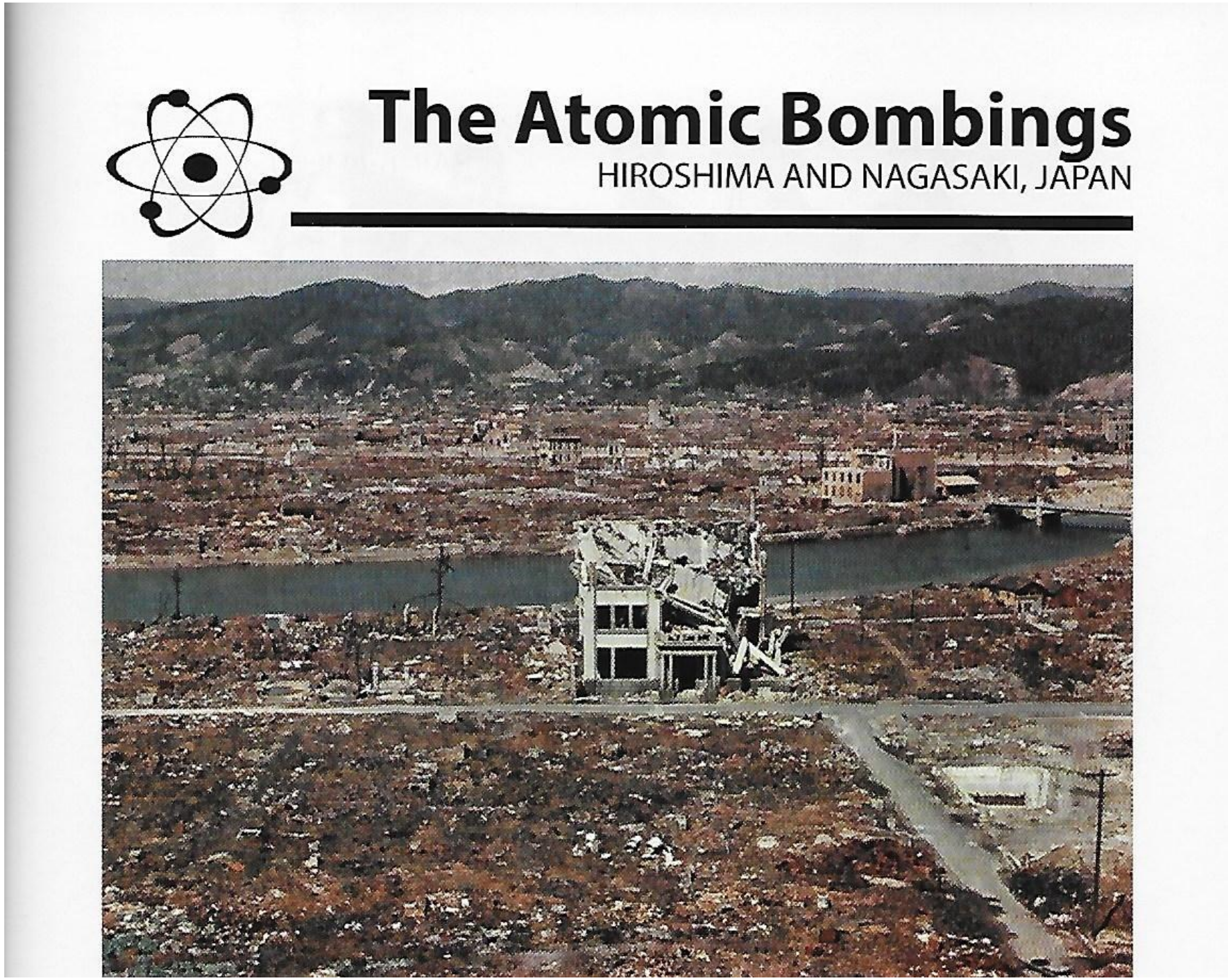
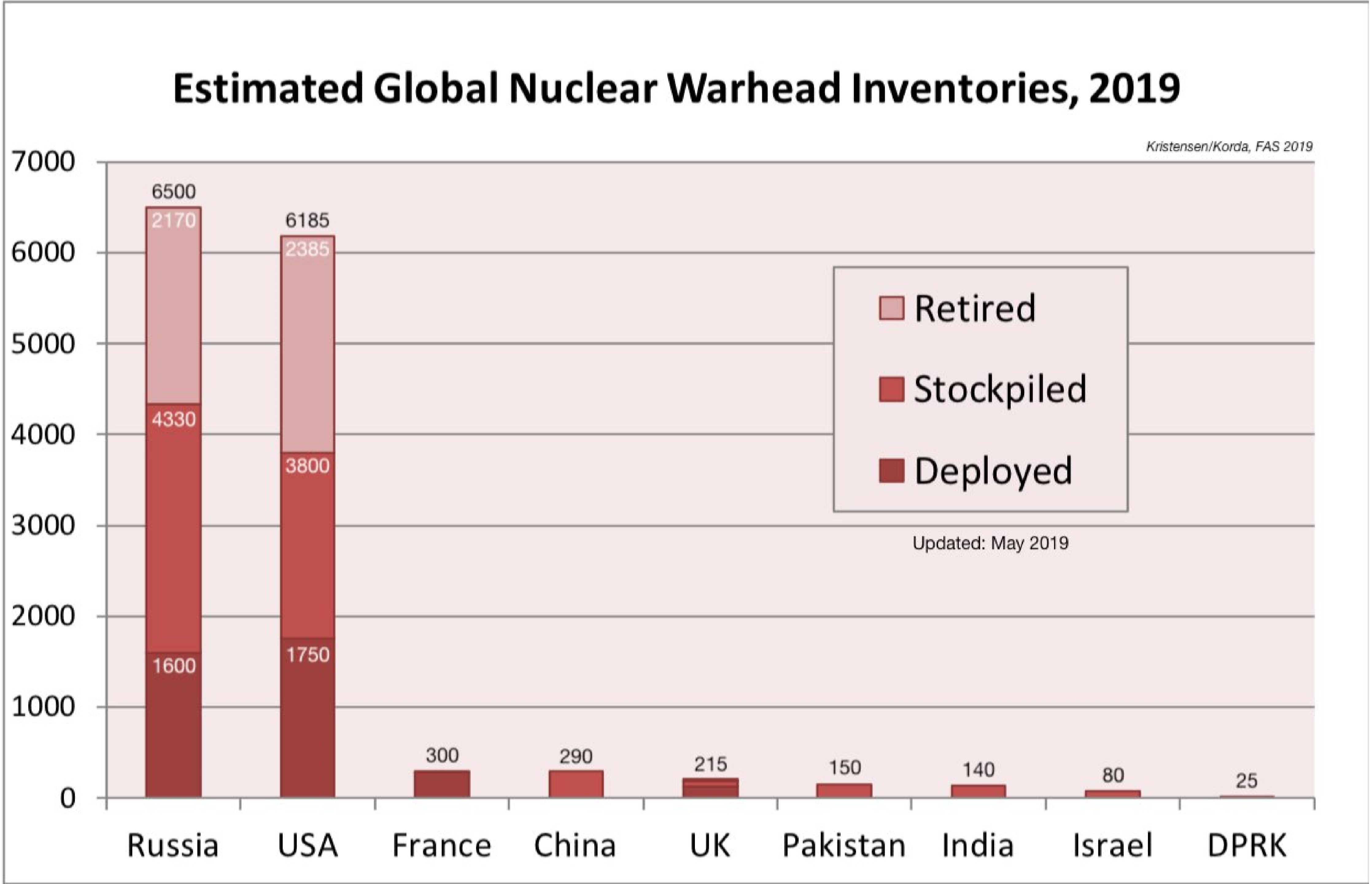
Intended Consequences





Estimated Global Nuclear Warhead Inventories, 2019
Kristensen/Korda, FAS 2019
7000
6000
5000
4000
3000
2000
1000
0
6500
2170
4330
1600
6185
2385
3800
1750
300
290
215
150
140
80
25
Retired
Stockpiled
Deployed
Updated: May 2019
Russia
USA
France
China
UK
Pakistan
India
Israel
DPRK

The Little Boy Bomb:

Dropped on the Japanese city of Hiroshima on August 6, 1945, it was the first nuclear weapon used in a war. Following are some approximate statistics for Little Boy. If you require more extensive information on this weapon, please contact us:

Weight: 9,700 lbs

Length: 10 ft.; Diameter: 28 in.

Fuel: Highly enriched uranium; "Oralloy"

Uranium Fuel: approx. 140 lbs; target - 85 lbs and projectile - 55 lbs

Target case, barrel, uranium projectile, and other main parts ferried to Tinian Island via USS Indianapolis

Uranium target component ferried to Tinian via C-54 aircraft of the 509th Composite Group

Efficiency of weapon: poor

Approx. 1.38% of the uranium fuel actually fissioned

Explosive force: 15,000 tons of TNT equivalent

Use: Dropped on Japanese city of Hiroshima; August 6, 1945

Delivery: B-29 Enola Gay piloted by Col. Paul Tibbets

The Fat Man Bomb:

Dropped on the Japanese city of Nagasaki on August 9, 1945, it was the second nuclear weapon used in a war. Following are some approximate statistics for Fat Man.

Weight: 10,800 lbs

Length: 10 ft 8 in.; Diameter: 60 in.

Fuel: Highly enriched plutonium 239

Plutonium Fuel: approx. 13.6 lbs; approx. size of a softball

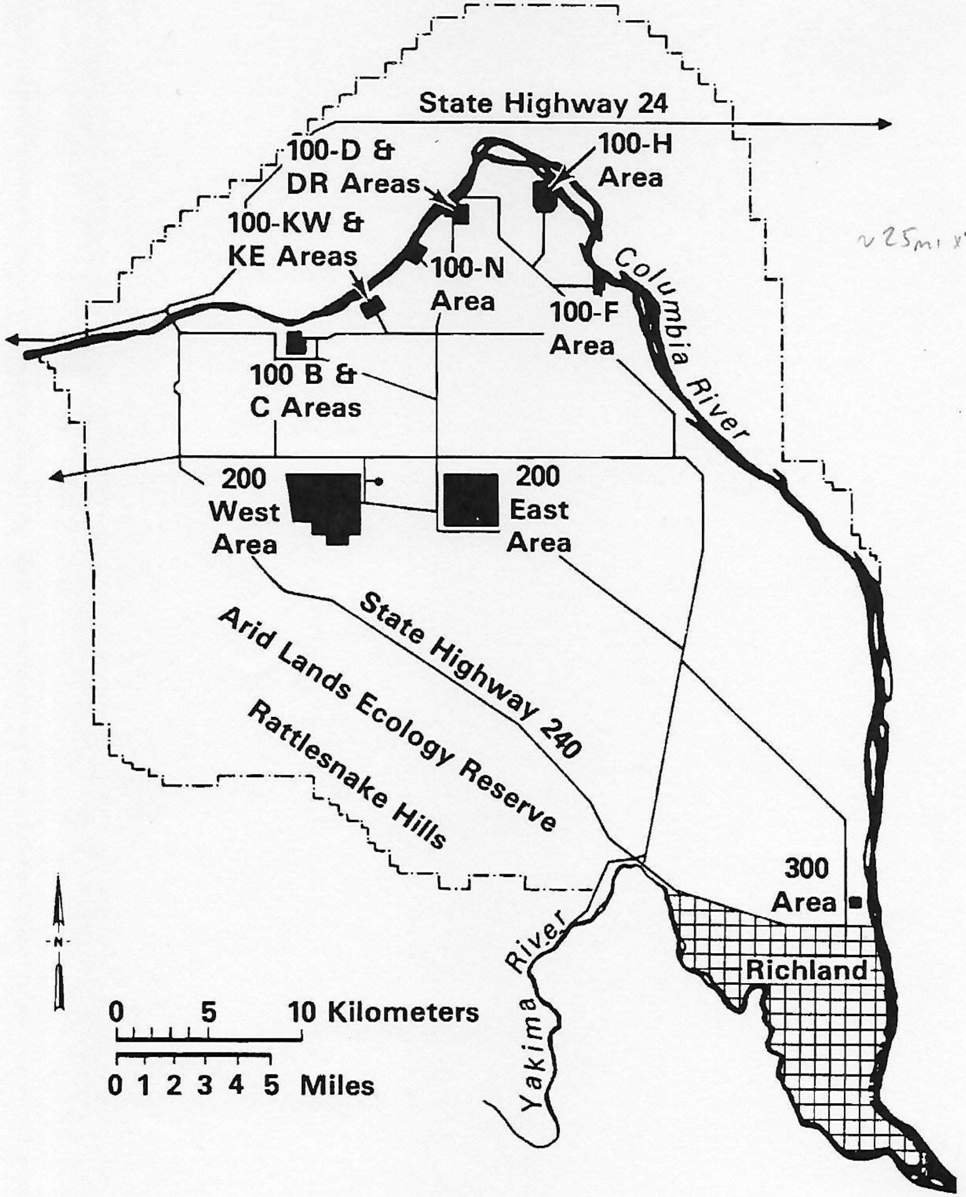
Plutonium core surrounded by 5,300 lbs of high explosives; plutonium core reduced to size of tennis ball

