

An Introduction to Hanford



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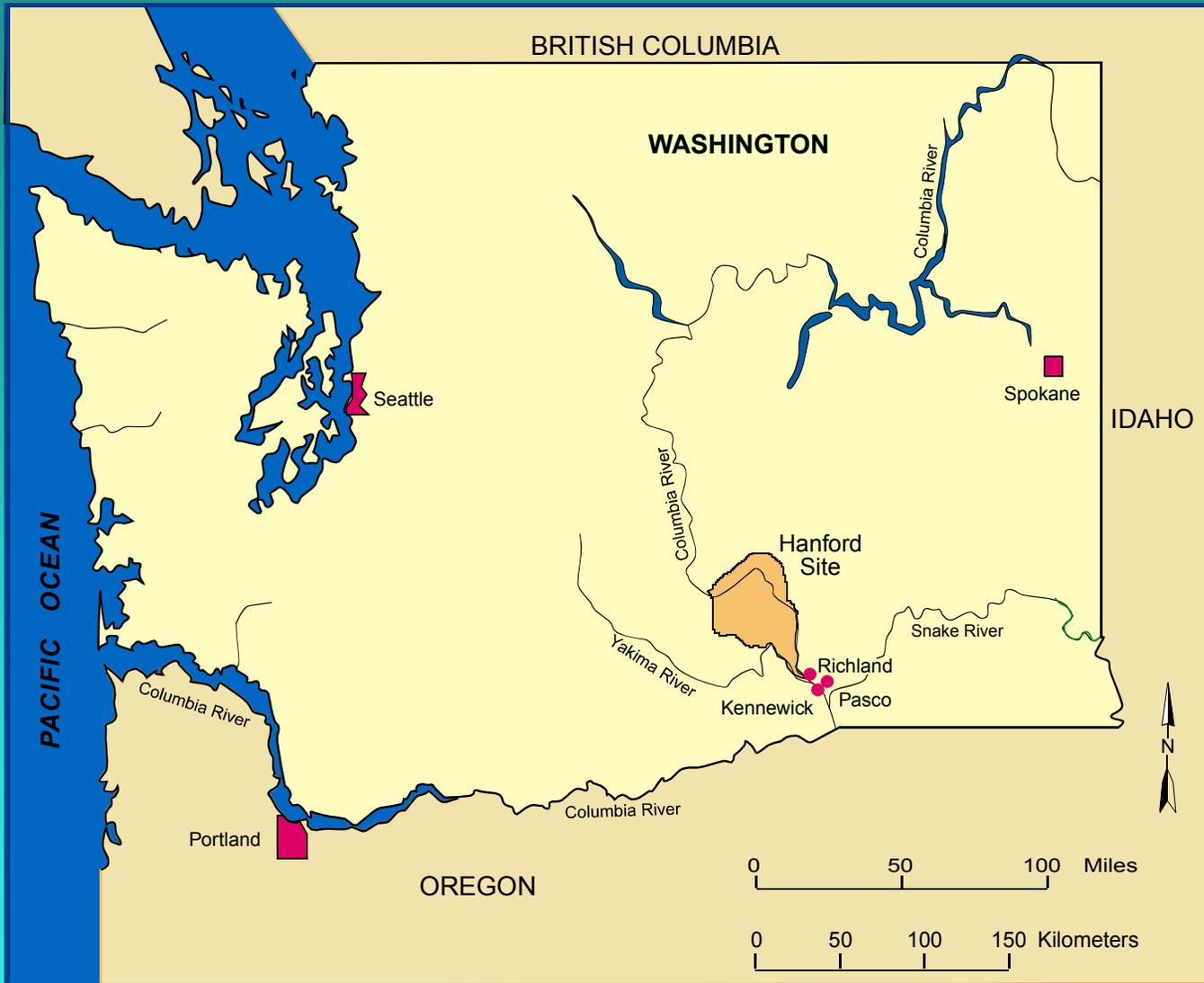


Hanford

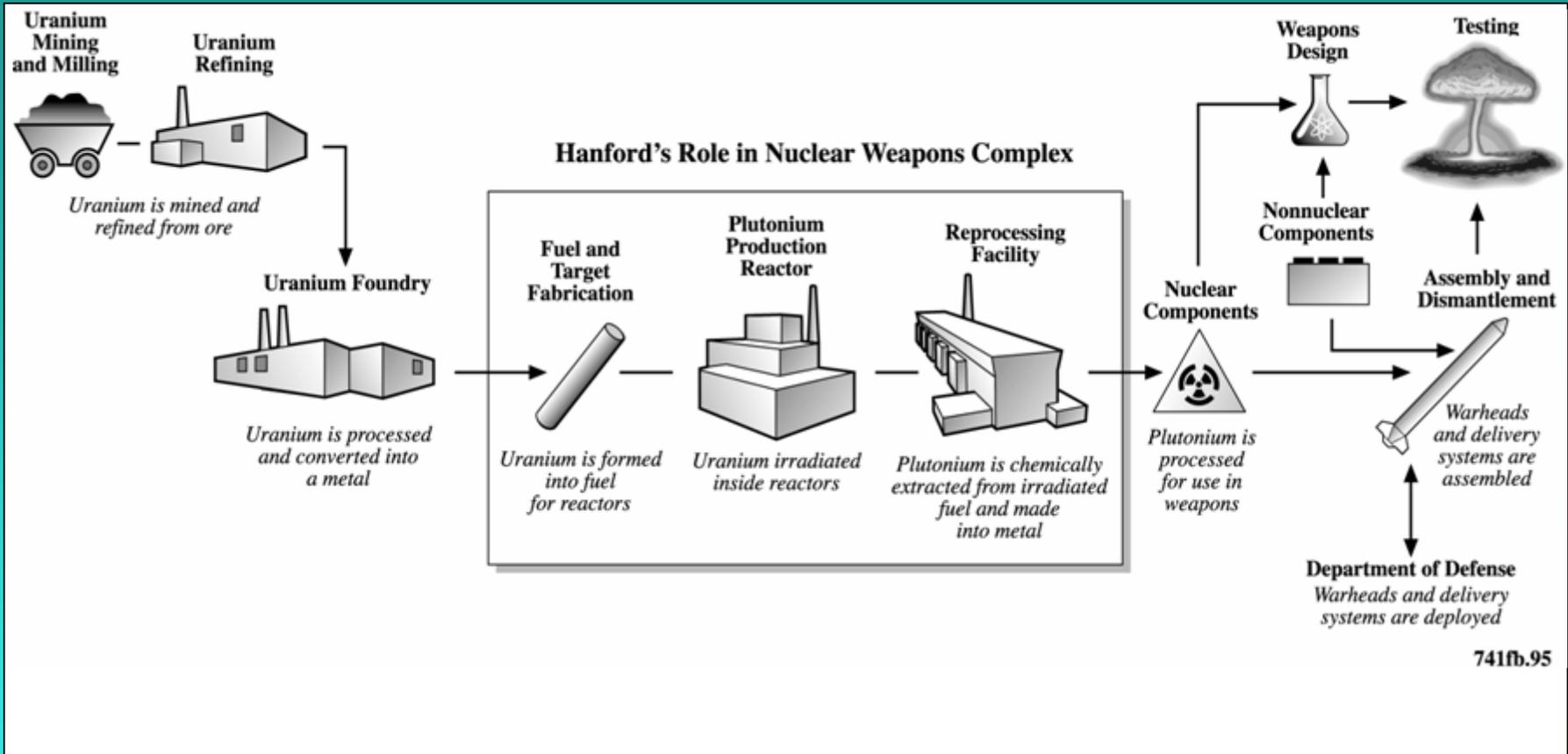
A conversation
about nuclear waste
and cleanup

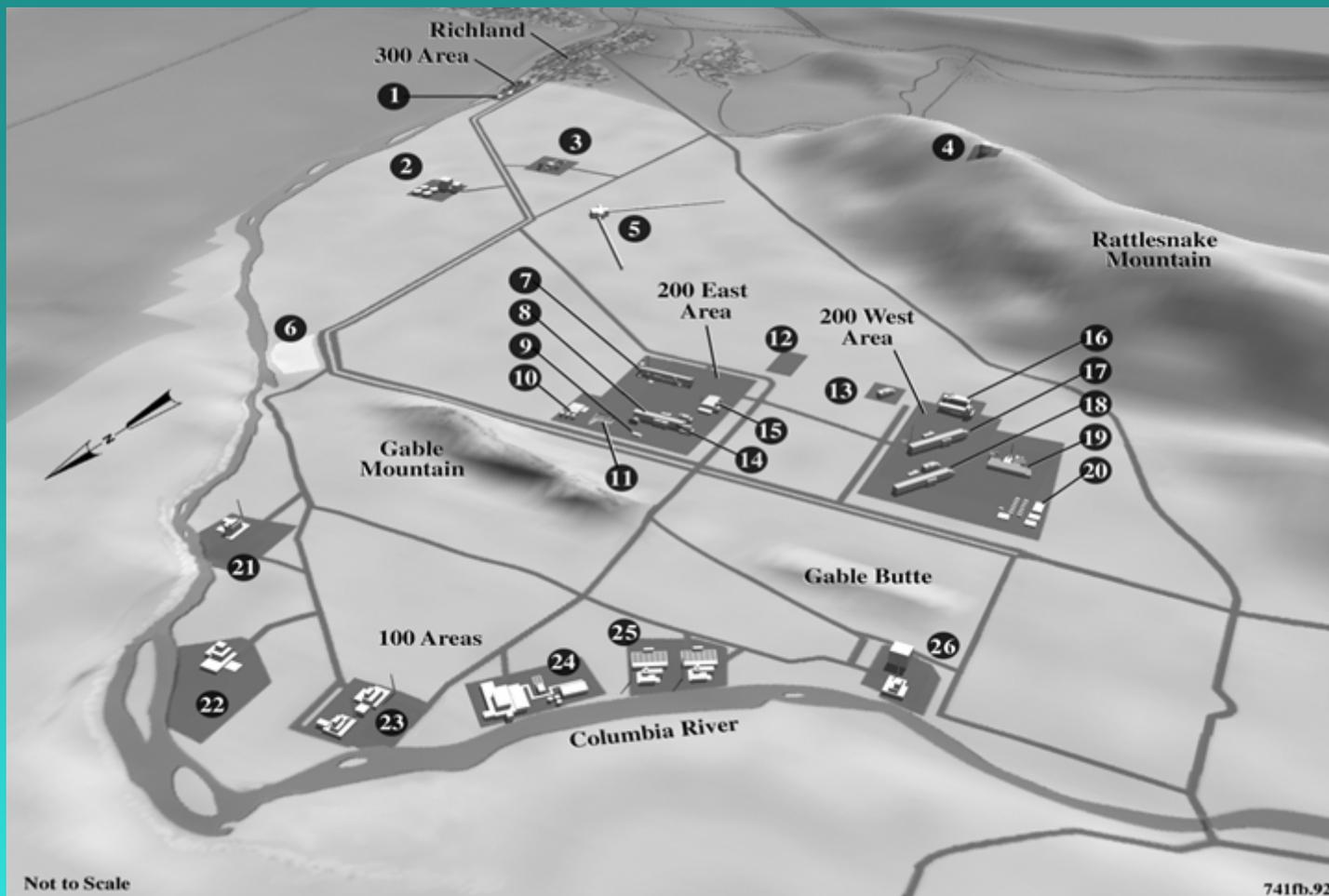
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Most photos, illustrations, and numbers given in talk are taken from this book available at local libraries.



