Hanford PUREX Tunnel 2 Stabilization

Current Status of Activities

Recent Investigations

2017 Structural Integrity Evaluation (Recap)

Updated Evaluation of Select Structural Elements

Nuclear Safety Perspective on Increased Risk

Background on Tunnel 2

August 2018

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CH2M HILL Plateau Remediation Company
Chief Operating Officer

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Current Status of Activities

- Grout trial batch testing and conveyance system mock-ups complete
- Road preparations complete
- Mobile grout plant set up, testing next week
- Temporary Authorization (partial) received Aug. 13
- Conveyance system installation underway
- **Will be ready to grout by Sept. 6**

Grout plant located outside PUREX boundary, 8/20/18

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Grout Conveyance System

Grout conveyance systems (1 of 6) to be installed in Tunnel 2, 8/16/18

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2018 Investigation

- Investigation Summary
  - Opened 14 of 17 risers (inner 3” steel observation port)
  - Conducted 360 degree camera inspection
  - Collected radiological and industrial hygiene data from risers and tunnel interior
  - Removed six – 30” concrete plugs (at identified grout points)
  - Closed and restored all risers to original condition

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Investigation – Railcar Placement

- Exact location of risers and railcars relative to risers confirmed

During grouting, Riser 2 will be connected to a passive HEPA filter
Risers 3, 5, 8, 11, 14, and 16 are grout insertion points, includes video cameras
Risers 4, 7, 9, 10, 12, 15 and 17 will have extra lighting installed
Risers 1, 6, and 13 not used

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Investigation - Radiological Results

- Air Sampling
  - Limited to no detectable airborne
  - No detectable hazardous vapors
- Vertical Dose Distribution
  - Includes shine from multiple cars
- Maximum Dose in each Riser (mRem/hr)

Riser 7	Elevation	Dose (mrem/hr)
Surface	1’	0
	3’	0
	6’	1
Top of Tunnel’	9’	2,680
	12’	2,380
	15’	1,720
	18’	1,250
	21’	1,080
	24’	900
	27’	570
Deck of Railcar	30’	970
	33’	900
Floor	35’	630

Canyon → Exhaust

Riser	Maximum Dose (mRem/hr)
1	No data
2	<0.5
3	3.0
4	30
5	1,500
6	No data
7	2,680
8	650
9	710
10	140
11	1,120
12	980
13	No data
14	1,088
15	17
16	1,400
17	5,570

Vertical dose example

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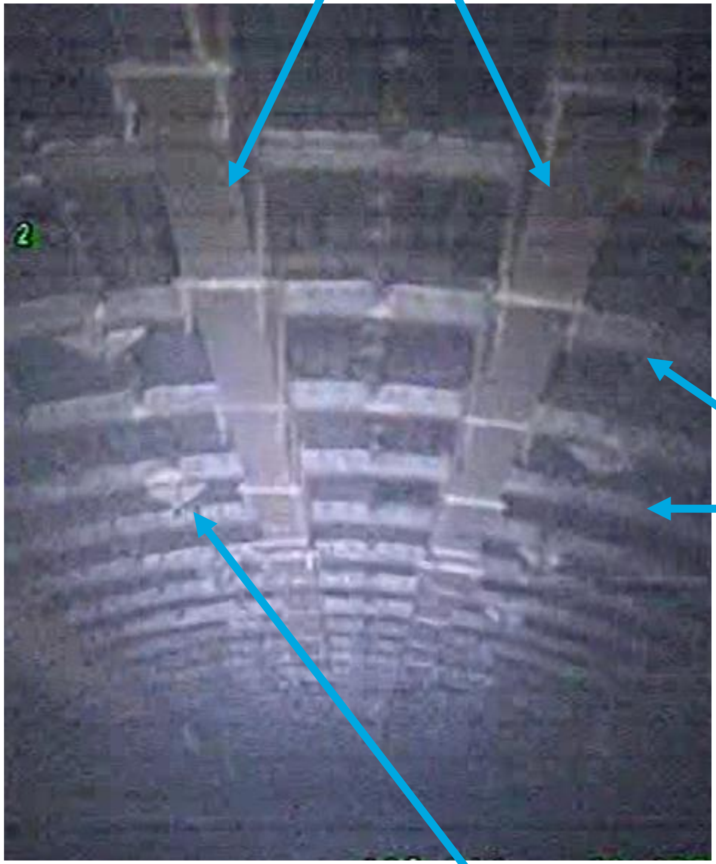
Investigation – Condition of Structure (Riser 2)