Bomb Initiator: Beryllium - Polonium

All components of Fat Man ferried to Tinian Island aboard B-29's of the 509th CG

Efficiency of weapon: 10 times that of Little Boy

Approx 1.176 grams of plutonium converted to energy

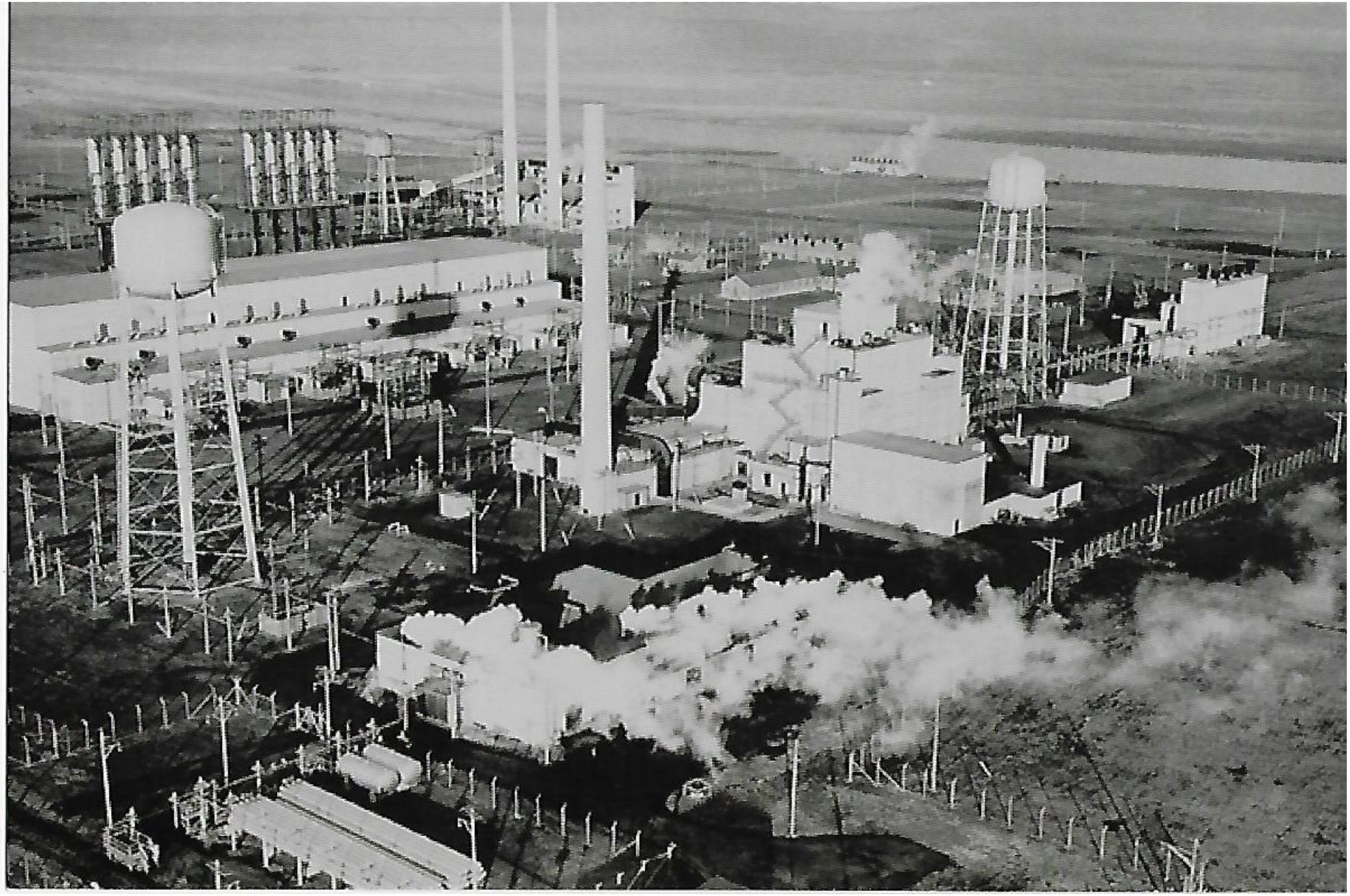


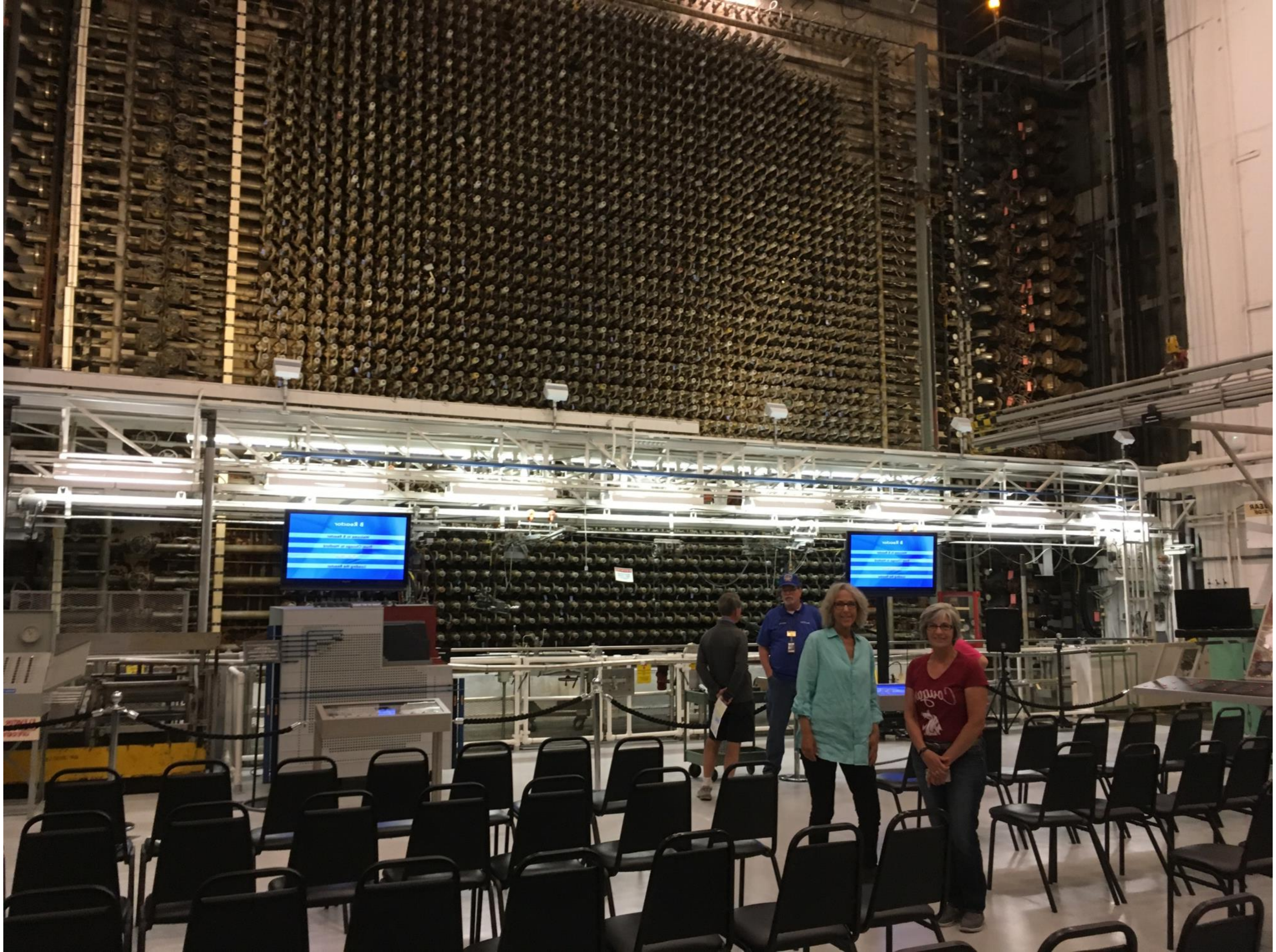
~25mi x25mi ≅ 600mi²

FIGURE 3.6. Location of Reactor Areas on the Hanford Site


National Park Service
U.S. Department of Interior & U.S. Department of Energy
Manhattan Project
National Historical Park
Hanford
Manhattan Project National Historical Park
NATIONAL PARK SERVICE
Hanford Unit
VISITOR CENTER
MANHATTAN PROJECT
B REACTOR
TOUR HEADQUARTERS
NATIONAL PARK SERVICE
RESERVED PARKING
STATE DISABLED PARKING PERMIT REQUIRED

