlett Packard (HP accelerator was originally installed in the Chemistry Laboratory in Building 100 (the main production building), then relocated to Building 800.

3.2.2 Beta radiation

Section 5.3.2 of the ER discusses potential external exposures from beta (electron) radiation. It notes that the principal source of this radiation was from tritium but does not find it a significant radiation hazard due to the low energy of its beta particle (5.7 keV average and 18.5 keV maximum energy), which would not allow it to penetrate the top layer of the skin. The ER (p. 39) states that "The maximum range of the beta particle is less than 5 millimeters in air. The range of this beta radiation is about $0.6 mg/cm^2$ [Weaver 1989, PDF p. 7], which is less than the thickness of the epidermal layer of the skin [NIOSH 2007]; therefore, NIOSH does not consider tritium to be an external radiation hazard." This assumption is consistent with usual health physics considerations in the Energy Employees Occupational Illness Compensation Program Act (EEOICPA) program in general and elsewhere.

Kr-85 (251 keV average and 687 keV maximum beta energy) poses a greater external beta exposure hazard than tritium because its beta particles have sufficient energy to cause a skin dose through exposure to a cloud of the gas. The plant used Kr-85 in leak detection systems. Although the plant recovered most of the gas after each leak test, some of it might have escaped into the environment despite the two leakage detection systems being surrounded by ventilation shrouds. However, SC&A's investigation of documented incidents at the plant found no instances of a cloud release of Kr-85.

X-ray diffraction and electron-beam equipment contained electron-producing sources and could only have directly exposed workers in the vicinity if the equipment containments were compromised. Various large and small sealed sources were also beta emitters. SC&A investigation of personnel exposures has not revealed any monitored external doses associated with these sources of radiation.

C-14 (49.5 keV average and 156.5 keV maximum beta energy) produces beta particles with energies greater than 15 keV and is thus considered an external beta radiation hazard. The plant used small amounts of this radionuclide as a tracer in some solvents. The ER notes that the amount of C-14 at the plant is considered negligible, with little potential for external beta exposure to personnel. SC&A concurs.

A 1992 Pinellas summary of natural uranium glass concerns notes that the plant used borosilicate glass containing 1.5 percent by weight of naturally occurring uranium oxide (Pinellas Plant, 1992–1994, PDF p. 2). As part of plant operations, this glass was cut and chemically etched. Site health physicists (HPs) evaluated the exposure risk and determined that the conservative highest whole body external dose expected from work with the glass was 15 millirem (mrem)/year and the highest dose to the extremities was 75 mrem/year. These are well below DOE limits at that time of 5 and 50 rem, respectively. Therefore, uranium glass is not considered a significant external beta radiation hazard.

3.2.3 Neutron radiation

As discussed in section 3.1 of this SC&A review, potential neutron exposures at the Pinellas plant could have come from either radiation-generating devices, such as the neutron generators, or from the sealed $^{238}PuO_2$ heat sources, which were used in the RTGs.

When activated, the neutron generators accelerated deuterium ions into deuterium- or tritium-containing targets and, through nuclear fusion processes, produced 2.5 MeV or 14.1 MeV neutrons, respectively. A 1986 GEND "Pinellas Plant Facts" summary notes that the neutron generators, which had to be replaced periodically in nuclear weapons due to radioactive decay of the tritium (12.33-year half-life), were designed by SNL (GEND, 1986, p. 14). A fuller description of how the neutron generators work can help inform a review of the ER and referenced sources; such a description appears in a 2002 SNL history of the Nuclear Weapons Complex, part of which is excerpted here:

> Deuterium atoms are entrapped in a source material located at one end of a high-vacuum tube. Tritium atoms are entrapped in a target material at the other end. The tube is connected to an electronic circuit.
>
> The weapons system provides an input signal to a timer in the neutron generator. The timer is synchronized with the weapon system's fuzing circuitry [which detonates a nuclear weapon] to ensure that neutrons are released at the precise time for initiation. A high current is sent to the source and ionizes the deuterium into a plasma. A very high voltage is placed between the source and the target and accelerates the deuterium ions into the tritium. . . . Fusion reactions occur between the deuterium and tritium nuclei and produce neutrons. [SNL, 2002, pp. 127–128]

The $^{238}PuO_2$ sealed sources were manufactured by Los Alamos National Laboratory; the 1990-vintage RTGs producing 5 watts thermal power and 25 milliwatts electric power at 2 volts for over 25 years (Pu-238 has an 87.7-year half-life). The plutonium in the RTGs also produced neutrons from fission initiated by (alpha, neutron) reactions, but continuously rather than intermittently as is the case with the neutron generators (GEND, 1990). The Pinellas 1990 ALARA report (Harder, 1991) states that the plutonium heat sources were the only measurable sources of neutrons at the plant.

3.3 Internal exposures

The petition requests inclusion of the Pinellas Plant in the SEC based partially on radiological characterizations that did not include strontium (Sr)-90, cobalt (Co)-60, thallium (Tl)-204, beryllium, and uranium. In contrast, the SEC ER asserts that only tritium was an internal exposure risk at Pinellas and, therefore, did not include other radioisotopes in its evaluation. The following sections discuss the radioisotopes mentioned in the petition, as well as several others that could have potentially caused an internal dose. It must also be noted that beryllium, cited by the petition, is a nonradioactive hazard and outside the scope of this program.

3.3.1 Tritium

The ER identifies tritium as the only source of internal radiation exposure risk to personnel. Tritium intakes and related issues have been extensively discussed with the Pinellas Plant WG and in both NIOSH and SC&A documents. The current occupational internal dose TBD, ORAUT-TKBS-0029-5, revision 03 (ORAUT, 2016), gives dose guidance for both soluble and insoluble tritium in different forms. Section 7.1.1.1 of the ER (p. 62) references section 5.8.1.1 of that TBD for a description of the methodology NIOSH uses to reconstruct internal doses from soluble tritium (tritium gas, tritium oxide, and organically bound tritium) from bioassay results. In summary, NIOSH:

- Calculates exposures to both 100 percent tritium gas and 100 percent organically bound tritium and then selects the most claimant-favorable value.

- Assumes that workers exposed to insoluble tritium compounds (i.e., metal tritides) would also have worked with soluble tritium and that they would have then been monitored for tritium. Consequently, NIOSH assigns insoluble tritium exposures only for periods when a worker submitted a urine sample. Pinellas had limited exposure potential for the insoluble forms compared to the soluble forms; however, NIOSH assesses all workers monitored for soluble tritium as though they received exposures to insoluble tritium at the same time. This is a claimant-favorable approach.

Potential tritium exposure at Pinellas has been a subject of concern and scrutiny since SC&A's earliest review of the Pinellas site profile TBDs, which were issued from 2005 through 2006 (ORAUT, 2005a, 2005b, 2005c, 2005d, 2005e, 2006). As discussed in section 2 of this review, SC&A reviewed the TBDs in 2006 and identified 11 primary and eight secondary issues (SC&A, 2006). Of these, primary issue 2 ("Potential doses from insoluble metal tritides not sufficiently addressed"), primary issue 7 ("Missing internal dose estimation methods for unmonitored workers, such as maintenance and support personnel, not provided"), and secondary issue 3 ("Perimeter tritium monitoring stations") relate to tritium. Subsequent documents, reviews, and discussions resulted in SC&A issuing an updated "Issue Resolution Matrix for Pinellas Plant" on March 15, 2016 (SC&A, 2016a), which indicated that primary issue 7 and secondary issue 3 were closed.

As part of resolving primary issue 2, NIOSH issued a paper in 2015, "Review of NIOSH's Current Approach to Reconstruction of Insoluble Tritium Particulate at the Pinellas Facility" (NIOSH, 2015), in which the Pinellas SMT model was based on that used for the Mound plant. SC&A responded with its own paper in February 2016, "Review of Proposed Stable Metal Tritide Dose Reconstruction Methodology at Pinellas" (SC&A, 2016c).

After discussions at WG meetings, the WG accepted the NIOSH SMT model and put primary issue 2 in abeyance until the internal dose TBD is revised appropriately and then reviewed (SC&A, 2016b). As stated in the March 2016 issue resolution matrix, "NIOSH indicated that the next TBD revision will include a discussion of how intakes of tritides, OBT, and HTO are addressed individually" (SC&A, 2016a, p. 3). While the WG and SC&A agree with NIOSH's stated resolution of the issue, the final language appearing in the revised TBD would have to be examined before the issue could be closed.

SC&A's presentation at the August 9, 2016, Board meeting (SC&A, 2016b, slide 5) summarized the five key aspects of the SMT model as follows:

1. **Resuspension factor:** Increased from 1E-6 to 5E-5 per meter (same as Mound).

2. **The use of the highest tritium contamination measurement (1957–1973):** Airborne contamination estimated based on highest observed value in monthly health physics reports from 1957 to 1973. *(Note: Assumed level of SMT contamination level is 1 to 2 orders of magnitude higher than the assumed values at the Mound site.)*

3. **Technical adequacy of the method to detect tritium that is bound to particulate metal:** Contamination swipes utilize a cotton ball that was rinsed with DI [deionized] water (counting liquid) and then filtered prior to measurement by liquid scintillation counting. Particulate tritium could potentially be trapped in the cotton ball and not transferred to the counting liquid.

4. **The magnitude and extent of potential for tritium contamination at Pinellas:** SMTs only handled in areas where tritium was handled, and all tritium workers were monitored via urinalysis. Model only applied to those with tritium bioassay (i.e., coworker intakes not applied to unmonitored workers).

5. **Choice of solubility type for the metal tritides present:** Assumes all SMT intakes are Type M or Type S depending on which is favorable to the individual claimant.

SC&A's Board presentation on the treatment of SMTs concluded that "All 5 key aspects of the SMT model have been incorporated into TBD-5 Rev. 3 [the occupational internal dose TBD; ORAUT, 2016]" (SC&A, 2016b, slide 11).

The Pinellas SEC ER (October 20, 2021) and the occupational internal dose TBD (rev. 03, July 18, 2016) do not incorporate the guidance for performing dose reconstruction (DR) for intakes of "special tritium compounds" (STCs, including SMTs) in revision 01 of ORAUT-OTIB-0066, "Calculation of Dose from Intakes of Special Tritium Compounds," issued October 15, 2020 (ORAUT, 2020; "OTIB-0066"). The TBD was released several years before revision 01 of OTIB-0066, and the ER was released at approximately the same time as the OTIB. The OTIB-0066, revision 01, publication record states:

> Removed recommendation to use ORAUT-OTIB-011 for assessing OBT. Added discussion on practical interpretation of urinalysis results following an intake of an SMT. Incorporates formal internal review comments. Constitutes a total rewrite of the document. [ORAUT, 2020, p. 2]

In recognition of the major changes in OTIB-0066, revision 01, compared to the original version, the Board tasked SC&A with reviewing it, which resulted in SC&A producing an assessment on April 28, 2021 (SC&A, 2021). The "Background" section of SC&A's memorandum references section 2.0 of OTIB-0066, revision 01 (ORAUT, 2020, p. 5), which summarizes the issue it addresses:

> Stable metal tritides (SMTs) are a class of tritium compounds that cannot be detected by urine bioassay as easily as tritium oxide ["water"]. "Stable" is used to

> indicate that the tritium is not easily separated from the metal matrix in which it is bound. The material is more strongly retained in the lung, resulting in much smaller fractions of the intake excreted in urine. Therefore, a relatively small amount of tritium in a urine sample can indicate a large intake of an SMT. **Ideally, workplace information, in the form of air monitoring, surface contamination activity, and process knowledge, are used to assign potential intakes of this material, which is addressed in a site profile when possible** [emphasis added].
>
> In the absence of other available monitoring data, urinalysis can be used to provide a best estimate of an intake. The purpose of this TIB is to provide guidance on how to use urine bioassay data to calculate best estimates of the annual organ doses for intake of tritium in a metal matrix.

Observation 2: Potential for tritium contamination is adequately addressed
SC&A notes that key aspect 4 of the accepted NIOSH SMT model indicates that SMT exposures would only be applied if the energy employee (EE) were also monitored via urinalysis. However, given the deficiencies noted by the Tiger Team in the performance of the bioassay program as late as 1990, relying on bioassay completeness to establish exposure potential is likely inappropriate.

SC&A's 2021 OTIB-0066 review (SC&A, 2021) notes that SC&A's 2008 evaluation of revision 00 of OTIB-0066 had four findings, two of which were closed (findings 2 and 4) and two of which were in abeyance (findings 1 and 3). "SC&A concludes that both findings [1 and 3] have been adequately addressed and resolved and recommends closure" (SC&A, 2021, p. 4). At its November 3, 2021, meeting, the Subcommittee for Procedure Reviews (SPR) agreed to close these two issues, leaving no remaining open issues (ABRWH, 2021a). Hence, the methodology presented in OTIB-0066, revision 01 (2020), for treating exposures to STCs has been accepted by the SPR.

It should be noted that the petitioners sent a letter to the Board dated December 12, 2017, describing their concerns with DR from exposure to metal tritides. SC&A believes that the conclusions from the 2021 SPR meeting address and resolve these concerns. SC&A's observation 3 recommends a TBD action and that NIOSH evaluate the issue for any significant SEC consequences.

Observation 3: The ER does not reference recent special tritium compound document
The SEC evaluation report and ORAUT-TKBS-0029-5, revision 03 (the occupational internal dose TBD), do not incorporate guidance for performing dose reconstruction for intakes of stable metal tritides from revision 01 of ORAUT-OTIB-0066 (2020). NIOSH should commit to reference and discuss guidance from OTIB-0066 in the next revision of the occupational internal dose TBD and evaluate whether it has any consequential effect on the SEC evaluation report conclusions. In addition, as noted in key aspect 2 of the SMT model accepted by the Board (as presented by SC&A at the August 9, 2016, Board meeting), sitewide air monitoring data or contamination survey data should be preferentially used over other modeling in dose reconstructions for SMTs whenever available.

A discussion of potential metal tritide exposures appears in an Oak Ridge Associated Universities Team (ORAUT) interview of a former Pinellas Health Physicist (HP), where the HP stated (as paraphrased by ORAUT) that “the same contamination survey procedures were used for metal tritide contamination as for tritiated water contamination” (ORAUT, 2013, p. 3). Furthermore,

> [The HP] indicated that they knew where tritide contamination would likely occur, which was typically limited to 2-3 areas within the operation line. [The HP] thought that there might be more causes of tritium contamination in destructive testing. [Another HP] discovered that tritide exposures were occurring in an unexpected area via the bioassay results of a worker that was offsite for a long enough period of time for any (soluble) tritium to be eliminated from their body. When that worker returned to work, their urine still had tritium in it, which could only have been from a (less soluble) metal tritide exposure. Once they figured out the cause of the metal tritide exposure, they move the operation that was causing it into a fume hood and eventually into a glove box, to help prevent further exposure to tritides. [ORAUT, 2013, p. 3]

Three takeaways from this account by a former Pinellas HP are that (1) the locations of metal tritide contamination were limited, (2) the Health Physics group was on the lookout for potential sources of metal tritide exposure, and (3) when sources of exposure were found, the Health Physics group took positive steps to eliminate the potential. In addition, it should be reiterated that SMT exposures are based on available sitewide air monitoring data; therefore, identifying workers in specific areas where SMTs are handled is not crucial to establishing a bounding exposure.

3.3.2 Uranium

Depleted uranium was used on site in tritium storage beds. Secondary issue 8 from the original SC&A TBD review (SC&A, 2006) concerns the potential for missed depleted uranium intakes. This issue arose when some literature and interviews with former employees raised the possibility that loose (not contained) depleted uranium was present in Building 100 from the cutting/machining of depleted uranium beds, which were used to store tritium. NIOSH investigated this issue and determined that the cutting work described by these workers and literature was done at the GE X-ray Milwaukee site, which is not part of the Pinellas SEC review. In 2009, SC&A reviewed the records identified by NIOSH and agreed that the records conclusively establish the work described was done off site from the Pinellas Plant. This issue was discussed and closed at the June 11, 2009, Pinellas WG meeting (ABRWH, 2009, pp. 58–64), as also noted in the issues resolution matrix (SC&A, 2016a, p. 8).

Another Pinellas report, concerned with potential exposure concerns from natural uranium glass used to store tritium, states that no internal hazards were identified (Pinellas Plant, 1992–1994).

In an ORAUT interview with a site HP, the HP indicated that there were two accidental breaks in the U-beds (stainless steel tritide storage beds that used uranium tritide to store tritium) (ORAUT, 2013). According to the HP, they were not large activity beds nor the main storage beds, and no uranium contamination was found. They were both classified as minor incidents, and the beds were taken out of service. The interview did not mention any dates associated with these incidents, and SC&A could not locate any documentation of incidents associated with these descriptions. One possibility is that the lack of documentation indicates the low degree of severity of the incident.

3.3.3 Plutonium

SC&A had previously examined the issue of plutonium monitoring at Pinellas as part of its review of revision 00 of the occupational internal dose TBD (SC&A, 2006; pp. 26, 33). This review was discussed at subsequent Board meetings (ABRWH, 2009, PDF pp. 26–31; ABRWH, 2011, PDF pp. 70–89; ABRWH, 2012, PDF p. 28). SC&A documented the final resolution in the March 15, 2016, update of the issue resolution matrix (SC&A, 2016a, p. 4), which summarizes the plutonium issue (issue 3) as follows:

> This was a concern early in the issues resolution process, when some potential exposure to plutonium (Pu) was not ruled out. Based on discussions at the October 2011 WG meeting, it was determined that the only source of potential intake was from handling of newly received triple encapsulated radio-thermal generators (RTGs). However, there was no surface contamination greater than 200 dpm (the rejection level), and NIOSH calculations show that to receive even 1 mrem annual dose would require handling thousands of RTGs in a year. Therefore there is no credible source of exposure. In Revision 2 of TBD 5 [occupational internal dose], all Pu discussion was removed based on discussion at the October 2011 WG meeting. If evidence of a positive exposure is discovered, NIOSH will need to develop a dose reconstruction (DR) methodology.

