Issues for Consideration in Reconstruction of Non-Radiological Exposures for Veterans at Hanford in 1943-1947

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Presentation to the NASEM Committee on Feasibility of Assessing Veteran's Health Effects of Manhattan Project (1942-1947) Related Waste
Richland, WA
July 18, 2024

Hanford Site Experience

- Consultation on beryllium health risks to a company that leased a building at Hanford
- Declarations on health risks of tank vapors on behalf of the State of Washington's motion for preliminary injunction
- Declaration on behalf of the State of Washington in their defense of the Washington State Hanford Worker Presumption Act
- Testimony on behalf of the State of Washington and Hanford workers defending the appeal of Presumption Act claims by the Department of Energy

Outline

- Elements of chemical exposure reconstruction for Hanford workers in 1943-1947
- Limitations in information on chemical exposures
- Substances to consider for exposure
- Sources of chemical exposure information
- Qualitative exposure assessment

Elements of Chemical Dose Reconstruction

Chemical Dose Reconstruction

- **Historical records**
  - Job task analysis
  - Chemicals involved in work processes
  - Workplace or personal monitoring*
  - Biomonitoring*
- **Simulation**
  - Measure chemical exposures associated with recreated historical work
  - Difficult for Hanford because of specialized processes involved and complexity of exposure

*Unlikely to be available for 1943-1947

Chemical Dose Reconstruction *(continued)*

- **Worker information**
  - Hire and termination dates
  - Work pattern
    - Shift: day, evening, night; rotating
    - Daily work period, 8 hours, 12 hours, 24 hours
    - Days per week
  - Exposure incidents
  - Prior or subsequent work/non-work exposures

Limitations on Chemical Exposure Information

Nature of Historical Worker Records

- **Less concern for chemical hazards until more recently**
- **Little to no records on chemical exposures historically**
- **Poor image quality, often handwritten**
- **Lack of exposure information**
- **May list a building number or area**
  - Location of primary work or incident
- **May list job title or activity**

Late Development of Worker Safety Program

- **U.S. GAO reports to Congress**
  - **1981.** *Better oversight needed for safety and health activities at DOE's nuclear facilities*
  - **1983.** *DOE's safety and health oversight program at nuclear facilities could be strengthened*
  - **1990.** *Need for improved responsiveness to problems at DOE sites.*
- **Noted deficiencies compared to OSHA requirements; Hanford examples:**
  - >10 times asbestos airborne limits without use of respiratory protection
  - Lack of formal documentation and follow-up despite widespread hazards and violations
  - An unremedied violation resulted in overflow of contaminated liquid to surrounding areas

Late Development of Worker Safety Program *(continued)*

- **1994 DOE Chemical Safety Vulnerability Working Group Report**
  - Lack of recognition and characterization of chemical hazards at nuclear facilities
  - Use of many hazardous specialty chemicals and materials
  - Insufficient knowledge places workers at risk
- **Improvements in mid-1990 and thereafter**
- **2007 10 CFR Part 851 established comprehensive worker safety and health regulations to govern contractor activities at DOE sites comparable to OSHA**

B Reactor;
www.energy.gov/em/articles/hanford-b-reactor-tours-returning-spring-limited-run

Substances to Consider for Exposure

T Plant; www.hanford.gov/page.cfm/TPlant

Plutonium Isolation building
www.energy.gov/em/articles/hanford-makes-progress-preparing-historic-building-demolition

Sources of Chemical Exposures Based on Historical Processes and Activities

- Plutonium production generated large amounts of wastes used in fuel preparation and plutonium separation and processing
- Construction and maintenance activities involved many hazardous materials
- Historical waste handling practices resulted in widespread and often undocumented contamination

(Gephart 2003; Gerber 1992, 1993; DOE 2014, 2024)

Historical Processes in the 1940s

- **Fuel preparation**
  - Nitric acid, sodium hydroxide, sodium dichromate, methanol
  - Molten bronze, tin, aluminum silicon
  - Acenaphthene, carbon tetrachloride, trichloroethylene
- **Plutonium separation used nitric acid, sulfuric acid, bismuth phosphate solution (T and B Plants)**
  - Highly corrosive
  - Reduction oxidation using solvent extraction (methyl isobutyl ketone) began in 1952; more efficient and considered safer
- **Further separation of plutonium nitrate from the solution using hydrogen peroxide (Plutonium Isolation Building)**

