Oak Ridge National Laboratory
Special Exposure Cohort
Petition Evaluation Report
SEC-00189

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Denver, CO

Special Exposure Cohort Evaluation Team

- **DCAS Lead – Timothy Taulbee**
- **ORAU SEC Lead – Mike Kubiak**
- **ORAU Lead Technical Evaluator – Mike Domal**
  - **Roger Halsey**
  - **Keith Varnado**
  - **Ray Clark**

Petition Overview

- 83.13 petition received on July 18, 2011
- Petition qualified on October 11, 2011
- Notification to ABRWH on January 6, 2012 that NIOSH would exceed 180-day deadline due to data retrieval difficulties
- SEC Evaluation Report sent to ABRWH on August 22, 2012
- SEC Evaluation Report received by Petitioner on August 31, 2012

Petition Overview - cont.

- **Petitioner requested class:**

  All contractor employees, subcontractor employees, and AEC employees who were monitored or should have been monitored for any of the various radionuclides and fission products present at the X-10 plant while working in all areas at the Oak Ridge National Laboratory (X-10) from January 1, 1943 through December 31, 1952.

Petition Overview - cont.

- **Class evaluated by NIOSH:**

  All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked in any area at the Oak Ridge National Laboratory (X-10) in Oak Ridge, Tennessee, from January 1, 1943 through July 31, 1955.

Proposed Class Definition

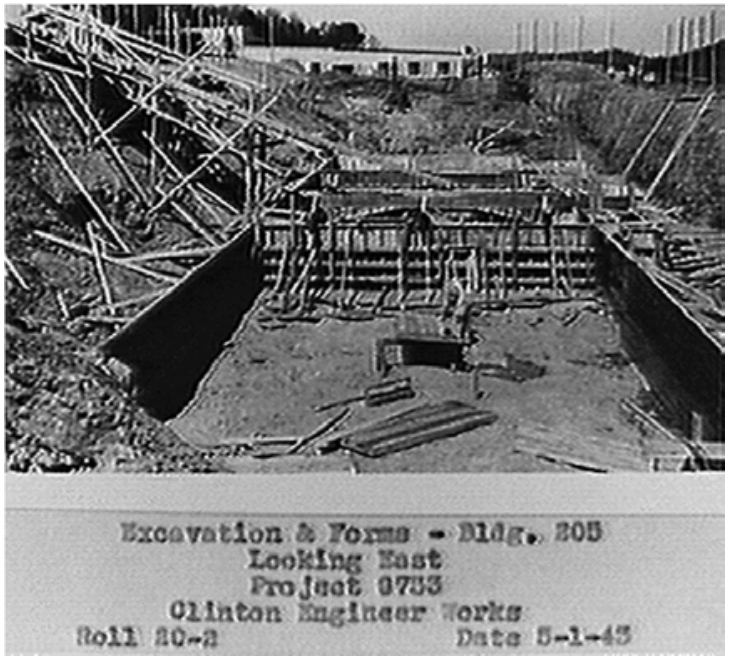
All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked in any area at the Oak Ridge National Laboratory (X-10) in Oak Ridge, Tennessee, from June 17, 1943 through July 31, 1955, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

Overview

- **How did NIOSH develop this recommendation?**
  - **ORNL Historical Background**
  - **Evaluation of Critical Exposure Issues**
  - **Monitoring Data**
  - **Feasibility of Dose Reconstruction**