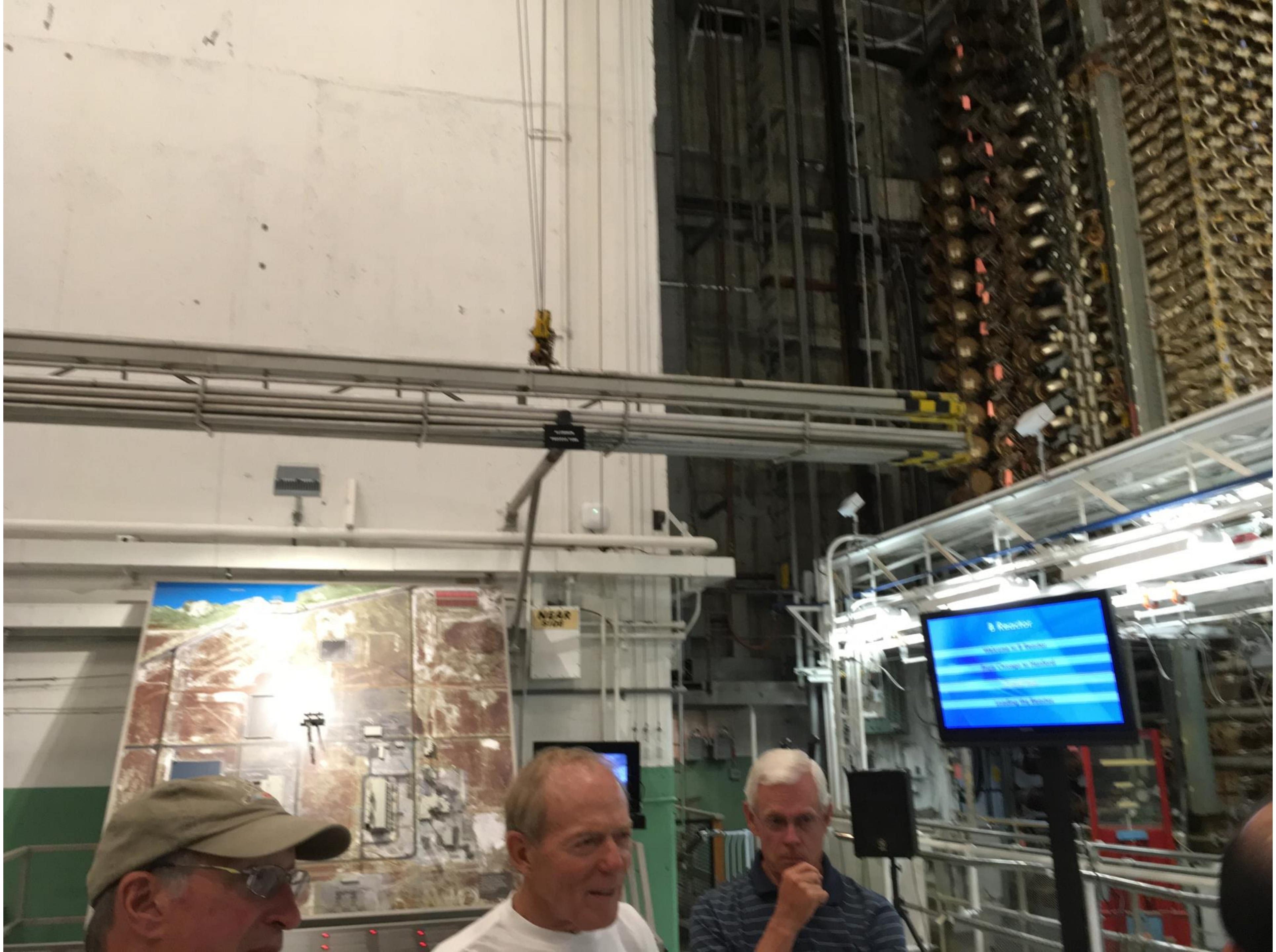

Motorcoach
B Reactor

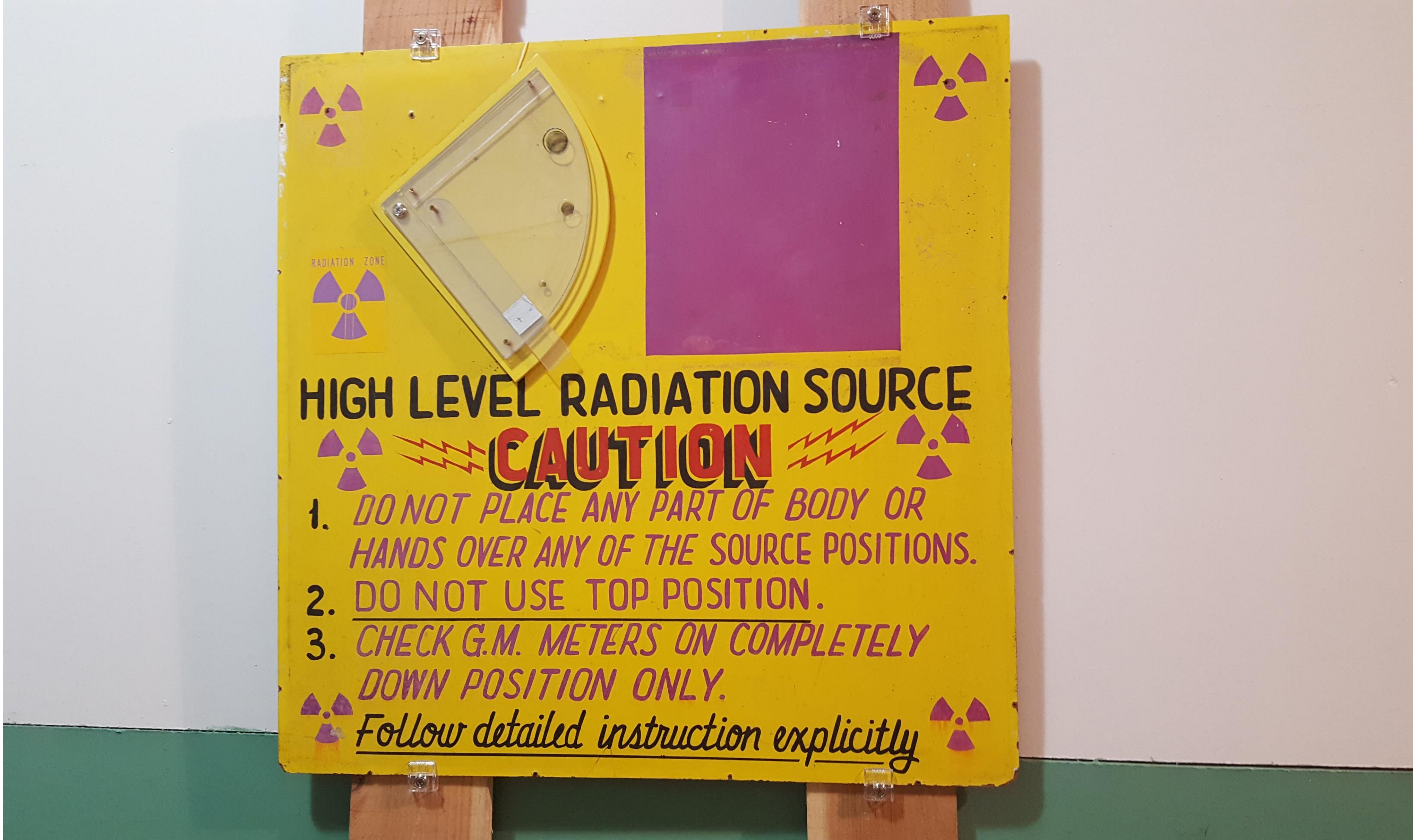





METAL
LOADER

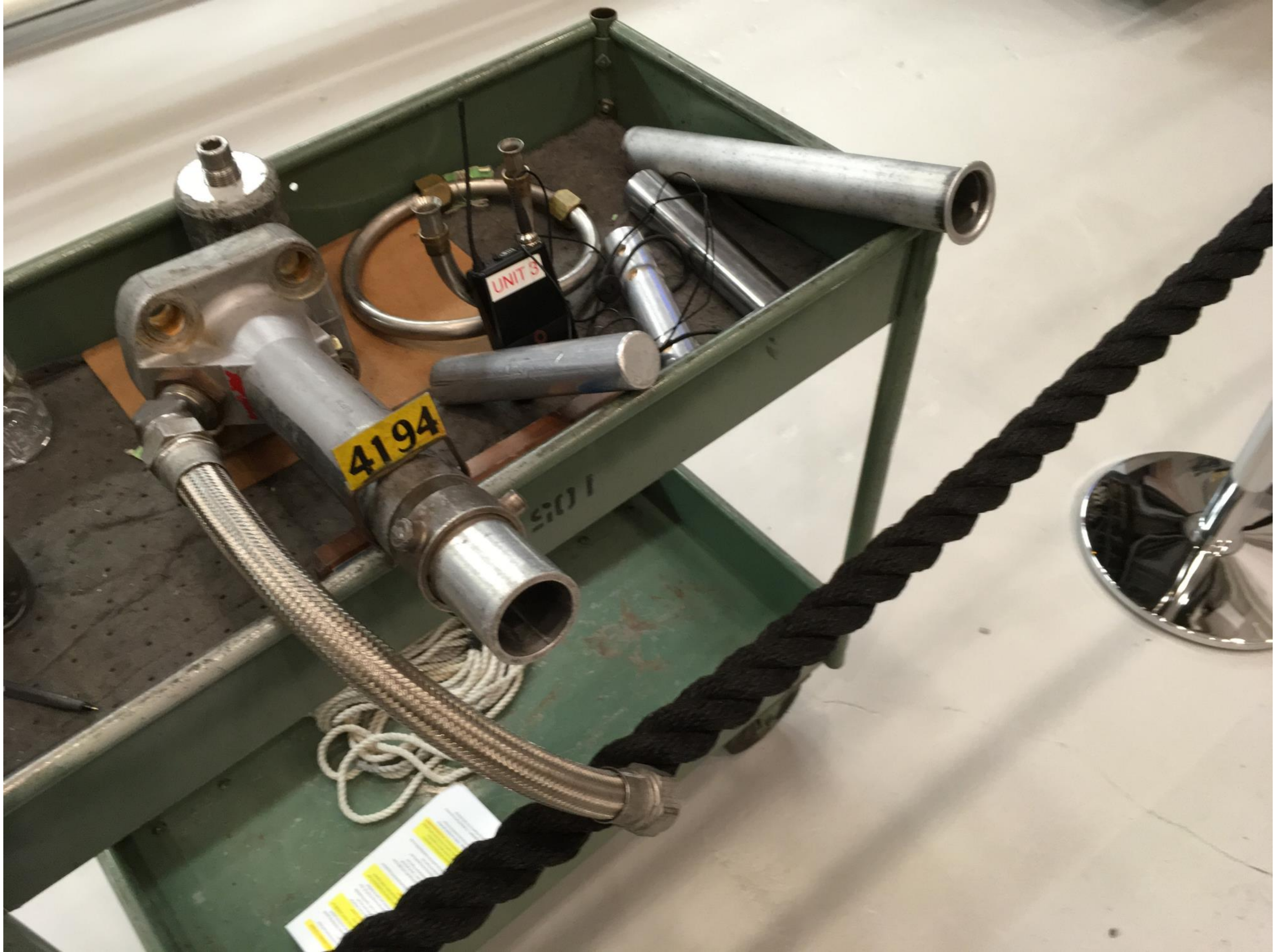

VALVE PIT


NEAR
SIDE
B Reactor


RADIATION ZONE
HIGH LEVEL RADIATION SOURCE
CAUTION
1. DO NOT PLACE ANY PART OF BODY OR HANDS OVER ANY OF THE SOURCE POSITIONS.
2. DO NOT USE TOP POSITION.
3. CHECK G.M. METERS ON COMPLETELY DOWN POSITION ONLY.
Follow detailed instruction explicitly

WHITE BLUFF
GEIGER
PATH
BUSES
BOXES WITH
RADIATION EMBLEM
TO BE USED ONLY FOR
BURIAL OF
CONTAMINATED
MATERIALS
SWP REQUIRED
FOR WORK ON This EQUIPMENT
EXCEPT FOR ADDING OIL
MASK
TESTING
STATION
USE DISCS
to insure
PROPER FIT
CAUTION
THIS EQUIPMENT
starts AUTOMATICALLY
RADIATION
CONTROL
ALARM
FLASHING LIGHT means
LEAVE ZONE UNLESS MONITORED
FISSILE
2 2
Caution
CAUTION
REPLACE CHAIN
BEFORE
LEAVING STORAGE
EQUIPMENT
STARTS BY
Remote
CONTROL
DANGER
AUTHORIZED
PERSONNEL
ONLY
DANGER
HIGH
VOLTAGE
3 3
Caution
4 4
Caution
CAUTION
CONTACT RMU
BEFORE CHANGING
FILTERS
RADIATION
DANGER ZONE
KEEP OUT
NOTICE
BEFORE
EXITING
SURVEY
REQUIRED
RADIATION
ZONE
FALLOUT SHELTER
STARTS HERE
CONTAMINATION
RESTRICTED AREA
DO NOT ENTER
WITHOUT APPROVAL
OF "S" DIVISION
SUPERVISION
Special WORK PERMIT
REQUIRED for
WORK ON
Cables-Sheaves & Hooks
DO NOT
ENTER
THIS AREA
Unless Specifically
Stated on SWP.
EVACUATION ALARM
WHEN HORN SOUNDS
EVACUATE AREA
Immediately
EVACUATE
1 WHEN RADIATION ALARM SOUNDS,
OR
2 WHEN ADVISED BY A RADIATION MONITOR
USE OF
WRENCHES
PROHIBITED
ON THESE
FITTINGS


PLEASE DO NOT TOUCH
Reactor 105-B
Graphite Stack

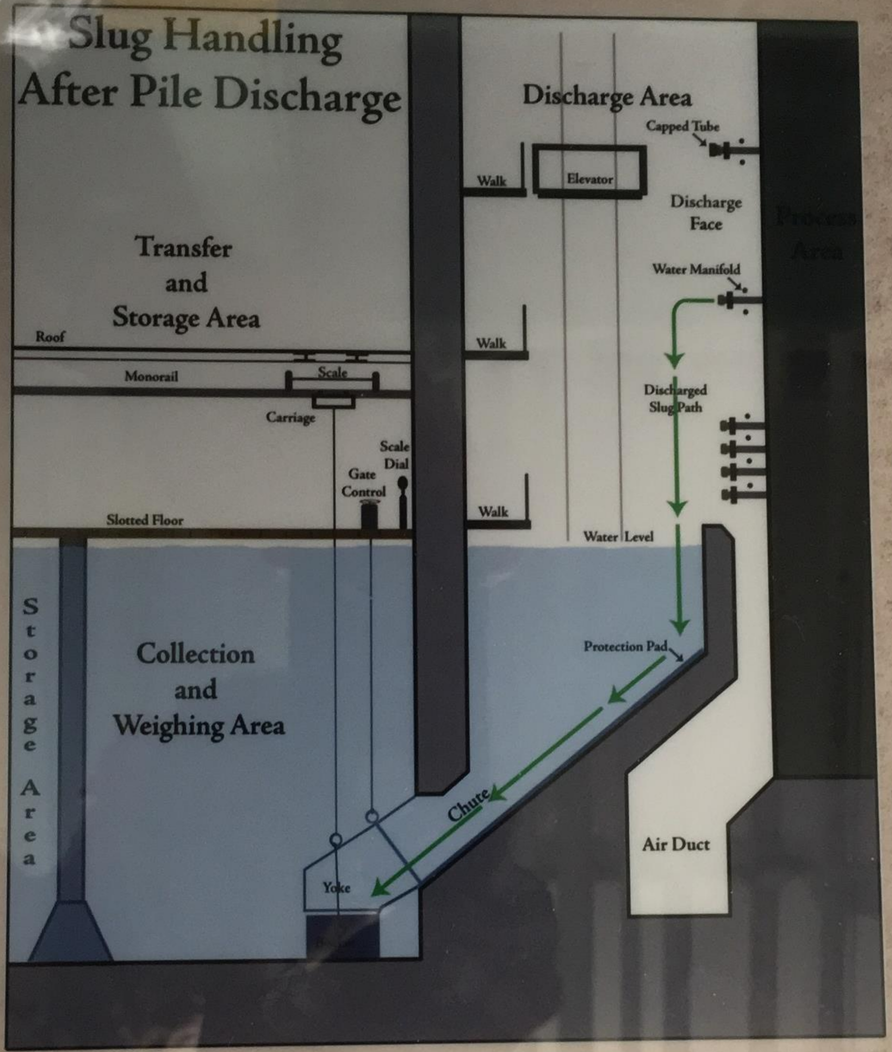

4194
UNIT 3

SAFETY CIRCUIT INDICATOR
PRESSURE MONITOR INDICATOR
FOXBORO
NO. 7
NO. 8
GALVANOMETER
(Power Indicator)
1/2 ROD
1/2 ROD

MANHATTAN PROJECT
National Historical Park
HANFORD
B REACTOR
B Reactor Museum
Association
SUPPLY
SAFETY CIRCUIT
INDICATOR
PRESSURE MONITOR
INDICATOR
PLEASE DO