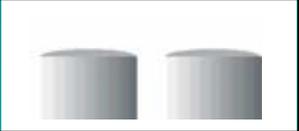
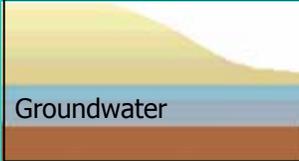
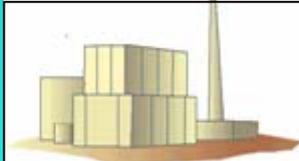
Past Mission of Hanford





- | | |
|---|---|
| 1. 300 Area Liquid Effluent Treatment Facility | 14. Waste Encapsulation and Storage Facility (WESF) |
| 2. Commercial Operating Nuclear Power Plant | 15. Canister Storage Facility |
| 3. Fast Flux Test Facility | 16. Reduction-Oxidation (REDOX) Plant |
| 4. Observatory | 17. U Plant |
| 5. Laser Interferometer Gravitational Wave Observatory (LIGO) | 18. T Plant |
| 6. Old Hanford Townsite | 19. Plutonium Finishing Plant |
| 7. Plutonium-Uranium Extraction (PUREX) Plant | 20. Waste Receiving and Processing (WRAP) Facility |
| 8. B Plant | 21. F Reactor |
| 9. Prototype Surface Engineered Barrier | 22. H Reactor |
| 10. 200 Area Liquid Effluent Treatment Facility | 23. D and DR Reactors |
| 11. Submarine Burial | 24. N Reactor |
| 12. U.S. Ecology Commercial Solid Waste Site | 25. KE and KW Reactors; Cold Vacuum Drying Facility |
| 13. Environmental Restoration Disposal Facility (ERDF) | 26. B and C Reactors |

Hanford: Remaining Waste and Nuclear Materials

	Volume	Curies	Chemicals
 Tank Waste	56 million gal	190 million	240,000 tons
 Solid Waste	25 million ft ³	6 million	70,000 tons
 Soil and Groundwater	35 billion ft ³	2 million	100,000 to 300,000 tons
 Facilities	200 million ft ³	1 million	----
 Nuclear Material	25,000 ft ³	185 million	----

Hanford Compared to Nuclear Weapons Complex

- 25% of waste storage and release sites
- 40% of 1 billion curies
- 60% of high-level waste
- 80% of spent fuel
- 25% of buried solid waste
- 60% of buried TRU solid waste

Examples of other Onsite Radioactive Material



Naval Nuclear Reactor Components

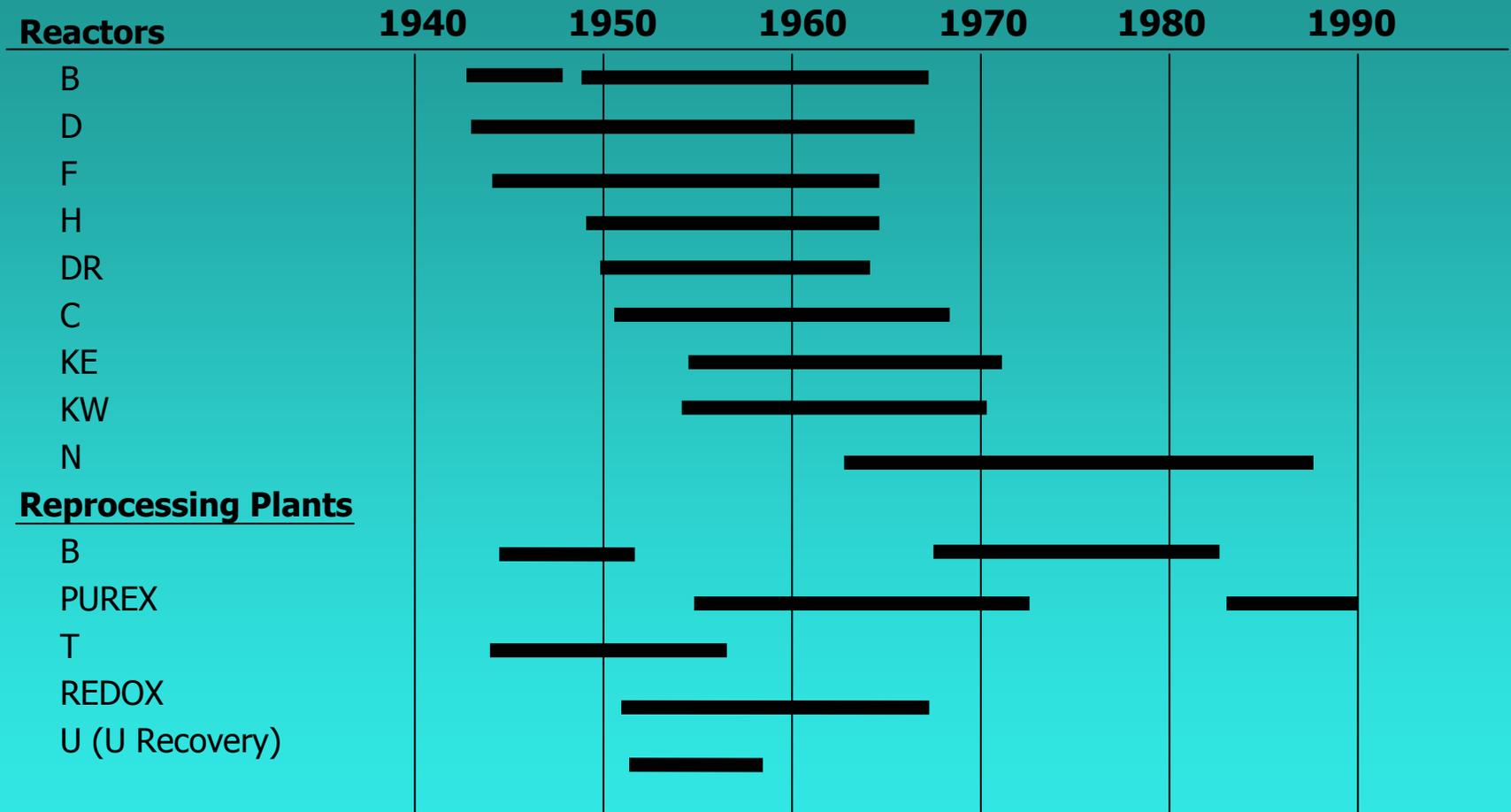


Trojan Reactor Vessel at US Ecology Site

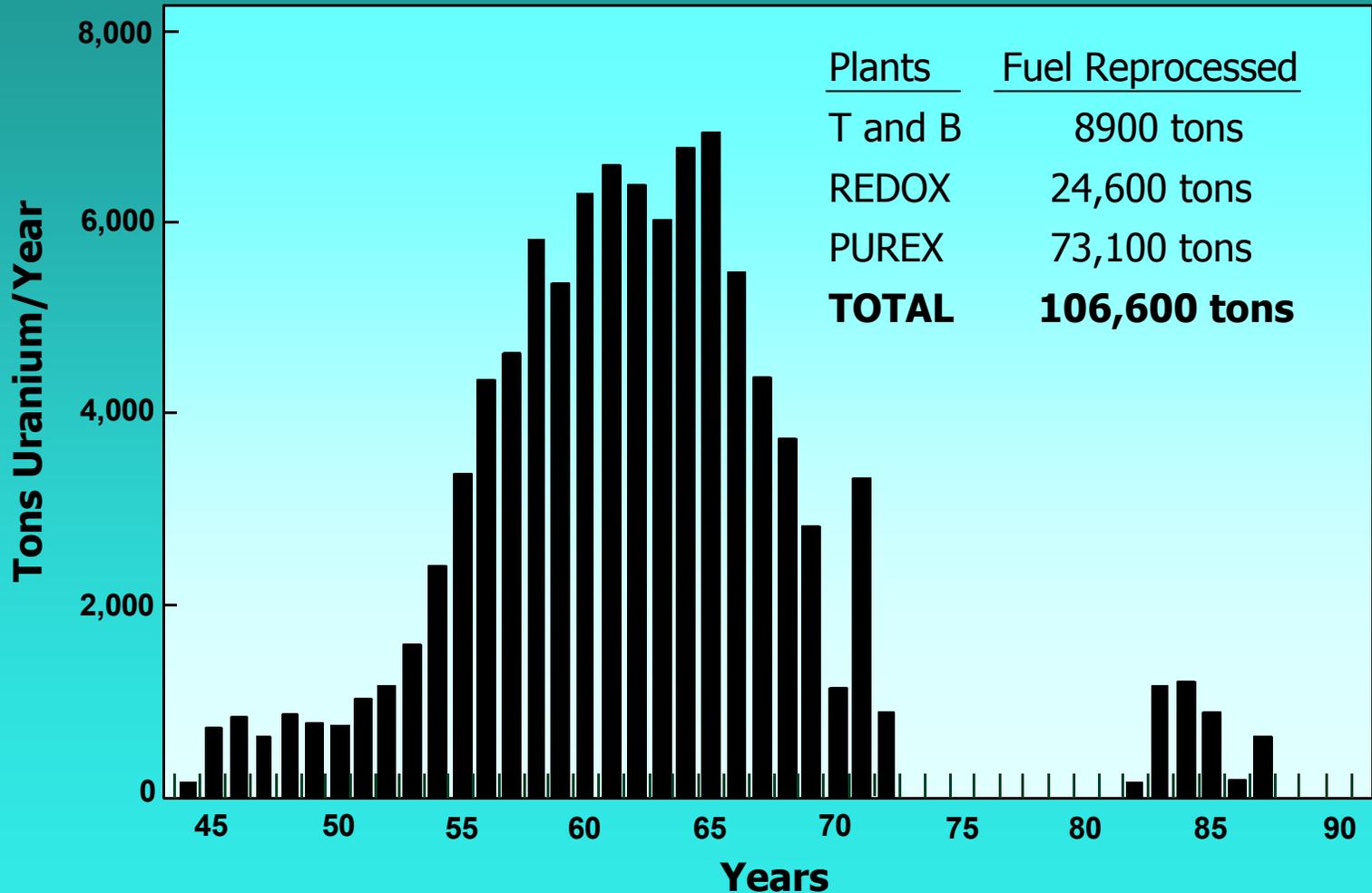
Onsite Nuclear Material Unrelated to Hanford Plutonium Mission