ORNL Historical Background

- **Construction of X-10 started in February 1943**



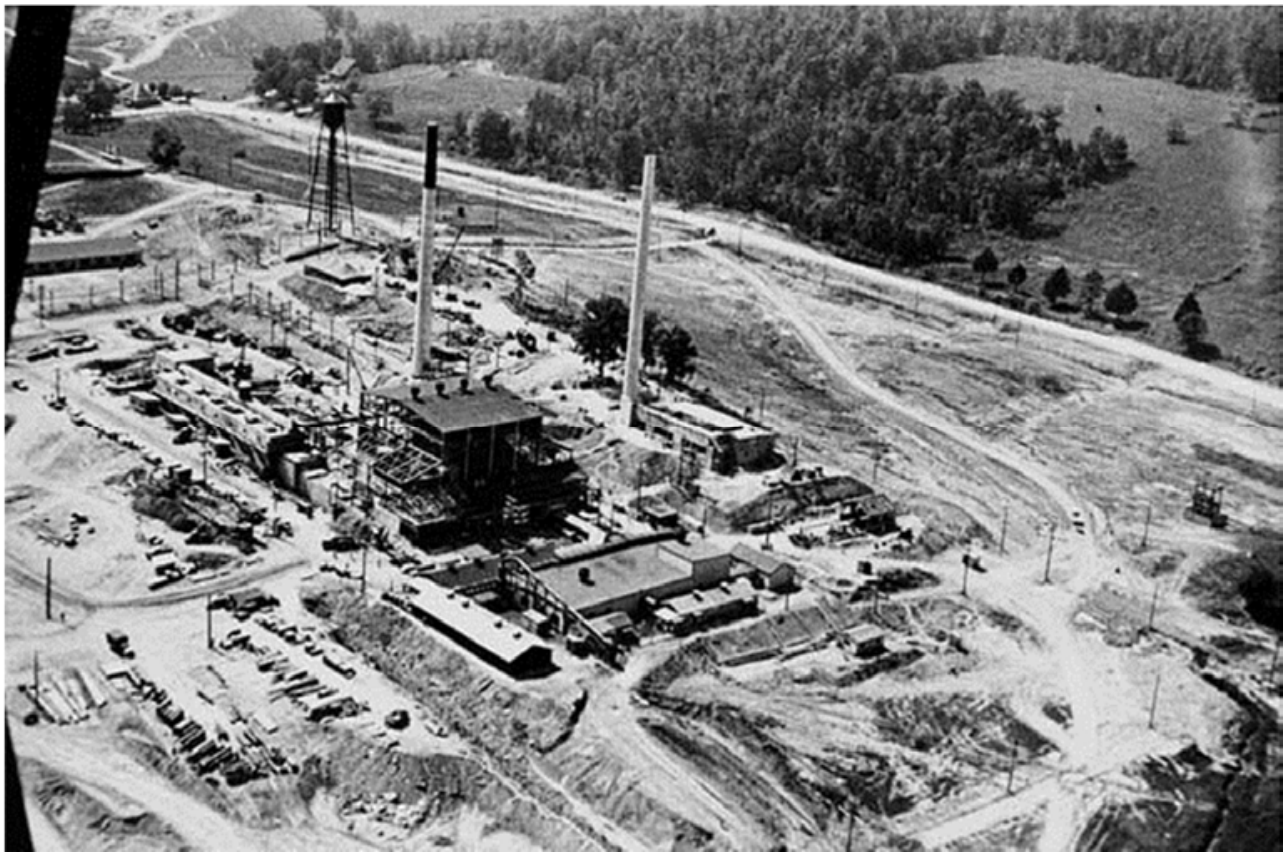
Bldg 205 - May 1943

Bldg 105 – June 1943

ORNL Website 2012

ORNL Background

- **Reactor Critical on November 4, 1943**



Bldgs. 105 and 205 – October 1943 *ORNL Web site 2012*

Start of Radiological Operations

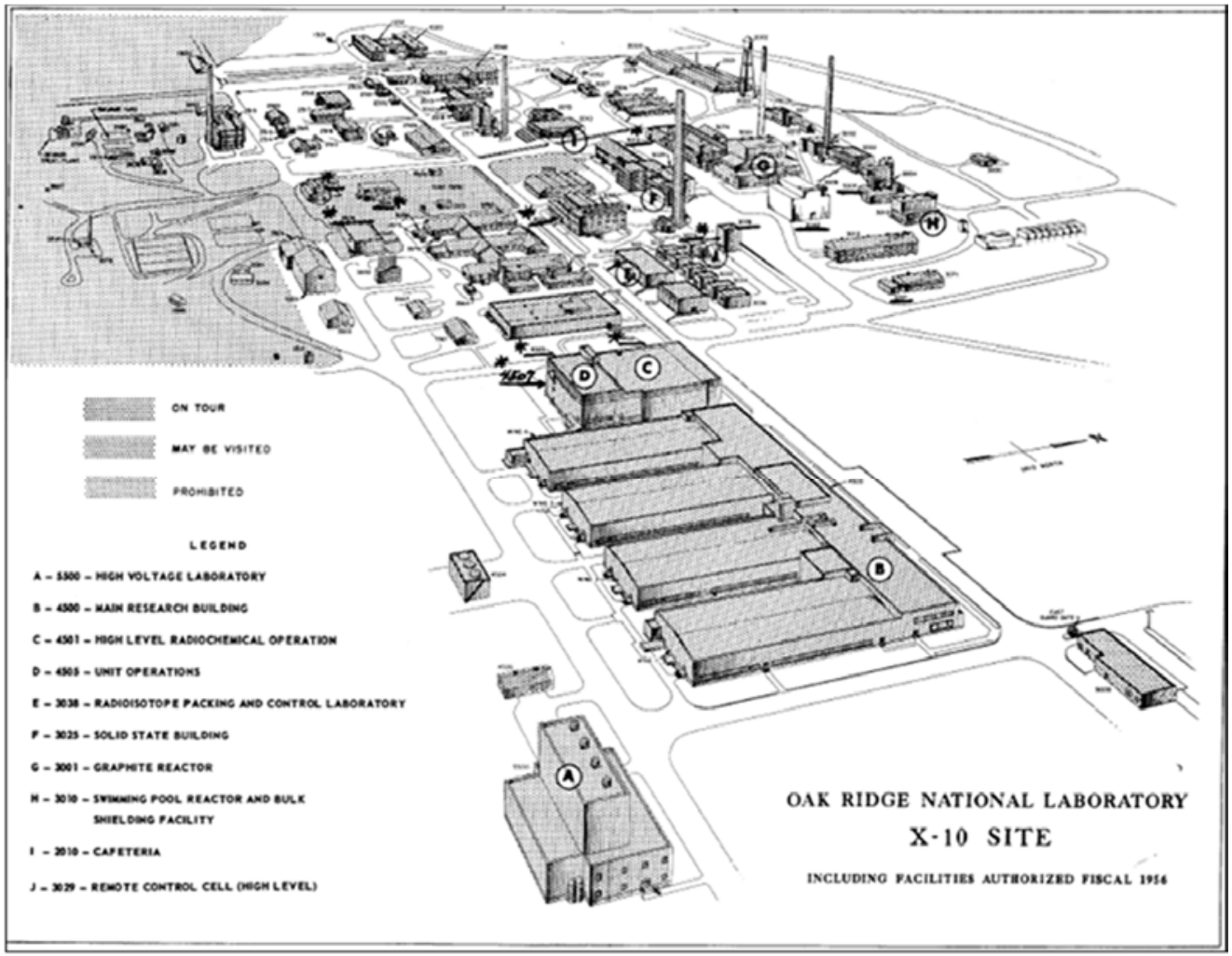
June 17, 1943

- Ground breaking February 1943
- Photographic evidence indicates construction still in June 1943
- First uranium slug shipment from Aluminum Company of America (ALCOA) left on June 17, 1943
- Uranium stored somewhere onsite until being loaded into the graphite reactor around October 31, 1943

Early ORNL Milestones

- Graphite Reactor Critical – November 4, 1943
- First discharge of irradiated uranium targets – End of November 1943
- 1.54 mg of plutonium separated and sent to University of Chicago – December 31, 1943
- First shipment of plutonium to Los Alamos in February 1944
- By the end of war, 326.4 grams of plutonium had been produced (1945)

ORNL Map - 1955



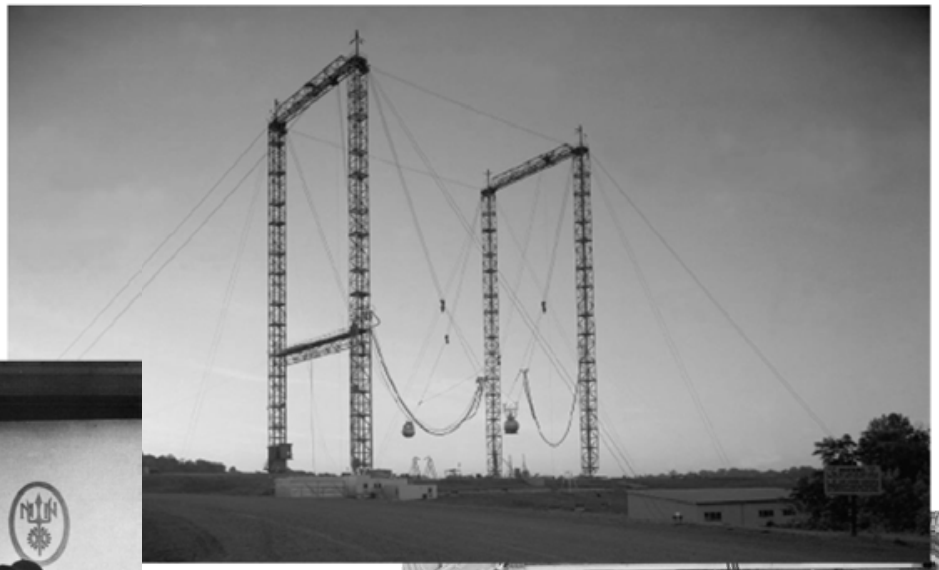
Reactor Development

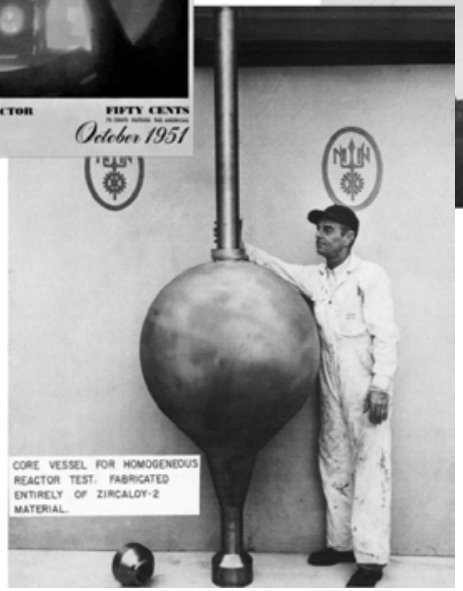
- 1943 – Graphite reactor
- 1945 – Critical experiments in Bldg. 205