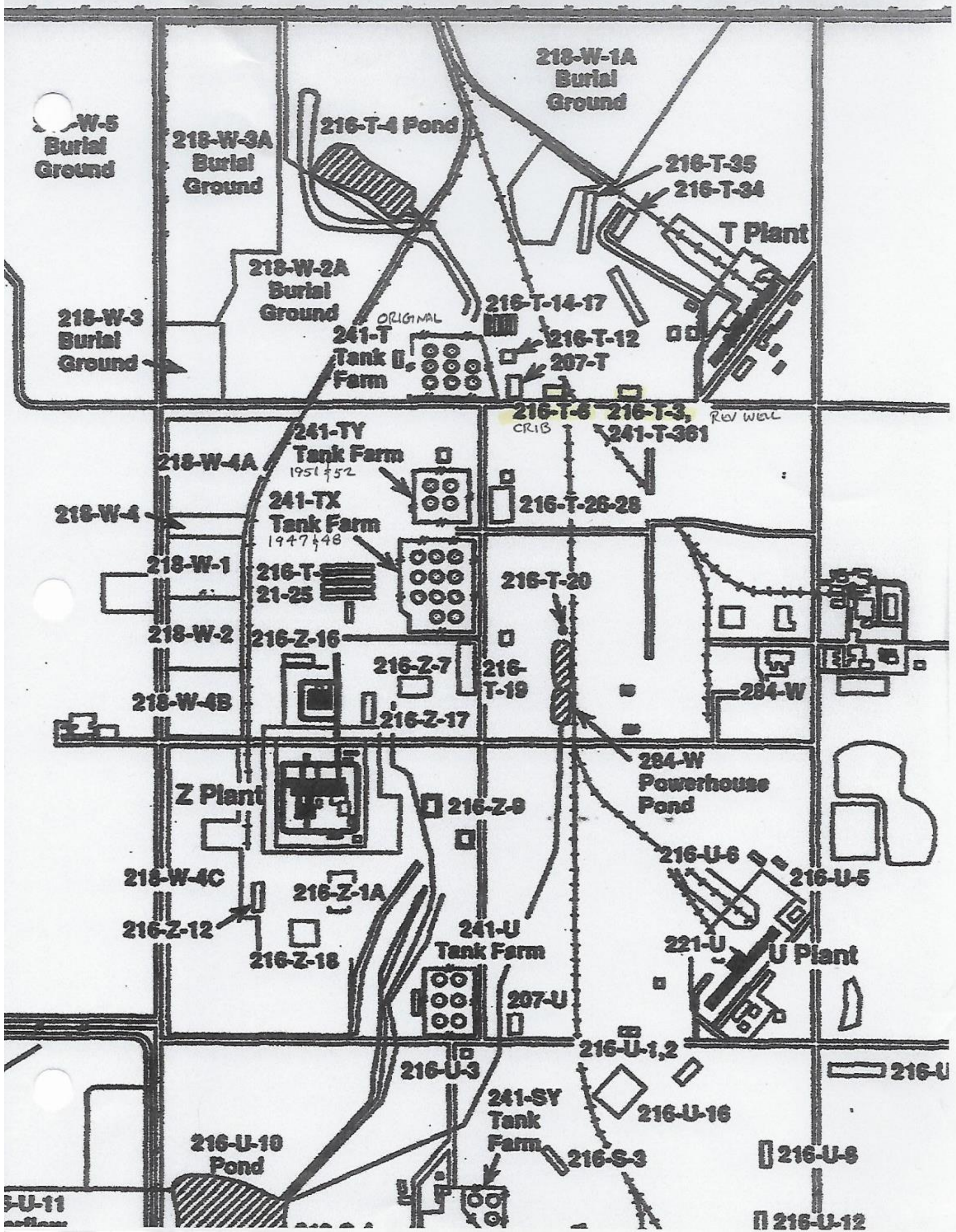

CAUTION: BUMPING PANEL MAY CAUSE SCRAM


43
42
41
40
39
38
37
36
35
34
33

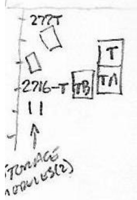

Slug Handling
After Pile Discharge
Discharge Area
Capped Tube
Walk
Elevator
Discharge Face
Process Area
Transfer and Storage Area
Water Manifold
Roof
Walk
Monorail
Scale
Discharged Slug Path
Carriage
Scale Dial
Gate Control
Walk
Slotted Floor
Water Level
Storage Area
Collection and Weighing Area
Protection Pad
Chute
Air Duct
Yoke

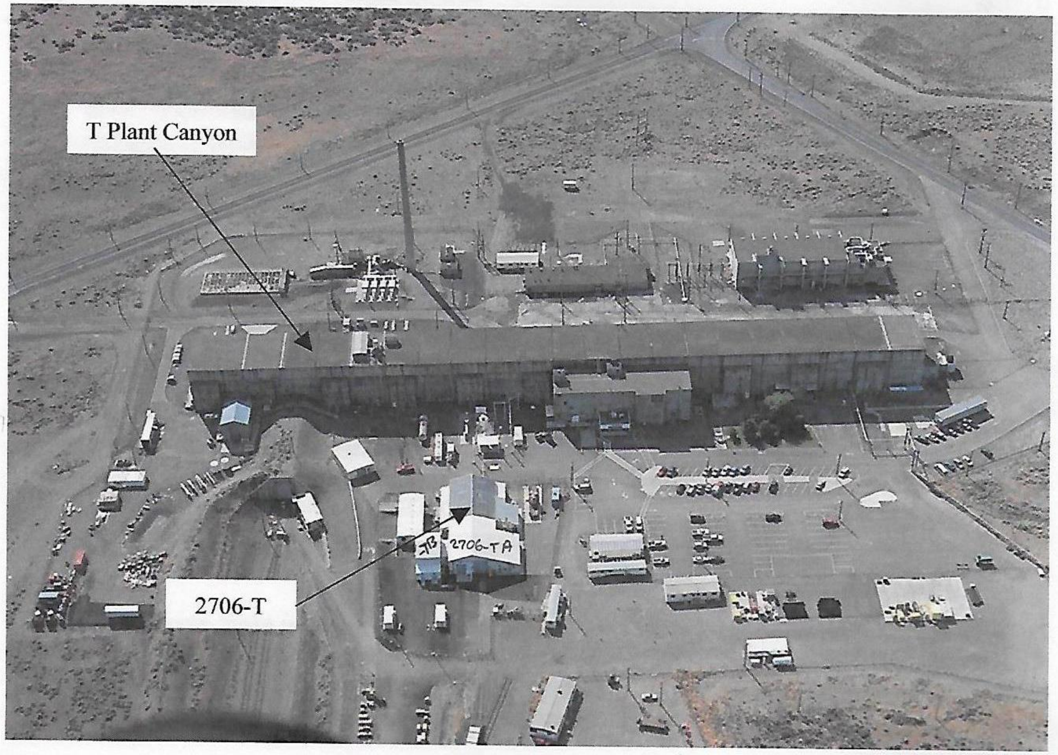

DO NOT REMOVE
WITHOUT
PERMISSION


3729
945



218-W-1A Burial Ground
W-5 Burial Ground
218-W-3A Burial Ground
216-T-4 Pond
216-T-35
216-T-34
T Plant
218-W-2A Burial Ground
218-W-3 Burial Ground
216-T-14-17
ORIGINAL
241-T Tank Farm
216-T-12
207-T
216-T-6
CRIB
216-T-3,
REV WELL
241-T-361
241-TY Tank Farm
1951 & 52
218-W-4A
241-TX Tank Farm
1947 & 48
216-T-26-28
218-W-4
218-W-1
216-T-21-25
216-T-20
218-W-2
216-Z-16
216-Z-7
216-T-19
284-W
218-W-4B
216-Z-17
284-W Powerhouse Pond
Z Plant
216-Z-9
216-U-6
216-U-5
218-W-4C
216-Z-1A
216-Z-12
241-U Tank Farm
221-U
U Plant
216-Z-18
207-U
216-U-1,2
216-U-3
216-U-16
241-SY Tank Farm
216-S-3
216-U-10 Pond
216-U-8
216-U-12





M0212-0286.16
HSW EIS 12-10-02

Figure 2.11. View of the T Plant Complex with 2706-T Facility and the T Plant Canyon Noted

Inspection, verification, opening, sampling, sorting, and limited treatment and repackaging of LLW, MLLW, and TRU waste are performed in the 2706-T Facility and other areas in the T Plant Complex. The 2706-T Facility, initially constructed during 1959 and 1960, was remodeled in 1998 to expand decontamination and treatment capabilities.

Proposed New/Modified Treatment Facility: Modified T Plant
In some MLLW alternatives and TRU waste alternatives, the T Plant Complex would be modified to establish the capabilities to treat/process waste for which no treatment capability currently exists. These waste streams include RH MLLW, MLLW in non-standard packages, RH TRU waste, CH TRU waste in non-standard containers, and PCB-commingled TRU waste. Specific capabilities provided by this modified T Plant would include stabilization, macroencapsulation, deactivation, sorting, sampling, repackaging NDE, and NDA.
MLLW would be treated to meet applicable regulatory requirements so that it can be disposed of in the MLLW trenches. TRU waste would be processed and shipped to WIPP.

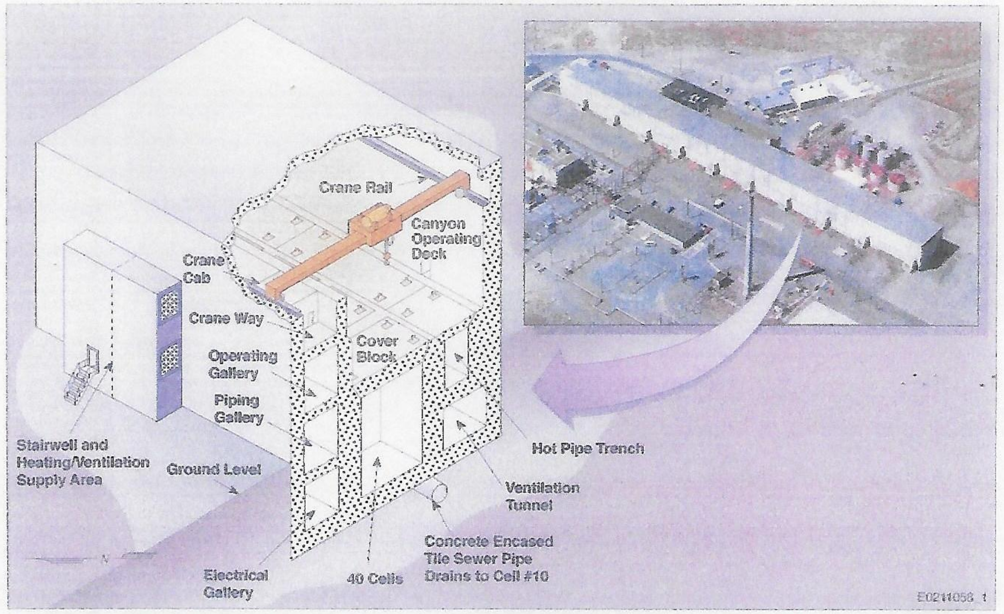


Fig. 1. U Plant Cross Section.

currently houses deactivated electrical switchgear and controls for process equipment located on the canyon side of the building. The pipe gallery is located directly above the electrical gallery and is also split into two separate sections by the railroad tunnel. The pipe gallery contains inactive piping and valves for process equipment located on the canyon side of the building. The U Plant pipe systems were flushed and drained when the facility was deactivated. The operating gallery is located above the pipe gallery and contains deactivated instrumentation and piping manifold stations for controlling the processes in the canyon. The crane gallery (craneway) is located directly above the operating gallery. The crane gallery is the operating area for two overhead traveling cranes that ride common tracks running the entire length of both sides of the facility. The results of direct radiological surveys and general area dose rate surveys of the crane gallery indicate low levels of process-related radionuclides. The crane gallery is controlled as a radiation zone with restricted access.

U Plant Canyon

The canyon portion of U Plant is divided into 20 sections. Each section of the canyon contains two process cells. The cells contain deactivated process equipment, such as vessels, centrifuges, and piping used for feed concentration and centrifugation, solvent-extraction, waste treatment, and solvent treatment. Much of this deactivated equipment came from other facilities over the years and was stored in U Plant (in cells and the canyon deck) (Figure 2). Removable concrete blocks cover each cell and provide access to the cells. Some of the process cells are highly contaminated with process-related radionuclides including strontium-90, cesium-137,

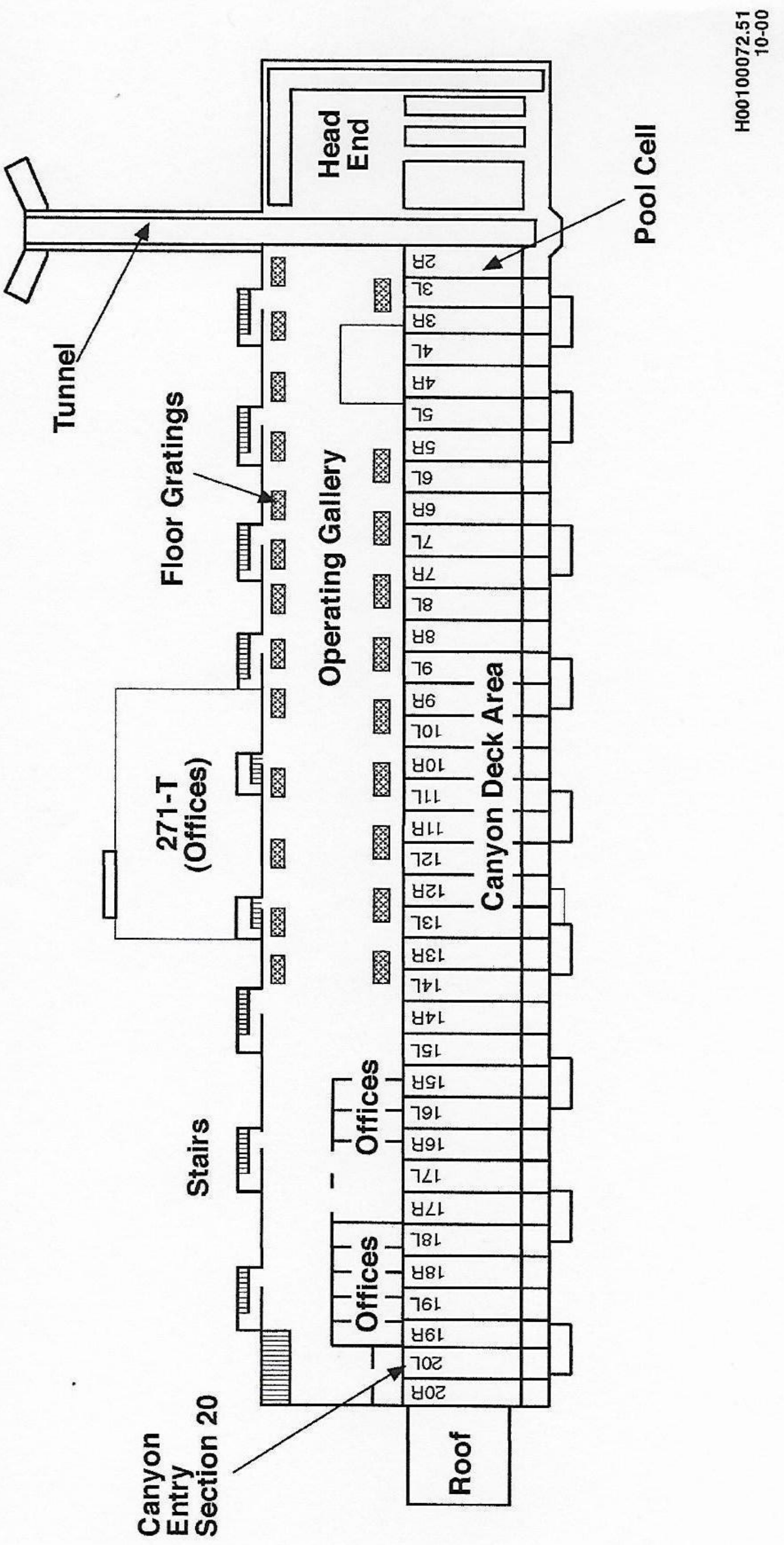


Figure 7. 271-T Building and 221-T Building Second Floor Cell Layout.