(Seaborg 1962; Gerber 1992, 1993; Gephart 2003; Bottenus et al. 2019)

Example Substances to Initially Evaluate

- **Hydrocarbon solvents, kerosene, toluene, fuels, oils**
- **Chlorinated solvents**
  - Carbon tetrachloride, trichloroethylene, perchloroethylene, etc.
- **Nitrosamines**
- **Aromatic amines**
- **Various other nitrogenous and sulfur-containing compounds**
- **Polycyclic aromatic hydrocarbons**
- **Acids**
- **Metals**
- **Pesticides/herbicides**

(WHC 1989; Gerber 1992, 1993; UW 1997; Gephart 2003; DOL 2024)

Metals

- **Beryllium**
  - Nuclear fuel production, research, selected industrial components/tools
- **Mercury**
  - Elemental Hg used in pressure regulators
  - Mercuric nitrate used in nitric acid processing of nuclear fuel
- **Lead**
  - Construction materials, plumbing, fittings, solder, paints
  - Lead-based paint used for shielding radioactive spills
  - Firing range exposure for security personnel
- **Others: chromium, nickel, zirconium, bismuth, etc.**

(Gerber 1992, 1993; UW 1997; Gephart 2003; Bottenus et al. 2024; DOE 2024; DOL 2024)

Construction, Operational, and Other Site Hazards

- Asbestos (coatings, building materials [transite], fireproofing, insulation, sound deadening)
- Silica, vitreous fibers
- Diesel exhaust
- Stack/fugitive emissions
- Welding fume
- Waste ponds emissions
- Tank waste vapors
- Irritant gases
- Dust

(Ibid)

Tank Waste

- First waste storage tanks were put into service in 1944
- Carbon-steel liner covered by steel-reinforced concrete; buried 10 feet below ground surface
- Pressure equalization via passive venting from stacks
  - Stacks were raised after 2010
- Contains 1,000's of chemicals

Tank under construction in 1944.

https://ecology.wa.gov/waste-toxics/nuclear-wase/hanford-cleanup/tank-waste-management/tank-monitoring-closure

64 tanks by August 1945;
Gerber 1992

Example Chemicals of Concern in Tank Vapor

- **Based on sampling in 2000's**
- **Need to consider historical waste**
  - Less ketones and other hydrocarbons

- **Ammonia**
- **N-Butanol**
- **Reduced sulfides**
- **CO**
- **Dimethyl mercury**
- **Hydrocarbons**
- **N-Hexane, benzene**
- **N_2O, NO_2, SO_2**
- **Nitrosamines**

(Burgeson et al. 2004; Anderson et al. 2006; Meachum et al. 2006)