- 1949 – Low Intensity Test Reactor (LITR)
  - Full scale mock-up of the MTR reactor (INL)
- 1950 – Bulk Shielding Reactor (BSR)
  - Swimming pool style
- 1952 – Homogeneous Reactor Experiment (HRE)
- 1952 – Tower Shielding Experiment
- 1953 – Aircraft Reactor Experiment

ORNL Reactors

LITR

Tower Shielding Reactor





Homogeneous Reactor Vessel
(before installation and operation)

Bulk Shielding Reactor

Isotope Production

- **August 1946 - First radioisotope shipment for medical research**

- **First year of production 60 different isotopes were shipped**

Removal of first radioisotopes for medical research Aug 1946

Isotope Production

- **Main isotopes shipped were C-14, P-32, I-131**
- **Y-12 Connection**
  - **Calutrons _ stable isotopes**
  - **Cyclotron - radioisotopes**
- **Some separations conducted at ORNL (X-10)**

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Uranium-233 Production

- **1944 - Labscale preparation and testing of thorium carbonate**
- **1946 – Research and Development for Uranium-233 extraction** *(Thorium is the target material)*
- **1948 – Temproary pilot plant for thorium extraction built in 706HB**
- **1949 – Thorium extraction runs begin**
- **1954 – Thorex Pilot Plant installed in building 205 (3019)**