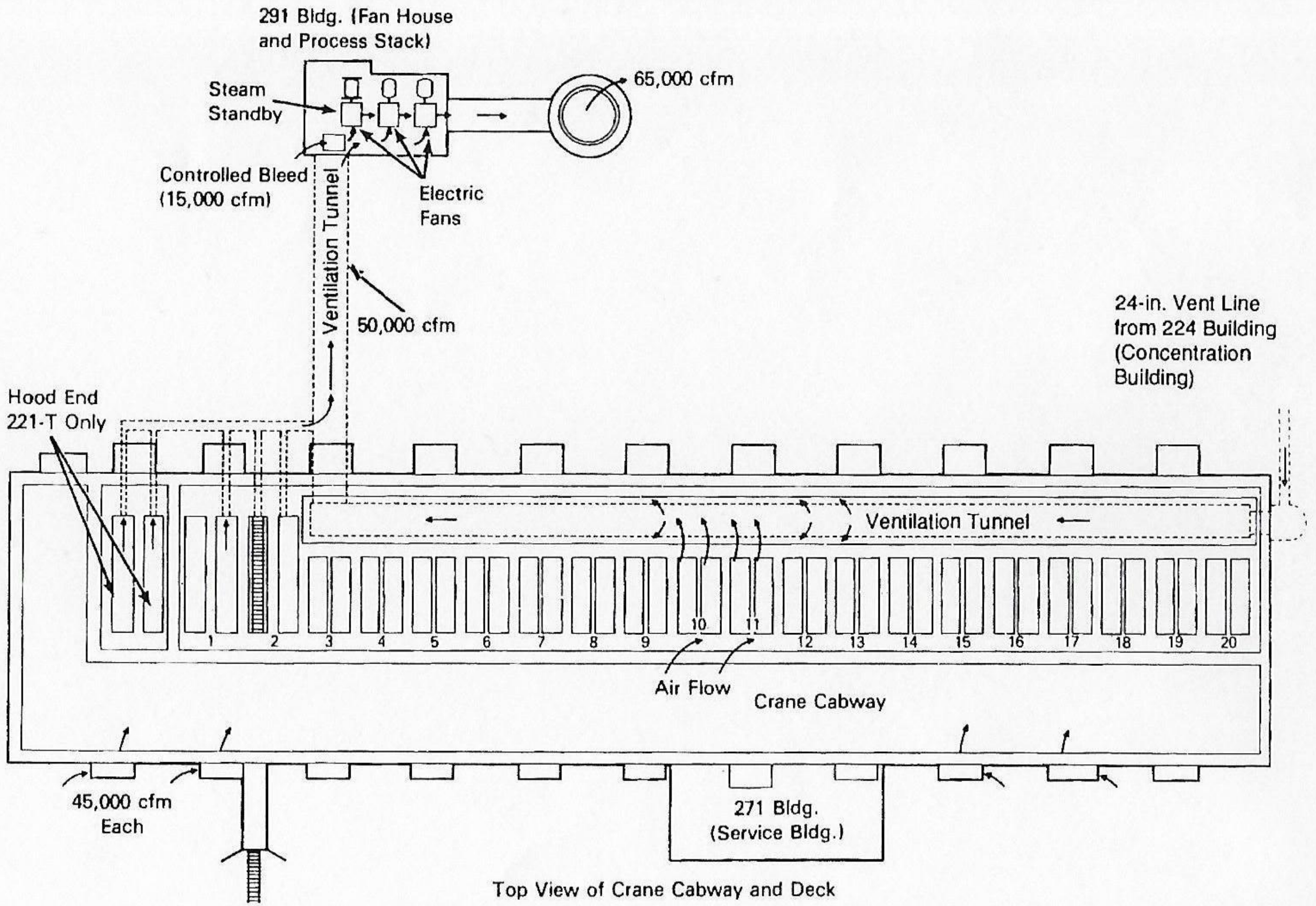
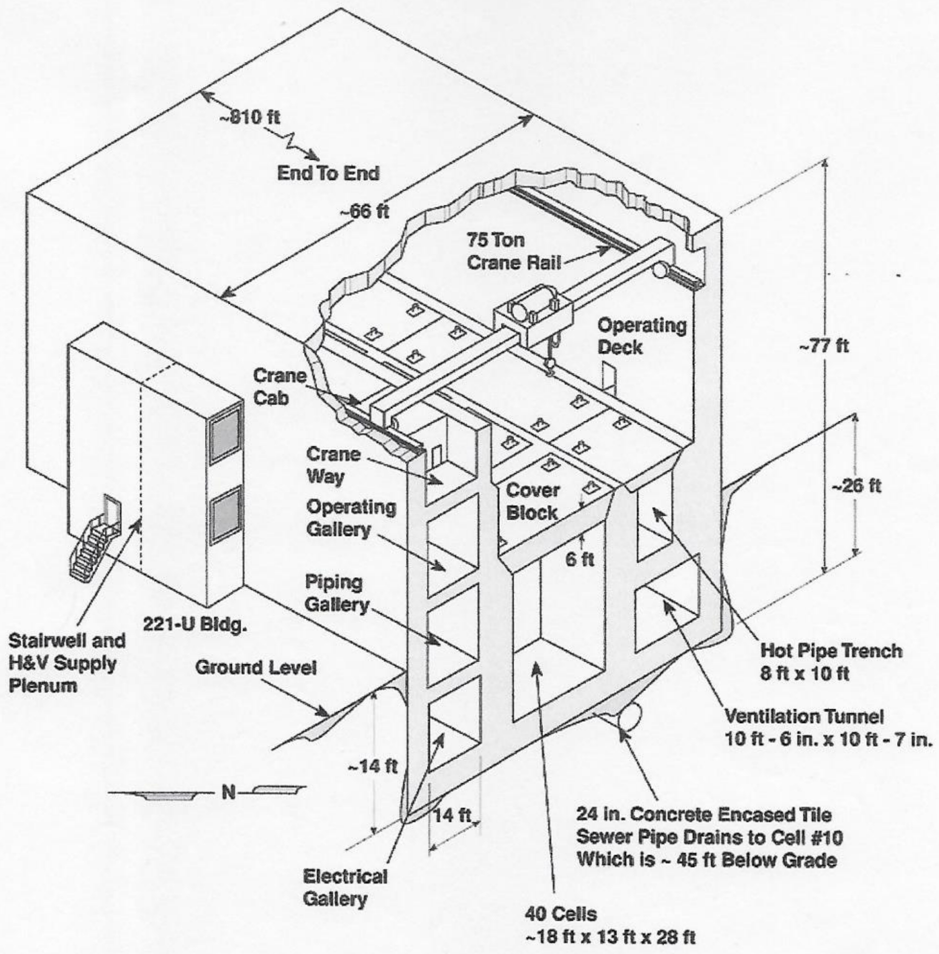
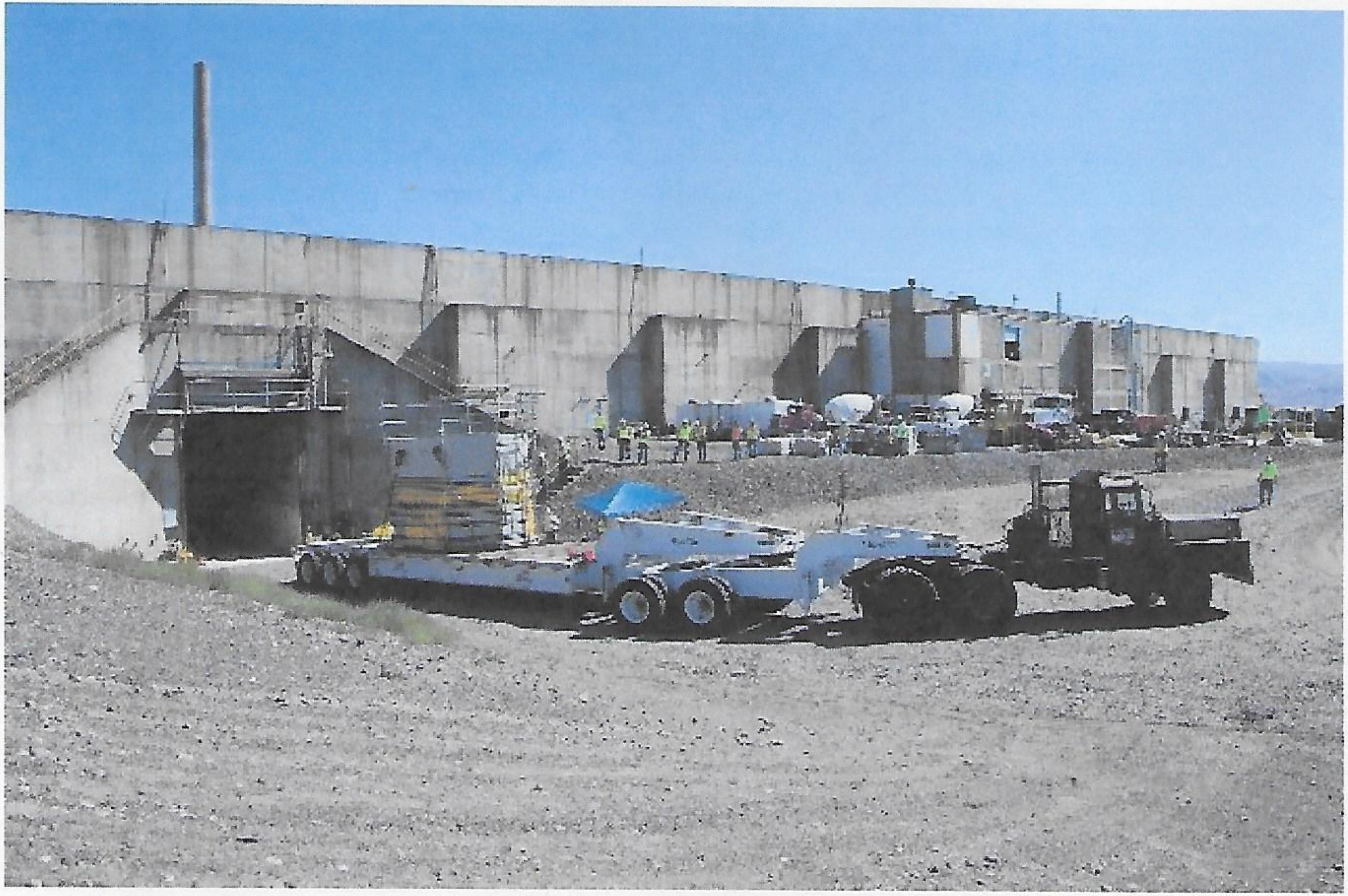