Potential for Interactions

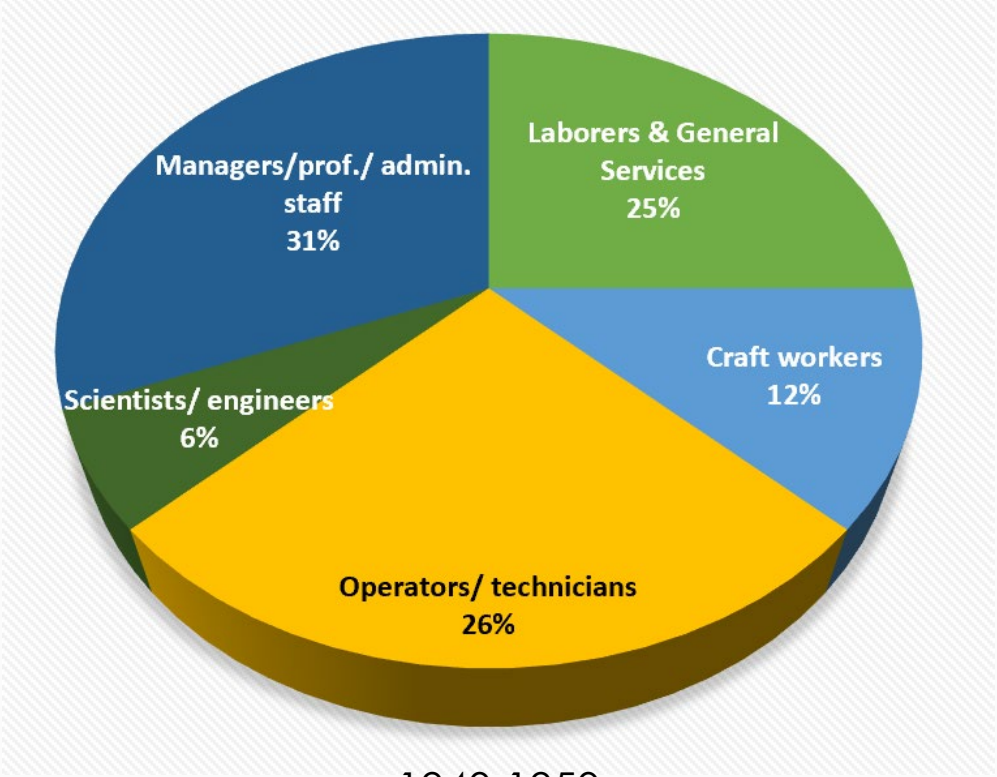
- **Chemical exposures**
  - Aromatic amines, polycyclic aromatic hydrocarbons, solvents, metal working fluids, diesel exhaust associated with bladder cancer
  - Vapors, gases, dusts, fume, Pu alpha particle inhalation associated with chronic obstructive pulmonary disease (COPD)
- **Personal habits**
  - Smoking

(Dement et al. 2010; Colt et al. 2011; Freedman et al. 2011; Baur et al. 2012; Carreón et al. 2014; Ryu et al. 2015; Hadkhale et al. 2017; Azizova et al. 2020; Koutros et al. 2020)

Available Information for Exposure Estimation

Sources of Information

- Job title/Job task analysis (if available)
- Processes involving chemicals associated with jobs



1940-1950

Source of data: UW (1997)

Sources of Information *(continued)*

- **Nature of work location**
  - Substances related to activities or other jobs present
  - Construction, repair, maintenance, renovation incur other exposures, e.g., asbestos or lead coatings on pipes and structures
  - Offices even for administrative staff could be in process buildings
- **Work shifts**
  - 8 to 9 hr/day, six days/week; overtime common
- **Living conditions**
  - On-site camps (50,000 workers in late 1944)
  - "Carry-home" exposure possible

(Gerber 1992)

Employee Records

- Employment record containing job title by year

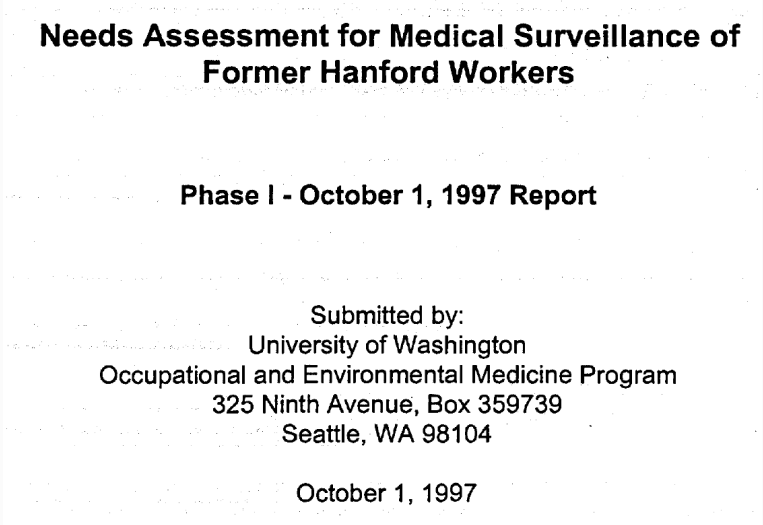
DATE	SUFFIX	CLASSIFICATION
12-15-52	944	Laundry Worker
2-16-53	"	Ldry. Trk. Swamper
3-16-53	"	"
5-18-53	"	"
6-10-53	"	"
6-22-53	528	Engr. Asst. Gr. 10
6-22-53	"	Engr. Asst. Gr. 12
9-28-53	"	"
12-28-53	"	"
3-22-54	"	"
6-10-54	"	"
6-28-54	"	"
9-27-54	"	"
12-27-54	5753	Engr. Asst. Gr. 15
3-28-55	"	"
5-9-55	6135	Rad. Mon. Trne.
8-15-55	6133	"
8-29-55	"	"
11-14-55	"	"
11-21-55	"	Rad. Mon.
5-7-56	6236	"