Wale Beams

Arched Rib-beam/splice



Arch Steel Ribs

Arched Rib-beam/splice

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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Investigation – Condition of Structure (Riser 16)

Wale Beams

Arch Steel Ribs

Wale Beam Anchor

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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Structural Evaluation - 2017 Methodology

Inputs:

- Construction drawings, photos and other files used
- As-built drawings have not been located
- Material properties, particularly soil, are not well known

Methodology:

- Based on 2012 International Building Code
- Load and resistance factor design techniques

Other Considerations:

- Current design standards are more rigorous and conservative than those used decades ago
- Older structures often exceed today's design-to-capacity (DCR) ratios
- Tunnels contain significant quantities of radioactivity
- Personnel entries into tunnels are too hazardous

Tunnel 2 (under construction in early 1960s)

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What is a Design-to-Capacity Ratio (DCR)?

Comparison of a structure's capacity versus the actual load

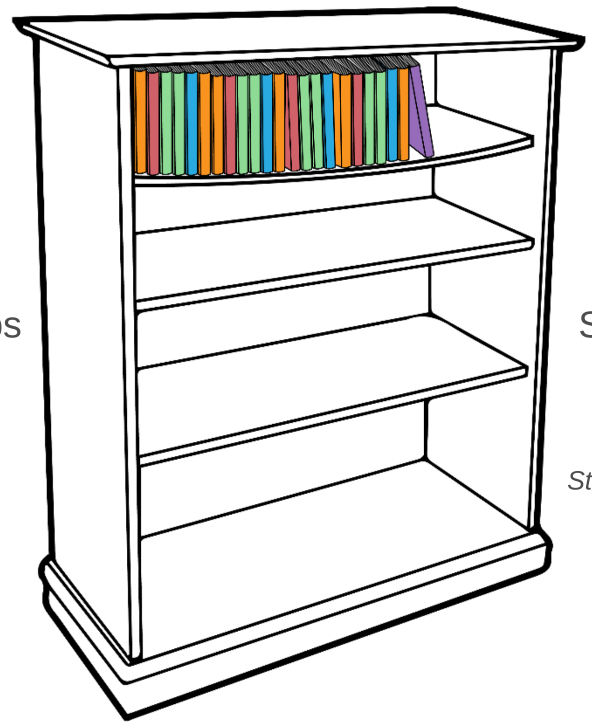
$$\frac{\text{Load}}{\text{Capacity}} \leq 1.0$$