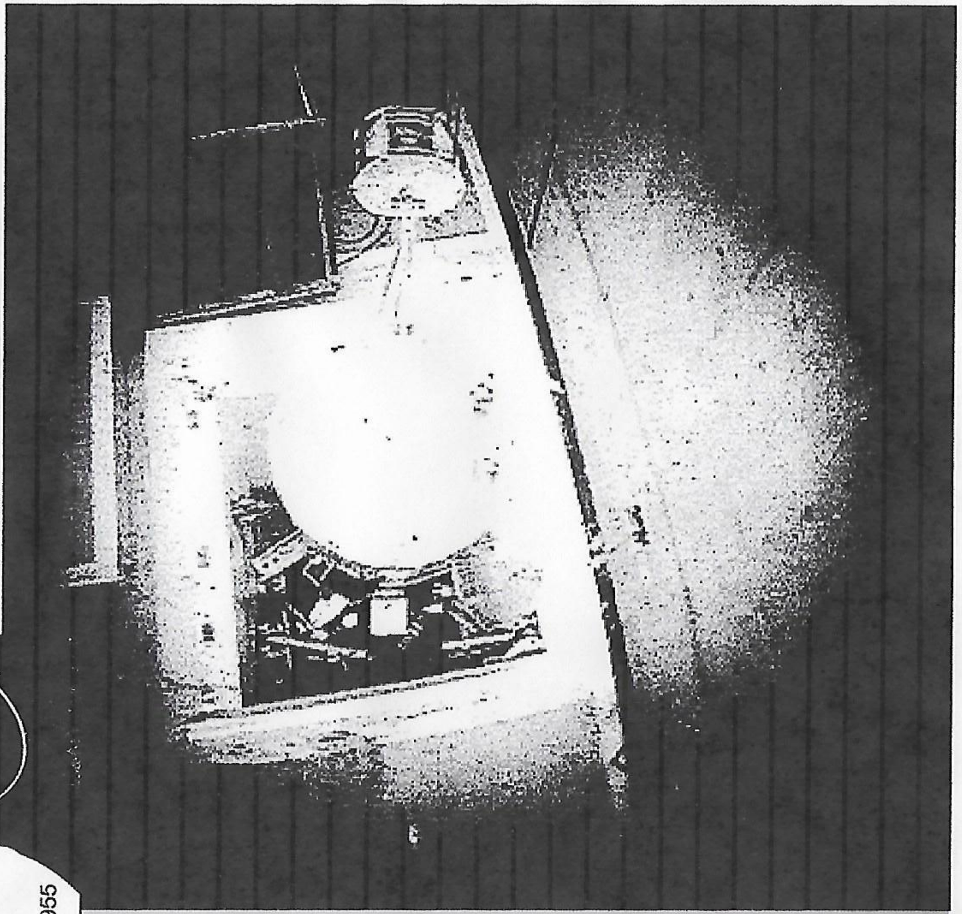
FIGURE 4.3. Ventilation Diagram of Processing Area Canyon (221) Building (E. I. du Pont de Nemours and Company 1944)

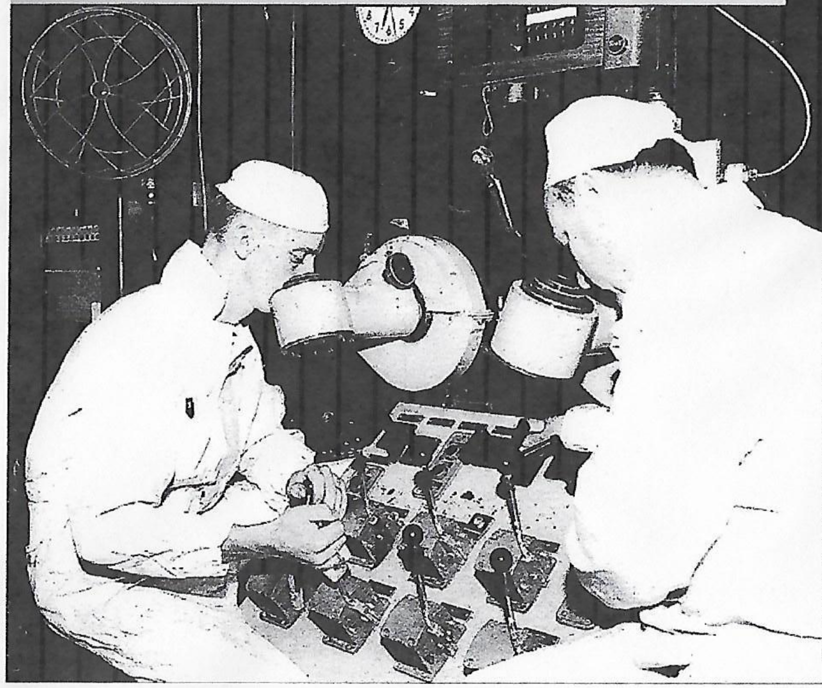
221-U Canyon Building Section





Operators in a Canyon building





Pictures for Life Magazine taken in 1955

UNINTENDED CONSEQUENCES

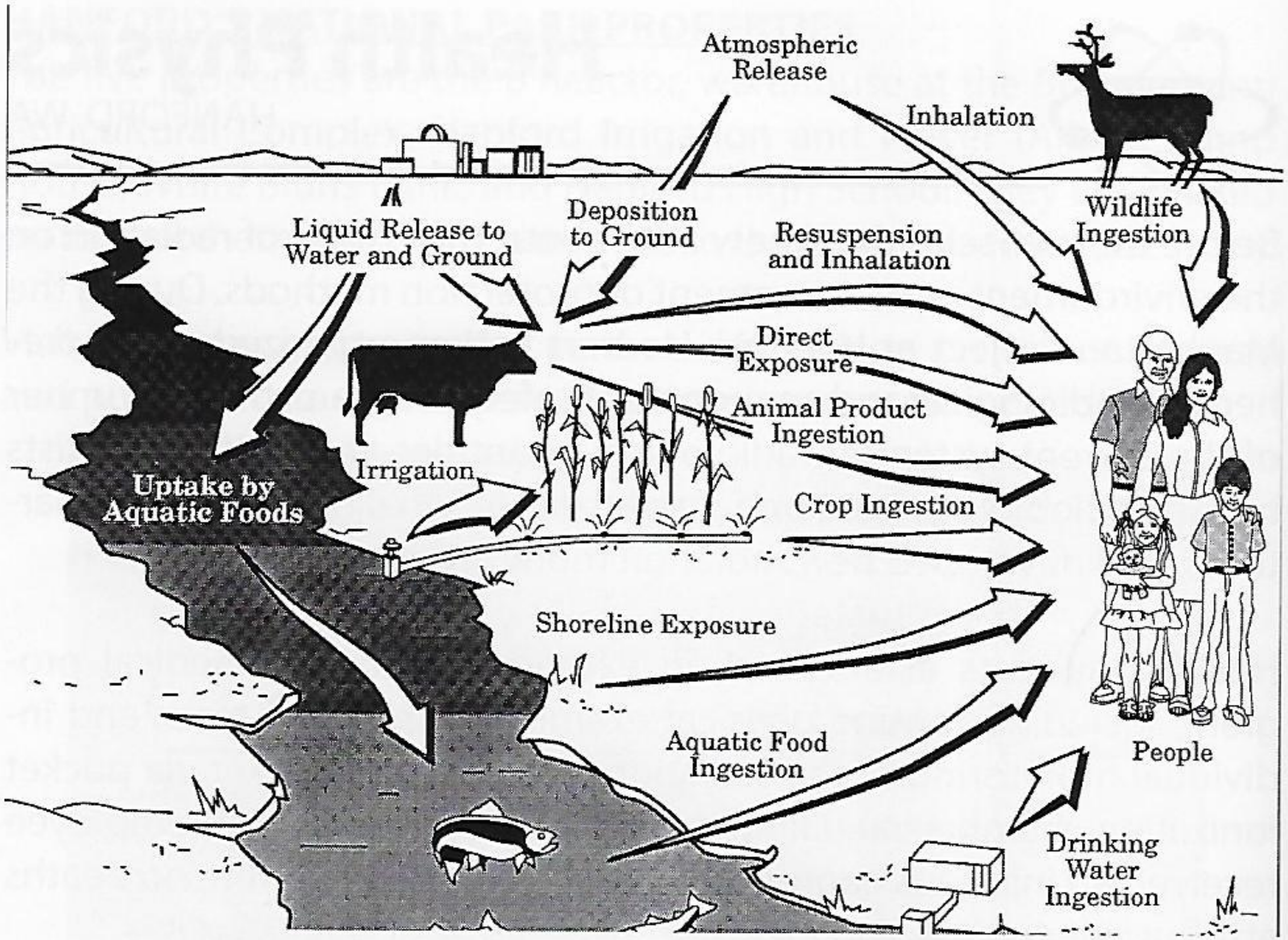


Diagram showing how people could have been exposed to radioactive materials from Hanford

Image courtesy of the U.S. Department of Energy, Hanford Collection, HASI_1996_001_213

Tiny cracks, big effect

by Eric Sorensen :: Of all the troubling images evoked by the Hanford Nuclear Reservation, the nation's most contaminated nuclear site, the plume of uranium-tainted groundwater seeping into the Columbia River comes near the top of the list. Millions of gallons of radioactive waste were processed at the site and, starting in the '40s, government scientists detected it in the area's groundwater.

One site, called the 300 Area, has a plume of several million gallons affecting a 3,000-foot stretch of the Columbia River shoreline. Monitoring wells and riverbank springs have had uranium levels in excess of drinking-water standards set by the Environmental Protection Agency.

The river provides drinking water to nearly a dozen water systems, including Richland, but so far, levels in the river itself have been negligible. Still, federal Superfund law requires that groundwater be returned to its "beneficial use." In other words, it needs to be drinkable again.

For a while, government scientists, cleanup contractors, and regulators envisioned a scenario where that would happen on its own. They removed and disposed of the top-most layers of contaminated soil in the mid-'90s and figured fluctuating groundwater levels would in effect wash away the remaining uranium, carrying it to the river at low enough levels over the course of a decade or so.

That has not happened. Kenton Rod ('12 PhD) looked closely—very closely—at the soil beneath the 300 Area and found it has a way of holding on to uranium, slowing its release into the environment.

"Nothing is going to happen fast here," he says.

Just why that is gets at the curious nature of soil, which Rod notes is "one of the most complex mediums that a scientist can investigate."

Sitting in a common area of the WSU Tri-Cities campus, he explains how soil has a mix of physical, biological, and chemical properties, while at the same time serving as an interface of solid, liquid, and gas.

"You try and pick those elements apart and it's not an easy task," he says.

In the case of the 300 Area's uranium waste, a byproduct of the process that made plutonium for the Nagasaki-bound atom bomb "Fat Boy" and the Cold War arms race, Rod saw something very small—the chemistry and structure of individual soil particles—having an inordinate effect on the area's 300-plus acres.

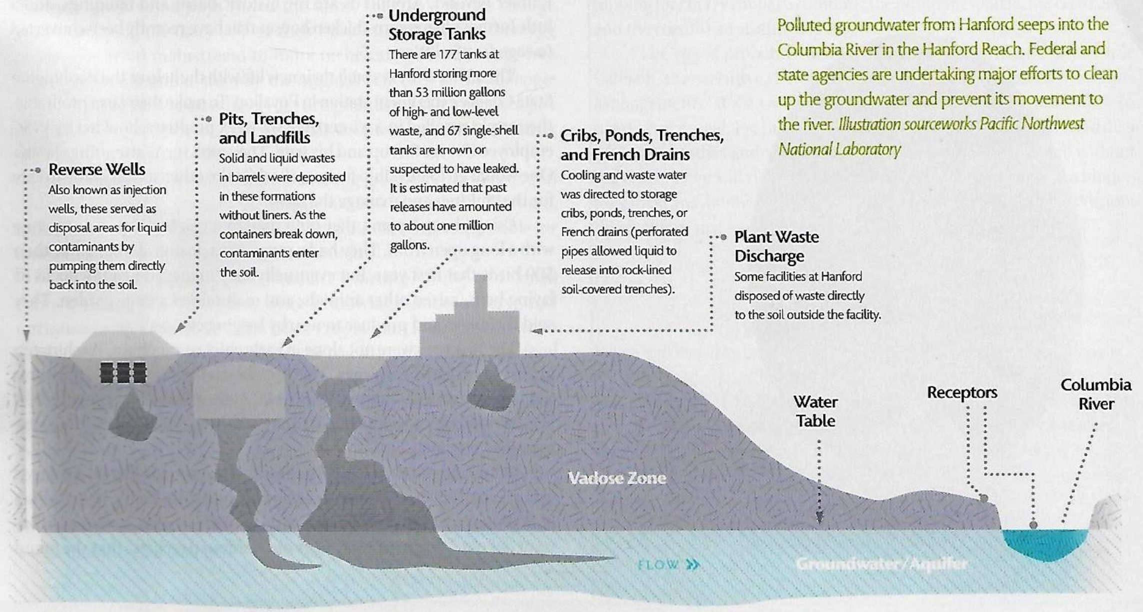
The soil, says Rod, wants to hold on to a certain amount of uranium all the time and will resist efforts to be rinsed clean. There is also a limit to how much uranium the water will want to pick up, just as there is only so much sugar you can put in your coffee before it's saturated.

But having a far greater effect, Rod found, are cracks in the soil particles. They are nanometers thin, which is to say they are measured in millionths of a millimeter. And once uranium enters, the crack is like a bottle in a dishwasher: water has a hard time getting it out.

"Add all those up and that's what helping these uranium plumes persist in the groundwater," says Rod. "But it's letting enough go, that it's keeping the groundwater above EPA standards. It is letting it go, just very slowly. It's a very slow process. It's going to be a while. People are keeping their eyes on it."

Indeed, in 2011 the Department of Energy released a draft proposed plan for remediating the 300 Area and noted that scientists were not seeing an expected decline in groundwater uranium levels.

"There's a continuing source," says Mike Thompson, a department hydrogeologist working on the area. The department is now proposing to put phosphates in the groundwater and soil above it. The phosphates will attach to the uranium, says Thompson, converting it into a more stable, less mobile, and otherwise insoluble mineral.