Employee Records *(continued)*

- Dosimetry badge record showing work area and building by date

ISSUED	CANCELLED	TYPE	AREA	BUILDING
12-16-52	2-16-53	A	200-W	XXX
2-16-53	5-[illegible]-53	A	200-W	221-T 231 234 221U [illegible]
2-16-53	5-8-53	A	200-E	221-B
2-16-53	2-18-53	A	100-B	105B 105-C
2-16-53	2-18-53	A	100-D	105
2-16-53	2-1-54	A	100-F	105
2-16-53		A	100-H	105
2-16-53	7-1-53		101	

Production Worker Needs Assessment for Medical Surveillance



Needs Assessment for Medical Surveillance of Former Hanford Workers

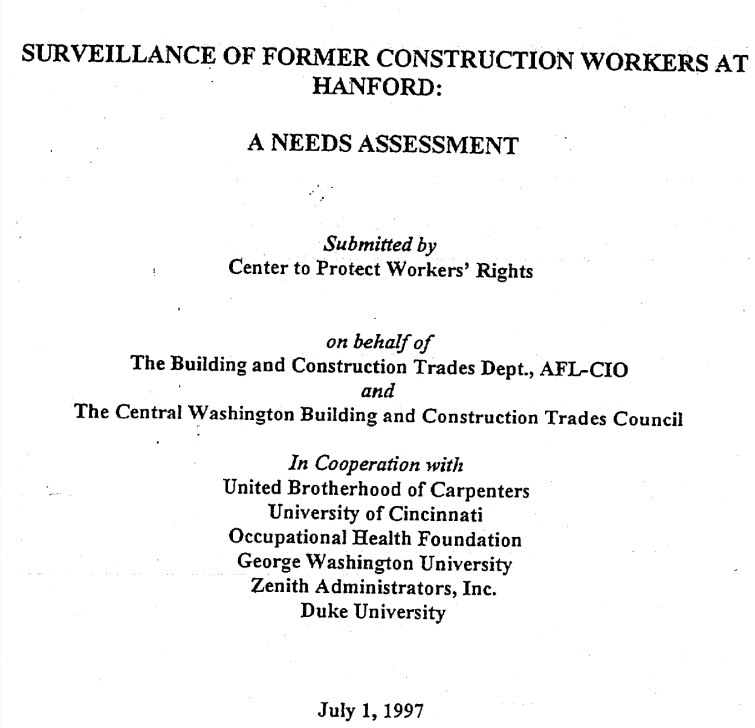
Phase I - October 1, 1997 Report

Submitted by:
University of Washington
Occupational and Environmental Medicine Program
325 Ninth Avenue, Box 359739
Seattle, WA 98104

October 1, 1997

- Lists sources of exposure information
- Matrix of substance exposure by job title and years
- Lists a subset of chemicals
- Surveillance recommended: asbestos, noise, beryllium
- Table of lung abnormalities by job category

Construction Worker Needs Assessment for Medical Surveillance



SURVEILLANCE OF FORMER CONSTRUCTION WORKERS AT HANFORD:

A NEEDS ASSESSMENT

Submitted by
Center to Protect Workers' Rights

on behalf of
The Building and Construction Trades Dept., AFL-CIO
and
The Central Washington Building and Construction Trades Council

In Cooperation with
United Brotherhood of Carpenters
University of Cincinnati
Occupational Health Foundation
George Washington University
Zenith Administrators, Inc.
Duke University

July 1, 1997

- History of buildings over time, including incidents and inferred hazards in the 100, 200, 300 areas
- Mentions Hazardous Exposure Database, although records not available pre-1970's
- Records of widespread asbestos exceedances noted
- Lead hazards

Department of Labor
EEOICPA* Site Exposure Matrix

Site: Hanford (1943-present)/PNNL (1965-2004) Select

Click here to locate a site by alias, description and owner/operator, if you cannot find the site you are looking for in the list above.