In this review, SC&A chose to revisit the potential for plutonium exposure beginning with a more detailed look at the form, handling, and plant operations involving plutonium. A good summary appears in a 1982 DOE safety analysis that was written in support of a planned expansion of Building 400, which housed the RTG facility (DOE, 1982):

> An RTG consists of a heat source containing a small amount of plutonium oxide encapsulated in a thimble-sized container. The heat source is enclosed within thermal insulating material so that its temperature approaches 500ºC [degrees Celsius]. It is mated with a thermopile consisting of many thermocouples connected electrically in series and thermally in parallel between this high temperature source of heat and the relatively cool outer case. The temperature differential causes heat to flow through the thermopile which the latter converts to electrical energy. . . . The current design produces 25 milliwatts of electrical power at low voltage for in excess of 25 years. [DOE, 1982, PDF p. 3]

This safety analysis also noted that RTGs had been manufactured in Building 400 since 1975 and that the sealed heat sources, containing Pu, were manufactured at another DOE facility (DOE, 1982, PDF p. 6).

An undated document in the Pinellas SRDB files elaborates that the first plutonium appeared at Pinellas on January 18, 1957, when a 7-gram Pu-239 calibration source was received (“First Plutonium,” n.d.). More importantly for this review, the “First Plutonium Delivered Onsite” document describes the chronology of the RTG operations as follows: “The first receipt of plutonium for use in the Radioisotopic Thermoelectric Generator (RTG) was on November 4, 1975, when seven heat sources totaling 54.4 grams of Pu-238 were received from Sandia Laboratories,” and “all plutonium, with the exception of calorimeter sources and small instrument calibration check sources, were removed from the plant in February 1991” (“First Plutonium,” n.d., PDF p. 2).

DOE (1982, PDF p. 6) states: “The heat source is mated with a thermopile, (manufactured at this site), enclosed in thermal insultation and packaged in a welded steel case. . . . The heat sources themselves are manufactured to a design verified to withstand external stresses in excess of those foreseen in any postulated accident [discussed elsewhere in the DOE report].” Discussing the environmental safety and health “programs, systems, procedures, facilities and equipment” related to the RTGs, the DOE safety analysis states that **“Their [controls] effectiveness can be demonstrated by the fact that there is not, nor has there ever been, any plutonium contamination inside the facility nor released to the environment”** (DOE, 1982, PDF p. 6; emphasis added).

Section 5 of DOE 1982 describes the operations associated with the plutonium heat sources, emphasizing contamination detection and control. This is worth repeating here to gain a sense of the flow of the sources from intake to assembly into RTGs:

> Shipments of heat sources are delivered directly to Building 400. The shipping packages are surveyed for surface contamination by instrument and swipe, then transferred to the source storage vault room. The truck is also surveyed before being released.
>
> When the shipment packages are to be opened, they are moved from the vault room to the source inspection hood. Here they are opened and surveyed in accordance with Radiological Safety Procedure F-3 (see Appendix A) and, if free of contamination, are placed in a source storage container and returned to the vault. If the unpacking survey shows greater than 200 DPM [disintegrations per minute], the source is immediately repackaged and returned to the supplier. If the survey shows detectable contamination less than 200 DPM, an effort is made to decontaminate the source in accordance with Radiological Safety Procedure F-4 (See Appendix A). **This circumstance has not occurred in over six years of RTG operations at this site** [emphasis added].
>
> When sources are to be placed in the glovebox for assembly into an RTG, they are moved from the vault to the source inspection hood, surveyed again in accordance with Radiological Safety Procedure F-5 (see Appendix A), cleaned with alcohol, placed in a cleaned storage container and transferred to the glovebox. [DOE, 1982, PDF p. 34]

Section 6 of DOE (1982, PDF p. 40) notes that “Three layers of encapsulation contain the source material (Figure 6-1). The outer layer is a nickel alloy and the inner two layers are a tantalum alloy.” The report’s accident analysis for “Source Leakage” concludes that “The probability of source leakage, although possible, is so small that it can be assumed that it will not occur” (DOE, 1982, PDF p. 45). The unidentified document on plutonium in the Pinellas SRDB files echoes that conclusion:

> Fall-out plutonium has been detected at the Pinellas Plant, but analysis for releases of RTG plutonium focuses on the isotopic ratio of 80% by weight Pu-238 and 16% by weight Pu-239. Pu-238 and Pu-239 have not been found in these ratios in environmental samples, therefore, no releases from Pinellas Plant operations have been detected in the environment. [“First Plutonium,” n.d., PDF p. 2]

Since (1) the plutonium radiological hazard issue has been discussed and is considered resolved by the Pinellas WG and (2) the current further investigation supports that conclusion, SC&A believes the potential for plutonium intakes has been adequately addressed and resolved. No further discussion is necessary unless new information becomes available.

3.3.4 Carbon-14

Table 4-2 of the occupational environmental dose TBD, ORAUT-TKBS-002904, revision 01 (ORAUT, 2011d, pp. 12–13), gives radionuclides released from Pinellas Plant exhaust stacks for the years 1957–1997. C-14 emissions are denoted as “no recorded release” for all years except 1979–1983, which total 0.000435 Ci. Note c of the table explains that the releases are based on the amount of C-14 labeled solvent used each year.

According to the State of Florida Department of Health and Rehabilitative Services (HRS), approximately 0.00034 Ci of C-14 were released from plant stacks from 1979 through 1983 (DOE, 1994b, PDF p. 42). SC&A previously identified C-14 as a potential exposure pathway in its initial TBD review as part of issue 7 and secondary issue 2. The issues were discussed with the Pinellas Work Group during the June 11, 2009, meeting (ABRWH, 2009). The quantity of material was determined to be “negligible” and contributed less than a mrem per year dose when modeled in the Integrated Modules for Bioassay Analysis (IMBA) program (PDF pp. 57–58). Since these issues have been discussed and are considered resolved by the Pinellas WG, SC&A believes the potential for C-14 intakes raised in the ER petition has been resolved. C-14 does not contribute significantly to the internal dose hazard on site. No further discussion is necessary unless new information becomes available.

3.3.5 Krypton-85

According to the State of Florida Department of Health and Rehabilitative Services, a total of 846 Ci of Kr-85 was released from plant stacks from 1963 through 1992 (DOE, 1994b, PDF p. 42). Kr-85 is a colorless, tasteless, radioactive noble gas that decays by beta emission to rubidium-85, a stable isotope. As a noble gas, it does not react chemically within the body when it is breathed in and out. Although a minute amount of decay can be expected in the lungs (10.8-year half-life), Kr-85 primarily represents only a potential external hazard. As stated in an Argonne National Laboratory (ANL) fact sheet for krypton (ANL, 2005, PDF p. 2):

> The main health concern [of Kr-85] is the increased likelihood for cancer induction, and the exposure pathway of most concern is external exposure in a cloud of gas. The radiation dose for krypton-85 (the primary isotope of concern) from an external cloud of gas is more than 130 times higher than the dose from

> any gas in the lungs and more than 200 times higher than that from any gas in body organs and tissues after being taken into the body. . . . much of the dose for krypton-85 is from beta particles, and the skin is the primary tissue of concern.

The ANL krypton fact sheet also states that there haven't even been lifetime mortality risk coefficients developed for inhalation/ingestion, only for external exposure from immersion in a cloud.

SC&A concurs with NIOSH's assessment in section 5.2 of the ER that this isotope does not pose a significant internal hazard.

3.3.6 Strontium-90, cobalt-60, thallium-204, and beryllium

The petition requests that Pinellas be added to the SEC based upon the claim of incomplete radiological characterizations of Sr-90, Co-60, Tl-204, and beryllium (uranium is discussed in section 3.3.2 of this review). SC&A notes that beryllium is an element, not a radionuclide, and while it may present a health hazard, it is not a source of radiological exposure at the site. The other three radionuclides were present on site according to inventory records.

SC&A reviewed the justification provided in the petition concerning the presence of radionuclides requiring bioassay monitoring. SC&A does not find that the presence of the radionuclides Sr-90, Co-60, and Tl-204 in inventory presented an internal exposure risk that should have been monitored for by Pinellas. Among other isotopes, Sr-90, Co-60, and Tl-204 were listed as nonproduction radioactive sources in the site inventory (DOE, 1994b, PDF p. 117). All Co-60 and Tl-204 sources were listed as sealed sources, thereby not constituting an internal radiation hazard. SC&A is aware of a 100 millicurie (mCi) Co-60 source that was found to be leaking in 1961 (Forest, 1961, PDF p. 4). Sealed sources are typically kept under control and undergo routine testing to ensure the integrity of the seal. The leak was detected as part of these routine surveys and was corrected immediately; as such, it did not pose a sitewide internal exposure risk. Sr-90 was present in both sealed and unsealed sources listed in inventory; however, the unsealed sources were small (0.013 microcurie (µCi) and 0.25 µCi) and did not pose a sitewide internal risk. While these isotopes can be used as a power supply for RTGs, SC&A has not found evidence that they were used in this capacity at Pinellas.

Additionally, the petition provided workers' heavy metal testing results for elements via urinalysis. However, this type of test is not a valid means of determining occupational exposure to radionuclides. The tests looked for elemental forms of strontium, cobalt, thallium, and uranium. In general, the lab results showed these elements were not detected or were below the detection limits of the test. Hence, these tests do not provide evidence of elemental or radiological intakes. These elements are found naturally in the environment, and their presence in urine cannot be used to establish occupational exposure to radioisotopes. The results of the heavy metals tests are discussed further with the petitioner concerns later in this report (refer to sections 6.1 and 6.2).

4 Radiation Monitoring

4.1 Monitoring during the SEC period 1957–1990

The NIOSH SEC ER defined and evaluated the SEC period as January 1, 1957, through December 31, 1990, and concluded:

> Both external and internal dosimetry results are available, and the available data extend beyond 1981. In addition, NIOSH has found that claimant records provided by DOE generally include both internal and external dosimetry results for potentially exposed workers. NIOSH finds that the Pinellas Plant did monitor potentially exposed personnel and did not find indications of lack of monitoring for the class under evaluation. NIOSH concludes that it has sufficient data to perform dose reconstructions. [NIOSH, 2021a, p. 82]

The NIOSH ER asserts that only tritium is important for internal exposure and that there are sufficient tritium bioassay data and also external monitoring data for DR for the SEC period (NIOSH, 2021a, p. 7):

- NIOSH reviewed the internal radiation exposure potential from other radionuclides used at the Pinellas site including plutonium, uranium, carbon-14, nickel-63, and krypton-85. NIOSH confirmed previous discussions by the Advisory Board on Radiation and Worker Health (ABRWH) Pinellas Plant Work Group that these radionuclides were not internal exposure concerns for the Pinellas Plant workers.

- NIOSH has access to the in vitro urinalysis monitoring records for Pinellas Plant workers with the potential for internal exposures including tritium urinalysis results, termination bioassay sample results, bioassay tabulation forms, exposure record cards, dose adjustment forms, bioassay dose summary reports, dosimetry cards for individuals, and individual plutonium in vitro bioassay results. NIOSH reviewed the NIOSH DCAS Claims Tracking System (referred to as NOCTS) claimant files and found over 20,000 tritium bioassay results for 230 individuals.

SC&A does not currently have access to the searchable NOCTS database to analyze claimant files for this ER review. Therefore, SC&A manually reviewed the list of approximately 2,500 documents made available by NIOSH. SC&A selected and reviewed documents that could potentially contain workers' bioassay and/or external dose data. Among those reviewed, SC&A located 13 PDF collections of personnel monitoring records (SRDB IDs 183490 through 183502) of approximately 2,500 pages each that covered employees with last names starting with A through W. The recorded data contained tritium bioassay results (and some plutonium bioassays) by urinalysis and external dose monitoring of photons, neutron, and betas, as applicable, on a badge exchange basis in the form of handwritten cards or computer printouts. SC&A followed one long-term employee who started in 1957 and had many years of service and found 73 pages of monitoring-related data consisting of bioassay results and external dose monitoring (Pinellas Plant, 1950s–1990s, PDF pp. 652–724). Other examples of long-term monitoring can be found in these dose records.

4.2 Period of SEC evaluation excluded from SEC petition, 1991–1997

The petition requested that the SEC cover the period January 1, 1957, through December 31, 1997. However, NIOSH evaluated only through December 31, 1990, justifying in the ER:

> The Tiger Team report focused on the 1988–1989 period and is not directly applicable to the time period that followed it because documentation shows that the Pinellas Plant responded to the finding. After the Tiger Team assessment, the Pinellas Plant began tracking individual compliance with bioassay sampling and had success in improving bioassay compliance. The Pinellas Plant documented this success in improving compliance in site As Low As Reasonably Achievable (ALARA) reports. Prior to these tracking efforts, it was unclear how widespread the non-compliance might have been. [NIOSH, 2021a, p. 6]

The Pinellas Plant action plan for fiscal years 1990–1994 concerning tritium bioassay sampling resulting from the Tiger Team assessment of 1990 (DOE, 1990a) is summarized in the "Pinellas Plant Final Action Plan" of December 3, 1990 (DOE, 1990b, pp. 273–274). This includes five activities to be implemented to improve compliance and tracking of tritium bioassay sampling, most to be completed in fiscal year 1990 (October 1, 1989, through September 30, 1990).

To support NIOSH's assumption that tritium bioassay compliance and tracking were adequate for the period 1991–1997, the ER states (NIOSH, 2021a, p. 20):

> During the qualification assessment, NIOSH reviewed available documentation and information related to the site follow-up to determine if the issue identified in the report continued. In response to the Tiger Team assessment, the Pinellas Plant Health Physics Department began tracking individual compliance with bioassay sampling and had success in improving the compliance. The Pinellas Plant ALARA reports document the Plant's success in improving compliance. The 1990 *Annual ALARA Program Report for Ionizing Radiation* [Weaver 1991, PDF p. 38] shows the bioassay program average participation was 78%, which is 2% short of the 80% target. NIOSH concluded, based on the bioassay compliance published in the 1990–1995 ALARA reports, that it is reasonable and prudent to consider 1990 a transition year to a more rigorous program.

4.3 Internal monitoring records

The ER provides a summary of tritium monitoring data in table 6-1 (NIOSH, 2021a, p. 43), reproduced here as table 2. These data represent the NOCTS monitoring results. Therefore, they include only *claimant* monitoring results and represent a subset of the Pinellas workforce.

Table 2. Pinellas claimants with tritium results

Year	Number of Pinellas claimants (all job titles) in NOCTS	Number of Pinellas claimants with tritium results	Number of "Maintenance" claimants (by job title)	Number of "Maintenance" claimants with tritium results
1957	110	12	10	1
1958	162	21	14	5
1959	178	42	19	9
1960	199	52	19	15
1961	212	56	20	12
1962	218	54	20	11
1963	218	45	21	10
1964	224	52	22	15
1965	219	47	21	12
1966	241	60	22	16
1967	248	57	22	16
1968	260	56	24	14
1969	259	56	24	11
1970	263	47	26	9
1971	264	41	26	12
1972	268	38	26	9
1973	271	32	25	8
1974	267	44	25	11
1975	264	37	24	7
1976	274	40	26	10
1977	282	29	29	8
1978	297	33	31	11
1979	314	29	32	9
1980	320	35	31	11
1981	329	34	35	10
1982	343	31	34	10
1983	345	38	36	8
1984	349	35	37	8
1985	354	25	37	6
1986	343	26	36	7
1987	330	21	36	6
1988	310	8	34	1
1989	299	3	0	0
1990	288	10	32	1
1991	280	14	32	2
1992	268	37	34	4
1993	190	9	0	0
1994	162	19	0	0
1995	127	1	17	4
1996	89	12	6	1

Source: NIOSH (2021a), table 6-1.

SC&A located SRDB 188333, which is an Excel workbook containing the data NIOSH used to generate table 2 of this report (ER table 6-1) (NIOSH, 2021c). While performing its review of the ER, SC&A requested that NIOSH provide the actual monitoring data supporting table 2, which NIOSH then supplied. The data provided are similar but represent the most current available data; therefore, they are not identical to the information used by NIOSH to generate table 2. SC&A compared the bioassay results to the historical reporting levels from table 5-3 of the internal dose TBD (ORAUT, 2016). Figures 3 and 4 show that, through the mid-1970s, most tritium urine bioassays were below the historical reporting levels of TBD table 5-3, which changed in April 1974 from 0.67 microcuries per liter (μCi/L) to 0.10 μCi/L. The minimum detectable concentration (MDC) reduced to 0.01 from 1987 through 1989 and again dropped to 0.006 μCi/L from 1990 through 1997. These reduced thresholds explain the increase in reported samples above the reporting level. SC&A has not found evidence that the increase in positive samples corresponds to an increase in dose or exposure risk.