Bookshelf 1

Shelf Load: 40 lbs
Shelf Capacity: 40 lbs

DCR=1.0

Structure likely not to fail



Bookshelf 2

Shelf Load: 60 lbs
Shelf Capacity: 40 lbs

DCR=1.5

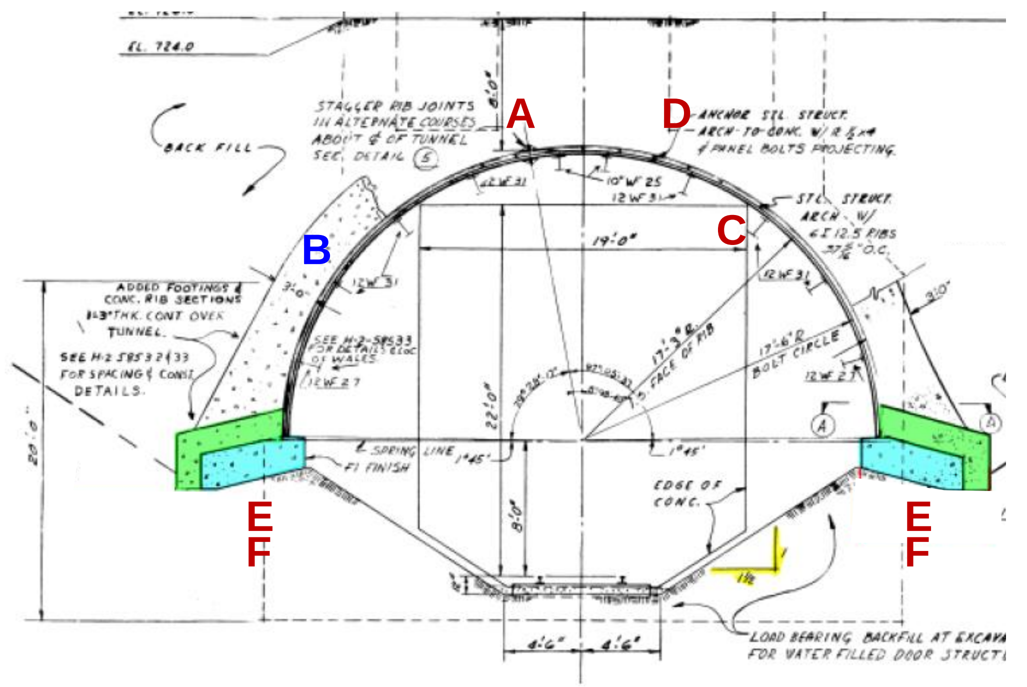
Structure at greater risk of failing

DCR greater than 1.0 is problematic

Tunnel 2 Structural Evaluation Results - 2017

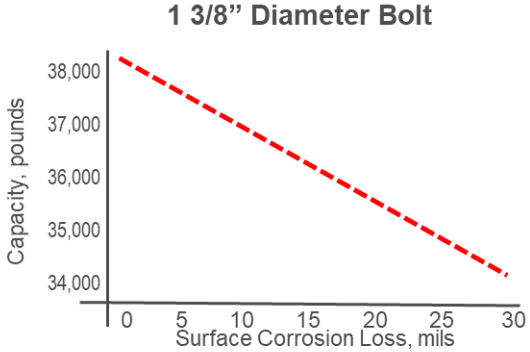
Element*	Max DCR
A: Arched Rib-beam/splice	1.09
B: Concrete Arch Girders	0.59
C: Steel Wale Beams	1.12
D: Wale Beam Anchors	1.04
E: Concrete Footing	1.09
F: Foundation Soil Load	1.03

Not all elements listed



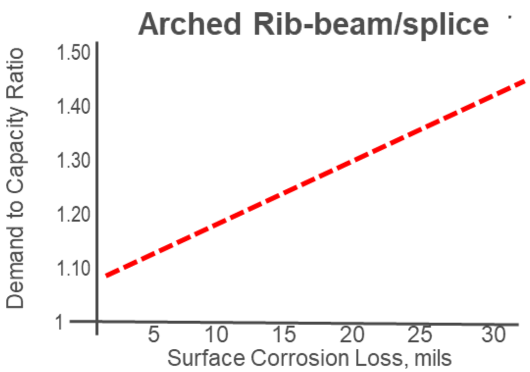
Loads on multiple structural members exceed building code design capacities; Tunnel 2 has a 'potential high' risk of collapse

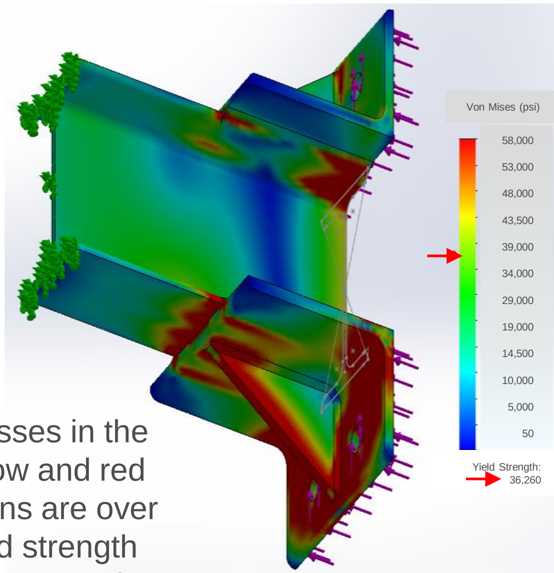
Effects of Corrosion on Structural Elements