Polluted groundwater from Hanford seeps into the Columbia River in the Hanford Reach. Federal and state agencies are undertaking major efforts to clean up the groundwater and prevent its movement to the river. *Illustration sourceworks Pacific Northwest National Laboratory*

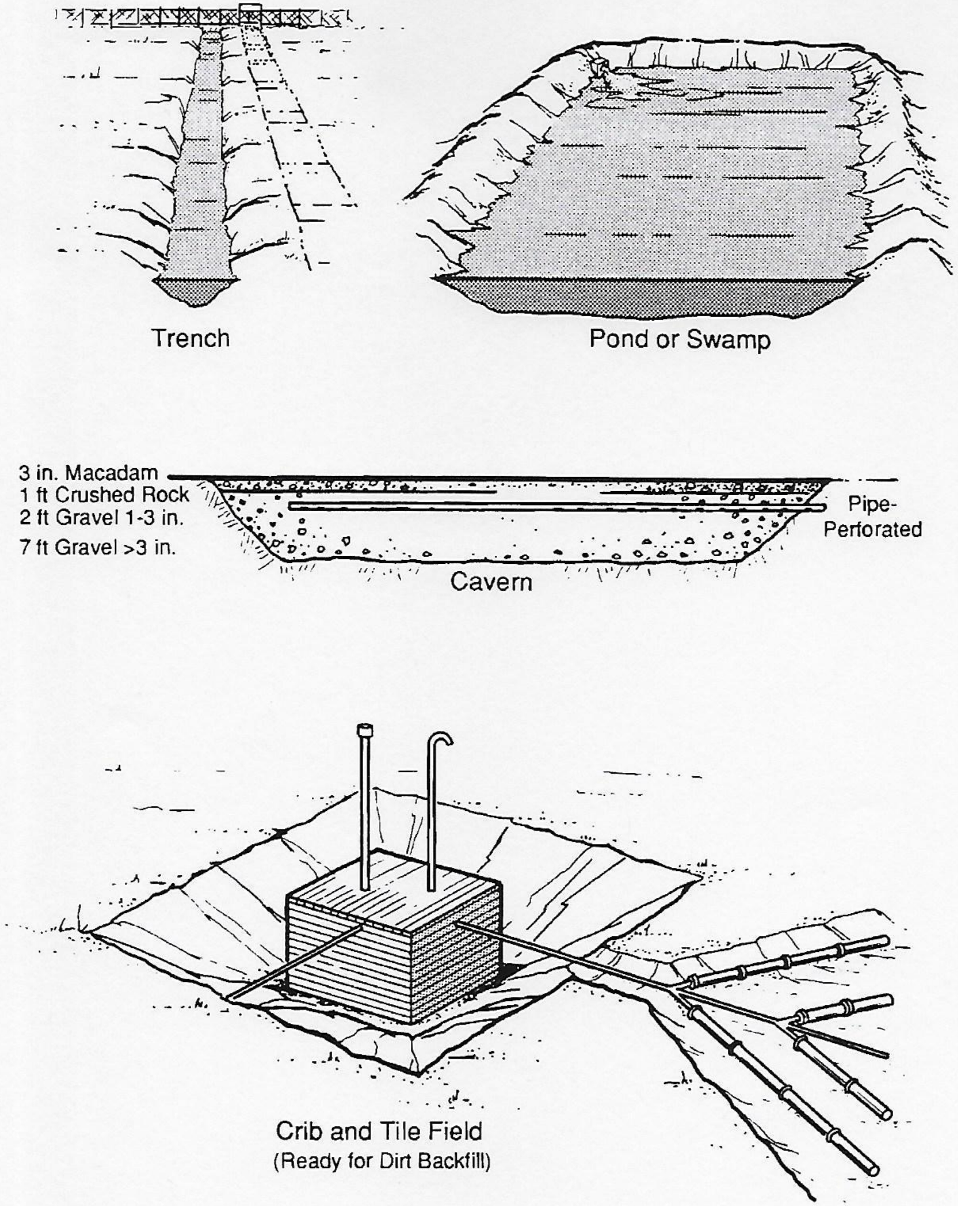


FIGURE 4.8. Typical Ground Disposal Facilities (Brown et al. 1956)

A tank farm on the Hanford reservation under construction
Photo courtesy of the U.S. Department of Energy, Hanford Collection, HASI_1996_001_2116

2.0 Tank Waste History Summaries

Between 1943 and 1964, 149 SSTs were built for storing radioactive wastes generated by the chemical processing of irradiated reactor fuels. The SSTs are located in 12 tank farms in the 200 West and 200 East Areas on the Hanford Site. Figure 2.1 is a reference schematic of these SST farms and the associated six double-shell tank (DST) farms. The capacities of the SSTs range from 208 m^3 (55,000 gallons) to 3,785 m^3 (1,000,000 gallons). Carbon steel lines the bottom and sides of the reinforced concrete shell of each tank. The tanks are below grade with at least 6 feet of soil covering them. A sketch of a typical SST is provided in Figure 2.2.

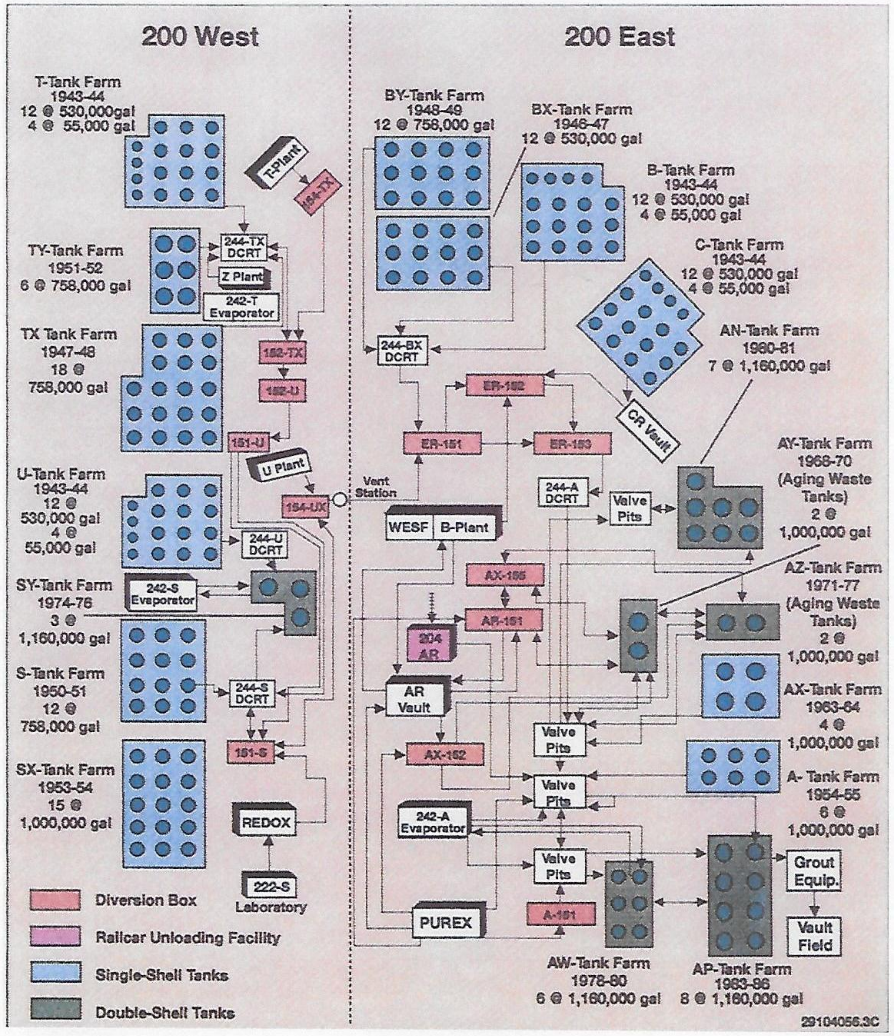
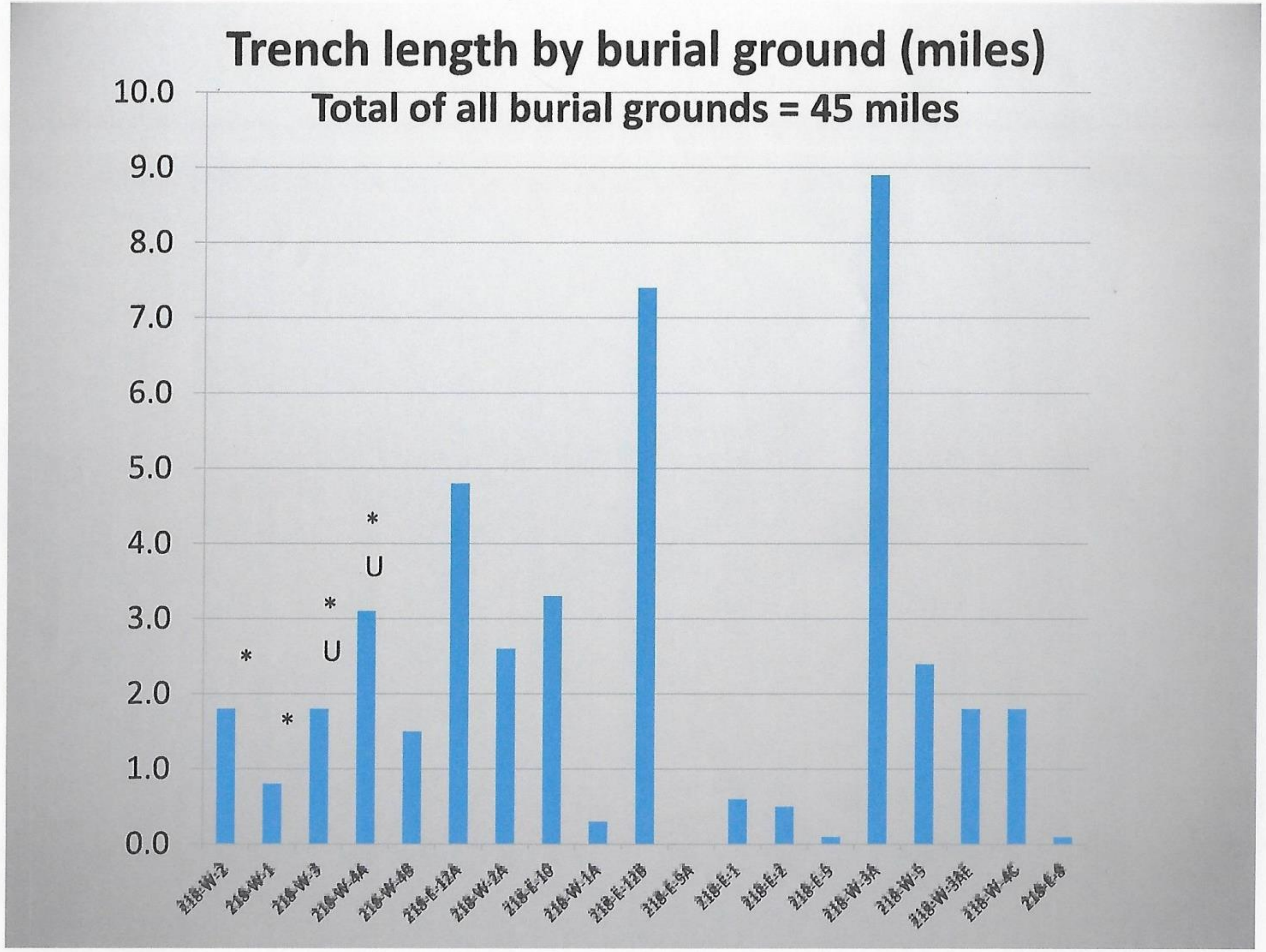
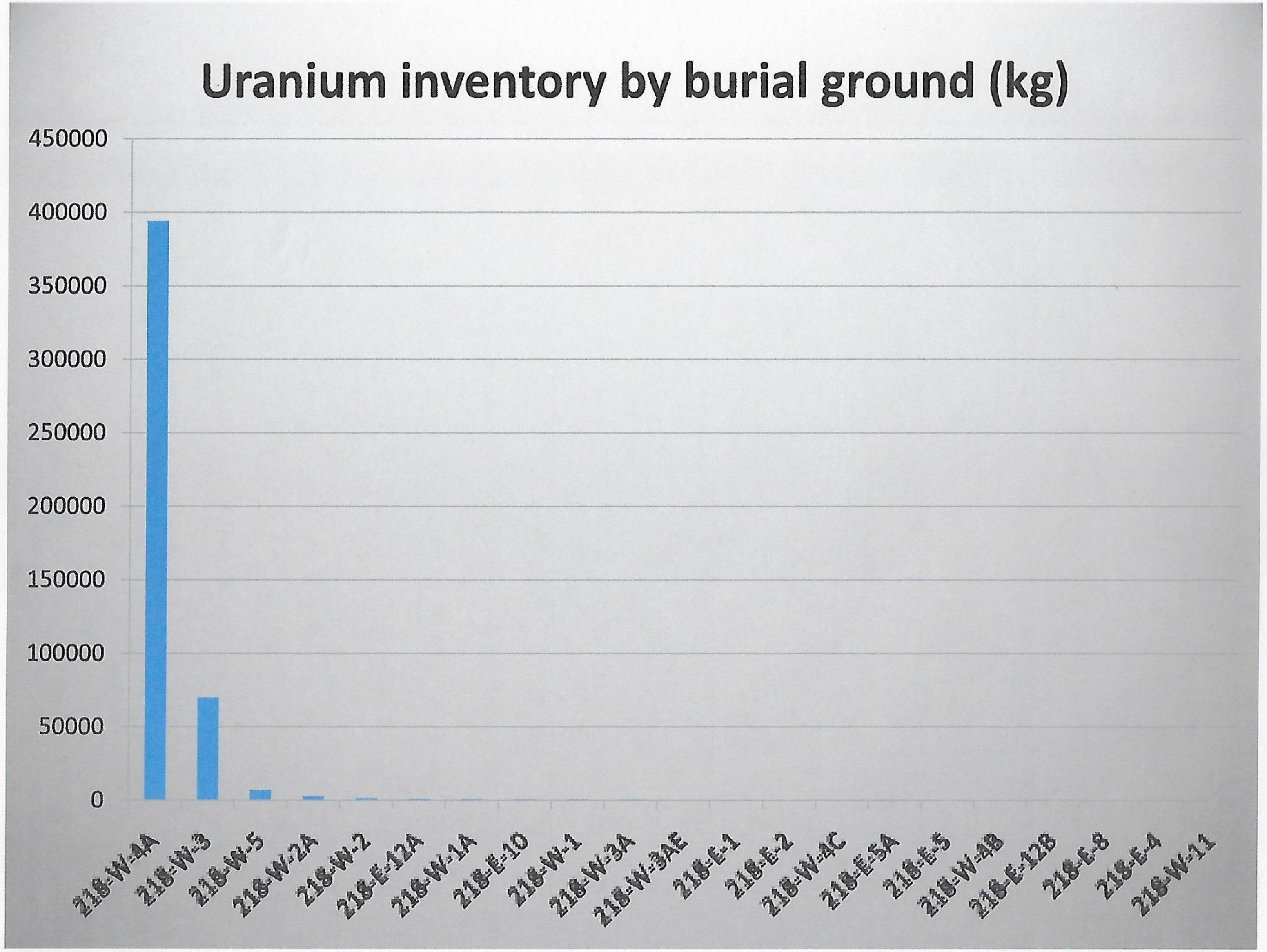
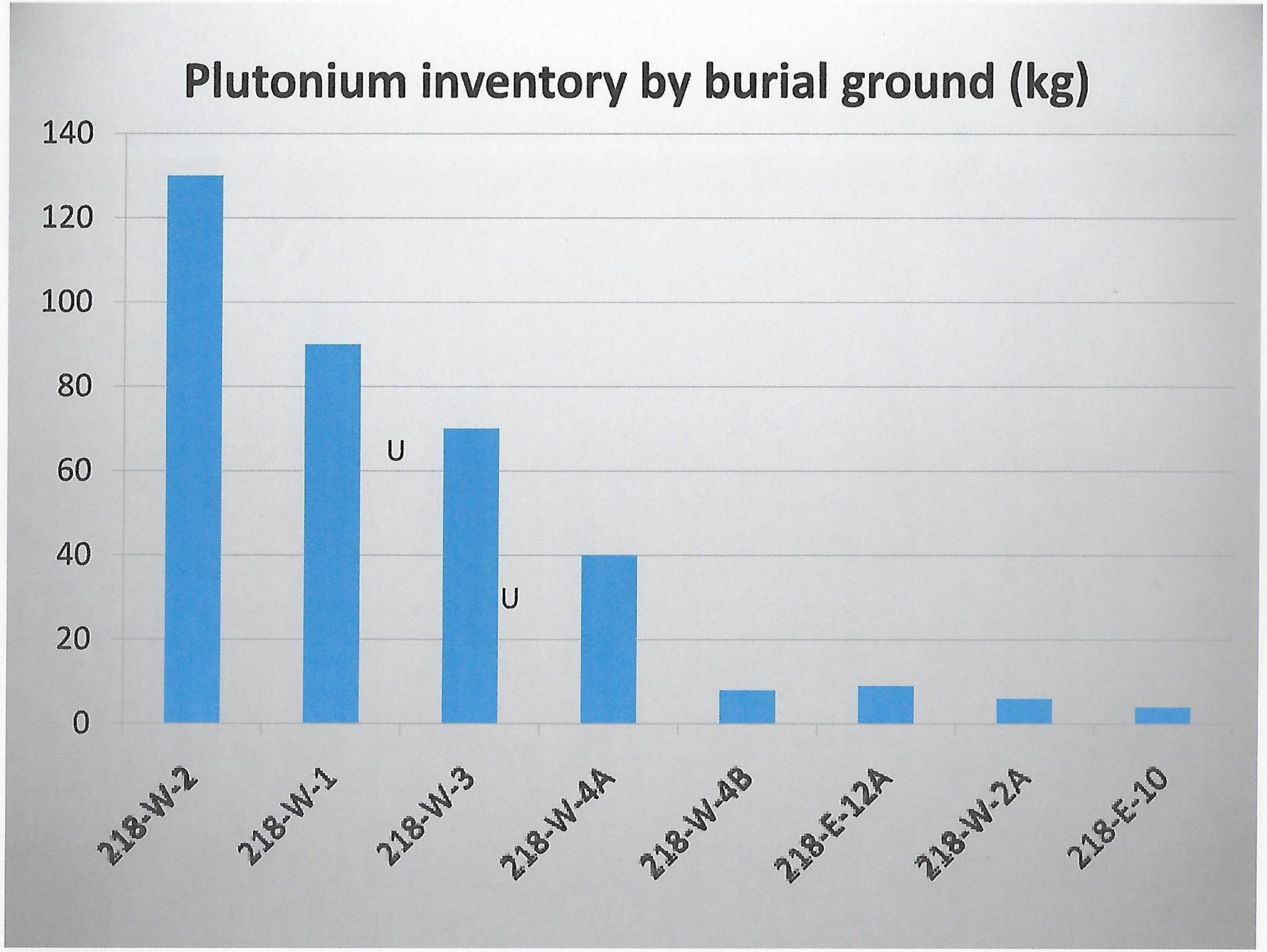