Figure 3. Comparison of tritium bioassays as a fraction of annual total

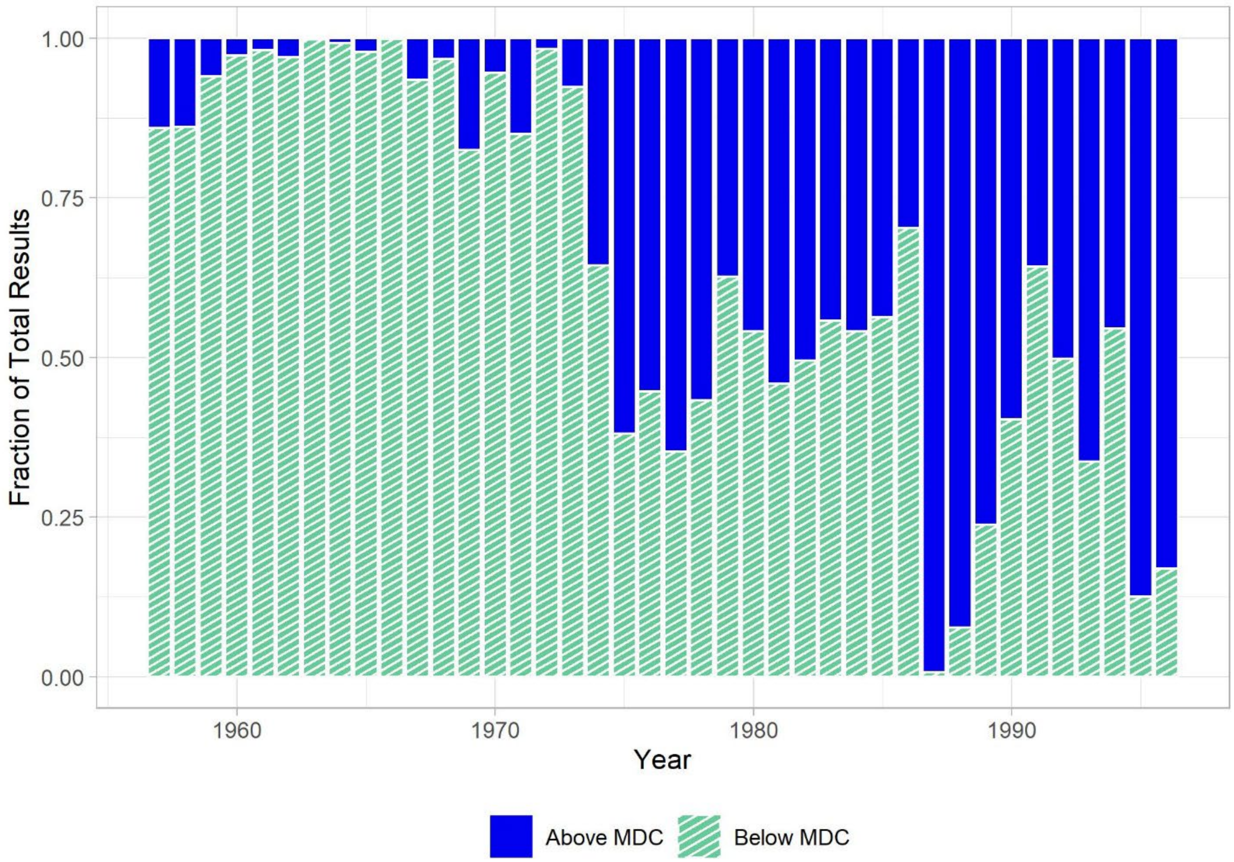
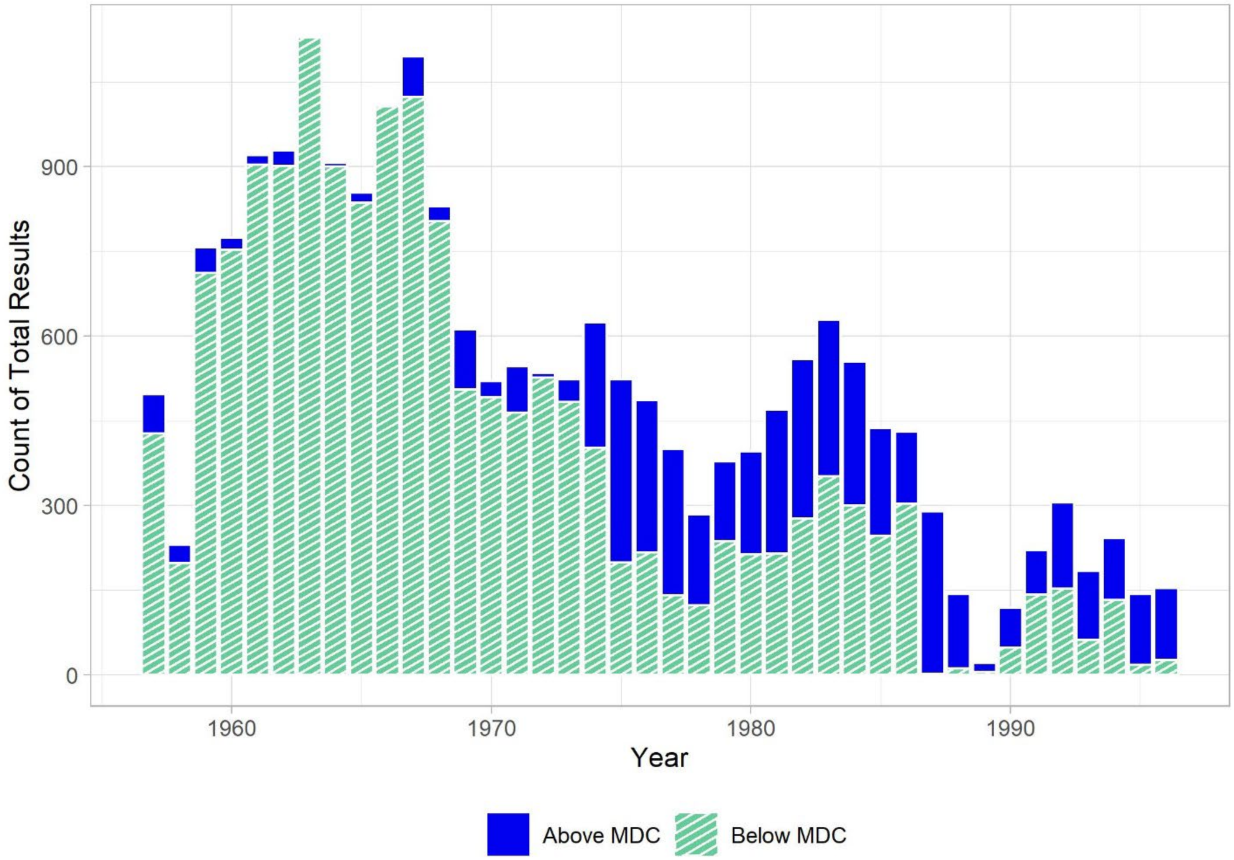


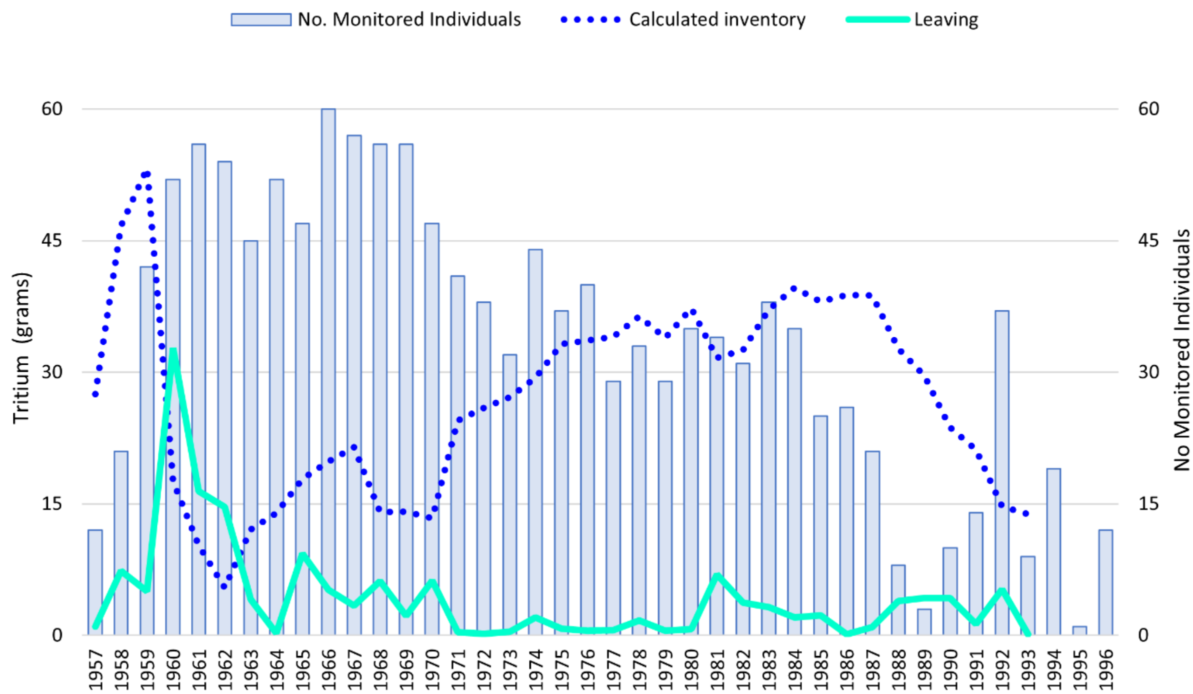
Figure 4. Comparison of tritium bioassays as annual counts



Observation 4: Lack of bioassay records for 1988–1990
From analyzing these results, the bioassay records from 1988 through 1990 stand out. Despite between 129 and 201 employees (table 3 and ER table 6-1) reportedly monitored by bioassays during these years, NIOSH only has monitoring records for 3–10 claimants per year (table 2 and ER table 6-2). According to the 1990 Tiger Team report, approximately 1,750 people were employed in 1989, suggesting that monitoring records are missing.

SC&A analyzed tritium inventories and throughput as an explanation of changes in bioassay monitoring. Biedermann (1994) provides an estimate of the historical tritium inventory at Pinellas. Inventory estimates for the period 1957–1993 were compiled by an Environmental Health Scientist for the National Center for Disease Control as part of an epidemiology feasibility study in September 1993 using plant tritium receipts, waste management disposal, and environmental monitoring records. These records were corrected to account for radioactive decay. Additionally, the scientist documented the tritium leaving the plant from product shipments, waste, air, and wastewater. These results are reproduced in figure 5 and compared with the monitoring data from table 2. As shown in figure 5, it is not clear that any correlation exists between the number of individuals monitored (per NOCTS) and the inventory or tritium throughput.

Figure 5. Comparison of tritium onsite to bioassayed individuals



The ER summarizes tritium monitoring data for the period 1986–1995 in table 6-2 (NIOSH, 2021a, p. 45), reproduced here as table 3. This table summarizes the information contained in ALARA reports rather than claimants and NOCTS data.

Table 3. Summary of Pinellas internal monitoring data for tritium 1986–1995

Year	Number monitored	Total dose (person-mrem)	Average dose (mrem)	Highest individual dose (mrem)
1986	194	699	3.6	86
1987	139	358	2.58	105
1988	129	565	4.38	130
1989	201	557	2.77	97
1990 [b]	177	184	1.04	31
1991	202	390	1.93	101
1992	164	150	0.91	35
1993	134	103	0.77	21
1994	217	17	0.08	6.3
1995	215	224 [a]	1.04	93 [a]

Sources: Weaver (1993), PDF pp. 20, 23; Weaver (1996), PDF p. 15.

a. Includes dose from a single incident in which one individual received an exposure of 93 mrem. The total site dose and highest individual dose (excluding this one individual) were 131 and 23 mrem, respectively.

b. The 1990 row is NIOSH's assumed year of transition and last year of SEC evaluation.

SC&A located semiannual and quarterly compliance records from the 1990 and 1991 tritium bioassay programs (Weaver, 1990–1991). These reports were started following the deficiencies identified by the Tiger Team report. Individuals who were on a routine (weekly or monthly) tritium bioassay program were tracked for compliance with the bioassay program on a semiannual basis. The reports list individuals by name and indicate the number of tritium bioassays required and those that the individuals submitted. Each report stresses a goal of maintaining 80 percent minimum participation for all monitored employees. The ultimate goal was 100 percent participation, but the goal of 80 percent allowed for absences and other work interruptions. The reports show between 58 and 62 individuals on routine monitoring in each period. After the initial tracking began, the reports show between 7 and 12 individuals falling below the goal in each monitoring period. Four of these individuals appear on each report as noncompliant.

Observation 5: Bioassay schedule noncompliance by the plant
One of the principal Tiger Team findings relevant to the SEC petition was noncompliance with the plant's own requirements for termination, monthly, and weekly bioassays. Appropriate bioassay compliance (data completeness levels) in general is a subjective judgment to be made by the Board. In addition, the level of compliance with the bioassay program is unknown before the findings of the Tiger Team. It is SC&A's opinion that at a minimum, NIOSH should demonstrate that an appropriate co-exposure model can be constructed to address apparent incompleteness in the tritium bioassay program (likely throughout its relevant operating history). Despite concerted efforts by the site to rectify the compliance issues, nearly one-fifth of worker bioassay requirements were still not met. Bounding co-exposure values would certainly appear warranted during this latter period (1991–1997).

4.4 Additional Tiger Team findings about internal dosimetry

Appendix A to this SC&A review consolidates in list form some of the information in the Tiger Team report (DOE, 1990a) that SC&A finds particularly relevant to a review of the Pinellas SEC ER. As stated in appendix A, the focus of all DOE Tiger Team investigations was environmental safety and health compliance issues and less so radiation exposure issues. Some of the issues related to internal dosimetry are highlighted in this section: Overall, the Tiger Team report represents a balanced assessment of the radiation protection program and its implementation, presenting both positive and negative observations and findings.

Section 3.5.8.2 (p. 3-75) of the Tiger Team report observes that,

> Although the dose equivalents to the maximally exposed individual reported by the Pinellas Plant have consistently been well below the NESHAP [National Emission Standards for Hazardous Air Pollutants] limit of 10 mrem/year for whole body irradiators (no target organ irradiators are released in detectable quantities), the program as it exists today is not capable of defending the quality aspects required by existing and draft DOE Orders.

Observation 6: Radiological protection program commended by Tiger Team
On a positive note, commending the radiological protection program, section 4.5.11.1 (p. 4-90) of the 1990 DOE Tiger Team report states, "The overall assessment is that all levels of the GEND organization are receiving adequate radiological protection. This is primarily due to a GEND staff that appears willing to accept line responsibility for radiological safety along with a technically strong health physics staff providing direction."

Observation 7: Bioassay sampling frequency requirements not followed as noted by the Tiger Team

Section 4.5.11.1 (p. 4-91) of the 1990 DOE Tiger Team report compliments the plant for maintaining low overall internal dose exposures but also makes an important finding on noncompliance issues related to the plant not following bioassay sampling frequency requirements. This is one of the bases given in the SEC petition: "Occupational internal exposures are low compared to other DOE sites. This accomplishment results from a conservative approach to working with tritium and through the extensive use of engineering controls. However, compliance with the rules on providing bioassay samples at specified frequencies has not been satisfactory."

Observation 8: Contamination controls found generally good by Tiger Team

Section 4.5.11.1 (p. 4-91) of the 1990 DOE Tiger Team report discusses the effectiveness of contamination controls at Pinellas and notes that while it is generally good, there are instances when it is not: "Contamination controls are generally good. Contamination levels within the work areas are kept low and generally confined to the source. Indications were found that proper contamination control techniques are not always being followed, in some areas causing contamination spread to the general areas of the facility."

Section 4.5.11.2 (p. 4-101) continues the discussion of contamination controls with a negative statement: "Proper contamination control techniques are not being followed by personnel when working in and exiting from Contaminated Areas." The report (p. 4-102) noted that a contractor disagreed that workers were inadequately protected given the extremely low contamination levels detected and that "radiation exposures from these contamination levels are not measurable, as supported by bioassay sampling."

Observation 9: Bioassay sampling program implementation inadequacies noted by the Tiger Team

Section 4.5.11.2 (p. 4-98 ff.) of the 1990 DOE Tiger Team report contains several radiological protection findings and concerns related to internal dosimetry that are relevant here. Of particular importance, finding RP.7 (p. 4-98) claims that "Procedural requirements have not been established for an employee's termination bioassay, nor a system developed to identify and address those individuals who fail to provide a bioassay sample." Additionally, "GEND estimated that 20 percent of the personnel that terminated in 1988 did not provide a termination bioassay," and that "Individual workers, their supervisors, and management are not ensuring that required bioassay samples are provided. In 1989, bioassay samples were not submitted in accordance with GEND procedures. Seventy percent of the required monthly samples and 35 percent of the required weekly samples were not submitted." NIOSH cited these Tiger Team findings as sufficient to qualify the SEC petition for further evaluation (refer to section 2 of this report).

Observation 10: Tiger Team assessment of deficiency root causes: emphasis on production and mindset that Pinellas poses no unusual radiological risks

Section 5.7 (p. 5-33) of the 1990 DOE Tiger Team report covers management assessments. It opines the following on the probable root causes of some of its deficiency findings and lists the following two: "First, emphasis on production has traditionally overshadowed interest in fully complying with environment, safety and health requirements"; and "Second, there is a wideset mindset that the Pinellas Plant poses no unusual or unique risks."

4.5 External monitoring

The ER summarizes external monitoring data for the period 1986–1995 in table 6-4 (NIOSH, 2021a, p. 51), shown here as table 4.