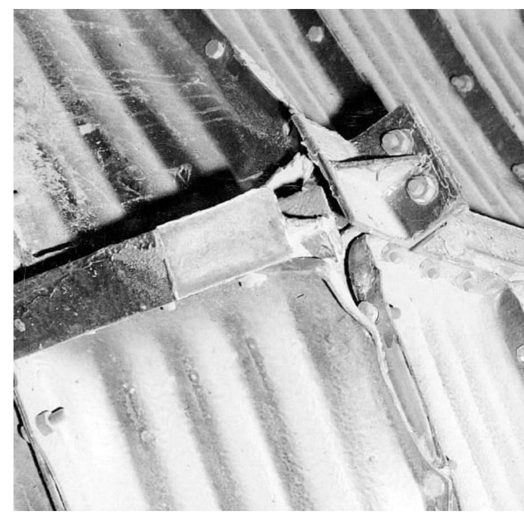
Industry Examples

Example: 1 3/8”, Grade 2 bolt, 4 mils of surface corrosion results in a ~1,000 lb reduction in load carrying capability (Paper is typically 4 mils thick)





Stresses in the yellow and red regions are over yield strength (DCR > 1.0)



Failed Arched Rib-beam/splice, c. 1963

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Tunnel 2 Structural – Updated Evaluation Results

Element*	2017 Max DCR	Updated Max DCR
A: Arched Rib-beam/splice	1.09	**1.45****
B: Concrete Arch Girders	0.59	No change
C: Steel Wale Beams	1.12	Indeterminant
D: Wale Beam Anchors	1.04	**Suspect**
E: Concrete Footing	1.09	No change
F: Foundation Soil Load	1.03	No change

**Not all elements listed*

*** Based in estimated 1/32" (0.031") loss of thickness, at 1/16" (0.063") the DCR could exceed 1.7*

Key elements are more overloaded than previously evaluated, the risk of failure is greater

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Risk and the ‘zipper’ effect

Risk is composed of the likelihood of failure and the consequence.

For complex structures the ‘zipper’ effect can greatly increase the consequence.

Consider a steel truss bridge – if one beam or connector fails, will the bridge fail?

Interstate I-35W in Minneapolis, MN

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Two Case Studies: Actual Structural Failures

Progressive Collapse of I-35W Bridge
(August 2007, Minneapolis, MN)

The 40-year-old steel truss bridge over the Mississippi River suddenly, and without almost any noticeable warning, collapsed entirely, killing 13 and injuring over 100.

Gusset plates thinner than today's code would allow and fatigue cracks had been noted.

Inspection reports showed the presence of corrosion on some gusset plates and adjacent areas, indicating that due to corrosion, some gusset plates and even some members may have thinned over the years and did not have the originally designed thicknesses at the time of collapse.

Asteneh-Asl, A., *Progressive Collapse of Steel Truss Bridges, The Case of I-35W Collapse*, 2008.

Structural Failures from Winter Snow
(December 2008/09, Spokane, WA)

Unusual pattern of heavy snowfall without intermittent melting caused heavy ground and roof loads.

Post-collapse evaluations were performed on 95 structures (wide variety of designs/materials).

Total collapses included one retail store with 'zipper' effect.

Most of the structural failures occurred prior to the roofs receiving more than the minimum basic roof snow load, thus other factors led to these failures.

Structural Engineers Association, Spokane Chapter, *Study of the Structural Failures associated with the Winter 2008-09 Snow Event in Spokane/Cour d'Alene Area*, 2009.