Curies	Source
2 million	Stored Commercial Nuclear Fuel from Pennsylvania
5 million	Stored De-Fueled Navy Nuclear Reactors
15-20 million	Irradiated Spent Fuel in Fast Flux Test Facility
4 million	Commercial Low-Level Waste Landfill
13 million	"Special Waste"; ~50% glassified
Total	39-44 million

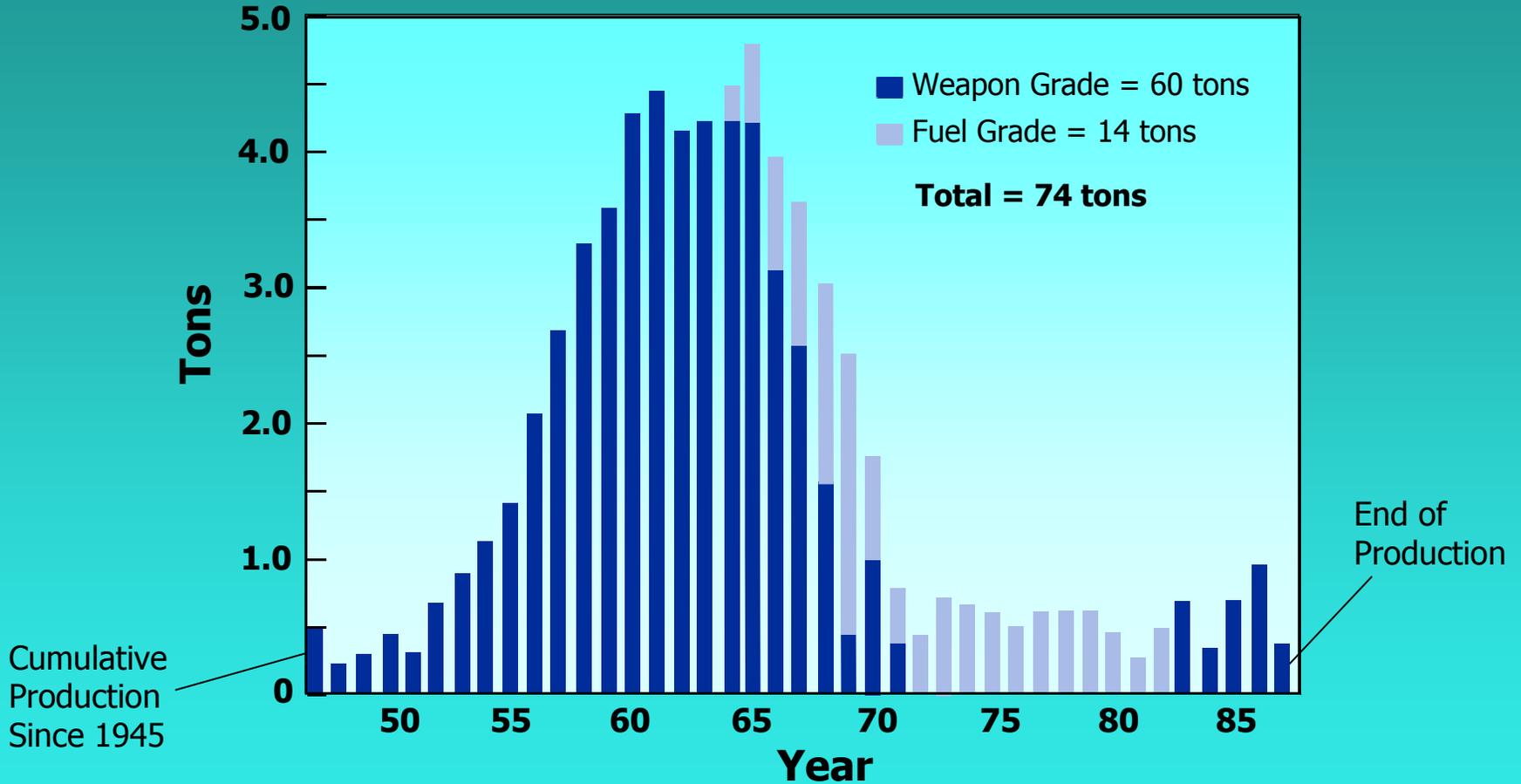
Operation History for Hanford Facilities



Uranium Fuel Reprocessed at Hanford



Hanford Plutonium Production



Uranium Metal Extrusion in the 300 Area

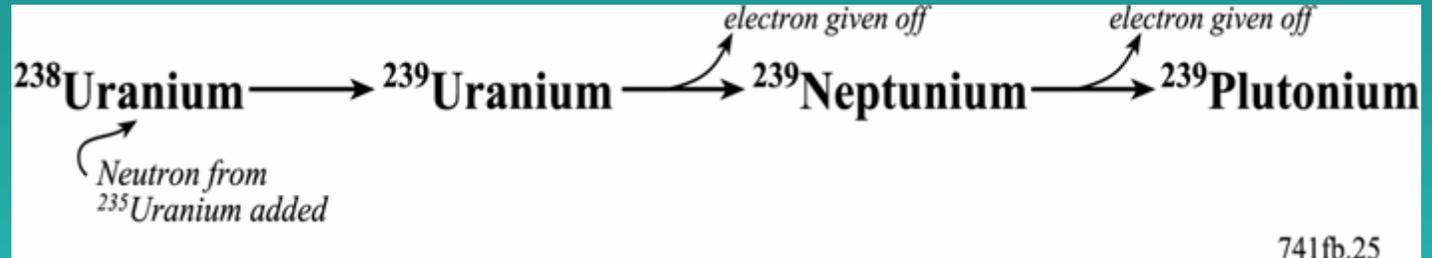


- 20 million fuel slugs
- 80% unenriched (99.7% U^{238} ; 0.3% U^{235})
- 20% slightly enriched (<1.2% U^{235})
- Al or Zr clad fuel

KE/KW Reactors and Support Facilities in the 100 Area



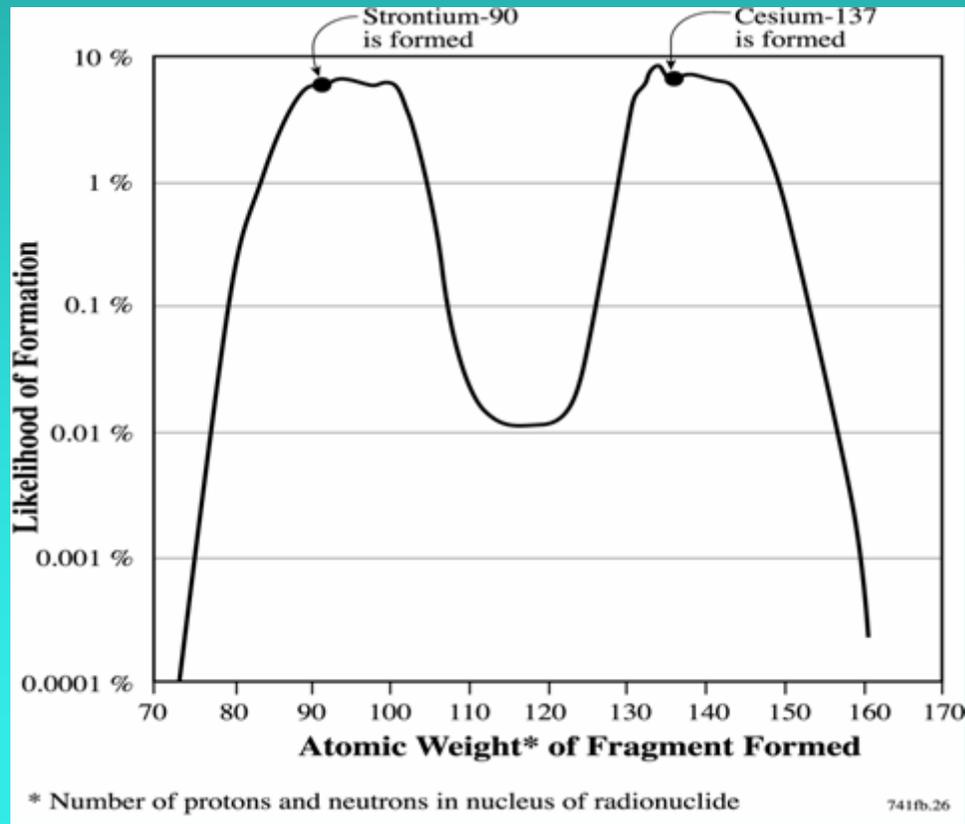
Nuclear Reactions inside a Reactor



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Pu²³⁹ from U²³⁸

Fission products from U²³⁵



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Average Liquid Volumes from Reprocessing Plants in the 200 Area