Table 4. Summary of Pinellas external monitoring data for 1985–1995

Year	Number monitored	Total dose (person-mrem)	Average dose (mrem)	Highest individual dose (mrem)
1985	Not reported	5,525	Not reported	411
1986	Not reported	2,837	Not reported	550
1987	Not reported	2,102	Not reported	321
1988	171	1,712	6.7	170
1989	187	1,847	4.9	180
1990 [b]	185	2,104 [a]	8.3	280
1991	107	830	3.9	40
1992	117	350	1.7	30
1993	88	270	2.3	50
1994	80	60	0.5	20
1995	72	243	0.28	10

Sources: Weaver (1992), PDF pp. 9, 15, 20; HRS (1995); Pinellas Plant (1996); Weaver (1996), PDF pp. 12–13.

a. Most external exposures were from RTG operations, which moved offsite in early calendar year (CY) 1991.

b. The 1990 row is NIOSH's assumed year of transition and last year of SEC evaluation.

Observation 11: Transition year of 1990 after Tiger Team assessment led to overall reduced exposures

The Tiger Team assessment took place in January and February 1990, and the Pinellas Plant initiated corrective action during fiscal year 1990 (October 1, 1989, through September 30, 1990). While data indicate a significant decrease for external doses from 1990 to 1991 (table 4), there was an increase in internal doses from tritium from 1990 to 1991, then a gradual decreasing trend during the years 1992–1995 (table 2). The number of workers bioassayed for tritium remained reasonably consistent during the period 1986–1995, and the number of workers monitored for external exposure gradually decreased during the period 1985–1995. According to the "1991 Annual ALARA Program Report for Ionizing Radiation" (Pinellas Plant, 1992), the increase in internal dose was due to the "T" box incident and recovery operations in Area 182C conducted in late December 1991. To date, SC&A has not found indications that there are issues with exposure records that would prevent DR feasibility for the SEC period 1957–1990, nor for the period 1991–1997.

As presented in more detail in section 5.1 of this report, SC&A reviewed the available CATI reports of employees and/or their survivors, representing 490 EEs, and compiled information on external and internal radiation monitoring. That section discusses the frequency of internal exposure monitoring (urinalysis) following incidents as reported in the CATIs. SC&A's review of the external monitoring information provided by the Pinellas claimants in the CATIs found that 40 percent (198) reported having either intermittent or routine external monitoring during employment.

5 Interviews, Incidents, and Other Information Associated with Claimants and/or Former Workers

5.1 Computer-aided telephone interview information

NIOSH provided SC&A with access to the 490 interviews (employees and survivors) available at the time of this review. SC&A examined these interviews for indications of internal monitoring, external monitoring, and incidents and followup. However, as noted in section 4.1, at the time of this review, SC&A does not have access to individual claimant monitoring files to compare CATI statements to relevant dosimetry records and/or included incident reports.

SC&A's review of the 490 CATI reports noted that 16 percent indicated that the EE was involved in some type of radiological incident, with 38 percent (185) stating that the EE received urinalysis monitoring following the event. Of the CATIs that were completed with the EE themselves, 46 percent (160) recalled being internally monitored and 45 percent (154) recalled being externally monitored. It should be noted that 27 percent of the claimants reported in their CATIs that they did not know if they were involved in an incident. Therefore, the number of EEs involved in incidents may be underestimated if using the CATI information alone.

5.2 Previously reviewed Pinellas dose reconstruction cases

As part of SC&A's ongoing work with the Subcommittee for Dose Reconstruction Reviews, SC&A reviewed five Pinellas cases. Full case records were not initially available due to the previously mentioned cybersecurity modernization initiative[5]; however, the DR review reports were available for the five cases evaluated. SC&A summarized the monitoring history of each individual and compared it in table 5 with the CATI reports and internal monitoring NOCTS history. Due to the limited currently available data, this comparison cannot be used to tell if records are complete, but it can be used more broadly to identify the presence or absence of records in an EE's files. Table 5 shows, at least for the limited sample, that internal monitoring records currently match the claimant recollections reported in the CATI. The external monitoring results are less conclusive: Two claimants reported being externally monitored, while the results were not available at the time of DR. SC&A does not have access to NOCTS to check if these records have since been located.

[5] Full case records became available just prior to publication of this review. This review looks only at the DR report and associated CATI reports.

Table 5. Comparison of monitoring records used in DR vs CATI reported monitoring history in previously reviewed cases

Tab	DR completion year	Start year	Stop year	Occupation	DR included internal monitoring records	CATI indicated internal monitoring	NOCTS 2022 internal records	DR included external monitoring records	CATI indicated external monitoring
80	Not specified (est. 2005)	[Redacted]	[Redacted]	[Redacted]	Monitored	Monitored	Monitored	Single dosimeter	Unmonitored
233	2004	[Redacted]	[Redacted]	[Redacted]	Unmonitored	Unmonitored	Termination only	Unmonitored	Unmonitored
299	2008	[Redacted]	[Redacted]	[Redacted]	Monitored	Monitored	Monitored	Unmonitored	Intermittent
138	2005	[Redacted]	[Redacted]	[Redacted]	Unmonitored	Monitored	Monitored	Monitored—monthly	Monitored—monthly
139	2005	[Redacted]	[Redacted]	[Redacted]	Unmonitored	Monitored	Monitored	Monitored	Unmonitored

5.3 Recordkeeping procedures

SC&A reviewed the procedure used for obtaining exposure records for DR purposes for Pinellas claimants. SC&A found that occasionally all the claimants' records and other information are not contained in the files that DOE forwards to NIOSH following a record request from NIOSH. In 2006, NIOSH found that its data captures provided additional data not always contained in the files sent by DOE. NIOSH has placed, and is still placing, these documents in the SRDB system. As briefly summarized on pages 80 and 81 of the ER, NIOSH uses the following procedure to obtain claimant exposure records, which include both external dosimetry and bioassay results.

- NIOSH uses the SPEDELite search system to query the SRBD using claimant identifiers, such as name, social security number, and employee badge number.
- The data from the search of the SRDB are entered into a file for the claimant.
- NIOSH uses both the DOE files and the personnel exposure files during the claimant's DR process.
- A Post Approval Dosimetry Evaluation Tracker System routinely identifies claims with new information.
- NIOSH reviews the information to determine if the SPEDELite-linked information has any impact on the previously completed DR. If the new information has the potential to increase the previously reconstructed doses, NIOSH reworks the noncompensable DR.

5.4 Documented communications with former workers

SC&A evaluated available documented communication (i.e., interview) summaries to determine if information existed pertinent to this SEC evaluation. These interviews were conducted by NIOSH and SC&A representatives in support of the TBD review. Appendix C to this review summarizes these interviews.

Observation 12: ER is consistent with interview records
SC&A reviewed all available documented communication (i.e., interview) records. The interviews reflect the full date range of work at Pinellas and encompass a broad range of professions. From the interviews, it is clear that site employees had a different experience with the health and safety policies at the site based on their role and job function. In general, the interviewed workers in physics, engineering, chemistry, and lab-related professions had experience with the site internal and external monitoring program. The recollections reported in the interviews, in general, are consistent with the NIOSH SEC ER.

6 Petitioner Concerns

The ER identifies and addresses nine different concerns extracted from the SEC petition. SC&A also examined the petition and categorized the same set of petitioner concerns into 12 different areas. Finally, the petitioners or their representatives made several additional submittals after the petition was received up to the time during which SC&A was preparing this review. The following subsections cover the entire set of petitioner concerns submitted to date and assess to what extent the ER adequately addresses each of them.

6.1 SC&A summary of petitioner concerns

SC&A reviewed the SEC petition and identified 12 general petitioner issues:

1. Former Pinellas workers were not monitored for all the radionuclides described in the table, "Pinellas Plant radioactive source material inventory status," in Pinellas Plant (c1994, PDF pp. 6–11).

2. Only a small fraction of the workers was monitored for radioactive exposures, and there was a failure to monitor all workers for all radionuclides, as described in the 24-hour heavy metals urine tests.

3. Incidents described in the Tiger Team report (DOE, 1990a), the "Historical Report of Radiation Protection at GEND" (n.d.), and the labor site exposure matrices are not explicitly addressed in the ER, particularly the leaking Co-60 source.

4. Employees falsely identified urine samples.

5. The Tiger Team found deficiencies in detecting plutonium in the air and soil, and the majority of workers were never monitored for Pu-238/239.

6. Building 100 rooms were not self-contained, which could allow contaminated air to circulate.

7. The majority of the workers were not afforded occupational x-ray exams.

8. No comprehensive radiological surveys were done of areas with radioactive contamination, including certain rooms in Building 100, several hoods in Buildings 200 and 800, and areas of Buildings 550 and 1000, as described in "Independent Technical Review of the Pinellas Plant" (DOE, 1994a).

9. There were insufficient environmental monitoring and recordkeeping, as described in "Pinellas Plant Feasibility Study" (DOE, 1994b).

10. DRs only reflect one location, job category, and work process and not the full range of employment locations held by workers.

11. Dosimetry records after 1981 were missing from all the DOL and DOE files.

12. There were inconsistent monitoring and dosimetry recordkeeping, as described in the Tiger Team report (DOE, 1990a).

SC&A found that each of these issues was addressed by NIOSH to various extents in the ER, although not always explicitly point by point, and are reviewed and discussed by SC&A throughout this SC&A review. The issues related to DR were not explicitly addressed, but the common practice employed by NIOSH for DR is to assign job titles, work location, and work processes for any given year or dosimetry exchange period based on the information provided by the claimant in the CATI or information in the EE's employment records. If there is any uncertainty, the dose reconstructor often assigns the job title, work location, or work process that yields the highest doses.

6.2 NIOSH response and SC&A review comments

SC&A examined the nine issues NIOSH summarized from the petition in sections 7.4.1 through 7.4.9 of the ER as well as material subsequently submitted to assess if the petitioner issues are adequately addressed. Note that petitioners have been submitting additional material subsequent to the release of the ER and SC&A has been reviewing it as it came in up to the beginning of March 2023.

6.2.1 Unmonitored exposures to Sr-90, Co-60, Tl-204, and uranium

The petitioners identify the radionuclides that are discussed in the TBD as potential sources of exposure for Pinellas workers, which include tritium, plutonium, depleted uranium, natural uranium, nickel-63, C-14, and Kr-85. The petitioners are concerned that this list of radionuclides is not complete and that Pinellas workers, particularly those workers who were not included in the monitoring program during employment, could have been exposed to additional radionuclides that were listed in exhibit 1, "Radioactive Material Inventory at the Pinellas Plant," of the August 2020 revised petition ([Redacted], 2020b). This concern prompted a sample of former workers to undergo 24-hour urine tests in 2019 and 2020, the results of which are reproduced in appendix 1, "24-Hour Urine Heavy Metals Tests," to the revised August 2020 petition ([Redacted], 2020b). Regarding these test results, the petition states that several former employees tested positive for Sr-90, Co-60, Tl-204, uranium, and beryllium. The petitioners concluded the following from these test results:

1. These exposures could have only come from employment at the Pinellas Plant.
2. These positive results indicate that the "radiological characterization of the Pinellas Plant is incomplete and insufficient" ([Redacted], 2020b, p. 24).
3. Employees who were not part of the monitoring program were not aware of their exposures.

NIOSH responded by referencing the documents (exhibits 1–5) included with the petition:

> Exhibits 1 through 3 are excerpts from documents that note the presence of radioactive materials in and around the Plant, including strontium check sources, and sampling results from five Pinellas County sampling locations for radium, tritium, strontium. The presence of radioactive materials at Pinellas is not an

> indication of an unmonitored exposure condition. Exhibits 4 and 5 are general references not specific to the Pinellas Plant that provide information about space isotopic-power systems and other isotopes useful for power generation. NIOSH found no indication of an unmonitored exposure condition at the Pinellas Plant related to strontium-90, cobalt-60, thallium-204, or uranium in these excerpts. . . .
>
> The metals urine analysis, purported to represent exposures to strontium-90, cobalt-60, and thallium-204, was not specific to these radionuclides; rather, the results were for elemental strontium, cobalt, and thallium, all of which occur in nature in a non-radioactive form. The presence of these elements, as indicated by chemical analysis, is not indicative of occupational exposure to the radioactive isotopes. The results of the uranium analysis were reported as either 'none detected' or <1.0 ng/ml. . . .
>
> Although the Pinellas Plant used other radionuclides, as discussed in Section 5.2.3 [of the ER], they were mostly limited to sealed and plated check sources (Pinellas Plant radioactive, no date) and would not have presented a significant internal exposure hazard. The site used strontium and cobalt sealed sources that were kept under control and some level of radiological surveillance to ensure that the materials were well fixed, as indicated by the identification of the leaking Co-60 source and indicated in routine health physics reports (Jech 1963, PDF p. 8). NIOSH's review of Pinellas Plant records suggests Pinellas addressed such incidents of contaminated sources immediately when found, including assessing involved personnel. **Consequently, contaminated sources are not evidence of unmonitored exposures** [emphasis added]. [NIOSH, 2021a, p. 74]

SC&A reviewed the petition exhibits, particularly the individual laboratory reports for the 24-hour urine heavy metal tests, and found that eight former Pinellas employees participated in the screening. All the results for the elements of concern showed that they were either not detected or were within normal range. SC&A agrees with NIOSH's comment that, in the case of cobalt, thallium, and uranium, the urine tests were screening for the elemental forms and not for the presence of the specific radioisotopes. Therefore, they do not indicate a known or assumed radiological exposure,[6] and this result was within the normal background range. These conclusions were previously discussed in section 3.3.6 of this SC&A review. Refer to section 6.2.2 for a further discussion of other Pinellas health physics reports.

6.2.2 Radiological incidents

The petition ([Redacted], 2020b, pp. 30–31) includes a list of incidents that occurred at Pinellas between 1963 and 1995 taken from the site exposure matrices (DOL, 2020). In addition, based on "information taken from microfilm records and the recollections of [Redacted], GEND Health Physicist" (p. 31), the petitioners raised the concern that numerous incidents that occurred

[6] The version of this screening report found in the petition for this individual shows Sr-90 results; however, the unredacted version of this screening report shows only elemental strontium. Otherwise, the reports appear to be identical. The source of this discrepancy could not be identified. Both reports show screening levels consistent with elemental strontium ([Redacted], 2020b, unredacted version).

during the years 1972 through 1982 were not documented in the site exposure matrices. The list of these incidents is included in appendix 2 of the petition. The petition also cites conclusions from the Tiger Team report, which describes various health and safety concerns at the Pinellas Plant.

NIOSH (2021a, pp. 75–76) responded as follows to the concerns raised by the petitioners regarding documented and undocumented radiological incidents:

> Based on NIOSH's review of available documentation, indications are that the Pinellas Plant was diligent about following-up on contamination-related incidents and personnel exposures, as documented in incident reports [GE 1972, PDF pp. 2–10; Holliday 1970–1979; Pinellas Plant 1976–1979; Pinellas Plant 1971–1975] and Health Physics Investigation Reports [Jech 1963; GE 1963[a]; GE 1983[a,b]; Holliday 1982a,b]. . . .
>
> The petition specifically cited three resources related to incidents:
>
> - *Tiger Team Assessment of the Pinellas Plant* by the U.S. Department of Energy, Environment, Safety and Health [DOE 1990a]
> - *Health Physics Report: Historical Report of Radiation Protection* [Historical report of radiation, no date]
> - Department of Labor's Site Exposure Matrices: Incident Search by Related Item – Pinellas Plant by the U.S. Department of Labor [DOL, 2020]
>
> None of the three resources identified by the petitioners provided documentation of incidents that were unmonitored, unrecorded, or inadequately monitored or recorded. . . .
>
> The petitioners cited an event listed in Appendix A of the report *Historical Report of Radiation Protection at GEND* [Historical report of radiation, no date, PDF pp. 9–12] related to a leaking Co-60 source in 1961 as an example of an incident involving potential unmonitored exposure. The full citation was: "100 mCi . . . Co-60 source found leaking was corrected" [Historical report of radiation, PDF p. 10; Burkhart 1990]. A review of monthly health physics reports for 1961 identified the source of the summarized information as the July 1961 report, which contained the following entry: "A routine survey revealed leakage of Health Physics' 100 mc [sic] cobalt source. Corrective action was taken immediately" [Forest, 1961, PDF p. 4]

Regarding radiological incidents, NIOSH (2021a, p. 76) concluded:

> The source documents do not provide any indication or evidence to indicate that the identified condition, which Pinellas immediately corrected, precipitated an unmonitored exposure condition to site personnel.

SC&A reviewed the available incident and health physics investigation reports along with the site exposure matrices (DOL, 2020) and compiled a list of all documented events that involved a potential or actual radiological release, contamination, and/or personnel exposure, shown in appendix B to this review. SC&A also included the incident information given in Burkhart (1990, p. 3), which includes “a list of unusual events involving environmental releases or personnel or area contamination” for the years 1957 through 1989. Burkhart (1990, p. 1) explained that the source of the unusual event information was “obtained from microfilm records and also from the personal recollection of [Redacted], GE Neutron Devices (GEND) Health Physicist from [Redacted].”

SC&A reviewed “Historical Report of Radiation Protection at GEND” and confirmed the description of the 100 mCi Co-60 source, which was “found leaking” and “was corrected” (“Historical Report of Radiation,” n.d., PDF p. 10). SC&A also confirmed the statement in Forest (1961) that the leaking Co-60 source was detected in routine swipes and immediately corrected. SC&A agrees with NIOSH’s conclusions that these incidents were detected and immediately remedied and, therefore, did not result in a sitewide source of employee exposure.