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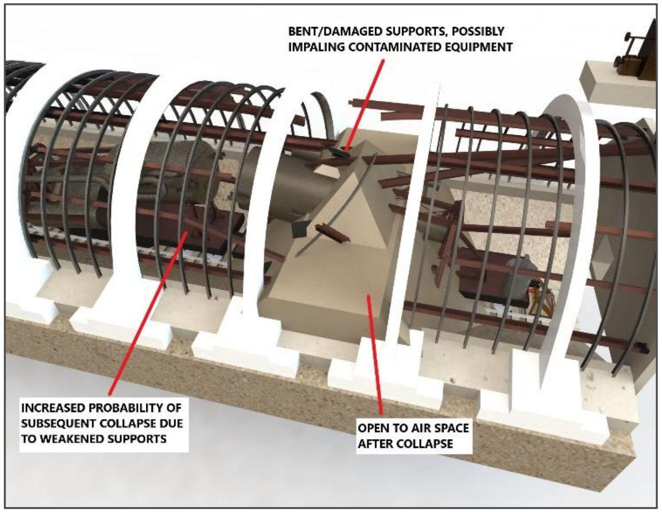
Nuclear Safety Perspective on Increased Risk

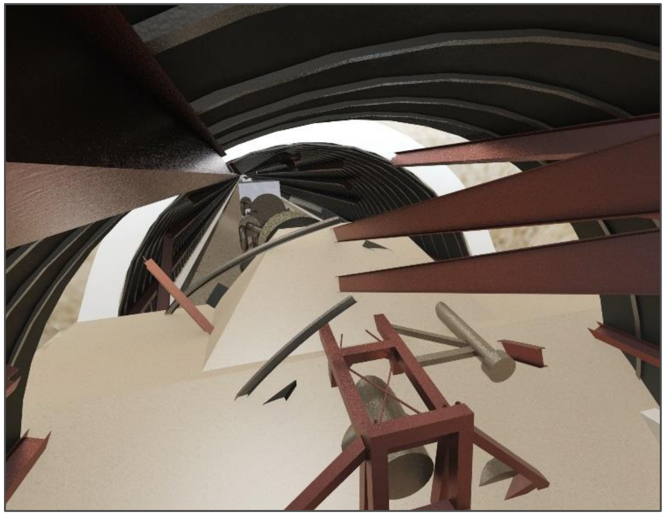
- Corrosion increases likelihood of failure.
- ‘Zipper’ effect increases potential severity.

		Severity			
		Negligible	Low	Moderate	High
Likelihood	Anticipated			2018	
	Unlikely		2017		
	Extremely Unlikely				
	Beyond Extremely Unlikely				

DOE Standard (DOE-STD-3009) *Preparation Guide for U.S Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*



Artist’s renditions of possible PUREX Tunnel #2 collapse



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Conclusions

- Structural failure must be anticipated
  - The time of failure— today, tomorrow or a year— is unknown.
  - Corrosion reduces the strength of the tunnel.
  - The full extent and rate of corrosion is unknown.
- Failure puts the workers, public and environs at risk from an airborne radiological release.

Background

Background - Why Tunnels?

Existing Rail Access

- Large equipment and fuel casks delivered via rail
- Rail cut below grade ~20 ft

Failed Equipment

- Too large for shielded casks
- Direct placement in ‘burial’ tunnel determined to be safest disposition