SEARCHES OF UNIVERSAL INFORMATION:

Toxic Substances (3102 listed for "Hanford (1943-present)/PNNL (1965-2004)")
Toxic substance information
Toxic substance by alias or property
Toxic substance by chemical category

Health Effects (from Haz-Map Disease List)
Disease or health effect information
Find toxic substance by disease or health effect alias
Disease or health effect by alias

Work Processes with embedded disease links (55 listed matching site-specific work processes for "Hanford (1943-present)/PNNL (1965-2004)")
Work Process information
Work Process by work process text

SEARCHES SPECIFIC TO THE SELECTED SITE -- "Hanford (1943-present)/PNNL (1965-2004)":

See the SEM profile for "PNNL" for PNNL activities after 2004.

Site
Site history
Onsite location by alias

Areas (22 listed)
Area information

Facilities (2 listed)
Facility information

Buildings (1410 listed)
Building information

Work Processes (774 listed)
Work process information
Work process by alias

Labor Categories (135 listed)
Labor category information
Labor category by alias

Incidents (72 listed)
Incident information
Incident text search
Incident search by related item (toxic substance, location, process or job)

*Energy Employees Occupational Illness Compensation Program Act of 2000.

EEOICPA Site Exposure Matrix *(continued)*

- **Can search by substance, work process, labor category, site area, building, incidents**
  - E.g., search on labor category, area, etc., yields list of substances
- **Allows secondary filters**
- **Can't search by year, although incidents have dates**
  - Earliest incident date: 1951 in building 120 in the 100 Area
- **Fairly extensive list of substances, but not complete**
- **Quirks, e.g.,**
  - "Chemist" yields only substances in 200E & W
  - "300 Area" yields chemist as one of the labor categories present

EEOICPA Site Exposure Matrix *(continued)*

Labor category: Chemist | Submit Labor Category selection and filters *(button must be clicked after changing any selection in order to update results.)*

Click here to locate a labor category by alias or description, if you cannot find the labor category you are looking for in the list above.

Secondary filters to apply to lists of related items (from Hanford (1943-present)/PNNL (1965-2004)) :

Toxic substance:

Health effect (per associated toxics):

Area: 300

Building: 333, Fuel Cladding Facility

Process:

Incident:

Site: Hanford (1943-present)/PNNL (1965-2004)

Labor Category: Chemist

DETAILS	Aliases: Analytical Chemist; Chemical Analyst; Nuclear Chemist; Process Chemist
RECORD HISTORY	Facility Data Last Updated: Dec 28, 2023 (Note: Toxic substance/disease relationships may have changed after this date.)
RELATED ITEMS IN SITE EXPOSURE MATRIX **Secondary filters applied -- Area: 300 Building: 333 Fuel Cladding Facility**	
HAZARDOUS CHEMICALS POTENTIALLY ENCOUNTERED BY LABOR CATEGORY (33 matching criteria)	**Acetic acid** CAS: 64-19-7 Aliases: Glacial acetic acid (Glacial acetic acid is the pure compound as distinguished from the usual water solutions known as acetic acid); Ethanoic acid; Ethylic acid; Methane carboxylic acid; Methanecarboxylic acid; Vinegar acid; Acetic acid glacial; Acetic acid, glacial; (1-C14) Acetic acid; HOAc; AcOH; HAc; Acetasol; Acetic acid (natural); Acetic acid 0.25% in plastic container; Aceticum acidum; Aci-Jel; Acide acetique; Acido acetico; Azijnzuur; EPA Pesticide Chemical Code 044001; Essigsaeure; Ethanoic acid monomer; FEMA No. 2006; FEMA Number 2006; HSDB 40; Kyselina octova; Octowy kwas; Orlex; Pyroligneous acid; Vosol; Acetic acid, of a concentration of

33 inorganic and organic substances

EEOICPA Site Exposure Matrix *(continued)*

Labor category: Security Guard | Submit Labor Category selection and filters *(button must be clicked after changing any selection in order to update results.)*

Click here to locate a labor category by alias or description, if you cannot find the labor category you are looking for in the list above.