SC&A reviewed the CATI reports for information on EE involvement in radiological incidents, which is summarized in section 5.1 of this review.

Observation 13: Pinellas Plant diligent in following up on contamination-related incidents and personnel exposures

Based on its review of the available incident information, SC&A concurs with NIOSH’s conclusion that Pinellas Plant was diligent about following up on contamination-related incidents and personnel exposures. The reports show investigations into the causes of various incidents, and most (1) indicate that followup monitoring was performed for employees involved in the incidents and (2) provide recommendations to prevent the incidents from reoccurring. However, given the lack of bioassay records for the years 1988–1990 described in observation 4 (section 4.3) and the issues surrounding bioassay noncompliance described in observation 5 (section 4.3), observation 7 (section 4.4), and observation 9 (section 4.4), it is possible that the program may not have captured all the internal exposures related to contamination incidents.

6.2.3 Plutonium

The plutonium exposure issue is discussed in depth in section 3.3.3 of this review. The following is a summary of the specific plutonium issue discussed in section 7.4.3 of the ER. The ER quotes the petition issue related to plutonium (NIOSH, 2021a, p. 76):

> Despite encapsulation, levels of plutonium 238 and 239 were detected in both air and soil samples. While the Department of Energy noted that the levels of plutonium were at environmental background levels, it is important to note that the Tiger Team found sampling deficiencies where plutonium was concerned. ([DOE, 1990a]) The majority of workers WERE NEVER monitored for plutonium 238/239 exposures ([redacted] 2020b, PDF p. 22).

NIOSH responds:

> The stack-sampling equipment monitors concentrations of radionuclides in effluent leaving the facility and is unrelated to the concentrations within the facility work areas. Accordingly, the finding has no bearing on the radiation exposure monitoring program associated with site employees. [NIOSH, 2021a, p. 76]

SC&A does not necessarily agree with the blanket posit that stack-sampling results from plant effluent are unrelated to workplace conditions. However, SC&A documented the final resolution in the March 15, 2016, update to the issue resolution matrix (SC&A, 2016a, p. 4), which summarizes the plutonium issue as follows:

> This was a concern early in the issues resolution process, when some potential exposure to plutonium (Pu) was not ruled out. Based on discussions at the October 2011 WG meeting [ABRWH, 2011], it was determined that the only source of potential intake was from handling of newly received triple encapsulated radio-thermal generators (RTGs). However, there was no surface contamination greater than 200 dpm (the rejection level), and NIOSH calculations show that to receive even 1 mrem annual dose would require handling thousands of RTGs in a year. Therefore there is no credible source of exposure [refer also to Section 3.3 of this report]. In Revision 2 of TBD 5 [ORAUT, 2012; occupational internal dose], all Pu discussion was removed based on discussion at the October 2011 WG meeting. If evidence of a positive exposure is discovered, NIOSH will need to develop a dose reconstruction (DR) methodology.

In section 5.2.2 of the ER, NIOSH (2021a, p. 35) describes how the issue of plutonium exposure at Pinellas was closed by the Board's Pinellas WG:

> Out of an abundance of caution, workers assigned to the RTG project submitted a pre-operational 24-hour urine sample [Internal dosimetry practices 1983, PDF p. 2]. Those working with RTG sources submitted annual samples while assigned to the work [Internal dosimetry practices 1983, PDF p. 2]. The plutonium urine sampling program concluded in 1992. During meeting discussions [[ABRWH, 2011, 2012, 2016]], the ABRWH Pinellas Plant Work Group determined there was no credible potential for personnel internal dose from activities involving plutonium [ORAUT [2016], PDF p. 12; [ABRWH] 2016].

SC&A reviewed the October 2011 (ABRWH, 2011) and February 2016 (ABRWH, 2016) transcripts of the Pinellas WG meetings and confirmed that the WG concluded that there is no potential internal plutonium exposure at Pinellas. As is discussed in section 3.3.3, environmental samples taken at Pinellas did not contain any plutonium results corresponding to the RTG characteristic isotopic ratio, indicating that plutonium releases from Pinellas operations had not been detected. Unless additional information becomes available, since the Pinellas WG has previously evaluated the issue and determined that there is no credible source of plutonium exposure, SC&A considers this issue resolved.

6.2.4 Duplicate samples

As quoted in the ER (NIOSH, 2021a, p. 77), the petitioners raised concerns of inaccurate monitoring results: "Health Physicist Holliday also reported that accurate monitoring was impacted by the fact that 'Employees were found falsely identifying urine samples' [[redacted] 2020b, PDF p. 22]."

NIOSH thoroughly researched this issue and found the source from a 1963 monthly health physics report:

> "During the past month it was discovered that some personnel were falsely identifying urine samples submitted for radioactivity analysis. This condition was brought to the attention of responsible supervision and efforts are being made to develop a technique to positively identify duplicate samples" (Forest 1963a, PDF p. 4). [Quoted in NIOSH, 2021a, p. 77]

The ER states (NIOSH, 2021a, p. 77):

> The response to the "condition" was to develop a technique to positively identify duplicate samples. This indicates the condition did not impact the actual individual sample results [i.e., the results derived from the samples were not falsified or otherwise impacted]. The September Health Physics Report identifying the condition states "some personnel" were falsely identifying samples, which leads NIOSH to believe a simple misunderstanding by workers of the bioassay-sampling requirements is the most likely scenario. If the issue of "falsely identifying urine samples" was related to deliberately and incorrectly associating individual samples to a particular person and/or sample date, such a circumstance would not likely impact the overall population of sample results (which NIOSH has access to).

NIOSH believes that this issue came about as a misunderstanding and misdating of urine samples. For example, an employee could have provided two samples and submitted them both on the same day. In the case of duplicate samples, NIOSH stated that they would include the higher of the two results in a DR. Regarding duplicate samples, NIOSH (2021a, p. 78) concludes the following:

> The Pinellas Plant bioassay program records show that results seldom reached or exceeded the site action levels for the radionuclides under assessment. Therefore, it is unlikely that the Pinellas Plant failed to monitor any significant worker exposures. Because individual duplicate results won't affect the population of results, NIOSH can use tritium bioassay data from this time period to determine an unmonitored dose approach, if needed. **NIOSH concludes that the issue does not impact its ability to perform individual dose reconstructions for all members of the NIOSH-evaluated class** [emphasis added].

SC&A reviewed the September 1963 health physics report (Forest, 1963a) and confirmed the concerns raised by the Pinellas Health Physics department during this month regarding "falsely identified" urine samples. In the same discussion, Forest (1963a, PDF p. 4) refers to these as "duplicate samples." Therefore, NIOSH assumes that the samples were not deliberately associated with the wrong individual but rather duplicate measurements from the same individual. SC&A also reviewed the October 1963 health physics report (Forest, 1963b) and found that the falsely identified urine sample issue was not discussed again. Therefore, it is difficult to interpret and assess the potential effect the issue has on DR feasibility. If the samples were, in fact, duplicates, SC&A agrees that those samples would not affect NIOSH's ability to perform DRs for members of the SEC class nor their ability to construct a co-exposure model.

6.2.5 Radioactive materials in Building 100

The petition discusses several concerns with emissions in Building 100, the "main" building, which contained many of the radioactive areas ([Redacted], 2020b, p. 22):

> In the US Department of Energy (June 1997) *Environmental Baseline Report* [DOE, 1997], mention is made of the potential for unconfined radioactive materials or emissions, resulting from Radioactive Materials Management Area (RMMA) located in Building 100 [DOE, 1997, p. 3-1]. . . .
>
> Also not taken into consideration is the fact that the rooms within Building 100 were not self-contained. In other words, the rooms were wide open so any radioactive materials that were in the air, would be circulated throughout the entire plant.

The ER addresses RMMA designation of various areas of the plant, particularly Building 100 (NIOSH, 2021a, p. 78):

> The reference to the RMMA designation in Building 100 comes from the 1995 report, *Moratorium Documentation Manual for the Pinellas Plant*. The purpose of this document is to identify areas where dispersible radioactive material is present in order to control the generation of mixed hazardous and radioactive waste [Ohlweiler, 1995, PDF p. 16]. Designation as an RMMA in and of itself does not relate to the potential for unmonitored radiological exposure to site personnel. NIOSH is aware of the designation of areas within Building 100 as RMMAs and has documented this in Table 2-3 of *Pinellas Plant – Site Description* [ORAUT 2011b, PDF p. 31]. The document does not provide any information specific to a lack of containment of radiological materials or a lack of radiological monitoring within the area identified as an RMMA within Building 100.

The ER responds to the issue of emissions and proper ventilation in Building 100 and notes the presence of adequate ventilation and hoods in the building (NIOSH, 2021a, p. 79):

> Pinellas designed and constructed buildings with ventilation systems, fume hoods, and gloveboxes to minimize inhalation uptakes by workers [[SC&A, 2006], PDF p. 28]. The Pinellas Plant conducted routine surface and air monitoring in work areas containing radioactive material [ORAUT [2016], PDF pp. 14–16], as discussed in Sections 6.1.2 and 6.2.2. **Design features (e.g., ventilation systems and fume hoods), in conjunction with the radiological monitoring program in**

> **place, would preclude unidentified and unmonitored exposure of general employees in areas that were "not self-contained"** [emphasis added].

SC&A reviewed Ohlweiler (1995), which identifies the areas of the Pinellas Plant that have been designated as RMMAs, several of which are in Building 100. Ohlweiler (1995, p. 7) defines RMMA as follows:

> An area in which the potential exists for contamination because of the presence of unencapsulated or unconfined radioactive material, or of beams or other sources of particles (neutrons, protons, etc.) capable of causing activation.

Ohlweiler (1995, p. 1) summarizes the handling of potentially radioactive waste as follows:

> The Pinellas Plant is dedicated to the goals of the DOE-led Performance Objective for the Certification of Hazardous Waste. The procedures following will be applied to all wastes that originate or have been stored in a Radioactive Materials Management Area (RMMA). These procedures effectively demonstrate the Pinellas Plant's ability to correctly determine whether a waste has DOE-added radioactivity.

SC&A reviewed the TBDs referenced by NIOSH regarding the issue of adequate ventilation in Building 100. The following description of RMMAs is taken from section 2.6.1 of the site description TBD (ORAUT, 2011b, p. 28):

> Radioactive materials in Building 100 were used in the production, manufacture, storage, and testing of various weapons components. Multiple areas were considered Radioactive Material Management Areas (RMMAs), which indicated the possible presence of unconfined radioactive materials or emissions.

The following is a description of contamination control at Pinellas from section 5.4.1 of the internal dose TBD (ORAUT, 2016, pp. 13–14):

> The monthly Health Physics Reports for the Pinellas Plant indicate that contamination monitoring for tritium was performed on a routine basis from the beginning of operations at the Pinellas Plant [GE 1957–1967, GE 1957–1973, GE 1963[b], GE 1967). Work areas and personnel were checked for contamination on a routine basis. Any significant personnel contamination that could have gone undetected from contamination surveys would most likely have been identified through the tritium bioassay program. The monthly reports also indicated that whenever contamination levels were greater than the contamination control limits, decontamination of those areas was initiated.

In addition, section 5.4.2 of the internal dose TBD summarizes air monitoring as follows (ORAUT, 2016, p. 14): "Monitoring for airborne tritium radioactivity was performed on a routine basis from the beginning of operations at the Pinellas Plant (GE 1957–1973)."

SC&A agrees with NIOSH's conclusion that the routine air and surface monitoring at Pinellas, including in Building 100, would have identified airborne contamination. Observation 8 in section 4.4 discusses the issue of contamination controls presented by the Tiger Team.

6.2.6 Employer-required chest x-rays

The petition raises concerns that the majority of the former Pinellas employees were not given annual chest x-rays. NIOSH (2021a, p. 79) responded to the concern as follows:

> DOE provides records of medical X-rays performed for individual claimants. NIOSH detailed the interpretation of, and assumptions related to medical X-rays in ORAUT-TKBS-0029-3, *Pinellas Plant – Occupational Medical Dose*. Current NIOSH dose reconstruction guidance assigns medical doses based on individual X-ray examinations recorded in the submitted medical records. When no X-ray examination records are available for an individual, the dose reconstructor assumes that an annual PA [posterior-anterior] chest X-ray was administered, in accordance with the *Pinellas Plant – Occupational Internal Dose*[7] site profile document [ORAUT 2011c, PDF p. 10]. **NIOSH notes that if employees were not given chest X-rays, the approach described above would overestimate radiation doses to those employees** [emphasis added].

SC&A notes that medical x-rays are a source of occupational exposure rather than a monitor of it. SC&A agrees with NIOSH's conclusion that the guidance in the occupational medical dose TBD (ORAUT, 2011c)—that if there are no x-ray examination records for an employee then the DR would include occupational medical doses from annual chest X-rays—would provide an overestimate of occupational medical doses.

6.2.7 Lack of radiological surveys

The petition references the "Independent Technical Review of Pinellas Plant" (DOE, 1994a) and indicates that this report notes that certain rooms and buildings were contaminated and that radiological surveys had not been performed for these areas:

> Certain rooms in Building 100, several hoods in Buildings 200 and 800, and areas of Buildings 550 and 1000, have some radioactive contamination. No comprehensive radiological surveys have been completed for these buildings. . . .
>
> Building 100 laboratories and processes handle or have handled radioactive isotopes. There is radioactive contamination in some hoods and associated duct work. A precise, accurate survey of location, quantity and type of radiological contamination does not exist. [[Redacted], 2020b, p. 22]

NIOSH (2021a, p. 79) responded in the ER by citing the intended purpose of the referenced document:

[7] "Internal" in the TBD title appears to be an error, as the document referenced is the medical dose TBD.

> The purpose of the cited *Independent Technical Review of the Pinellas Plant* document is to document the transition of the Pinellas Plant from operations to either community-developed reuse or safe deactivation leading to decontamination and decommissioning [DOE 1994[a], PDF p. 6]. **The cited Technical Review is unrelated to the potential for unmonitored worker exposure during Pinellas Plant activities** [emphasis added].

SC&A reviewed the cited "Independent Technical Review of the Pinellas Plant" (DOE, 1994a) and concurs with NIOSH that the purpose of the document is for either community-developed reuse or safe deactivation leading to decontamination and decommissioning. The petitioner-quoted sections of this report are in reference to establishing a comprehensive baseline to minimize DOE liabilities. SC&A agrees that is unrelated to establishing the exposure potential of unmonitored workers.

6.2.8 Environmental monitoring record keeping

The petitioners ([Redacted], 2020b, p. 22) quoted "Pinellas Plant Feasibility Study: Final Report" (DOE, 1994b) on environmental monitoring deficiencies: "Typical of many DOE facilities, meticulous environmental monitoring and records keeping did not take place until the early to mid 1970's. Prior to that, monitoring and records keeping was not very thorough."

NIOSH (2021a, p. 80) responded:

> The complete citation includes the following statement: "However, after reviewing plant publications, interviewing key personnel, and checking the existence, accessibility, and quality of documents important to dose reconstruction at the plant, we have concluded that a dose reconstruction is feasible" [[DOE, 1994b], PDF p. 124]. **The scope of the document relates to the reconstruction of exposure to members of the public, not site employees, and is unrelated to the potential for unmonitored worker exposure during site activities** [emphasis added].

SC&A reviewed the "Pinellas Plant Feasibility Study" (DOE, 1994b) and confirmed that the report is an analysis of the available environmental data in the vicinity of the Pinellas Plant. The report states that environmental monitoring of site radiological emissions has been performed and recorded since 1975. DOE (1994b, p. 1) concludes:

> The United States Public Health Service Centers for Disease Control and Prevention (CDC), in assisting HRS, has determined that sufficient radiological data exist by which a dose reconstruction can be done. A dose reconstruction can provide an estimate of how much radiological exposure someone living in the vicinity of the Pinellas Plant may have suffered from environmental releases.

SC&A agrees with NIOSH's conclusions that this document pertains to exposure to the general public and not to employee occupational exposures.

6.2.9 Missing dosimetry records

The ER quotes the SEC petition as follows (NIOSH, 2021a, p. 80):

> "A small number of workers were monitored for radiologic exposures, although inconsistently, and some were never monitored for such exposures. For those that were monitored, their dosimetry records only included information until 1981. Dosimetry records beyond 1981 were missing from all of their DOL and DOE files that were examined [[redacted] 2020b, PDF p. 24]."

NIOSH's (2021a, pp. 80–81) ER responded as follows:

> NIOSH reviewed ALARA reports, which are available from 1986 through 1995, and that review showed the site monitored 1,772 workers over those 10 years. NIOSH has estimated an average workforce size of 1,500 for all of those ten years, primarily from reviewing the annual site environmental reports and counting the number of employees listed on rosters. Dividing the number of employees monitored by the number of workers for 10 years indicates that the site monitored approximately 12% of employees for tritium intakes from 1986 through 1995. **Therefore, in response to the claim the Pinellas Plant monitored a small number of workers for radiological exposures, NIOSH agrees that this could be considered a small number of workers but finds that the monitoring practices at the Pinellas Plant were based on exposure potential rather than plant population and that adequate dosimetry records are available for dose reconstruction** [emphasis added]. . . .
>
> In 2006, NIOSH became aware it was not receiving all of the dosimetry records from DOE for some Pinellas Plant claimant files. Following this discovery, NIOSH worked with DOE to locate additional dosimetry records at archival locations across the DOE complex; NIOSH uploaded that additional data to the SRDB. NIOSH has completed linking this captured dosimetry data in the SRDB to individual NOCTS claimant files via the SPEDELite process.