T and B Plants (BiPO₄)

- 1 to 1.5 T of spent fuel/day
- ~ 4000 gal/ton

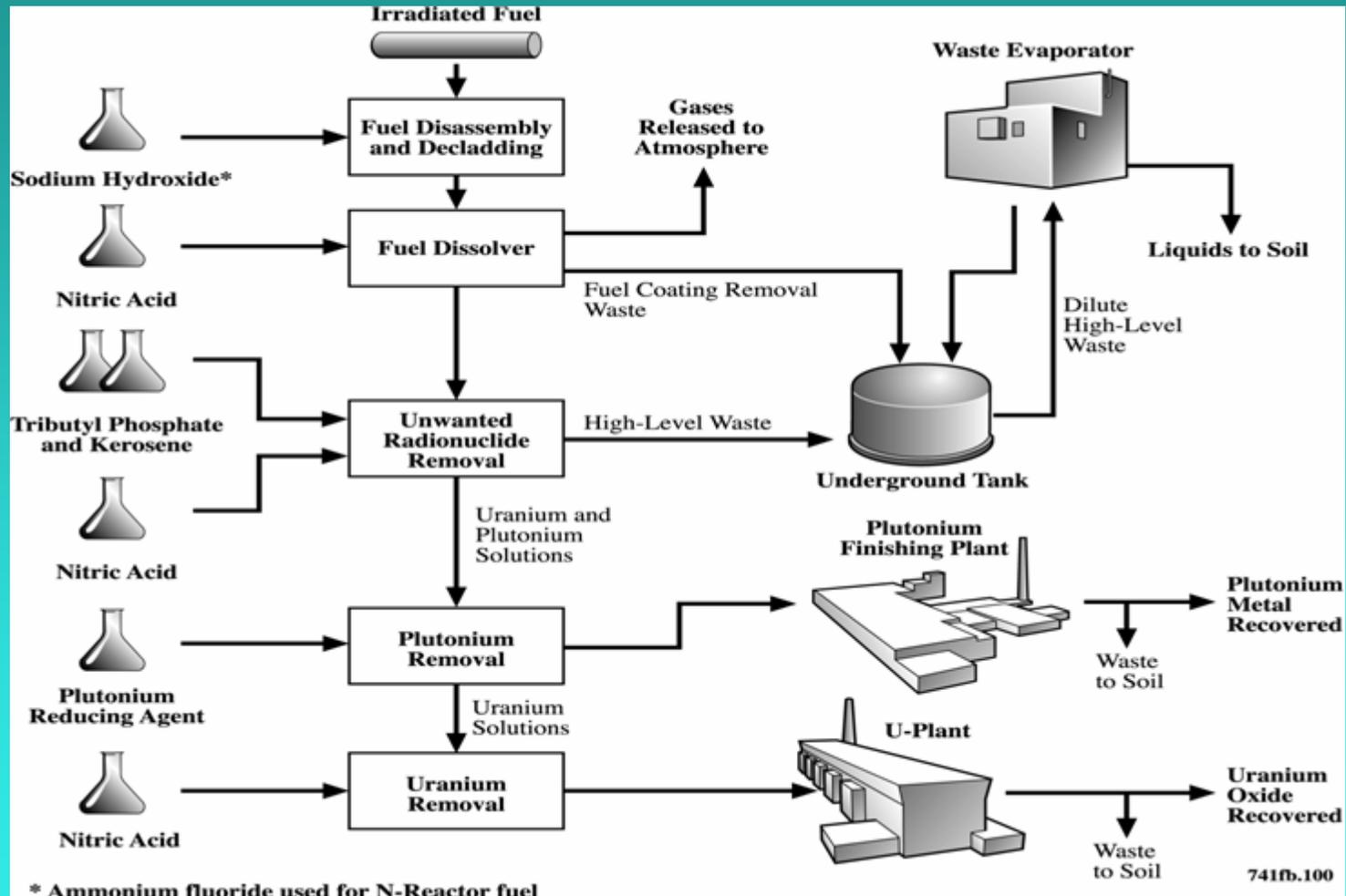
REDOX Plant (hexone)

- 3 to 12 T of spent fuel/day
- ~2000 gal/ton

PUREX Plant (TBP)

- 10 to 33 T of spent fuel/day
- ~500 gal/ton

Spent Fuel Reprocessing in PUREX



Waste Management at Hanford

Waste or Material Disposition

Activity

Nuclear Fuel Fabrication

Reactor Operations

Nuclear Fuel Reprocessing



Highly Radioactive Waste → Tanks

Less Radioactive Liquids → Underground

Solid Waste → Buried

Nuclear Material → Stored or shipped offsite

Gases → Atmosphere

Reactor Cooling Water → River

“American people were served without having to waste time explaining what was being done on their behalf.”

Garry Wills, *A Necessary Evil: A History of American Distrust of Government* (1999)

Early Waste Management

- Water quality and radiation doses received downstream...were of "academic interest" compared to other "practical problems." (Kornberg 1950)
- "Working code of minimum interference" with production (Parker 1952)
- "If all this [underground] material escaped to the river we might have a poor condition, but hardly a disastrous one." Parker (1952)
- "Economic use" of entire Hanford Site (Pearce 1959)

Early Contaminant Releases

- Rainwater with radionuclide levels “up to 3 times the tolerable value.” (Parker 1945)
- Thyroid tissue samples collected offsite contained iodine levels that “significantly exceeded” the chronic maximum permissible concentration for humans (Herde et al 1951)
- Some airborne particles found in Richland could give a radiation dose to the skin well above safe limits (Parker 1954)
- “Revelation of a regional iodine-131 problem would have had a tremendous public relations impact.” (Stannard 1988)



Radionuclide Releases to the Atmosphere

32M curies released

- 12M curies from reactors (99% Ar⁴¹)
- 20M curies from reprocessing plants (90% Kr⁸⁵)

Key Radionuclides Contributing to Radiation Dose (curies)

Year	I-131	Ru-103/-106	Ce-144	Sr-90	Pu-239
1944-1949	697,000	290	1740	30	2
1950-1959	43,000	1130	630	10	<1
1960-1969	460	130	1350	25	<1
1970-1972	<1	1	50	2	<1