Evaluation of Critical Exposure Issues

- **Internal Dose**
  - **Plutonium**
  - **Uranium**
  - **Mixed Fission Products**
  - **Thorium**
  - **Exotic Radionuclides**
- **External Dose**
  - **Beta / Gamma Monitoring**
  - **Neutrons**

Internal Dose Monitoring

- **Hierarchy of internal data**
  - **Personal bioassay**
    - —***urine, feces, whole body count, chest count***
  - **Personal breathing zone sampling**
  - **Representative breathing zone sampling**
  - **Surface contamination measurements**
  - **Source term**

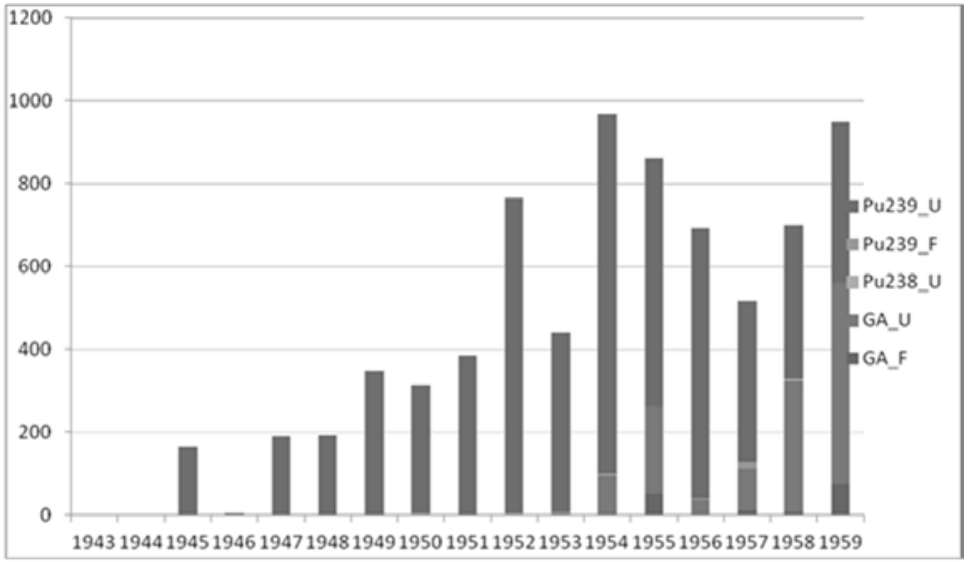
Plutonium

- First plutonium monitoring data February 1945
- Urine samples sent to Argonne National Laboratory (ANL) for analysis
- Several positive results could have resulted from impure lanthanum carrier used in analysis
- Sampling and analysis improved over 6 month period

Plutonium – cont.

- **Plutonium production operations ended in 1945; however, research continued**

- **Urine monitoring decreased significantly in 1946 but picked up in 1947 and increased into the 1950s**



Plutonium – cont.

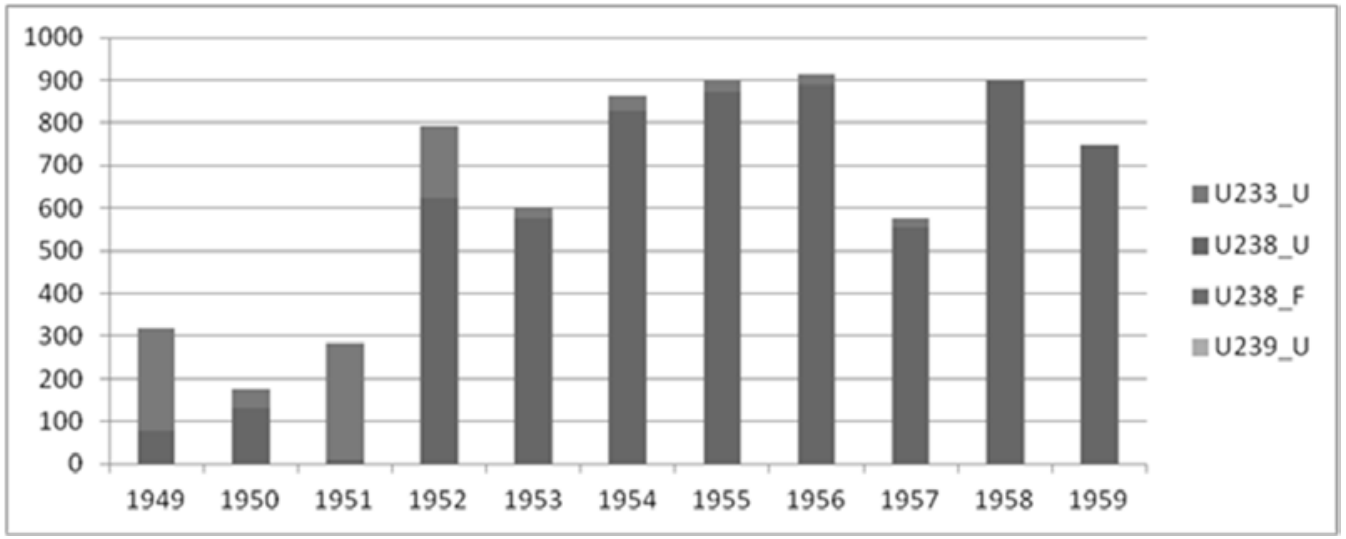
- **Approximately 1500 air samples are available from 1944 through 1947**
- **Sample descriptions indicate many were taken 6” from hood face**
- **Interviews with former workers indicate the samplers were positioned at head height with the intent of sampling the breathing zone**
- **Most samples were from 706 Radiochemistry building** *(i.e. research)*

Plutonium – cont.