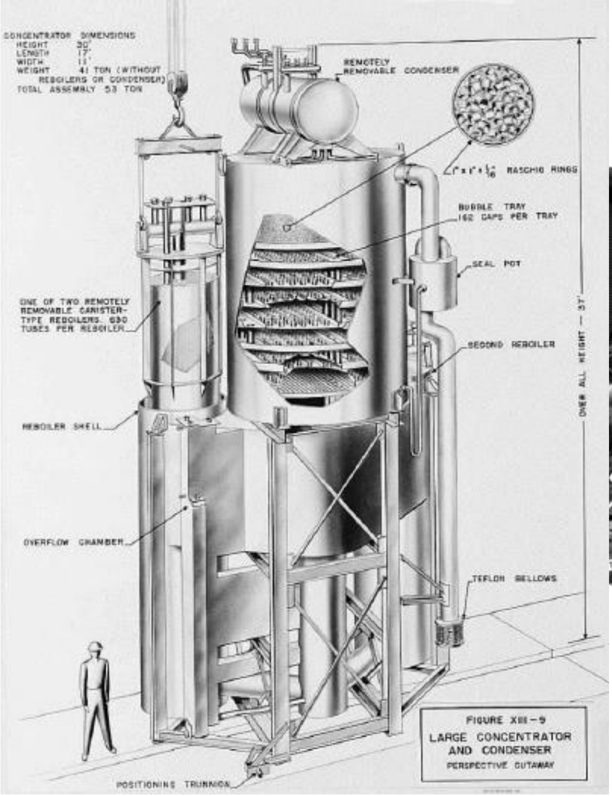
Capacities

- Tunnel 1 – 8 railcars
- Tunnel 2 – 40 railcars
- Tunnel 3 – never built

10. Equipment Disposal Facility(3) DECLASSIFIED

In other separations plants contaminated equipment which has failed is crated and hauled from the plant on flatcars to the burial ground. Owing to the size of some of the Purex equipment pieces, particularly the large concentrators, this method of equipment disposal becomes more difficult and costly. In order to minimize the difficulties, costs, and potential hazards encountered in handling large radioactive equipment pieces on the railroad right-of-way, a new facility has been added to the south end of the Railroad Tunnel. It consists of a 500-ft.-long extension of the tunnel into which failed equipment can be pushed on expendable flatcars. At the extension entrance is a "Y" for future addition of another disposal facility. A water-filled door will shield this area from the tunnel during routine operation.

PUREX Tech Manual – HW-31000 (1955)



Waste Concentrator

Pulse Column

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Background - What is in the Tunnels?

Examples*:

Position	PUREX #1 Storage Tunnel (218-E-14)
1. & 2.	HA column and miscellaneous jumpers in box placed in Tunnel #1 on 6/60 HA 4,700 Cu. Ft. Jumpers 2,190 Cu. Ft., Pb-~115 Kg
3.	E-F11 #1 (1WW Waste) Concentrator failed 7/24/60. Placed in Tunnel #1 on 7/29/60, 1,900 Cu. Ft.
4.	G-E2 Centrifuge, miscellaneous jumpers in box and two tube bundles. Placed in Tunnel #1 on 12/24/60. (FUG SER# 762) 2,465 Cu. Ft., Pb-~115 Kg.,
5.	E-H4 (3WB) Concentrator failed 1/4/61. Placed in Tunnel #1 on 1/4/61, 2,336 Cu. Ft.
6.	E-F6 (2\NW Waste) Original Concentrator failed 4/21/61. Placed in Tunnel #1 on 4/21/61, 2,336 Cu. Ft.
7.	E-F11 (1WW Waste) #2 Concentrator failed 2/1/62. Placed in Tunnel #1 on 2/8/62, 2,336 Cu. Ft.
8.	E-F6 (2WW Waste) #3 Spare Concentrator failed 5/23/64. Placed in Tunnel #1 on 1/22/65 Flat Car 3621, 2400 Cu. Ft.

Position	PUREX #2 Storage Tunnel (218-E-15)
1.	E-F6 # (2WW Waste) Concentrator, TK F 15-2, One tube bundle and agitator motors, placed in Tunnel on 12/12/67 on Car 61439. 2,400 Cu. Ft.
2.	E-F6 #5 (E-H4 3WB) Concentrator, two tube bundles placed in Tunnel on 3/26/69. On Car MILW 60883, 2,400 Cu. Ft.
3.	E-F6 #6 (2WW Waste) Concentrator, two tube bundles failed placed in Tunnel on 3/19/70. On Car 3612, 2,400 Cu. Ft.
4.	L Cell Package in a sealed steel box (H2-66012) placed in Tunnel on 12/30/70 on Car MILW 60033, 2,400 Cu. Ft.
5.	F2 Silver Reactor, F6 Demister, Vessel Vent Line, Steel Catwalk and Guard Rails, placed in Tunnel on 2/26/71. On Gondola Car 4610, 2,400 Cu. Ft., Ag-~625 Kg
6.	Modified A3-1 tower, scrubber, liquid, and vapor line placed in Tunnel on 12/12/71. On Gondola Car 4611, 2,400 Cu. Ft.
7.	A3 Dissolver placed in Tunnel on 12/22/71. On 9 Ft. shortened Car B58, 2,400 Cu. Ft., Hg--~45 Kg.
8.	A1W1 Fuel ends in steel liner box and NPR fuel handling equipment. Used with the suspected canisters, on Car 19808. Placed in Tunnel on 8/29/72, 800 Cu. Ft.