Secondary filters to apply to lists of related items (from Hanford (1943-present)/PNNL (1965-2004)) :

Toxic substance:

Health effect (per associated toxics):

Area: 100-B

Building:

Process:

Incident:

Site: Hanford (1943-present)/PNNL (1965-2004)

Labor Category: Security Guard

DETAILS	Aliases: Guard; Patrolman; Plant Patrolman; Security Officer; Security Patrol; Security Police Officer; Security Staff; Security Watchman; Special Security Officer; SPO
RECORD HISTORY	Facility Data Last Updated: Dec 28, 2023 (Note: Toxic substance/disease relationships may have changed after this date.)
RELATED ITEMS IN SITE EXPOSURE MATRIX **Secondary filters applied -- Area: 100-B**	
HAZARDOUS CHEMICALS POTENTIALLY ENCOUNTERED BY LABOR CATEGORY (7 matching criteria)	**Asbestos** CAS: 1332-21-4; 12001-28-4; 12172-73-5; 14567-73-8; 77536-66-4; 77536-67-5; 77536-68-6; 132207-32-0 Aliases: Amosite; 16F; Anthophyllite; Anthophyllite UICC; Anthophyllite asbestos; Chrysotile; Crocidolite; Tremolite; Tremolite asbestos; Tremolitena; Filterbestos; Hysol Epoxi-Patch Kit 615, Part A; Epoxi-Patch Kit 615, Part A; Amianthus; Asbest; Asbestos dust; Asbestos fiber; Asbestos fibers; Asbestos fibre; Asbestose; Ascarite; AT 7-1; BK 6-20; BP 3-50; BP 5-65; Calidria HPP; Calidria R-G 244; Carey 4T; Chlorobestos 25; EPA Pesticide Chemical Code 099301;

In addition to asbestos, includes:

- Lead
- Gun cleaners/ lubricants
- Combustion products

EEOICPA Site Exposure Matrix *(continued)*

- **Unique aspects of Hanford exposures**
- **E.g., Laundry worker, 200 W area**
  - Acetic acid
  - Detergents
  - Sodium carbonate
  - Nonidet P-40 (glycol ethers)
  - Nitric acid
  - Asbestos
- **Possibility of handling chemically-contaminated clothing not included**

Site Exposure Matrix Labor Categories

Accounting clerk	Chemist	Engineer, assignment	Environmental scientist	Hazardous materials specialist
Administrative staff/support	Chlorinator	Engineer, chemical	Expediter	Health physicist
Alarm monitoring system	Coal handler	Engineer, environmental	Fingerprinter	Industrial hygienist
Architect	Computer scientist	Engineer, fire protection	Firefighter	Insulator
Asbestos worker	Construction worker	Engineer, maintenance	Food service worker	Investigator
Auto body repair/painter	Decontamination/ decommissioning	Engineer, nuclear	Geologist	Ironworker
Back tender	Drafter	Engineer, plant	Glass blower	Janitor
Biologist	Driller	Engineer, process	Glazier	Laboratory leader
Boilermaker	Electrician	Engineer, quality assurance	Graphite machinist	Laborer
Carpenter	Engineer	Engineer, welding	Groundskeeper	Laundry worker

Site Exposure Matrix Labor Categories *(continued)*

Lineman	Mechanic, HVAC	Operations specialist, administrative	Painter	Roofer
Linoleum layer	Mechanic, vehicle	Operations specialist, technical	Paramedic	Safeguards and security specialist
Locksmith	Medical personnel	Operator, material moving equipment	Pathologist	Sampler
Machinist	Metal fabricator	Operator, neutron multiplication facility	Photographer	Scientist
Manager	Metal handler	Operator, nuclear plant	Physicist	Security guard
Manipulator repairman	Meteorologist	Operator, nuclear process	Pilot	Sheetmetal worker
Mason	Millwright	Operator, production systems	Pipefitter/plumber	Social scientist
Material coordinator	Motor messenger	Operator, substation	Psychologist	Stock and tool attendant
Materials scientist	Office machine repairman	Operator, switchboard	Railroad worker	Student
Mechanic, heavy equipment	Oiler	Operator, utilities	Remediation worker	Supervisor