- **Based on availability of plutonium bioassay (urine) results in conjunction with alpha air sample data from research facilities, dose reconstruction from plutonium exposures is believed to be feasible.**

Uranium

- **NIOSH has not located any uranium bioassay results until 1949**
- **A 1949 plutonium bioassay logbook indicates sample split and a co-analysis for Uranium-233**



Uranium – cont.

- According to a 1954 review of the urinalysis program, ORNL began processing plutonium and uranium urinalysis onsite in 1947

- NIOSH has not located any uranium urinalysis results before 1949

Uranium (Air Sample) – cont.

- Majority (80%) of 1944-1947 air sample data is for radiochemistry building (706)
- Limited data (8%) from separations facility (205) where plutonium was separated from uranium and mixed fission products
- NIOSH found a few air sample logsheets attached to correspondence indicating a routine air monitoring program

Uranium – cont.

- Interviews with former workers confirmed routine air monitoring program

- Monthly reports also indicate a routine air monitoring program and report number of samples collected
  - (≈ 60 samples per week in 1948 = 3000 per year)

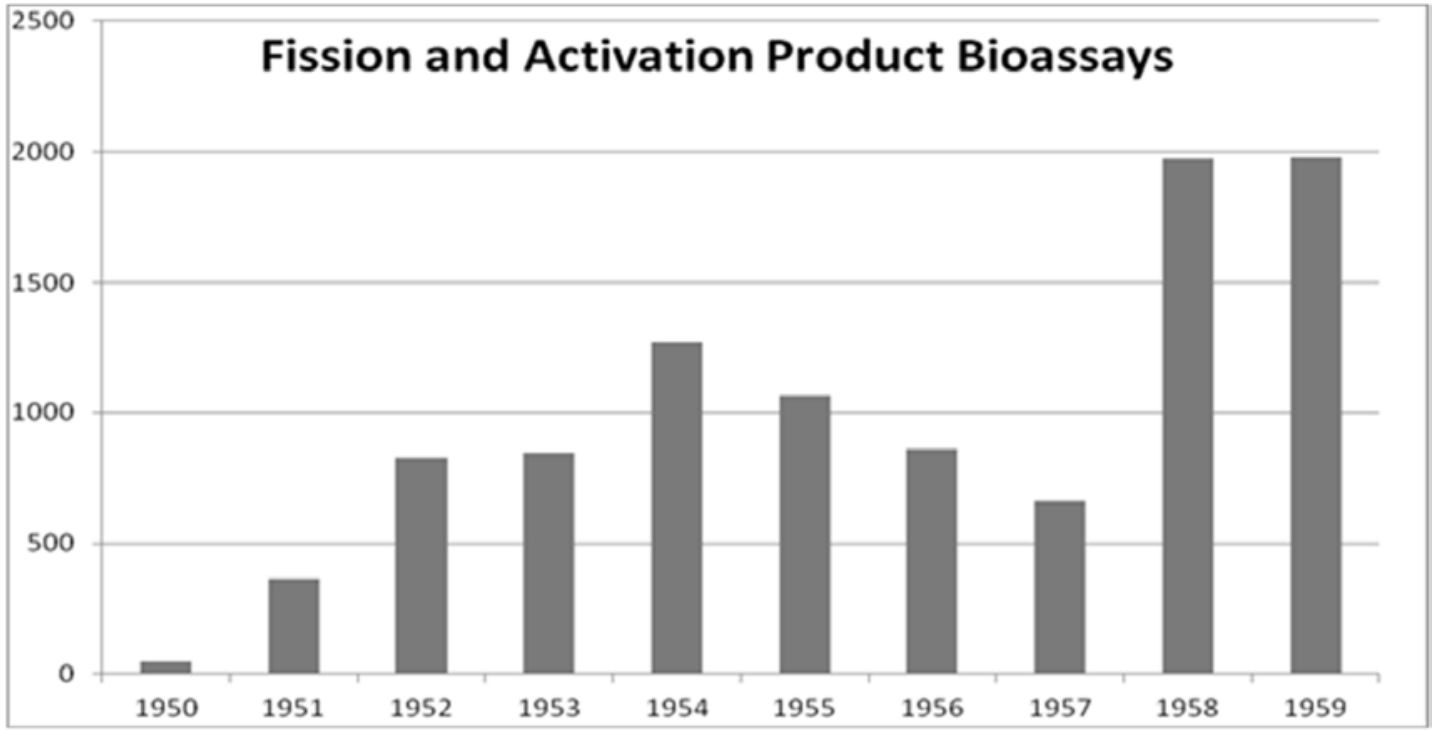
Uranium – cont.