Figure 2.1. Hanford Site Tank Farms



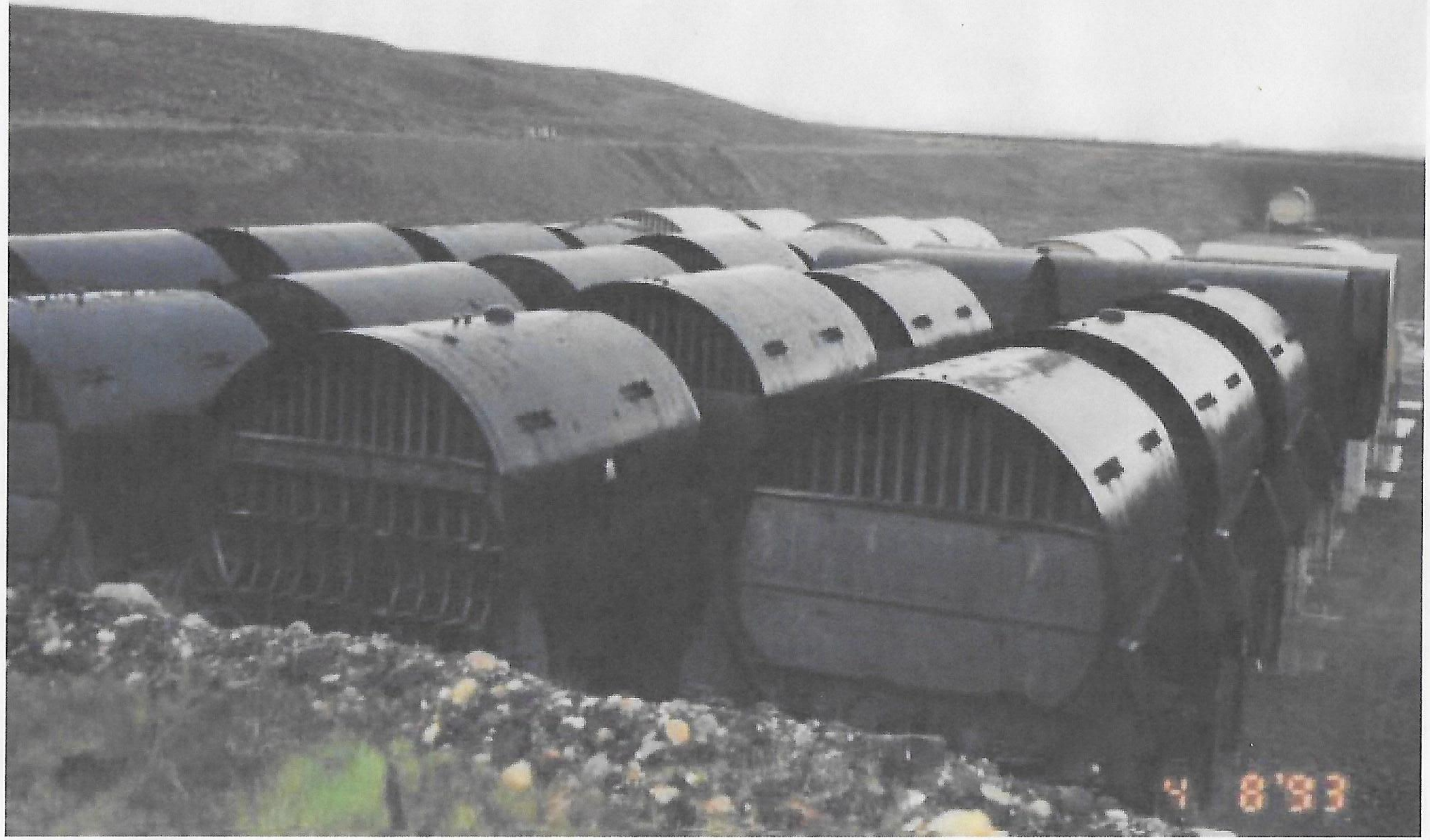
Trench length by burial ground (miles)
Total of all burial grounds = 45 miles
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
*
*
*
U
*
U
218-W-2
218-W-1
218-W-3
218-W-4A
218-W-4B
218-E-12A
218-W-2A
218-E-10
218-W-1A
218-E-12B
218-E-9A
218-E-1
218-E-2
218-E-5
218-W-3A
218-W-5
218-W-3AE
218-W-4C
218-E-8


Uranium inventory by burial ground (kg)
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
218-W-4A
218-W-3
218-W-5
218-W-2A
218-W-2
218-E-12A
218-W-1A
218-E-10
218-W-1
218-W-3A
218-W-3AE
218-E-1
218-E-2
218-W-4C
218-E-5A
218-E-5
218-W-4B
218-E-12B
218-E-8
218-E-4
218-W-11



Plutonium inventory by burial ground (kg)
140
120
100
80
60
40
20
0
U
U
218-W-2
218-W-1
218-W-3
218-W-4A
218-W-4B
218-E-12A
218-W-2A
218-E-10

Trench 94
Nuclear submarines/cruisers



56 million gallons of Hanford's high-level radioactive waste is contained in 177 underground waste tanks. More than a third have leaked, and nearly all are beyond their design-lives. 28 of the tanks are double-shell tanks and 149 are single-shell tanks.

- At least one million gallons of high-level radioactive waste has leaked into the soil and groundwater under the tanks. Sixty-seven tanks have been known to leak in the past, one double-shell tank has failed and is currently leaking waste into the space between the two shells of the tank.
- The leaked waste is a huge cleanup challenge. The tanks are able to accommodate between 55,000 to 1,000,000 gallons of waste and are buried about 7-8ft. under the soil. The majority of the leaked waste is under the tanks in the vadose zone, the area between the surface of the soil and the groundwater, and some of the waste has reached the groundwater.
- In addition to the waste *inside* the tanks, waste was also deliberately discharged to the soil. An estimated 120 million gallons of waste from the Hanford tanks were directly ejected into the soil in this manner.
- The tanks hold waste created during the process of extracting plutonium from spent fuel, and contain both radioactive and chemical waste. It has also separated out into sludge, liquid, solids, and vapors. Its complexity, along with the fact that it is highly radioactive, caustic, and toxic, makes it particularly difficult and dangerous to treat.

The only plan for dealing with Hanford's tank waste is to immobilize the waste in glass through a process called vitrification. The Waste Treatment Plant (WTP) is being built for that purpose, however it is riddled with design problems, delays, and an escalating cost. It is also not designed to have the capacity to treat all of hanford's tank waste, so additional vitrification capacity, i.e. new facilities, will be required.

- Potential short-term fixes include building new tanks to provide space for waste in leaking tanks; building barriers over some of the tank farms to prevent water from further mobilizing the contamination until the waste can be pumped out of the tanks; and looking at other treatment technologies.
- There are no estimates available from the DOE about how much the WTP will cost, but taxpayers have already spent billions of dollars so far, and costs may exceed $20 billion for design and construction alone. Operational costs may be as high as $45 to $60 billion. The WTP needs to work safely and effectively to remove and stabilize the waste from Hanford's aging tanks. Efforts to build a vitrification plant started in the late 1990's and have stopped and started repeatedly. The latest effort (the fourth attempt) was initially scheduled to operate in 2019, but it is now not expected to reach full capacity until 2036 or later. Hanford Challenge has called for the dismissal of the contractor and for work at the WTP to stop while new tanks are built, and while an independent review both evaluates whether the plant can be salvaged and investigates alternatives.
- Decisions about what to do with the tanks themselves and the waste that is difficult to remove have yet to be made. It will be extremely challenging to remediate the vadose zone contamination without removing the tanks. If we want to protect future generations from that waste, it must be removed.
- Working around the tanks is a hazardous job. Exposure to toxic chemical vapors that vent from the tanks is a major concern. Since March 2014, over 100 workers suffered vapor exposures serious enough to seek medical evaluation. Serious reforms are needed to protect workers from these hazards and provide them with good medical treatment.

DOE - Department of Energy
Hanford Lifecycle Scope, Schedule & Cost

(Current Hanford Budget ~ 2.5B $/Yr)

Year

2016 (Complete)	**2019 (Complete)**
Best Case	
$ 103 B	**$ 323 B (2079)**
Worst Case	
$ 107 B (2066)	**$ 677 B (2102)**