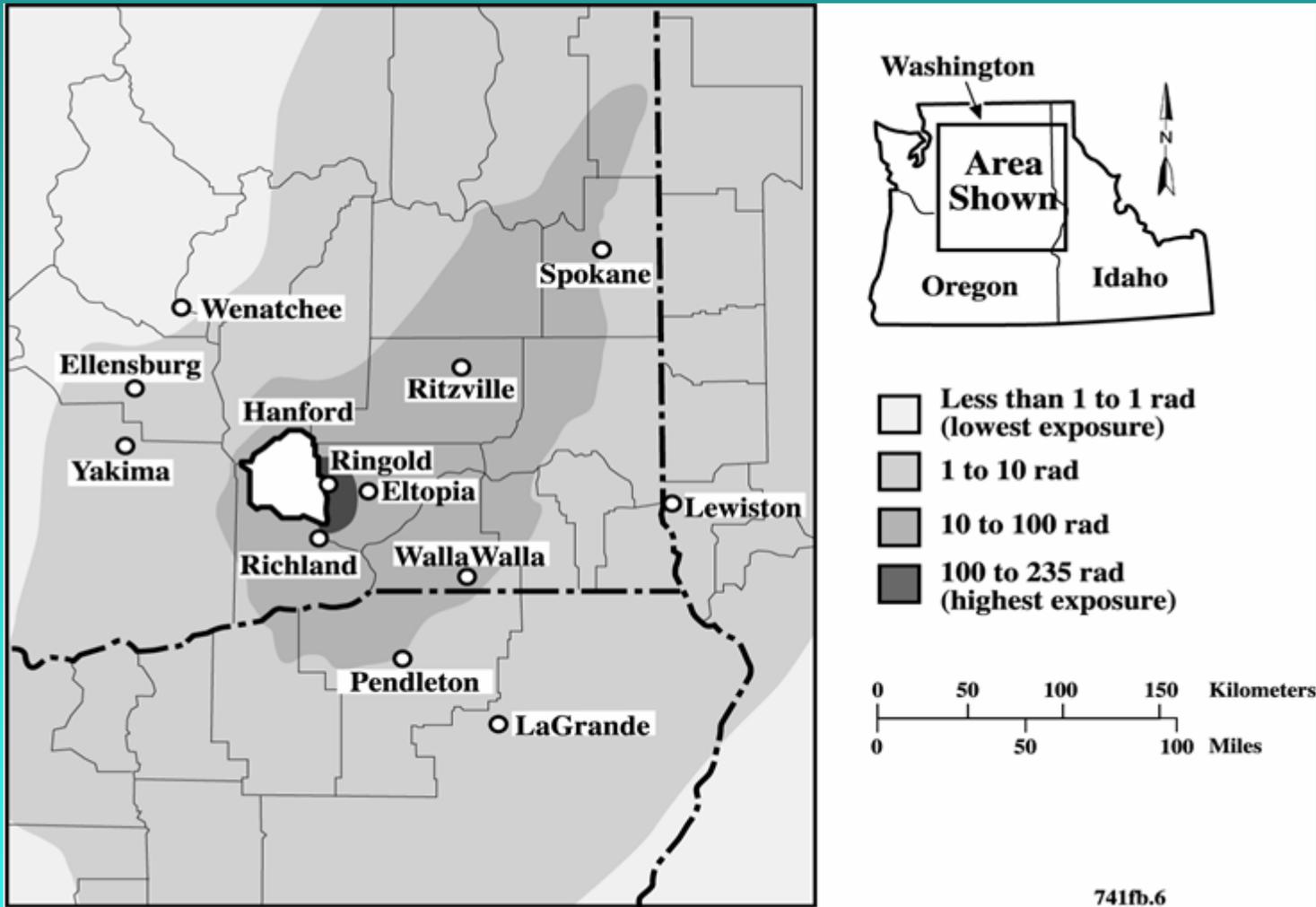


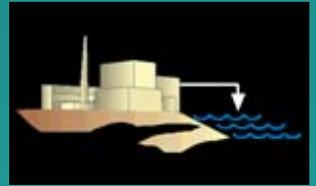
99% of dose from I-131



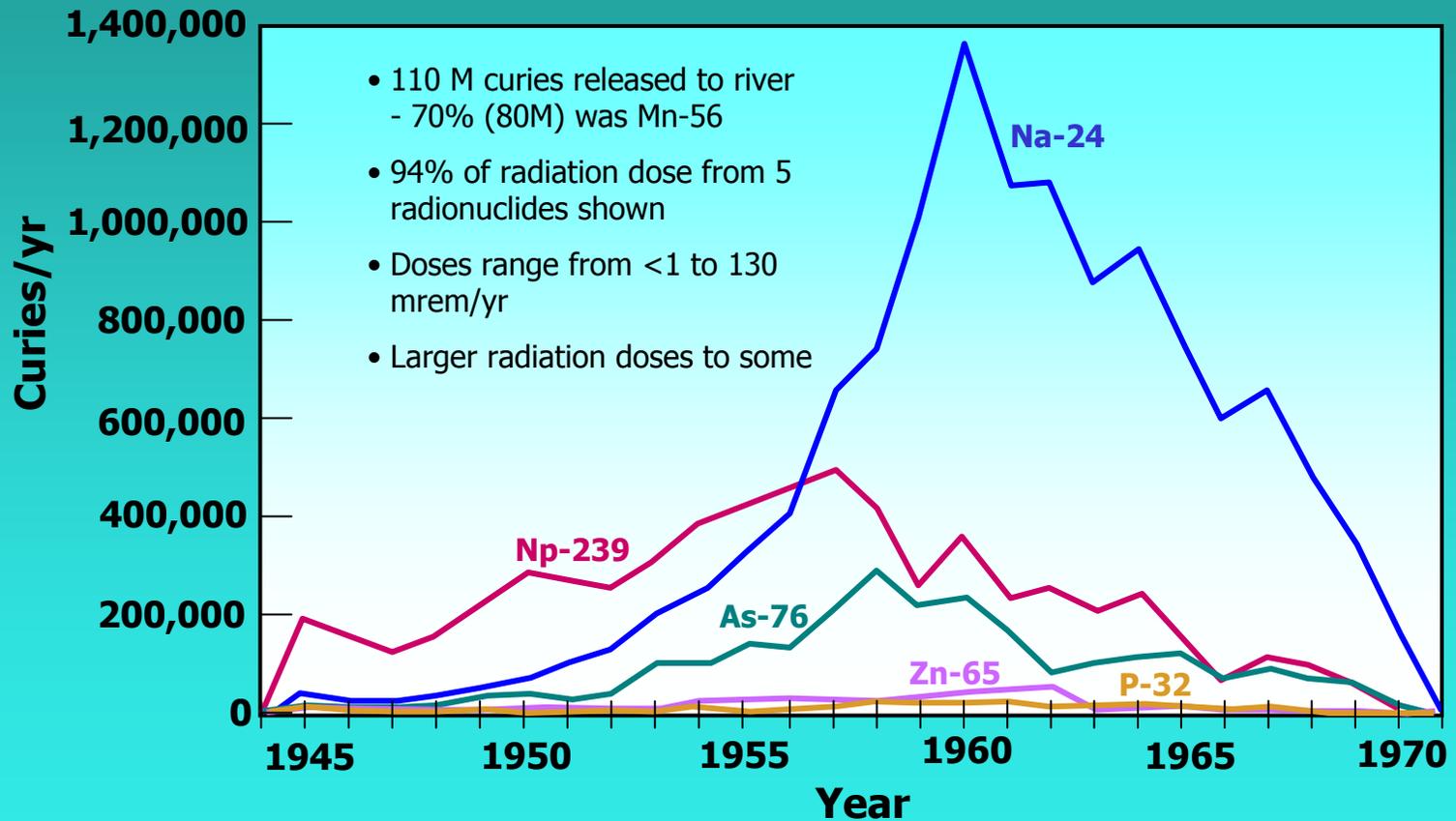
1% of dose from these radionuclides

Estimated Average Downwind Radiation Releases





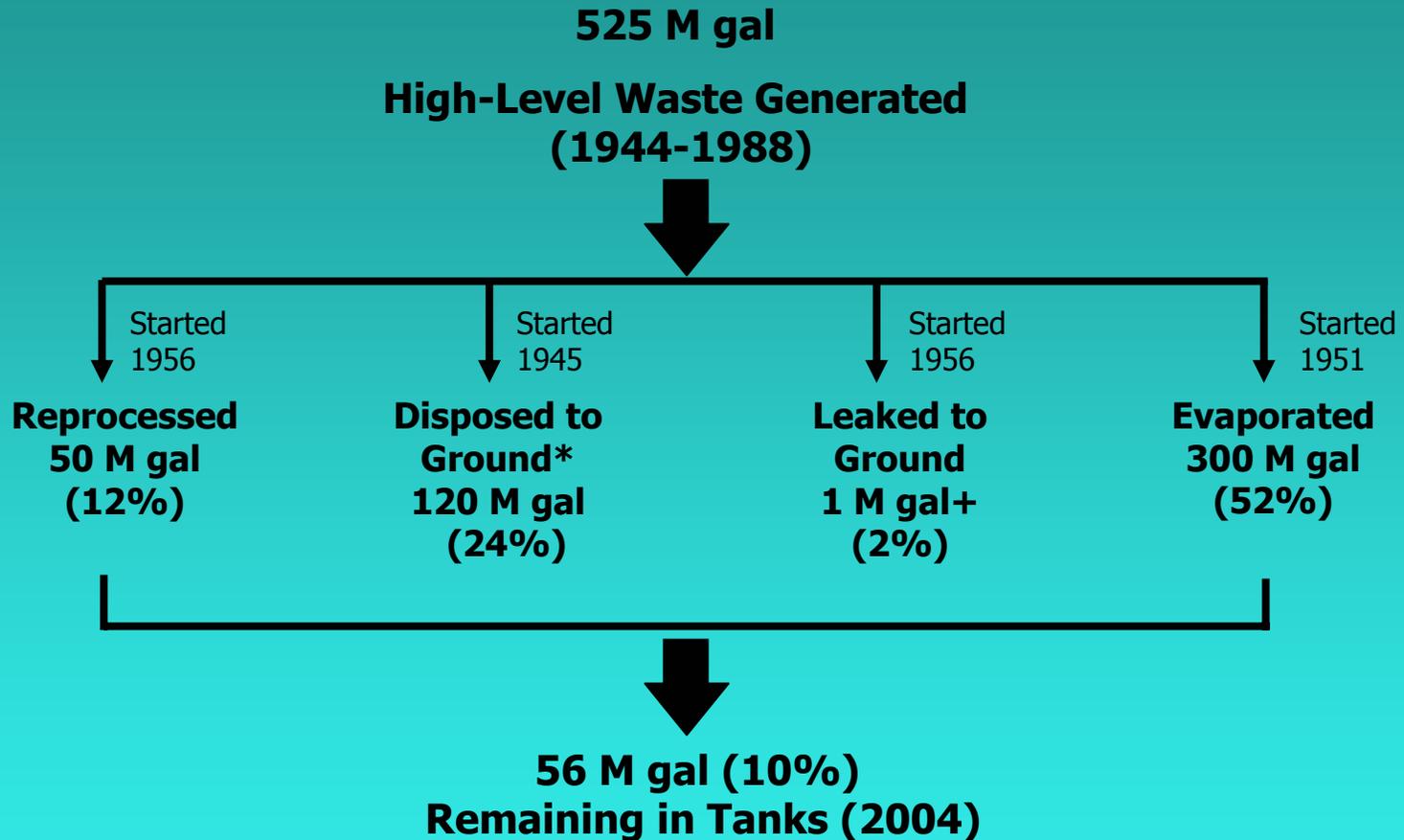
Key Radionuclides Released to Columbia River



Interior of Whole-Body Radiation Counter (1965)