It should be noted that NIOSH found that compliance with the bioassay program did increase following the publication of the DOE Tiger Team report in 1990 (DOE, 1990a). However, neither the total measured internal dose nor the average individual internal dose increased following the increase in compliance, which indicates that most of the exposures have been accounted for in the bioassay data during this timeframe. In addition, NIOSH states the following in section 7.1.3 of the ER regarding the internal dosimetry data (NIOSH, 2021a, p. 65):

> The Plant monitored those with the highest internal-exposure potential the most often, i.e., on a daily or weekly frequency. This group of workers was more compliant with the sampling program, according to the 1990 Tiger Team report. Therefore, the dataset available to NIOSH for determining an unmonitored dose approach would likely be biased high.

SC&A currently does not have access to the NOCTS database to review individual claimant files for this ER review. A review of the dosimetry data in the claimant files would allow SC&A to confirm the presence of sufficient dosimetry data for the SEC period. However, as described in section 4.1 of this review, SC&A has reviewed dosimetry data from 13 SRDB documents and has not found indications that there are issues with exposure records that would prevent DR feasibility for the SEC period 1957–1990.

6.3 Additional petitioner concerns submitted following the December 2022 Board meeting

The December 2022 Board meeting had a session on the Pinellas petition, the ER, and SC&A's progress in evaluating the ER. The petitioners submitted additional materials after that meeting, which were reviewed by SC&A and are addressed in the following subsections.

6.3.1 "Leaking plutonium" submitted January 16, 2023

The petitioners' representative submitted (Petitioners' Representative, 2023a) a one-paragraph *Tampa Bay Times* article from December 9, 1994 (updated October 8, 2005), "Department of Energy Says Don't Worry About Plutonium Leak from Plant." The article references plutonium being stored poorly at other weapons production facilities but quotes a DOE representative who indicates that Pinellas "used relatively little plutonium and has nearly none left" ("Department of Energy Says Don't Worry," 1994/2005).

In addition to this article, the representative's memorandum (Petitioners' Representative, 2023a) cites two documents, DOE (1992) and Weaver (1996), indicating that plutonium heat sources were removed from the site in February 1991. Because the DOE representative quoted in the *Tampa Bay Times* article indicated that there was "nearly none left" on site, the memorandum draws the erroneous conclusion that there was leaking plutonium on site because there was a non-zero quantity of plutonium remaining in 1994. This conclusion is not justified. The presence of "poorly stored and at risk of leaking" plutonium at other DOE facilities is not evidence of these conditions existing at Pinellas. Both references cited by the petitioners' representative indicate that plutonium was removed in 1991 when the RTG product line was discontinued. This reference is to the production quantities of plutonium. As alluded to in the memorandum, DOE (1992, p. 4-8) indicated that "There still exists on-site standards used to calibrate ECL [Environmental Chemistry Laboratory] analytical instrumentation and used in calorimetry."

Additionally, elevated external doses during RTG production are not indicative of leaking plutonium. Elevated external doses in this instance were caused from being near plutonium. If plutonium were leaking, evidence of plutonium contamination would have been found in swipe samples, bioassay sampling, or environmental monitoring.

6.3.2 Letter in reference to multiple myeloma study

The petitioners' representative submitted a second memorandum to the Board on January 16, 2023, taking issue with Pinellas not being included in a 1997 University of North Carolina at Chapel Hill (UNC) study of multiple myeloma in nuclear workers (Petitioners' Representative, 2023b). The memorandum included a copy of the study (UNC, 1997). This was not new information, since the petitioners had previously provided the study to NIOSH on December 9, 2020, according to the ER (p. 29).

The UNC (1997, p. 3) study indicates that "there was no documented evidence of radiation exposures" at Pinellas. This statement is based on UNC's (1997) cited personal communication with Donna Cragle in 1993, who was an ORAUT Senior Vice President and Director. SC&A agrees with the petitioners' representative (2023b) that this statement is inaccurate. SC&A was not able to locate a copy of this personal communication to verify the cited statement. Without this communication, it is not possible to verify the author of the UNC study correctly interpreted statements made by Ms. Cragle.

In any event, Pinellas not being included in the 1997 UNC study has no impact on the SEC feasibility determination.

6.3.3 History of radiologic incidents

The petitioner's representative provided a copy of the "Historical Report on Radiation Protection at GEND" (n.d.). This copy was a duplicate of SRDB 12026. SC&A discusses these incidents and others at the site in appendix B.

6.3.4 Supplemental information provided December 8, 2022

In conjunction with the December 2022 Board meeting, a worker advocate submitted a letter with supplemental information related to the "petitions that did not qualify and the petition that did qualify" for evaluation (Worker Advocate, 2022, p. 2). The letter cites 42 USC § 7384o(b) and 42 USC § 7384q(a) to argue that "the Advisory Board must be assured that the data from the Pinellas Plant is sufficient and accurately addressing the maximum dose received at the facility. The Advisory Board must be assured that the guidelines and the methods that are in the regulations are followed" (Worker Advocate, 2022, p. 1).

NIOSH and the Advisory Board are governed by the requirements of the Energy Employees Occupational Illness Compensation Program Act of 2000, as amended, 42 USC § 7384-7385 (EEOICPA), and 42 CFR Part 83. The regulation at 42 CFR 83.13(c)(1)(i) states that "Radiation doses can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to estimate the maximum radiation dose, for every type of cancer for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class, **or** if NIOSH has established that it has access to sufficient information to estimate the radiation doses of members of the class more precisely than an estimate of the maximum radiation dose" (emphasis added).

The letter presents seven exhibits as supplemental evidence (Worker Advocate, 2022). The following sections 6.3.4.1–6.3.4.7 discuss each exhibit.

6.3.4.1 Exhibit 1

This exhibit is a quote from Dr. Graham F. Peaslee, Professor of Physics at the University of Notre Dame, that gives an opinion on DR feasibility. This is not a technical comment and, therefore, is not within the scope of SC&A's purview for this review.

6.3.4.2 Exhibit 2

This exhibit quotes finding 2 from SC&A's (2006) site profile review, which was discussed extensively by the Pinellas WG. NIOSH had developed a new process for assigning dose to metal tritide exposures. It was evaluated by SC&A (2016c) and discussed by the Pinellas WG during their February 11, 2016, meeting. During that meeting, the Pinellas WG accepted NIOSH's proposed method (ABRHW, 2016, p. 114). The methodology for assigning doses from metal tritides is discussed extensively in section 3.3.1 of this ER review.

Additionally, the exhibit quotes from several places in SC&A's (2016c) review of NIOSH's DR methodology for SMTs. SC&A notes that additional Pinellas records, including health physics reports, have been located since the issuance of SC&A (2016c). The exhibit concludes that "Maximum accumulated radiation exposure in 1962 was greater than 300 mrem, not 100 mrem" (Worker Advocate, 2022, p. 2). SC&A agrees that the December 1962 health physics report shown in appendix A to SC&A (2016c) shows that the maximum annual external dose was >300 mrem (p. 32). It also shows the average annual dose was approximately 20 mrem. The NIOSH justification for the 100 mrem default annual dose is in attachment B to ORAUT-TKBS-0029-6, revision 02 (ORAUT, 2017). Workers who were monitored for external exposures are assigned dose based on their monitoring records.

6.3.4.3 Exhibit 3

This exhibit quotes from several places in earlier revisions of ORAUT-TKBS-0029-6, the occupational external dose TBD. The current version is revision 02, dated December 11, 2017 (ORAUT, 2017). No new information is provided. Attachment B to ORAUT-TKBS-0029-6, revision 02, provides a basis for the 100 mrem default external dose assumption for unmonitored workers. The Pinellas WG previously approved this methodology.

6.3.4.4 Exhibit 4

This exhibit quotes from several places in the "Pinellas Plant Environmental Baseline Report" (DOE, 1997) on known radioactive materials on site. This reference is already cited by NIOSH in the SEC ER and provides no new information.

6.3.4.5 Exhibit 5

This exhibit provides critical opinions about a former NIOSH employee. This is not a technical comment and, therefore, is outside the scope of SC&A's purview for this review.

6.3.4.6 Exhibit 6

This exhibit indicates that the DOL Division of Energy Employees Occupational Illness & Compensation Site Exposure Matrix (DOL DEEOIC SEM) lists 17 radionuclides and associates uranium with processes and areas that uranium was located in and used at Pinellas. No new information is contained in this material. Uranium is discussed in section 3.3.2 and throughout this SC&A review.

6.3.4.7 Exhibit 7

This exhibit makes the following two statements (Worker Advocate, 2022, p. 4):

> ….. Pinellas encapsulated products as well as received encapsulated products.
> NOTE NRC states that radiation can still come from encapsulated products.

> ….. **The radioactive heat source (RTG) is produced by Los Alamos National Scientific Lab while the thermal-to-electric energy converter is produced entirely within the Pinellas Plant**

This exhibit contains no new information. SC&A agrees that radiation can come from encapsulated products. In the case of Pinellas, the plutonium was triply encapsulated. This poses an external exposure hazard, which NIOSH accounts for in the SEC ER.

6.3.5 Requested review of cancer incidence study of Pinellas County included in appendix 5 to DOE 1994b

A petitioner representative sent an email on January 31, 2023, requesting that the Board review appendix 5, "Cancer Incidence Patterns in Pinellas County: 1981–1990," to the "Pinellas Plant Feasibility Study" (DOE, 1994b). The following is an excerpt from the abstract of that appendix:

> The cancer incidence patterns among the Pinellas County population where a DOE facility is located were examined for the period 1981 to 1990 using the Florida Cancer Data System. During this period, there were a total of 60,522 cases of cancer diagnosed in Pinellas County. . . .
>
> Consistently high incidence rates among all four race-gender groups were found for colorectal cancer including colon cancer and rectal cancer separately. Consistently low incidence rates among all four race-gender groups were found for liver cancer. Some reproductive organ cancers (female breast, cervix uteri, testes) were high in their gender groups. These results should be interpreted with caution because of the limitations of this type of study. [DOE, 1994b, p. 127]

Limitations of this study described by the authors include:

- lack of cancer incidence data prior to 1981
- dramatic demographic changes in Pinellas County, Florida, since 1956
- lack of environmental monitoring information, which could include effects of other industrial contamination to the Pinellas population over the years
- no information on socioeconomic status, smoking history, or resident history
- possibility the observed cancer incidence rates of Pinellas population are due to stochastic effects

The study does not specifically include employees of the Pinellas Plant and does not draw any conclusions about cancer incidence and radiation exposure to the population. Regardless, the cancer incidence rates of Pinellas County residents from this study would not affect NIOSH's ability to reconstruct doses with sufficient accuracy.

The petitioners' representative requested special attention be paid to the following points, as quoted by the Designated Federal Official (DFO) in the March 3, 2023, email transmitting the request to the Board:

- "The report shows the overall cancer rates are *slightly* increased in Pinellas County; however, cancer rates are *significantly* elevated in certain populations for the thirty-eight (38) cancers examined.
- "In Appendix 5, one (1) potential limitation of the study and of importance to the Pinellas SEC is limitation identified by the authors involving radiation exposure, ' … lack of radiation exposure data and other chemical exposure information, and lack of knowledge concerning' (27).
- " … there is an acknowledgement in the report of lack of data regarding radiation exposure in the facility which has a significant impact on the ability of DCAS to reconstruct doses.
- "Moreover, the document provides data showing there were indeed releases of radioactive materials from the plant during its operation – releases that have been denied as having occurred," according to [name redacted].

It is not possible to draw causality conclusions from the study (DOE, 1994b). There is no evidence supporting a conclusion that the elevated cancer incidences rates were caused by radiation exposure from Pinellas Plant. Table 5-9 of the Pinellas Plant feasibility study (DOE, 1994b) estimates that the highest annual dose (1973–1991) to a member of the public from releases of radioactive material from the plant at the site boundary was 0.098 mrem from 1990. This dose is significantly less that the minimum dose of 1 mrem annual dose considered in DRs under EEOICPA.

SC&A notes that the NIOSH ER, the Pinellas TBDs, and this review all acknowledge releases of tritium and krypton gas. These releases are documented.

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Appendix A: DOE Tiger Team Report

As discussed elsewhere in this review, the SEC petition cites the DOE Tiger Team report (DOE, 1990a) as a basis for the request to grant an SEC, and the NIOSH ER (NIOSH, 2021a) also cites the Tiger Team report to support qualifying the petition but terminating the period under consideration at the end of 1990. Since the Tiger Team report is a pivotal document dividing Pinellas's history into two periods, pre- and post-1990, SC&A has reviewed it thoroughly and extracted some information relevant to petition qualification and to feasibility of dose reconstruction. This information is presented in list form in this appendix. Tiger Team report sections and page numbers are included for convenience. A more complete picture of the Tiger Team's charter, practices, and findings is found in the report itself.

It should be understood that, as was the focus of all DOE Tiger Team investigations across the DOE complex in the early 1990s, the 403-page Pinellas report is largely concerned with environmental safety and health compliance issues—including regulatory compliance, organizational, and documentation—but less so with radiation exposure issues. The Pinellas Tiger Team report is based on an onsite assessment conducted from January 15 to February 2, 1990. All page citations in the following list are to DOE (1990a).

- Executive Summary, p. ES-1: "The assessment did not identify any problems at the Pinellas Plant which present an undue risk to public health or the environment."
- Executive Summary, pp. ES-2–ES-3: The Environmental Subteam identified six key findings (see also section 2.1.1, p. 2-1):
    1. the addition of small quantities of radioactive waste to nonradioactive classified waste to solve a classified waste disposal problem
    2. incomplete documentation of dose assessments, not fully documenting methodologies and actual dose assessment calculations
    3. lack of adequate characterization of inactive waste sites
    4. deficiencies in the sitewide environmental monitoring program
    5. on- and offsite groundwater contamination
    6. failure to apply for air pollution permits (National Environmental Policy Act)
- Section 1.3.3, p. 1-5: "This assessment reflects a fixed point in time. As a result, improvements in the environment, safety and health areas that were planned, but were not completed at the time of the assessment, are identified as findings or concerns if the Tiger Team judged that failure to complete these improvements would have a significant impact."
- Section 3.5.1.1, p. 3-8: "Tritium gas and tritium oxide are discharged from the Bldg. 100 laboratory (west main stack), the Bldg. 200 stack and the Bldg. 800 stack, while tritium gas, tritium oxide and krypton-85 gas are discharged from the Bldg. 100 main exhaust

stack (east main stack), all of which are monitored." One of the findings was that "air pollution and air radiological programs need further attention."

- Section 3.5.1.2, p. 3-13: Finding A/CF-2, "Tritium Stack Releases – Procedure Deviations and Sampling Deficiencies": Lists some deficiencies in equipment calibration, probe locations, and procedure.

- Section 3.5.1.2, p. 3-15, Finding A/CF-5, "Kane Chamber Calibration Inadequacies": "Kane Chambers which are used to monitor tritium stack releases from Bldgs. 100W and 200, and tritium plus krypton stack releases from Bldg. 100E have not all been verified using tritium gas."

- Section 3.5.1.2, p. 3-16, Finding A/CF-6, "Plutonium Stack Sampling Deficiencies": "The stack sampling equipment for Bldg. 400 which has been installed for the purpose of detecting potential releases of particulate Pu-238 and 239 is not of an isokinetic design. . . . Failure to properly sample particulate effluent streams can lead to inaccurate estimates of doses to the public. The site is aware of this situation and has an approved project budgeted for fiscal year 1990 . . . to correct this situation."

- Section 3.5.1.3, p. 3-18, Finding A/BMPF-1, "Ambient Air Monitoring Deficiencies": "The siting and design of the radionuclide ambient air sampling stations do not provide measurements that are representative of public exposure conditions in the vicinity of the Pinellas Plant. . . . Ambient air monitoring is carried out in the vicinity of the Pinellas Plant to measure air concentrations of tritium and plutonium. All five of the offsite air monitor locations, and all seven onsite locations were visited during the Tiger Team Assessment. None of the air samples were collected at the recommended breathing zone height of 2.0 meters."

  p. 3-19: Other deficiencies were present at different monitoring stations. However, the air sampling measurements are substantially below U.S. Environmental Protection Agency (EPA) and DOE radionuclide health criteria. There are variances from guidance, but the conclusion holds that the plant is in compliance with applicable health criteria for air pathways.

- Section 3.5.1.2, p. 3-22, Finding A/BMPF-5, "Lack of Silica Gel Tritium 'Breakthrough' Documentation": "Documentation does not exist demonstrating that sample exchange frequency precludes breakthrough on silica gel tritium columns for daily stack, monthly stack, and monthly ambient air tritium samples. . . . Failure to document breakthrough conditions . . . may lead to unwanted loss of sampled material and subsequent underestimation of doses to the public."

- Section 3.5.2.3, p. 3-27, Finding SS/BMPF-1, "Lack of Background Plutonium Soil Sampling Location": "The site has not established a background plutonium soil sampling location . . . collocated with a background ambient air monitoring station (see related Finding A/BMPF-1)."

- Section 3.5.3.1, p. 3-28: "The low-level contaminated tritium waste is collected from Health Physics . . . drains and dedicated piping within the facility and pumped to [Health Physics] holding tanks where the wastewater is tested to determine tritium concentrations. The facility discharges industrial (Metal Finishing), sanitary, and low-level radioactive wastewaters to the POTW [Cross Bayou Publicly Owned Treatment Works]."