Site Exposure Matrix Labor Categories *(continued)*

Swamper	Technician, development facility operation	Technician, instrument	Technician, whole body counting project	Welder
Teamster	Technician, development laboratory operation	Technician, laboratory	Technician, X-ray	
Technical graduate	Technician, engineering	Technician, media	Technologist, experimental reactor physics	
Technical specialist	Technician, environmental sciences	Technician, Outage	Telephone cable splicer	
Technician	Technician, fire extinguisher	Technician, PAPR maintenance	Trackman	
Technician, animal care	Technician, health physics	Technician, post irradiation	Trainee	
Technician, auto body	Technician, helicopter maintenance	Technician, quality assurance	Trainer	
Technician, business machine	Technician, hot cell	Technician, surveying and mapping	Upholsterer	

Bolded titles are examples of possible veteran jobs

Other Evidence to Inform Exposure

- **Dosimetry data for specific workers or job categories may approximate non-radiological exposures**
- **Chemical exposure with low radiological exposures and vice/versa also possible, e.g.,**
  - HEPA particulate filters reduce radiological constituents in tank waste vapors (although perhaps not in 1940's)
  - Areas cleared for radiation may still have chemical hazards
- **Studies of health outcomes by trade indicative of substance exposure**

Evidence on health risks by job category from Surveillance at Nuclear Sites*

- **Respiratory effects (construction workers; Dement et al. 2003)**
  - Trades with regular exposures to silica, asbestos, and welding had increased risk of pleural disease
  - 42.7% had ≥1 pulmonary function defects
  - Risks increased with longer employment
- **Hearing loss increased compared to low noise workers (Dement et al. 2005)**
  - Also may be affected by solvent exposure
- **Mortality (Dement et al. 2009)**
  - Increased risk of all cancers, lung cancer, mesothelioma, and at Hanford, multiple myeloma

*Savannah River, Hanford, Oak Ridge, Amchitka, beginning in 1996-1997

Evidence on health risks by job category from Surveillance at Nuclear Sites* *(continued)*

- **Airway obstruction (Dement et al. 2010)**
  - Highest risks for: *asbestos, silica, welding, cement dusts and some tasks associated with exposures to paints, solvents, and removal of paints*
- **Chronic obstructive pulmonary disease (Dement et al. 2021)**
  - Increased risk for workers employed prior to 1995
  - Trades with highest risk: cement mason/bricklayer and roofer
- **Beryllium disease (Cloeren et al. 2022)**
  - Certain trades had higher Be sensitivity, e.g., production worker, boilermaker, sheet metal worker, roofer, millwright, insulator/asbestos worker
  - Rates are imprecise for some trades with small numbers

*Savannah River, Hanford, Oak Ridge, Amchitka, beginning in 1996-1997

Lung Function and X-Ray Results by Trade at Nuclear Sites* (Dement et al. 2003)