** from WA7890008967, Hanford Facility RCRA Permit Dangerous Waste Portion, PUREX Storage Tunnels, similar information available for all cars*

Failed equipment (on right) being inserted into Tunnel 2

Last Manned Entries

Tunnel 1 - 1965

Tunnel 2 - 1996

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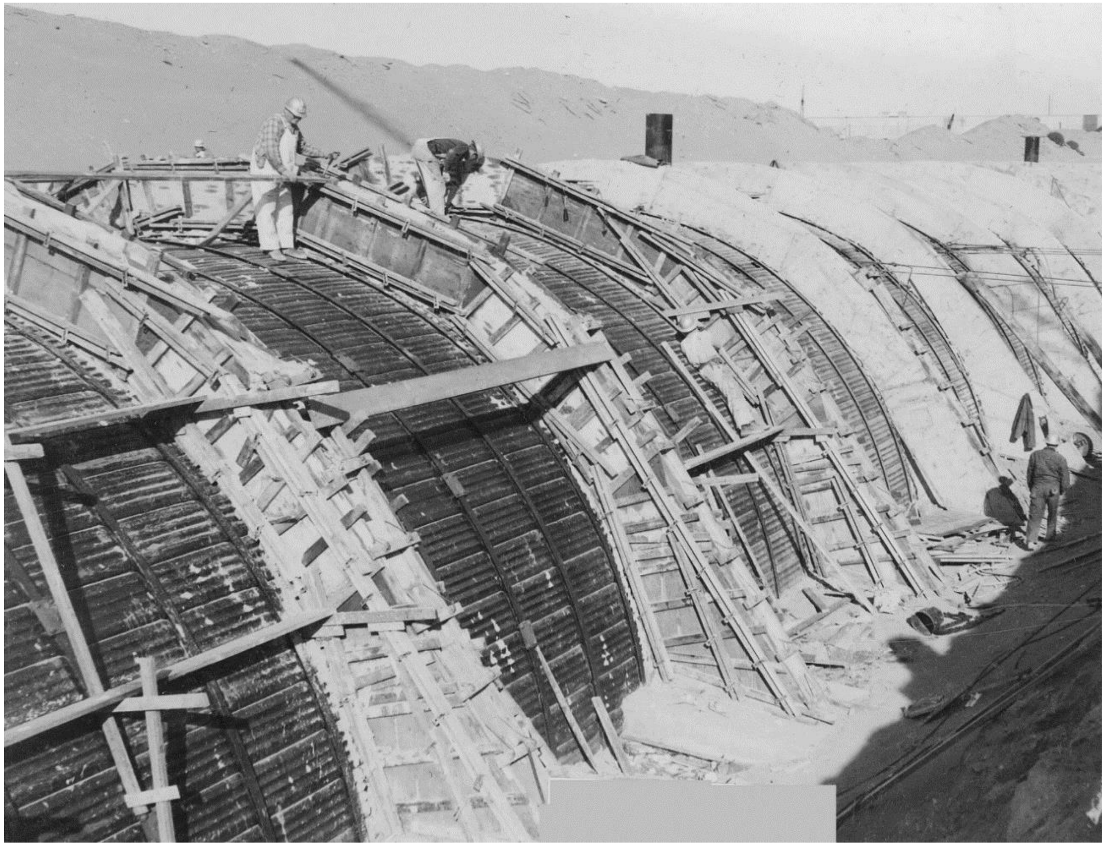
Background - Tunnel 2 Construction