- Section 3.5.5.1, p. 3-53:

  - "The Pinellas Plant has generated in the past, and is currently storing 38 drums of mixed radioactive and hazardous waste (mixed waste)."

  - "Radioactive wastes at the Pinellas Plant are generated from the use of tritium in manufacturing and engineering of neutron generators, from the destructive and nondestructive testing of neutron generators, and duct work from decommissioning of certain areas. Radioactive wastes are stored onsite prior to periodic shipment offsite to the DOE Savannah River Plant for disposal."

- Section 3.5.7.1, p. 3-65: "The Pinellas Environmental Health and Safety Program (EH&SP) department is responsible for administering the site environmental monitoring program. All radiological analyses are performed on site by the Environmental Chemistry Laboratory (ECL). Radiological analyses include tritium in air and water (surface water and plant effluent to the POTW) samples, and plutonium in air and soil samples."

- Section 3.5.8, "Radiation":

  - Section 3.5.8.1, p. 3-70: "The Environmental Subteam found no processes or operations which pose an immediate and unacceptable radiation safety risk to the environment or public. . . . The radiological environmental monitoring program at the Pinellas Plant evaluates stack air effluents for tritium, krypton and plutonium; ambient air for tritium and plutonium; water effluents for tritium and soil samples for plutonium."

  - Section 3.5.8.2, p. 3-74, Finding R/CF-1, "Deficiencies in Dose Assessment Methodologies": "Dose assessment methodologies are not sufficiently documented to demonstrate full compliance with Federal and DOE requirements":

    - Overall, written site dose assessment plan does not exist.
    - Written procedures for dose assessment computer programs do not exist.
    - Computer programs used to perform dose assessment calculations are not periodically benchmarked.
    - Plutonium and krypton source term inputs are not completely documented.
    - Default values used in the dose assessment program are not documented as being appropriate for Pinellas.

p. 3-75: "Although the dose equivalents to the maximally exposed individual reported by the Pinellas Plant have consistently been well below the NESHAP limit of 10 mrem/year for whole body irradiators (no target organ irradiators are released in detectable quantities), the program as it exists today is not capable of defending the quality aspects required by existing and draft DOE Orders."

- Section 4.5.1.1, "Safety and Health Assessment Findings and Concerns, Organization and Administration, Overview," p. 4-5: "In the past the Pinellas Plant has been acknowledged as a moderate hazard, non-nuclear, and non-critical facility. However, recently the General Manager requested an official determination regarding the hazard level and nuclear status of the plant. This official determination had not yest been made. Currently there are few in depth and technically competent safety analyses of product lines, activities and operations at the Pinellas Plant. In addition, there has been no detailed evaluation or risk assessment regarding offsite hazards effects upon the plant."

- Section 4.5.7.2, p. 4-66, Finding EP.6, "Emergency Assessment and Notification": "A catalogue of pre-determined consequences from likely accidents (other than plutonium releases) is not available to the emergency response cadre. One of the plant health physicists has performed 50-year dose commitment calculations for plutonium releases using extremely conservative assumptions."

- Section 4.5.11, "Radiological Protection":

    - Section 4.5.11.1, "Overview":

        - p. 4-90: "The overall assessment is that all levels of the GEND organization are receiving adequate radiological protection. This is primarily due to a GEND staff that appears willing to accept line responsibility for radiological safety along with a technically strong health physics staff providing direction." Several procedural caveats are noted after this statement.

        - p. 4-90: "External exposure, both individual and integrated plant personnel, at GEND is generally kept very low. GEND has taken adequate measures to continue the reduction of personal external exposure. Accreditation of the dosimetry system needs to be completed along with the formalization of employee exposure investigations. Radiation workers were observed not to wear their personnel dosimeters consistently, or failed to ensure that they were properly located on their body."

        - p. 4-91: "Occupational internal exposures are low compared to other DOE sites. This accomplishment results from a conservative approach to working with tritium and through extensive use of engineering controls. However, compliance with the rules on providing bioassay samples at specified frequencies has not been satisfactory."

- p. 4-91: “Contamination controls are generally good. Contamination levels within the work areas are kept low and generally confined to the source. Indications were found that proper contamination control techniques are not always being followed, in some areas causing contamination to spread to the general areas of the facility.”

- p. 4-91: “GEND’s strength lies in its commitment to an ALARA philosophy that prevails across all departments. Commitments to ALARA are demonstrated by installation of the new Tritium Recovery System (TRS) and the conservative approach to performing work.” SC&A notes that a formalized ALARA program was a fairly new concept to the nuclear profession in 1990 and did not apply in the earlier years of Pinellas operations.

- Section 4.5.11.2, p. 4-96, Finding RP.5, “External Radiation Dosimetry”:

  - “GEND’s dosimetry program is not accredited as required by DOE 5480.11.” GEND determined that it had to switch from Landauer G-1 film dosimeter to Landauer Z-1, 3-chip TLD 700.

  - “There is no formal documentation of investigations into personnel exposure anomalies.”

  - “Radiation workers do not consistently wear their personnel dosimeters as required or ensure proper placement on their body.”

  - “Personnel indicated that they wear their dosimeters only when performing work involving the exposure to radiation.”

- Section 4.5.11.2, p. 4-98, Finding RP.7, “Internal Radiation Dosimetry”:

  - “Procedural requirements have not been established for an employee’s termination bioassay, nor a system developed to identify and address those individuals who fail to provide a bioassay sample.”

  - “GEND estimated that 20 percent of the personnel that terminated in 1988 did not provide a termination bioassay.”

    - “Individual workers, their supervisors, and management are not ensuring that required bioassay samples are provided. In 1989, bioassay samples were not submitted in accordance with GEND procedures. Seventy percent of the required monthly samples and 35 percent of the required weekly samples were not submitted.”

- Section 4.5.11.2, p. 4-99, Finding RP.8, “Fixed and Portable Instrumentation”: “Numerous deficiencies associated with instrumentation calibration and use were noted during the appraisal.”

  - Section 4.5.11.2, p. 4-101, Finding RP.10, "Radiation Monitoring/Contamination Control":
    - "Proper contamination control techniques are not being followed by personnel when working in and exiting from Contaminated Areas."
    - Note: The contractor disagreed that workers are inadequately protected given the extremely low contamination levels detected and stated that "radiation exposures from these contamination levels are not measurable, as supported by bioassay sampling."
- Section 5.7, p. 5-33, "Probable Root Causes": "There are at least two probable root causes for the deficiencies observed at the Pinellas Plant."
  - "First, emphasis on production has traditionally overshadowed interest in fully complying with environment, safety and health requirements."
  - "Second, there is a wideset mindset that the Pinellas Plant poses no unusual or unique risks."

Appendix B: Radiological Incidents

SC&A reviewed the available incident and health physics investigation reports along with the site exposure matrices (DOL, 2020) and compiled a list of all documented events that involved a potential or actual radiological release, contamination, and/or personnel exposure.

Table B-1. Radiological incidents at Pinellas Plant

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
December 10, 1957	"Operator error in manometer use (Room 18)," 458 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
February 11, 1958	"Error in estimating the amount of T_2 remaining in the system (Room 18)," 1,253 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
July 8, 1958	"Glass system breakage (Room 22)," 280 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
March 7, 1958	"Glass system breakage (Room 18)," 567 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
August 16, 1958	"Operator error in loader valve position (Room 21)," 780 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
August 18, 1958	"Glass breakage [bed] (Room 21)," 1,180 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
February 10, 1959	"Operator error in stopcock use (Room 8)," 286 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
February 20, 1959	"Hand contamination – operator not wearing gloves."	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
February 21, 1959	"Area contamination – operator broke glass system (Room 18)."	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
March 12, 1959	"[Redacted] contaminated during system cleaning by another worker [redacted]."	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
June 4, 1959	"GEL personnel error working on SECS test (Room 21)," 753 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
June 5, 1959	“Area contamination – diffusion pump exploded in Hood 14.”	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
June 18, 1959	“Near miss explosion on glass system – operator error.”	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
June 18, 1959	“Air in loading system [explanation questioned] (Room 20),” 423 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
September 11, 1959	“Tritium in holding tank H_2O, possibly from drum washing,” 6.5 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
October 5, 1959	“Stopcock blew out of glass system (Room 15).”	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
January 1960	“Operator left stopcock open,” 40 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
February 5, 1960	“Glass bed broke from strain,” 72 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-3 (SRDB 12026)
February 11, 1960	“Operator left stopcock open,” 308 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
March 25, 1960	“Operator error caused exposure to [redacted].”	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
May 14, 1960	“Broken flask caused area contamination (Room 10).”	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
June 21, 1960	“Ion gage exploded (Room 18).”	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
July 8, 1960	“Sample bulb dropped (Room 23),” 6.8 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
July 13, 1960	“Manifold shattered, exposing worker (Room 23).”	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
August 12, 1960	“Contamination spread (TiH_2) in Area 108 from broken flask.”	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
April 1961	“Area contamination from system breakage.”	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
July 1961	Routine survey revealed leakage of 100 µCi Co-60 source.	No additional information	“Corrective action was taken immediately.”	Forest (1961), quote on p. 3 (SRDB 182941)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
December 1962	"Breathing air supply line connected to Area108 exhaust duct."	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
April 5, 1963	Uncontrolled spread of tritium air contamination from open valve of uranium tritide bed into glove box interior.	All personnel were evacuated, adjacent areas surveyed and found to be normal. Urine samples taken from all involved personnel and no significant body deposition found.	Gloveboxes flushed and valves sealed.	Jech (1963) (SRDB 12221); listed in EEOICPA site exposure matrices for Pinellas Plant (sem.dol.gov)
February 4, 1965	Removal of 81 Ci of Kr-85 from Radiflo Unit #1 in preparation for maintenance. Plastic line ruptured, releasing radioactivity into Rooms 1 and 5. 38 Ci of Kr-85 released.	Entire Radiflo area was evacuated and surveys performed to determine extent of contamination. Maximum exposure received during transfer operation and associated release was 160 mR.	Investigation committee formed to review procedures and develop corrective actions.	HP Incidents at GEND (1965–1975), PDF p. 2 (SRDB 26399); Burkhart 1990 (SRDB 12026)
March 10, 1965	"Worker exposed when x-ray interlock failed (XRE shutter)."	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
March 30, 1965	"Broken flask (Room 9)."	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
May 20, 1965	"Flask explosion (Room 12)."	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
May 1966	"SECS col water removal problem," 252 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
January 27, 1967	"Glove box pump oil degassed (Area 182C)," 32 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
October 12, 1967	"Personnel contamination – O-ring mishandled (Room 18)."	No additional information	No additional information	Burkhart (1990), p. B-4 (SRDB 12026)
January 17, 1968	129 Ci of Kr-85 was released from Radiflo Unit #1.	Personnel in room received 5 mR exposure.	Equipment malfunction corrected.	HP Incidents at GEND (1965–1975), PDF p. 5 (SRDB 26399); Burkhart 1990 (SRDB 12026)
June 18, 1968	Explosion occurred in a hood in Area 81 involving solutions used to chemically clean molybdenum parts. [Redacted]	No mention of radiation exposure.	No additional information	HP Incidents at GEND (1965–1975), PDF p. 7 (SRDB 26399); Burkhart 1990 (SRDB 12026)
February 1969	"Leaking flange at sorb pump (Area 108)," 8 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
February 1969	"Area contamination when pump exhaust lines were cut during hood removal (Room 2)."	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)
February 3, 1969	"Equipment failure – value did not seal properly," 20 Ci of Kr-85 released.	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)
August 11, 1969	'Holding tank overflow after pump failure."	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)
September 29, 1969	[Redacted] from a deuterium flask in [Redacted].	Urine sample taken 2 hours after injury. Whole body exposure of [redacted].	No additional information	HP Incidents at GEND (1965–1975), PDF p. 14 (SRDB 26399)
November 5, 1969	Deuterium bed in Area 108 developed a leak, and the bed had to be moved to Building 400 in order to seal the leak. [Redacted] Shoes were decontaminated and the steps were retraced along the route to determine extent of contamination.	High contamination of tritium in Cell 3 Building 400, airborne tritium contamination detected. Next day, Building 400 personnel submitted bioassay samples that showed increases. Air supply redirected to Building 200 and those personnel put on weekly bioassay schedule. Maximum personnel exposure was 50 mrem.	No additional information	Tritium Incident Building 400 (1969) (SRDB 12810); listed in site exposure matrices for Pinellas Plant (sem.dol.gov); Burkhart (1990) (SRDB 12026)
January 1970	"Area contamination/personnel exposure from flaking tube part in gas lab."	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)
February 1970	"Area contamination from pressurized sorb pump [air expansion] (Room 2)."	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)
April 21, 1970	[Redacted] with probe used on a contaminated tube loading system.	[Redacted] Bioassay records included in the file.	No additional information	HP Incidents at GEND (1965–1975), PDF p. 14 (SRDB 26399)
November 20, 1970	"Area contaminated when operator used vacuum cleaner on ScH_2 dust (Area 182D)."	No additional information	No additional information	Burkhart (1990), p. B-5 (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
December 29, 1970	Between 12/27/1970 and 12/28/1970, 117 Ci of tritium oxide was detected in exhaust monitoring data.	"The discharge occurred when the SECS absorption columns became saturated with moisture" (PDF p. 5). Tritiated water in the columns exchanged with the moisture and was release to the stack. No personnel exposures noted.	Various corrective actions recommended, formation of investigative committee to track implementation of corrections.	Holliday (1970–1979), PDF pp. 3–5 (SRDB 12804); Burkhart (1990) (SRDB 12026)
March 12, 1971	Worker exposed to tritium while cleaning out hood, exhaust monitor went off scale. Release of 7.3 Ci.	Worker submitted urine samples for several days following.	No additional information	Holliday (1970–1979), PDF p. 2 (SRDB 12804); Burkhart (1990) (SRDB 12026)
June 14, 1971	"Area 108 Wallace Tiernan Gage repair – high internal dose."	No additional information	No additional information	Burkhart (1990), p. B-5
October 9, 1971	Krypton release and discovery of the deteriorated condition of the storage tank on Radiflo Unit 2. Release of 6.1 Ci.	No mention of employee exposure	Contacted vendor. Checked integrity of other storage units and new program for cleaning and maintaining storage tanks.	Pinellas Plant (1971–1975), PDF pp. 5–8 (SRDB 12805); Burkhart (1990) p.B-5 (SRDB 12026)
October 21, 1971	129 Ci of tritium was released in Building 100/Area 182 from an improperly baked evaporator system.	No additional information	No additional information	Site exposure matrices for Pinellas Plant (sem.dol.gov); Burkhart (1990) (SRDB 12026)
November 10, 1971	A [redacted] accidently spilled tritium sample onto the floor while trying to fit them into a spectrometer.	[Redacted] reported incident, area was surveyed for contamination and [redacted].	No additional information	Pinellas Plant (1971–1975), PDF pp. 2–4 (SRDB 12805); listed in site exposure matrices for Pinellas Plant (sem.dol.gov); Burkhart (1990) (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
November 23, 1971	[Redacted] reported hood exhaust monitor went off scale after removing a bed from the system.	"The [redacted] was instructed to tighten the blank which is installed on the system when the bed is removed" and was reminded "to exercise caution in order to avoid exposure and to wear gloves, laboratory coat and a fresh air mask while performing the operation." Health and Safety was confused as to why there was an exposure if protective gear was used. Next day, a bioassay sample showed a tritium deposition, which will result in a whole body exposure of [redacted].	Discussion with the [redacted] to determine how to prevent future exposures.	HP Incidents at GEND (1965–1975), PDF pp. 36–37, quotes on PDF p. 36 (SRDB 26399); Burkhart (1990) (SRDB 12026)
April 1972	"Area contamination/liquid discharge from flaking fixture (Area 182D)," 1.5 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-6 (SRDB 12026)
May 15, 1972	Scattered radiation from GE x-ray emission unit, [redacted] and was not wearing badge, [redacted].	"reflects an inadequacy in the Department's safety orientation/ education effort." Worker using equipment outside of their area.	Recommendations include educating employees on safety program, creating a system to help supervisors with training, and reducing response time in the radiation alarm system.	GE (1972), quote on PDF p. 3 (SRDB 13196); Pinellas Plant (1971–1975), PDF pp. 17–20 (SRDB 12805); Burkhart (1990) (SRDB 12026)
August 3, 1972	"Leaking sorb pump," 12 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-6 (SRDB 12026)
January 4, 1973	"Water leak in Area 182D."	No additional information	No additional information	Burkhart (1990), p. B-6 (SRDB 12026)
May 11, 1973	Fire in Building 200 occurred during destructive testing.	No mention of employee exposures.	Wood portion of device to be replaced with noncombustible material.	Pinellas Plant (1971–1975), PDF pp. 22–24 (SRDB 12805); Burkhart (1990) (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
May 29, 1973	Building 100 routine contamination survey revealed floor and surface contamination in Area 158B; shoes of the area personnel also contaminated.	Decontamination followed. Environmental health should have been notified when the radioactive material was dropped. Poor judgment was exercised in removing the sources from the shield assemblies in Area 157.	Provide instrumentation, increase frequency of routine surveys to daily	Pinellas Plant (1971–1975), PDF pp. 10–16 (SRDB 12805)
November 1973	Tritium-containing boom box fire in Building 200.	No tritium released.	No additional information	Site exposure matrices for Pinellas Plant (sem.dol.gov)
March 17, 1974	Water leak occurred in Area 109, and there was water leakage into Rooms 19 and 20. Safety employee was in Rooms 19 and 20 in Area 108 and directed the water to the floor drains so only those rooms were affected.	Floor smears showed no significant contamination. No mention of personnel exposures.	Investigation conducted.	HP Incidents at GEND (1965–1975), PDF p. 58 (SRDB 26399); Burkhart (1990) (SRDB 12026)
April 11, 1974	Unusual rise in tritium oxide discharged in laboratory stack effluent from [Redacted]. Indicates high concentration in the hood in the exhaust system.	"If the [redacted] performing the work did not adhere strictly to radiological safety procedures [fresh air mask and gloves], a significant exposure could be expected." [Redacted] mask contaminated. [Redacted]	Environmental Health and Safety (EHS) will be notified before opening any metal exhaust or loading system in [Redacted].	HP Incidents at GEND (1965–1975), PDF p. 72 (SRDB 26399); Burkhart (1990) (SRDB 12026)
October 1974	Investigation of contaminated valve shipment: Gate valve used at GEND became contaminated with tritium, confusion as to the level of contamination and valve was not properly labelled before shipment.	Comprehensive investigations followed, Extensive surveys, analysis performed to determine maximum possible exposures to personnel. Possible dose very low, no health hazard.	No additional information	Pinellas Plant (1976–1979), PDF p. 2 (SRDB 12806)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
January 31, 1975	Tritium-deuterium gas release to atmosphere and surroundings in Room 4 and the west side of Area 108.	Release due to improper valve closure on uranium beds. No mention of personnel exposures.	Investigation conducted, various preventative measures implemented.	Phillips (1975) (SRDB 13125); Burkhart (1990) (SRDB 12026)
February 10, 1975	"Sorb pump leak – Area 182D," 42 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-6 (SRDB 12026)
May 10, 1975	Rain water pouring in Area 8 from roof leaks.	Surveyed area and found water did not present a significant contamination problem.	No additional information	HP Incidents at GEND (1965–1975), PDF pp. 76–77 (SRDB 26399)
January 31, 1976	"Contaminated 6-inch valve shipped"	No additional information	No additional information	Burkhart (1990), p. B-6 (SRDB 12026)
April 13, 1976	"During the low temperature bake operation, the oven fan blade disengaged from the fan motor shaft and struck the array of ten (10) MC 1451B tubes being processed," shattering one tube in metal exhaust system #503, Area 108.	No injury or exposure to personnel.	Installation of protective screens.	Pinellas Plant (1976–1979), PDF p. 89–91, quote on PDF p. 89 (SRDB 12806); Burkhart (1990) (SRDB 12026)
June 1976	7,100 Ci of tritium gas that came from a tritium tank during bed loading process in Room 18, Area 108.	"This gas accidently was slowly absorbed in the stack effluent control system columns through the bed loading system rough pump." "The accidental discharge and the accountability of the loss were not recognized or acted on soon enough." No mention of personnel exposures.	Many suggestions involving record keeping, monitoring, and alarm systems.	Pinellas Plant (1976–1979), PDF pp. 98–103, quotes on PDF p. 103 (SRDB 12806)
February 1977	"Packaging of fixtures in Area 182D glovebox," 28 Ci of tritium released.	No additional information	No additional information	Burkhart (1990), p. B-6 (SRDB 12026)
May 23, 1977	"Radiflo valve failure during cold trapping," 16 Ci Kr-85 released.	No additional information	No additional information	Burkhart (1990) p. B-6 (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
September 11, 1979	Release of tritium oxide from the [redacted]. 5.7 Ci released.	Release was larger than anticipated. Worker exposure was avoidable and resulted from "techniques which were less than adequate." [Redacted].	Improved "planning and instruction when performing non-routine operations." Upgrade health physics monitoring equipment.	Holliday 1970–1979, PDF pp. 20–38, quotes on PDF pp. 21, 30 (SRDB 12804); also listed in site exposure matrices for Pinellas Plant (sem.dol.gov); Burkhart (1990) (SRDB 12026)
April 1980	"Area contamination from film flaking (Area 158B)."	No additional information	No additional information	Burkhart (1990), p. B-7 (SRDB 12026)
May 14, 1980	Cooling water hose rupture in Room 13, Area 108.	No personnel were present in Room 13 and no injuries reported.	Investigation conducted.	HP Investigation Reports (1980–1986), PDF pp. 2–12 (SRDB 12808)
July 1980	Disposition of scanning electron microscope that had some tritium contamination.	No health hazard to personnel. "External surfaces of all components indicated radiation levels below the standards for unconditional release."	No additional information	HP Investigation Reports (1980–1986), PDF pp. 15–28, quote on PDF p. 17 (SRDB 12808)
April 29, 1981	"SECS overpressure when purge valve left open."	No additional information	No additional information	Burkhart (1990), p. B-7 (SRDB 12026)
February 25, 1982	Memo to file: east stack tritium monitor showing two discharges totaling 8.6 Ci of tritium.	No mention of personnel exposure.	No additional information	HP Investigation Reports (1980–1986), PDF p. 46 (SRDB 12808)
April 20, 1982	Memo to file: 48 Ci tritium release from mass spectrometer in Room 20, Area 108.	Valve in discharge line directed to stack instead of the SECS.	No additional information	HP Investigation Reports (1980–1986), PDF p. 47 (SRDB 12808)
May 24, 1982	9.5 Ci discharge from east stack, vacuum maintenance personnel working and system discharge valve was turned from tritium recovery system to the stack.	No additional information	No additional information	HP Investigation Reports (1980–1986), PDF pp. 48–49 (SRDB 12808)
September 1, 1982	Tritium release in Area 108, alarm went off but personnel confused because it is hard to identify location. 3.0 Ci released.	"Most often alarms occur when personnel are performing work with a high potential for tritium release in a hoodroom. In this instance, evacuation of the general area is not required."	Change the sound of the various alarms so workers can determine location of release.	HP Investigation Reports (1980–1986), PDF pp. 52–55, quote on PDF p. 53 (SRDB 12808); Holliday (1982a) (SRDB 187684), (1982b) (SRDB 187683); Burkhart (1990) (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
January 5, 1983	Release of 130 Ci of tritium in [Redacted] during routine procedure to unload and oxidize a tritium bed.	"The results of the investigation indicate that improper equipment usage resulted in the gas leakage, and that installations exist in the plant that could result in similar tritium release events." [Redacted].	Investigation conducted.	HP Investigation Reports (1980–1986), PDF pp. 57-67, quote on PDF p. 57 (SRDB 12808)
January 19, 1983	9 Ci of tritium released from a sorption pump into the manufacturing section of Area 108, Building 100 and exhaust to the environment through the Building 100 east exhaust stack.	No personnel exposures or area contamination.	No additional information	HP Investigation Reports (1980–1986), PDF pp. 68–82 (SRDB 12808)
April 5, 1983	"Bed heater control failure (Area 108)."	No additional information	No additional information	Burkhart (1990), p. B-7 (SRDB 12026)
April 3, 1984	"SECS blockage when Trichlor was introduced in Area 182D."	No additional information	No additional information	Burkhart (1990), p. B-7 (SRDB 12026)
July 25, 1984	"Sorb pump sieve dumped into drum in Area108 [Unusual occurrence report (UOR) 84-07]," 67 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-7 (SRDB 12026)
December 9, 1985	"Sorb pump overheat – area contamination [UOR 86-01]."	No additional information	No additional information	Burkhart (1990), p. B-7 (SRDB 12026)
June 5, 1986	"Waste drum removed from Area 108 without survey."	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
June 24, 1986	"Mass spectrometer oil change workers exposed to T_2 gas [UOR 86-04]," 1.5 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
November 24, 1986	"Tracerflo maintenance," 3.6 Ci Kr-85 released.	No additional information	No additional information	Burkhart (1990), p. B-8 9SRDB 12026)
February 5, 1987	"270 Ci pumped from Room 18 to SECS."	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
June 16, 1987	"SECS pressurization by argon (Ar) purge in Area 108."	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
August 1987	"Cold trapping," 26 Ci Kr-85 released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)