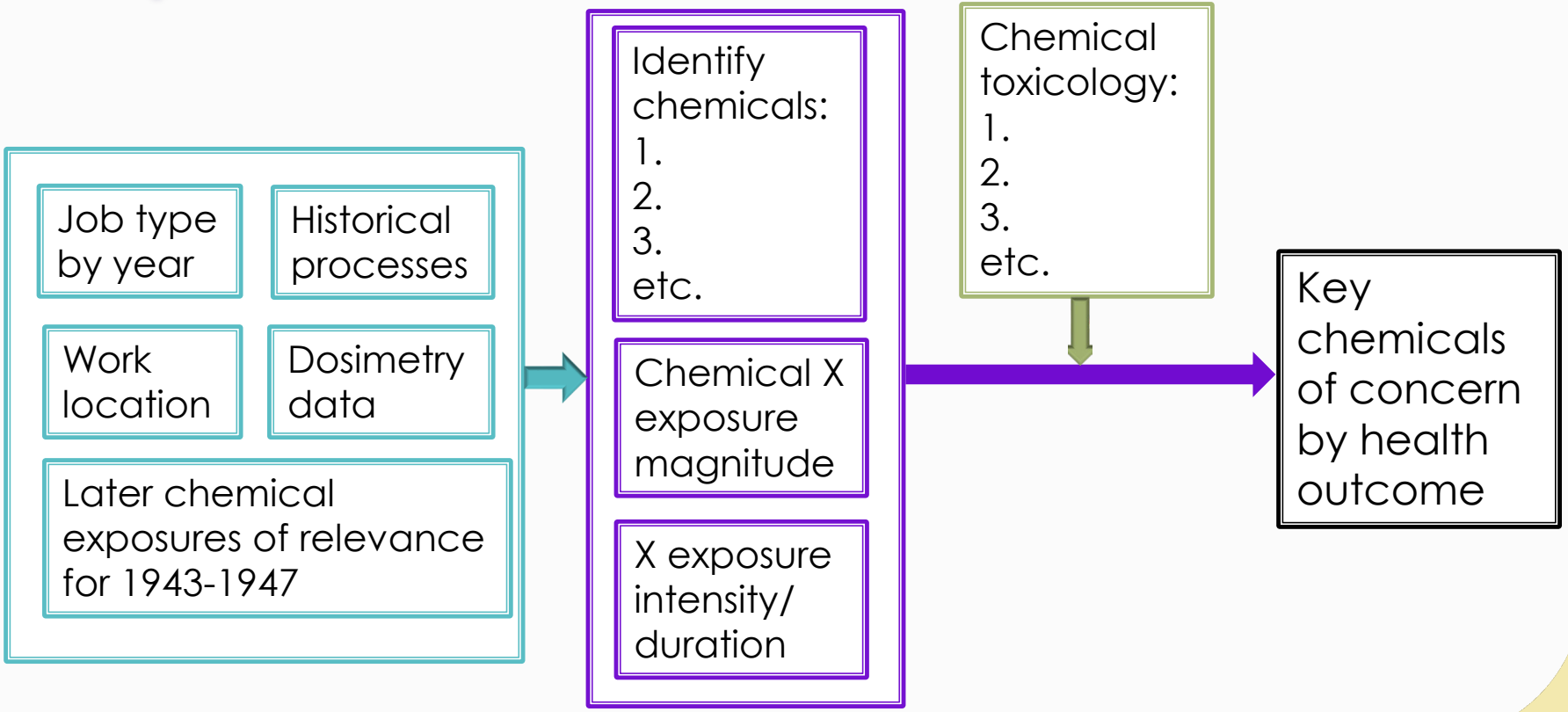
	Any PFT@ abnormality	
Longest trade	**N**	**%**
Painter	45	50.6
Millwright	36	47.4
Teamster	34	46.6
Carpenter	102	46.4
Laborer	185	45.6
Sheetmetal worker	60	45.5
Asbestos worker	21	44.7
Operating engineer	60	43.2
Plumber/steam fitter	41	42.7
Electrician	200	42.2
Pipefitter	194	38.7
Ironworker	54	33.8
Boilermaker	22	33.3

	Any X-ray abnormality	
Longest trade	**N**	**%**
Plumber/steam fitter	42	43.8
Asbestos worker	19	40.4
Millwright	25	32.9
Boilermaker	19	28.9
Pipefitter	143	28.5
Sheetmetal worker	36	27.3
Operating engineer	36	25.9
Electrician	122	25.7
Ironworker	39	24.4
Carpenter	42	19.1
Painter	17	19.1
Laborer	77	19
Teamster	13	17.8

*Oak Ridge, Hanford, Savannah River; enrolled for surveillance 1997 to 2001; @PFT – pulmonary function test

Qualitative Assessment of Chemical Exposure

Triangulation of evidence for chemical exposure



Conclusions

- **Few if any records of chemical exposures for veterans or other workers from 1943-1947**
- **Available evidence on chemical exposures for a qualitative assessment may include:**
  - Job title/trade
  - Work history
  - Area or location of work
  - History of chemical use in site processes and activities
  - Evidence from later workers involving similar processes/exposures
  - Dosimetry measurements

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