History of Hanford Tank Waste



**after radionuclide scavenging or cascading*

Hanford Tanks

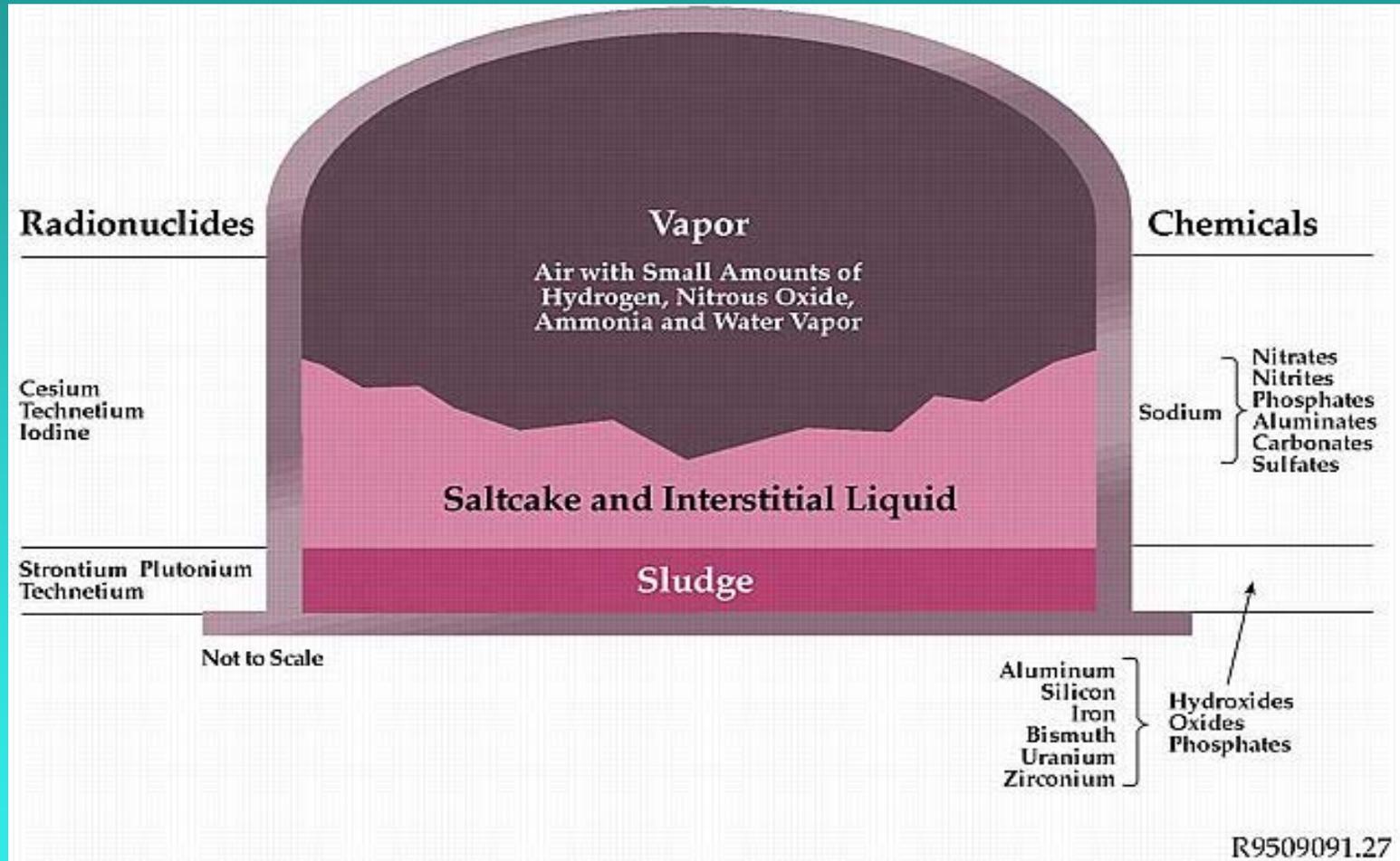


149 single-shell tanks
Built 1943-1964
67 leaked or suspected



28 double-shell tanks
Built 1968-1986
No leaks

Generalized Contents of Single-Shell Tanks



Unique Contents of Some Hanford Single-Shell Tanks

- 400 tons of diatomaceous earth added to 6 tanks
- 63 tons of cement added to 1 tank
- 57 plastic bottles in 2 tanks containing Pu²³⁹ and U
- 6 cask loads of experimental fuel and samarium “poison” ceramic balls
- 25 ft³ of organic ion exchange resins

Single-Shell Tank SX-105



- 1 million gal tank
- Build 1953-1954
- No leaks

Single-Shell Tank U-104



- 530,000 gal tank
- Built 1943-1944
- Leaked 55,000 gal
- Diatomaceous earth added in 1970s

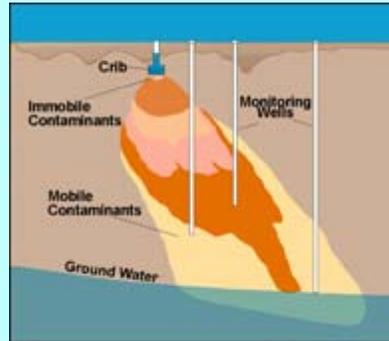
Single-Shell Tank B-105



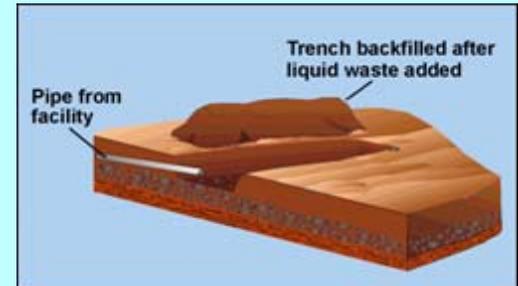
- 530,000 gal tank
- 75 ft diameter
- Saltcake layers show past waste levels
- 8000 gal assumed leaked

Methods of Liquid Releases to the Ground

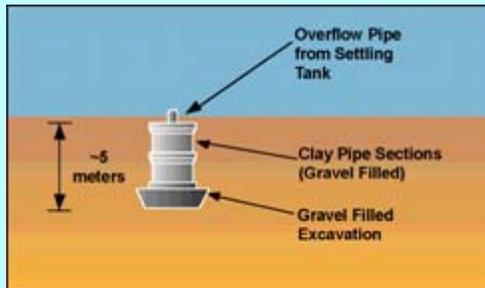
Cribs 1944-1990s



Specific Retention Trenches 1944-1973



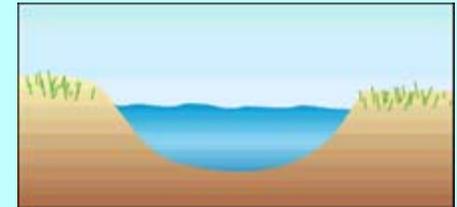
French Drains 1944-1980s



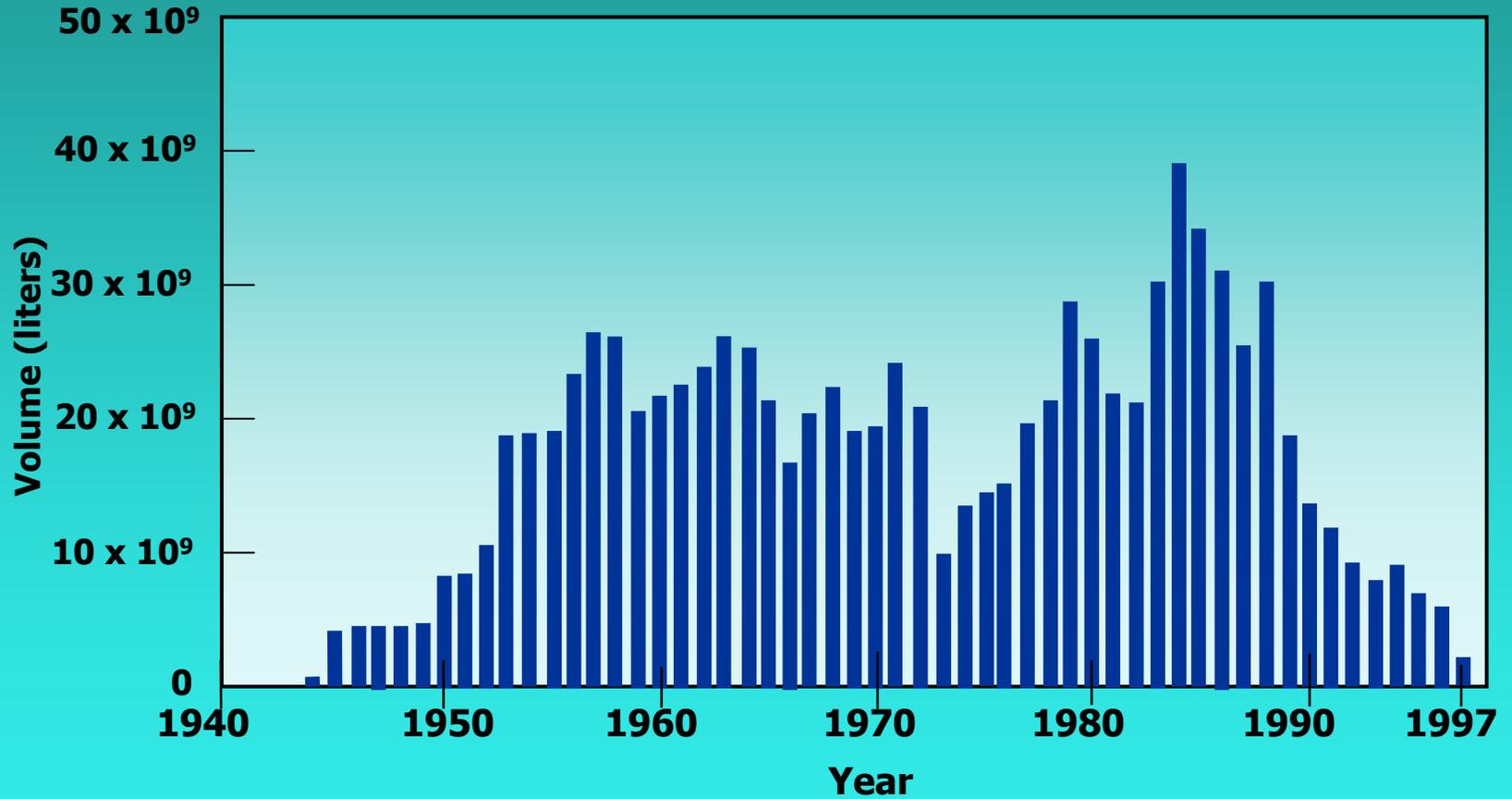
Reverse Wells 1945 - 1955 (one to 1980)