Date of incident	Incident description	Personnel exposures/ comments	Corrective actions	Citation (SRDB ID)
September 8, 1987	"ELDS No. 6 sorb pump leakage (bad weld at neck)," 0.7 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
November 4, 1987	"Test of O_2 regeneration need by SEC system," 12 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
February 11, 1988	"Leaking sample bulb from 182 in Area 108," 8 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
March 7, 1988	"E-Beam welder shield failure – workers exposed [UOR 88-03]."	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
May 5, 1988	"Purge left on over third shift in Area 108 – SECs overpressure," 2.7 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
May 27, 1988	"Leakage from Radiflo system No.2," 0.4 Ci Kr-85 released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
September 1988	"Lab area release over two-week period," 16.2 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
January 6, 1989	"Water in SECS line (Area 182D) [UOR 89-02]," 1 Ci released.	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
September 7, 1989	"Loss of control of radioactive material [UOR 89-08]."	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
December 15, 1989	"Work performed in Area 109 without permit [UOR 89-12]."	No additional information	No additional information	Burkhart (1990), p. B-8 (SRDB 12026)
1995	Investigation meeting held March 22, 1995.	• Total of 175 leaks located in plant have been surveyed and analyzed. • External tritium levels were very low and would not be predictive of internal contamination levels. • The internal tritium contamination appears to be from Area 108 and Area 158A, and possibly from mass spectrometer in Area 157.	Continue surveys to isolate contamination sources. Personnel informed of best practices to minimize contamination.	Burkhart (1995) (SRDB 13503); listed in site exposure matrices for Pinellas Plant (sem.dol.gov)

Appendix C: Former Worker Interview Notes

SC&A evaluated available documented communication (i.e., interview) summaries to determine if information existed pertinent to this SEC evaluation. These interviews were conducted by NIOSH and SC&A representatives in support of the TBD review. Table C-1 summarizes these interviews.

Table C-1. Summary of interview notes with former workers

SRDB No.	Employment period	Occupation	Interview information
37343	[Redacted]	[Redacted]	The EE remembers taking both posterior-anterior (PA) and lateral (LAT) chest x-ray exposures. The films would then be sent out to a radiologist to be read. Does not recall any photofluorography (PFG) or any abdominal x-rays. The EE does remember doing some back (lumbar spine) x-rays. They did not do any pre-employment lumbar spine x-rays.
37342	[Redacted]	[Redacted]	Provided information on the Radiflo systems used at the plant.
127111, 185745	[Redacted]	[Redacted]	Indicated that they knew where tritide contamination would likely occur, which was typically limited to 2–3 areas within the operation line. The EE thought there might be more causes of tritium contamination in destructive testing. Another HP discovered that tritide exposures were occurring in an unexpected area via the bioassay results of a worker that was off site for a long enough period of time for any (soluble) tritium to be eliminated from their body. When that worker returned to work, their urine still had tritium in it, which could have only been from a (less soluble) metal tritide exposure. Once they figured out the cause of the metal tritide exposure, they moved the operation that was causing it into a fume hood and eventually into a glove box, to help prevent further exposures to tritides. Neutron doses were only estimated for the RTG workers if one of the individuals lost a badge. They almost always relied on the dosimetry data only, and rarely had to estimate doses for RTG workers. The workers were required to leave their badges in the area. The results were not based on a photon dosimeter reading. They always had a separate badge for neutron exposures. Building 100 was basically one building within a larger building. One area in Building 100 had aluminum walls. The walls for the process areas went all the way to the ceiling. There were walls separating process areas from non-process areas. The building contained elaborate ventilation systems.

SRDB No.	Employment period	Occupation	Interview information
129125	[Redacted]	[Redacted]	The focus of this interview was to confirm whether or not the tritium contamination smears were routinely rinsed and filtered through a Whatman #1 filter. An undated and unsigned Health Physics procedure that was previously captured indicates that the sample rinsate from the tritium contamination smears was filtered prior to adding an aliquot of the sample to a vile of liquid scintillation cocktail. The interviewees recall rinsing the cotton balls used to collect the tritium contamination smear samples. However, neither recalls filtering the rinsate through any filter. Filtering the rinsate through a filter was not part of the routine analysis procedure when they were at the Pinellas Plant. They suspect that procedure that involved filtering the rinsate may have been a nonroutine procedure. There weren't any routine procedures for analyzing the tritium contamination smears when metal tritide contamination was suspected, and they were not aware of any nonroutine procedures for doing that.
185748	[Redacted]	[Redacted]	According to EE, the EE's department was asked to participate in urine bioassays; they were not required. The EE states that everyone but secretaries and management gave samples in the EE's department.
185752	[Redacted]	[Redacted]	EE visited site on three occasions in the 1990s. As [redacted], the EE felt Pinellas HPs had a good program and were responsive. In the 1990s, the EE felt that the plant had good participation in the bioassay program.
185809	[Redacted]	[Redacted]	"We filled neutron tubes with radioactive gasses. I believe people gave routine samples, complied with the requests on a regular basis. I was assigned a film badge but didn't use it very often because I was not near equipment and not in rad areas very long (the tube exhaust area with tritium that went into tubes). We were testing tubes to generate neutrons. The personnel were not exposed to tritium sealed in the tubes, but neutron exposure was possible. The test area and floor were marked off with tape into zones not to enter. The RTGs were built in another area. They contained highly radioactive pellets with plutonium. The RTGs had doubly encased pellets (2 layers of metal on receipt). This was in its own building, in a contained area. The rules were followed in handling the RTG pellets."

SRDB No.	Employment period	Occupation	Interview information
185753	[Redacted]	[Redacted]	The site developed corrective actions for the Tiger Team process. These were submitted to Albuquerque for review and approval. The corrective action plan was signed-off on by the plant manager and the DOE area office. The EE recalled that there were reasonable explanations for the lack of management followup on mission bioassay samples. Recalled there being a delay in analysis of some submitted samples and people being off site as some reasons. Pinellas HPs actively tried to collect samples should a sample not be submitted. They had a list of people to collect samples from.
185749	[Redacted]	[Redacted]	The EE participated in both the dosimetry and bioassay program. Selection for bioassay sampling was based on the work assignment with potential for exposure. The EE does not recall ever being in a high-exposure environment.
185754	[Redacted]	[Redacted]	As a supervisor, the EE never was contacted about workers not leaving a bioassay sample. All that was handled by Health & Safety/Health Physics people. The EE reported the Tiger Team came in 1989 and required signs be put up and carcinogens be specified in the operating instructions. There were no materials safety data sheets “until 22 years after we started working with all these chemicals” (p. 3).
185929	[Redacted]	[Redacted]	According to the EE, an HP told the EE that the equipment for bioassay sample analysis was down frequently, once for up to a couple of months. The [redacted] just filled in the blanks (gun-decked) when the equipment was down. The EE was on and off the bioassay program for their first [redacted] of employment and submitted weekly samples. Was given a dosimeter when the EE worked with the accelerator. The EE remembers weekly safety meetings around someone’s desk with rotating industrial safety concerns. Recalls [Redacted] (HP) giving a presentation and saying, “if you were married you would get more radiation from your spouse, then being at the plant” (p. 2).
185747	[Redacted]	[Redacted]	The EE recalled they had Health Physics Technicians who did routine surveys and collected bioassay samples. The primary contaminant of concern was tritium, not on the scale of Mound, but there were lots of tritium beds. Exposures to radiation workers was from tritium. There was one large building with several smaller outbuildings. The plant had a good radiation protection program and was a well-run facility, with high security standards. Conduct of operations was taken seriously. The EE did not recall things being done ad hoc.

SRDB No.	Employment period	Occupation	Interview information
185813	[Redacted]	[Redacted]	If you were a radiation worker/wore a radiation badge, you gave a urine sample every Friday. If it was close to quitting time and you hadn't given a sample, by 3:30 p.m. they were paging you over the intercom. Everyone in the whole building knew what they were paging you for: to come and give a sample. If you were given a dosimeter, it was understood that you were expected to give urine samples. Workers in Building 400 did not have to give urine samples. The plutonium was stored in the walled-off half of the building.
185751	[Redacted]	[Redacted]	The EE operated [redacted], to determine what compounds were available (nondestructive testing). The EE recalls monitoring at times and wore a badge after the Tiger Team audit. The EE does not recall generally wearing a badge or being in bioassay program. The EE was unaware of pushback on the bioassay program and doesn't recall hearing any comments about people not wanting to participate.
185810	[Redacted]	[Redacted]	The EE did not participate in the bioassay program and "was never assigned a dosimeter. I believe the workers were compliant and followed instructions. I think if a worker didn't provide a bioassay sample it is likely because they didn't know they were supposed to" (p. 2).
185812	[Redacted]	[Redacted]	The EE recalled the plant was very compartmentalized and information was shared on a need-to-know basis. The EE had never heard of the bioassay program but recalled everyone did what was asked of them at the Pinellas Plant. The atmosphere was one of compliance with management instructions.
185811	[Redacted]	[Redacted]	The EE worked on nonradiation hazardous waste issues related to groundwater contamination. The EE does not recall radiation safety issues and thought it was a well-run plant.
185814	[Redacted]	[Redacted]	The EE had 5-7 direct reports in the bioassay program. As [redacted], they tried to be good stewards of the program and were reliable participants. "The Tiger Team did not discover a new problem. The plant was aware, had self-identified the issues with not always getting samples returned. The site was working on it prior to and continued to work on it after the Tiger Team audit. The problem ebbed and flowed over time. Who knows why? Laziness? Lack of mgmt. focus? In the processing end I know we always had samples to run. There may have been pockets of non-compliance but we never had a shortage of samples to run" (p. 2). The EE does not recall there ever being followup samples required. If you missed a weekly sample, you were told not to miss it next time.