- To date, neither NIOSH nor DOE has been able to locate these air sample results through exhaustive records searches

- As a result, NIOSH finds that reconstruction of internal doses to uranium is infeasible from June 17, 1943 through December 31 1948

Mixed Fission Products

- **No mixed fission product bioassay has been located until 1950**



Mixed Fission Products – cont.

- 1954 review of urinalysis program indicated that the capability to monitor for mixed fission products was developed in 1949
- In August 1949 ORNL-368 *Procedure for the radiochemical analysis of barium, strontium, and rare earths* was published
- Some very limited incident based sampling was conducted in 1949 based weekly and monthly reports

Mixed Fission Products – cont.

- Difficulties with obtaining fission product sampling and request methodology appears to have changed in 1951 resulting in more robust monitoring program
- Most of the air sampling data was for product contamination in the air (alpha)
- Limited air sampling data for beta/gamma emitters

Mixed Fission Products – cont.

- Limited data for separations facility (205), most air sample data was for Radiochemistry Building (706)
- Evidence indicates no bioassay program for mixed fission products until late 1949
- Limited air sample data for separations facility

Mixed Fission Products – cont.

- **NIOSH finds that reconstruction of internal doses to mixed fission products is infeasible from June 17, 1943 through December 31, 1949**

- **NIOSH believes that dose reconstruction from January 1, 1950 through July 31, 1955 may be feasible**

Thorium

- ORNL began conducting research involving thorium in 1944
- Most of the early research was conducted in the radiochemistry building (706) where NIOSH has located extensive alpha air sample results
- NIOSH has confirmed through records and interviews that these air sample results are representative of a worker's breathing zone in the chemistry laboratory environment

Thorium – cont.

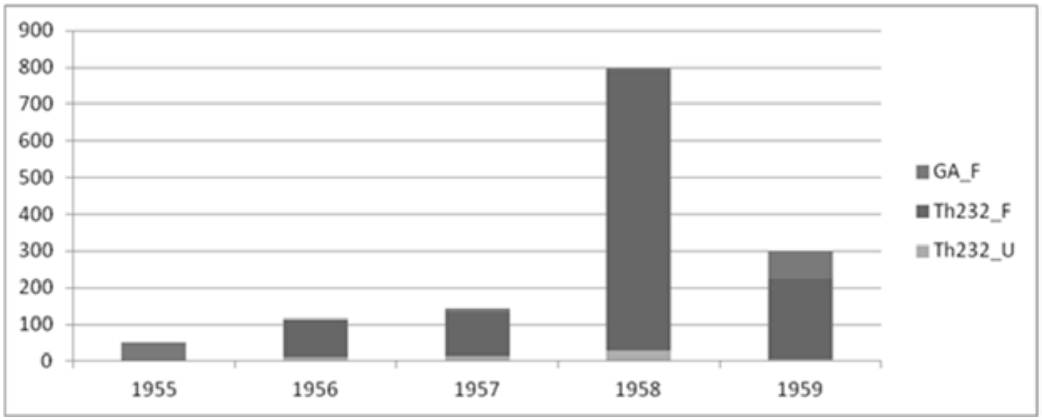
- However, NIOSH has only been able to locate air sample data from 1944 through 1947
- No air sample data post 1947 has been located
- As discussed in the uranium section, a routine air monitoring program was conducted, but neither NIOSH nor DOE has been able to locate the records

Thorium – cont.

- NIOSH has not been able to locate any thorium bioassay prior to August 1955
- Generally urinalysis for thorium results in a missed dose that has been characterized as insufficiently accurate
- At ORNL, however, thorium was monitored via fecal analysis
- NIOSH has obtained thorium fecal results for ORNL workers starting in August 1955

Thorium – cont.

- Uranium-233 separations increased significantly upon receipt of irradiated thorium from the Savannah River site in 1956 and 1957
- Following receipt of this irradiated thorium, the ORNL bioassay program also increase