- Completed in 1964
- 26’ wide, 34’ high, 1,688’ feet long
- Steel and reinforced concrete “Quonset Hut” structure
- ~ 8’ of overburden
- Shield door, storage area, and vent shaft
- Two collapses during construction followed by re-designs



Tunnel 2 under construction

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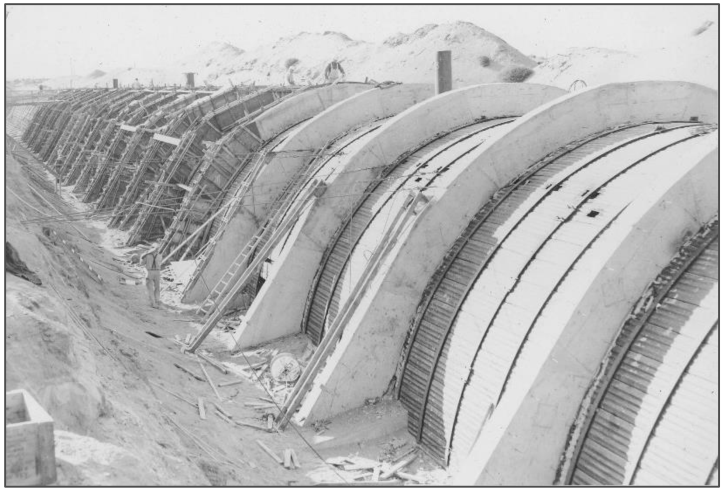
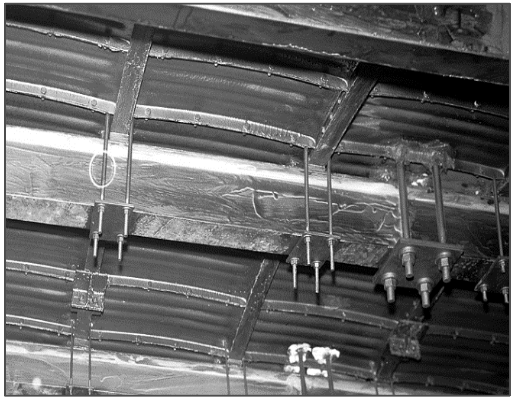
Background - Tunnel 2 Construction Progress

Tunnel 2 initial construction

Tunnel 2 collapse during backfill



Re-designed with external Concrete Arches



Internal Reinforcement – Wale Beams

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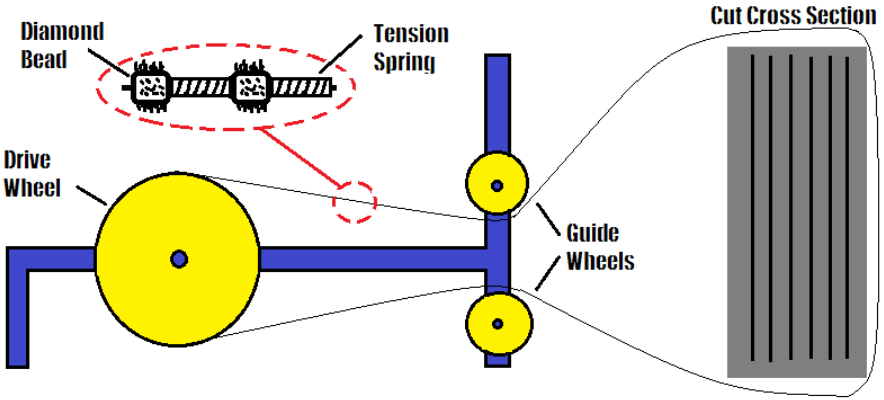
Diamond Wire Saw Experience

- Over 30 years of industrial experience
- Use in variety of applications world-wide
- High radiation fields require shielding to protect workers – diamond wire saw size reduction is common decommissioning technique

Diamond wire sawing in decommissioning



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