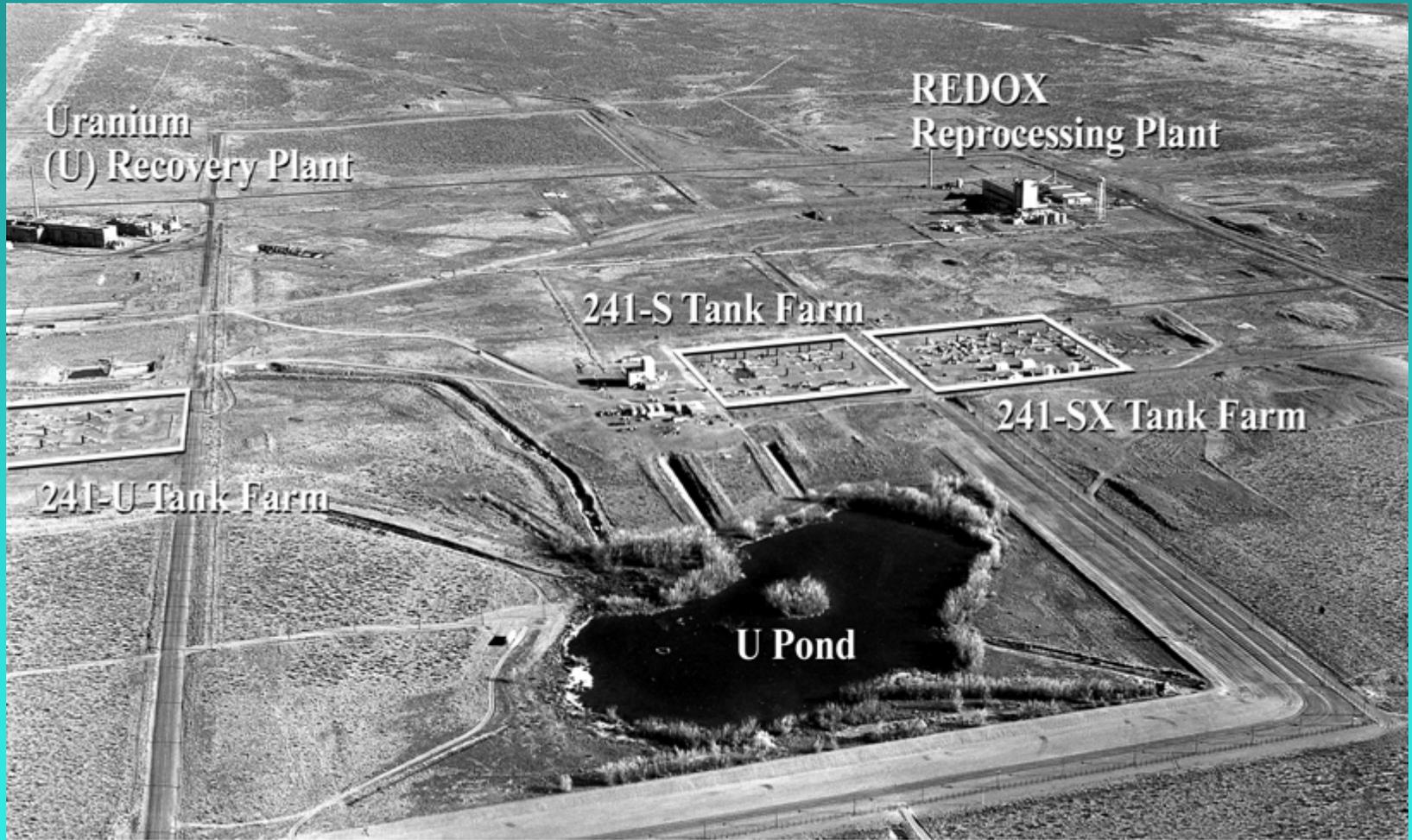
Ponds 1944-1990s



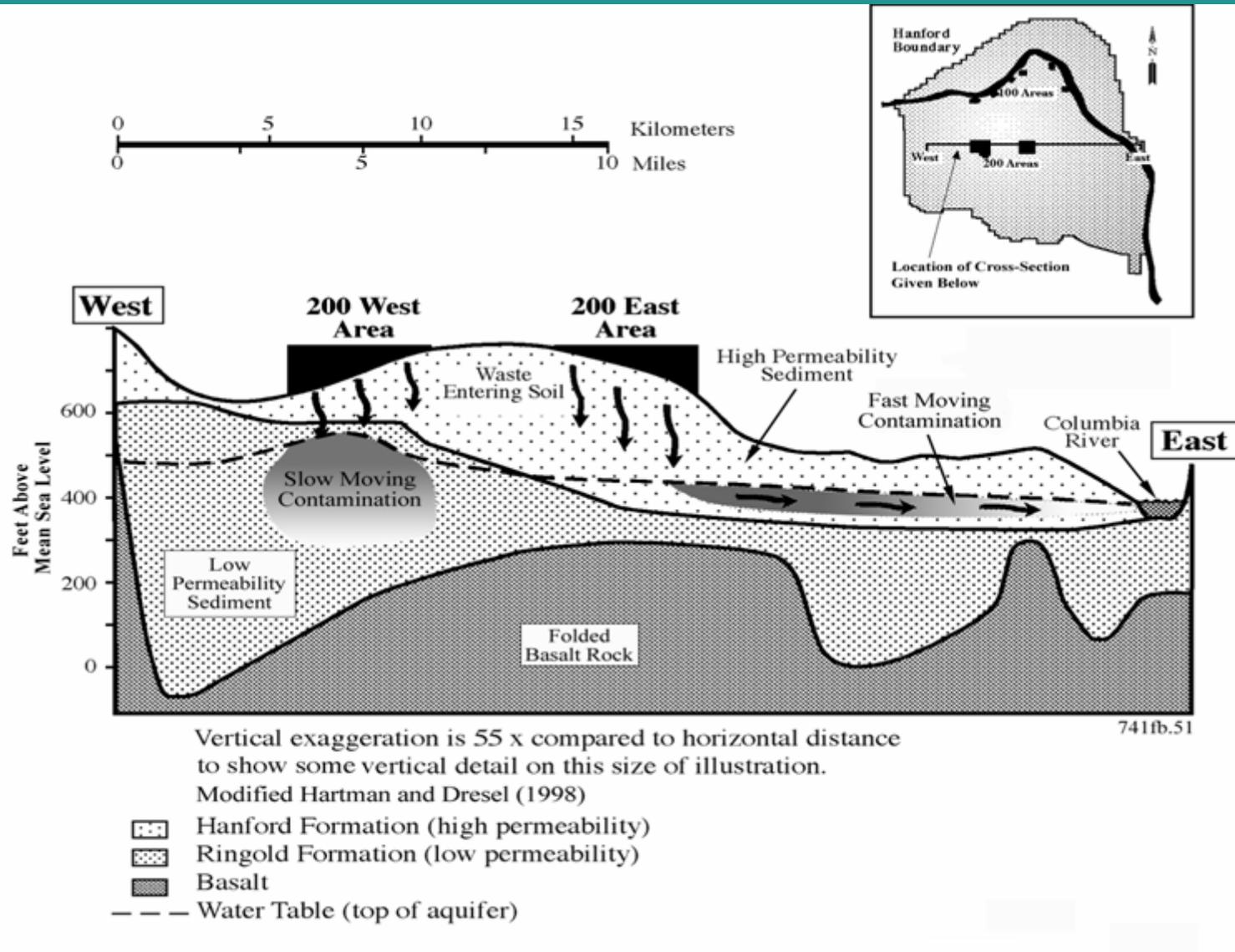
Liquids Discharged to Ground (450 billion gal)



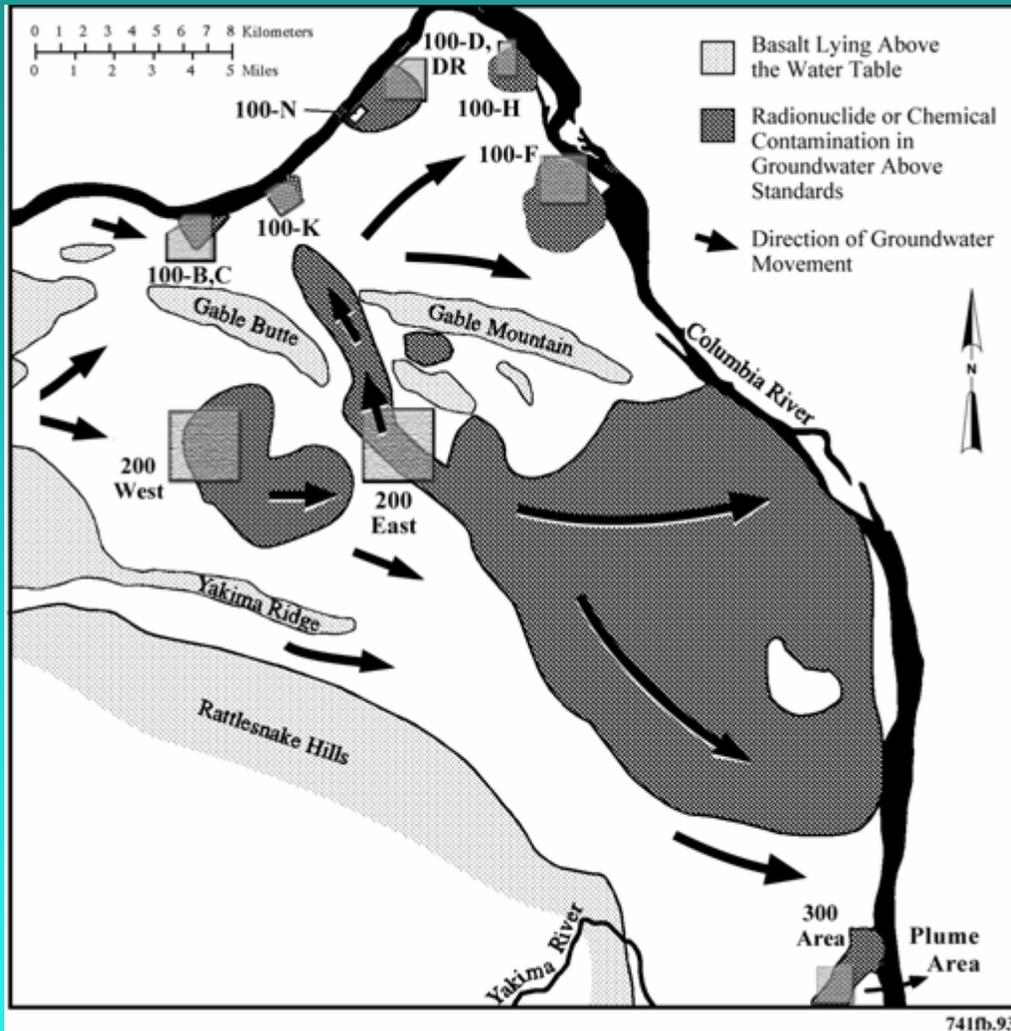
U-Pond and Adjoining Areas (1962)