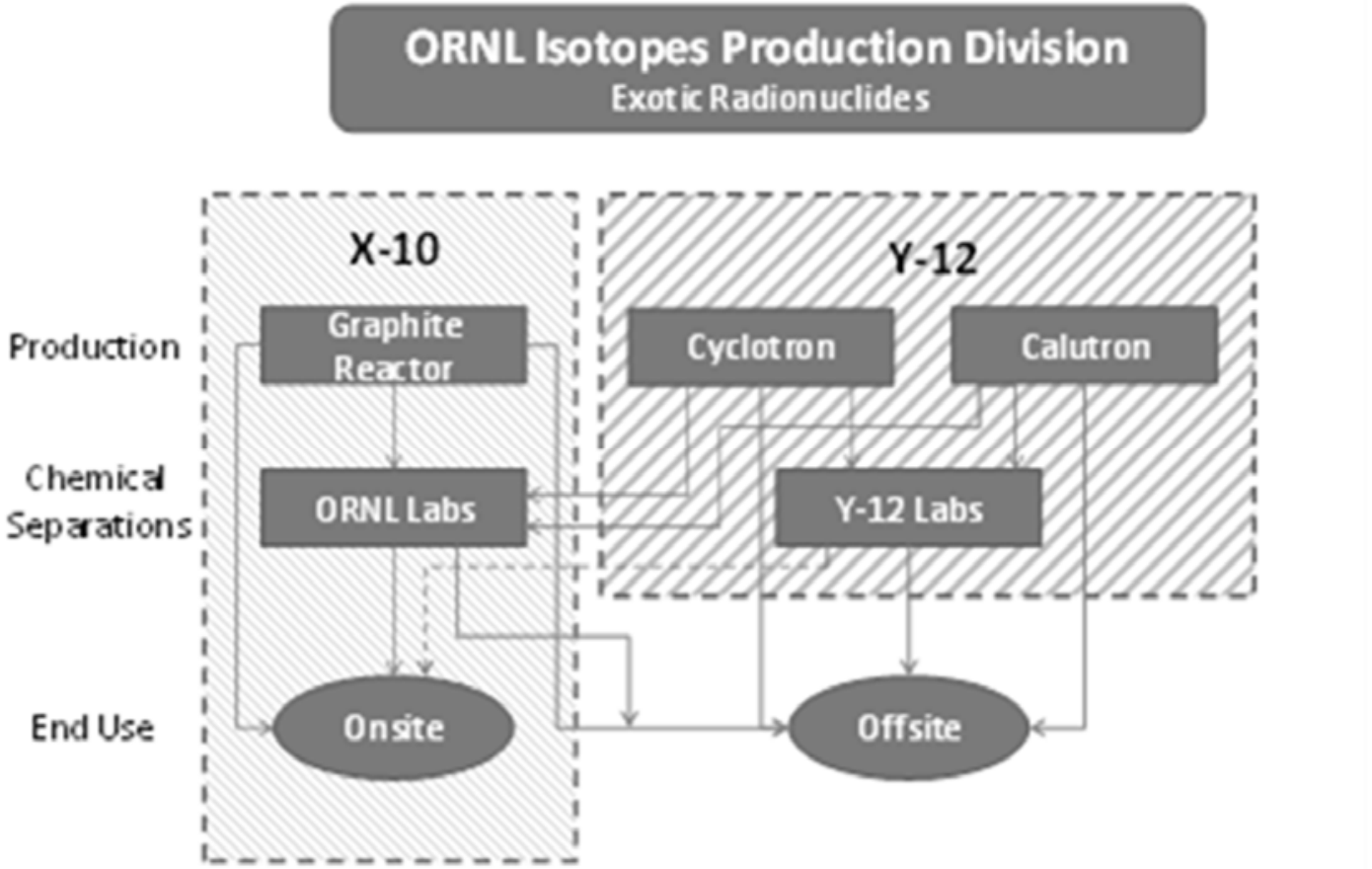
Thorium – cont.

- Due to extensive representative air samples available from 1944 through 1947, NIOSH believes dose reconstruction for thorium exposure may be feasible
- Due to the lack of air sample data from 1948 through July 1955, NIOSH finds that dose reconstruction of thorium exposure is infeasible
- Due to availability of thorium fecal samples in August 1955, NIOSH believes that dose reconstruction for thorium exposures may be feasible

Exotic Radionuclides – cont.

- Starting in 1944 ORNL began producing polonium-210 (Dayton Labs) and lanthanum-140 (LANL)
- By 1946, ORNL also produced C-14, P-32, I-131, Y-90
- By 1948 hundreds of isotopes were being produced, and there was a special Isotopes Production Division at ORNL
- Based on NIOSH's research to date, this division appears to have operated the calutrons and 86-inch cyclotron at Y-12

Exotic Radionuclides – cont.



Exotic Radionuclides – cont.

- NIOSH initiated an 83.14 evaluation of isotope productions from the cyclotron and calutrons at the Y-12 facility in March 2012
- The ORNL SEC-00189 team began to evaluate which radionuclides were produced and separated at ORNL; we discovered that there was significant overlap in research
- Table 5-3 and Table 5-4 lists isotope production that NIOSH has found to date

Exotic Radionuclides – cont.

- **Due to resource overlap, NIOSH decided to *Reserve* the exotic radionuclide evaluation at ORNL and combine with the Y-12 83.14 effort once SEC-00189 was completed and presented**

- **On August 30, 2012 NIOSH/ORAUT had a kick-off meeting for this combined effort**

- **NIOSH will update the ABRWH as we progress in our evaluation**

Internal Dose Monitoring

- **Summary of internal monitoring data**

Internal Sources	Year												
	43	44	45	46	47	48	49	50	51	52	53	54	55
Plutonium		Air	Bio	Air	Bioassay								
Uranium	No Data						Bioassay						
Thorium		Air Data				No Data							
Fission Products		No Data						Bioassay					
Exotic Radionuclides	*Reserved for a joint ORNL (X-10) and Y-12 evaluation*												

- **Overall internal dose reconstruction is infeasible from June 17, 1943 through July 31, 1955**

External Monitoring

- **Beta – Gamma**
  - **Pocket Ionization Chambers**
    - **—12721 readings – December 1943**
  - **Film Badge Dosimeters**

- **Neutron**
  - **1944 – Neutron / Photon Surveys**
  - **1947 – Special Fine Grain Films**
  - **1949 – NTA**

External Beta / Gamma Monitoring

Number of External Records by Year in Exposure Database		
Year	Record Count	No. of Names
1943	1345	857
1944	4117	2106
1945	2946	1747
1946	2674	1799
1947	3215	2266
1948	3793	2584
1949	2516	2039
1950	3442	2599
1951	4174	3086
1952	4355	3271
1953	3953	3158
1954	4536	3336
1955	4536	3471
---	Total = 46,928	---

Neutron Monitoring

- **Cadmium filtered neutron badge**
- **Capability for both thermal and fast neutrons**
  - **Used ^{14}N(neutron,proton)^{14}C reaction for thermal neutron response** *(584 keV proton)*
  - **Thermal response of neutron dosimeter calibrated using a thermal column from the graphite reactor**
- **1947 studies of track fading by Joseph Checka**

Other Neutron Monitoring Data

- **Graphite Reactor**
  - Neutron / photon surveys
- **Low Intensity Test Reactor (LITR)**
  - Full scale mockup of MTR and neutron / photon surveys of MTR indicate a NP ratio of 0.58
- **Bulk Shielding Reactor (BSR)**
  - Typically zero 20 feet of water
  - Experiments lowered into pool
  - Neutron / photon surveys

Other Neutron Monitoring Data – cont.

- **Homogeneous Reactor Experiment (HRE)**
  - **Confirmed workers at HRE wore neutron dosimeters through review of claimant files**
- **Aircraft Reactor Experiment (ARE)**
  - **Neutron / photon surveys**
- **Tower Shielding Reactor (TSR)**
  - **Neutron / photon surveys**
  - **Neutron spectra**

External Dose Summary

- **Beta / Gamma Exposures**
  - **Pocket ionization chambers and film badge data**
- **Neutron Exposures**
  - **Neutron / photon surveys**
  - **Neutron dosimeter (thermal and fast capability)**
- **Due to use and availability of pocket ionization chamber data, film badge dosimetry, neutron surveys, and neutron dosimetry, NIOSH believes external dose reconstruction is feasible**

Conclusion from Research

- **NIOSH has evaluated the available information and determined that it does not have access to sufficient personnel monitoring, workplace monitoring, or source-term data to sufficiently estimate potential internal exposures to:**
  - **Uranium: June 17, 1943 – December 31, 1948**
  - **Fission Products: June 17, 1943 – December 31, 1949**
  - **Thorium: January 1, 1948 – July 31, 1955**
- **Combined infeasibility**
  - **June 17, 1943 through July 31, 1955**

ORNL SEC Petition 00189—cont.

- **Why everyone?**
  - **Unlike other large facilities (Savannah River, Idaho), ORNL was a relatively small main campus. The main campus is about the same size as the 700/300 area at Savannah River. The facility was largely open once you entered through the guard checkpoints. NIOSH could not find a practical way to identify the uranium, mixed fission product, and thorium exposed workers. Organizational charts could really only identify likely exposed workers based on job title and organizational function.**

ORNL SEC Petition 00189—cont.

- **What about employees not included in the SEC?**
  - **NIOSH intends to use any internal and external monitoring data, and medical doses that may become available for an individual claim (and that can be interpreted using existing dose reconstruction processes or procedures). Therefore, partial dose reconstructions for individuals employed at Oak Ridge National Laboratory during the period from June 17, 1943 through July 31, 1955, but who do not qualify for inclusion in the Special Exposure Cohort, may be performed using these data as appropriate.**

Health Endangerment

- **The evidence reviewed in this evaluation indicates that some workers in the class may have accumulated chronic radiation exposures through intakes of radionuclides and direct exposure to radioactive materials.**
- **Consequently, NIOSH is specifying that health may have been endangered for those workers covered by this evaluation who were employed for a number of work days aggregating at least 250 work days within the parameters established for this class or in combination with work days within the parameters established for one or more other classes of employees in the SEC.**

Proposed Class

All employees of the Department of Energy, its predecessor agencies, and their contractors and subcontractors who worked in any area at the Oak Ridge National Laboratory (X-10) in Oak Ridge, Tennessee, from June 17, 1943 through July 31, 1955, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort.

Feasibility Summary

Feasibility Findings for Oak Ridge National Laboratory (X-10) SEC Petition SEC-00189 (January 1943 – July 1955)		
Source of Exposure	**Reconstruction Feasible**	**Reconstruction NOT Feasible**
Internal		
- Plutonium	X	
- Uranium	Jan 49 – Jul 55	Jun 43 – Dec 48
- Thorium	Jan 44 – Dec 47	Jan 48 – Jul 55
- Fission Products	Jan 50 – Jul 55	Jan 44 – Dec 49
- Exotic Radionuclides	*Reserved*	*Reserved*
External		
- Beta-gamma	X	
- Neutron	X	
- Occupational Medical X-ray	X	

Feasibility Summary

Internal Sources	Year												
	43	44	45	46	47	48	49	50	51	52	53	54	55
[illegible]		Air	Bio	Air	Bioassay								
[illegible]	No Data						Bioassay						
[illegible]		Air Data				No Data							
[illegible]		No Data						Bioassay					
[illegible]	*Reserved for a joint ORNL (X-10) and Y-12 evaluation*												

Claimant Statistics

(July 10, 2012)

- **Total number of ORNL claims submitted: 2036**
- **Total number claims with employment in proposed class: 1302**
  - **Number of dose reconstructions completed 1074**
  - **Number of claims for which internal dosimetry records in the proposed class 236**
  - **Number of claims for which external dosimetry records in the proposed class 668**

Questions