Generalized Geologic Cross-Section

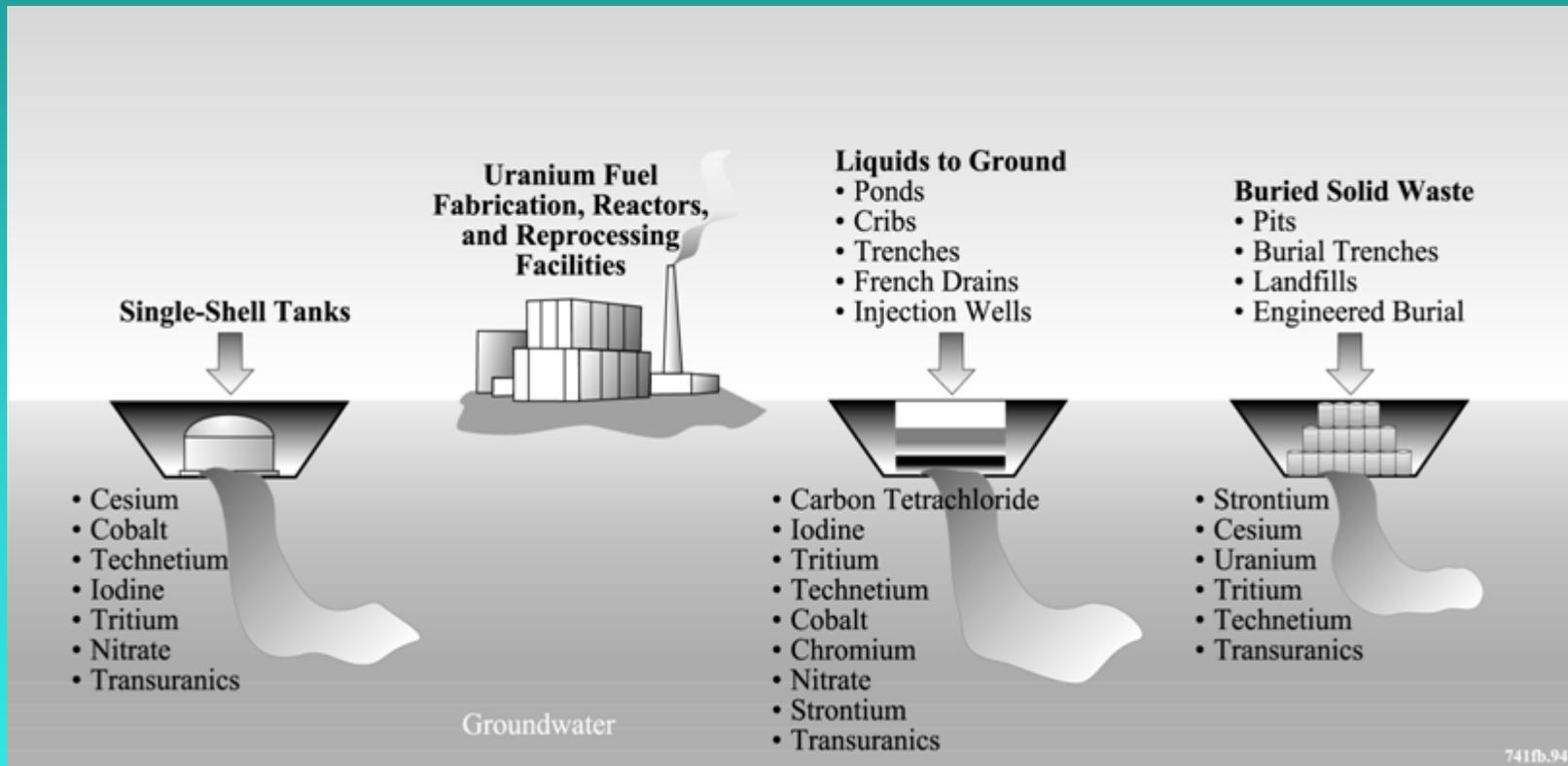


Groundwater Flow Patterns and Plumes



- 80-100 mi² above drinking water standards
- 1.8 M curies (40% from tank leaks)
- 100K to 300K tons of chemicals
- Plumes H³, NO₃, I¹²⁹, Cr⁶, CCl₄, others

Examples of Contaminants in Hanford Soil and Groundwater



Buried and Stored Solid Waste



Early Years



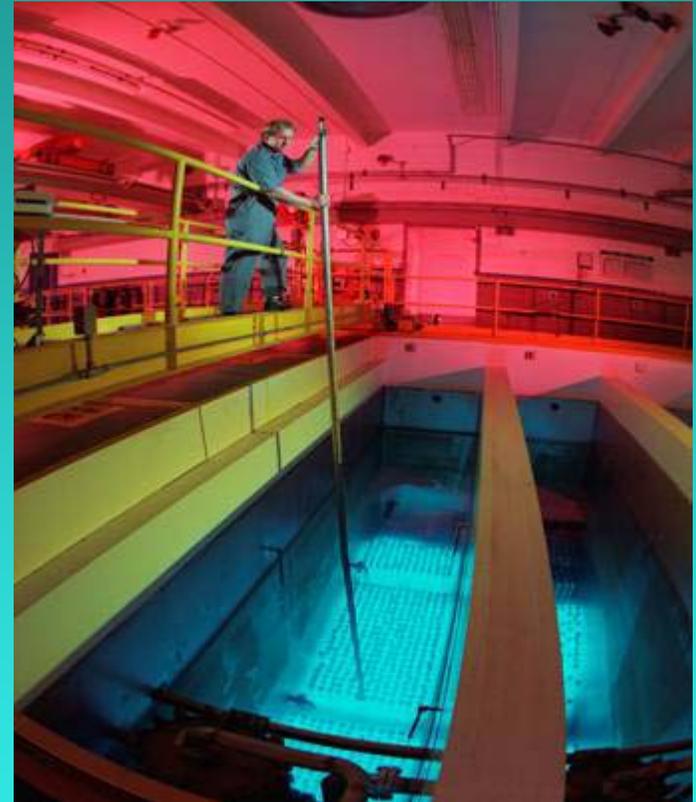
Later Years

- 25M ft³ of low-level and transuranic waste (60% buried pre-1970)
- 10% transuranic contaminated
- 75 solid waste burial grounds (8 active)
- 6 million curies; 70,000 tons of chemicals
- 800 pounds of Pu
- 650 tons of U

Nuclear Materials Onsite

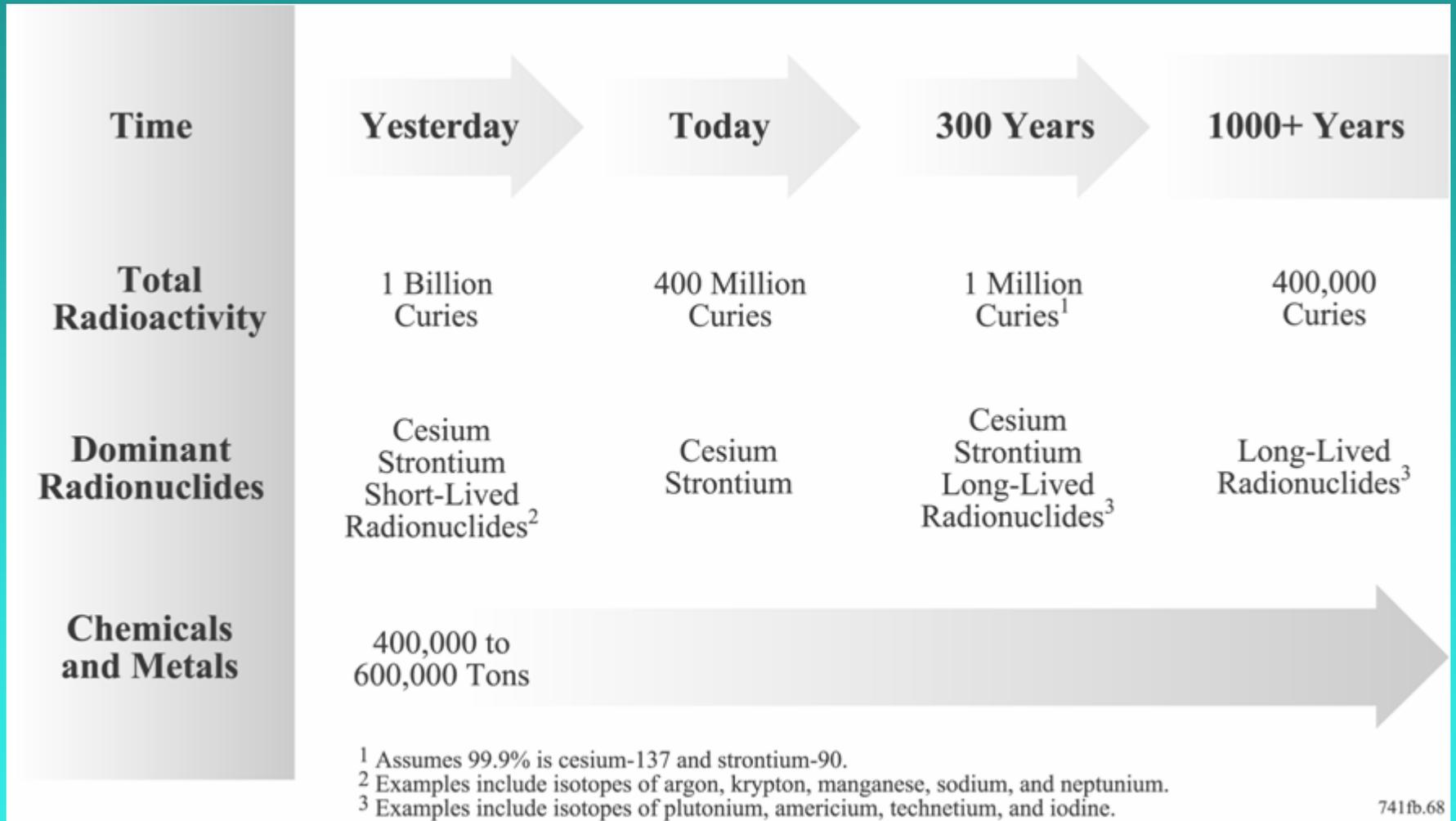


- 2300 tons of spent fuel (55 M curies)
- 90% dried, packaged, and stored



- Cs and Sr capsules (130 M curies)

Changing Face of Onsite Waste and Nuclear Materials



What is Cleanup?

- No single answer
- Negotiated end-state (exit-point?)
- Adaptive process--learn as go
- Bottom line: health and environmental protection
- Science (knowledge) and technology (capability): partners in decisions/actions used to explain and enable
- Society: directs what's done based upon desirability