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Revision 0

RECOMMENDATION AND SUMMARY REPORT

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
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Program/Project: CPRM

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RL-40 AGING STRUCTURES RECOMMENDED ACTION PLAN AND SUMMARY REPORT

Report No. 67569-RPT-002
Revision 2

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Revision	Date	Pages/Sections Changed	Brief Description
0	09/2019	All	Original Issue.
1	10/2019	Section 1.0 Section 2.0 Section 5.1.3 Section 5.2.3 Section 6.0	242-T Incorporation. 242-T Incorporation. Incorporated Additional Phase 1 Option for interim stabilization. Incorporated Additional Phase 1 Option for interim stabilization. 242-T Incorporation.
2	10/2019	Section 5.2.1 Section 6.0	Comment incorporation. Corrected estimated plutonium from 110 kg to 48 kg. Added reference to RHO-ST-21.

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Acronyms and Abbreviations

PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RECUPLEX	Recovery of Uranium and Plutonium by Extraction

1.0 INTRODUCTION

A risk assessment Report 67569-RPT-001, *RL-40 Aging Structures Risk Assessment*, was performed to rank and prioritize underground aging structures in the Central Plateau based on relative probability of failure and consequence of failure. The structures were grouped based on similarity of construction and materials. The highest ranked structures in each group were then further evaluated for structural stability in Report LA181779-R-001, *Structural Assessment of Aging Legacy Buried Cribs and Tanks at the Hanford Central Plateau*. Five of these structures (241-Z-361, 216-Z-9, 216-Z-6, 241-CX-70, and 216-B-12) were found to be structurally inadequate to withstand the loads and, therefore, are at a higher risk for failure. This report summarizes the results of 67569-RPT-001 and LA181779-R-001 and presents recommended action plans for these five higher risk structures.

In addition, supplementary analyses on select buried structures was performed, including a progressive failure analysis of Tank 241-Z-361 and surcharge standoff calculations for the PUREX and REDOX filters. These analyses are documented in LA181799-R-002, *Additional Analyses: Structural Assessment of Aging Legacy Buried Cribs and Tanks at the Hanford Central Plateau*. Also, a structural evaluation of the 242-T Evaporator building was performed to determine if margin from collapse exists in the structural members and is documented in LA181779-R-003, *Structural Assessment of 242-T-Building*.

2.0 SCOPE

This assessment focused on below-grade structures located within the Central Plateau of the Hanford Site (Table 2-1). These legacy structures included cribs, trenches, tanks, and vaults constructed of timber, concrete, and/or steel.

The assessments did not include structures such as abandoned septic tanks, dry wells (also known as underground injection control wells), abandoned sanitary and process sewer manholes, piping, retention basins, and pipe/rock cribs. These below grade structures are largely non-radiological, contain low radiological inventories, and/or pose little to no collapse potential due to minimal subsurface void space. contains

The structures were grouped based on the structure type where construction materials and geometry are similar. Structural evaluation of one structure in a group of similar structures can then be applied to all the structures within the group. For those structures with unique construction, the groups contain only one structure.

Table 2-1. RL-40 Aging Structures Evaluated. (2 Sheets)

Group	Structure	Date Constructed	Caved-In, Subsidence	Depth of Soil Overburden	Type of Construction	Approximate Size (ft.)	Facility Hazard Classification
C1	216-B-7A/B	1945	No	24 feet	Timber Crib Box	12W x 12W x 4H	Exempt
	216-B-8	1944	Yes	16 feet	Timber Crib Box	12W x 12W x 7H	Exempt
	216-B-9	1948	No	22 feet	Timber Crib Box	14W x 14W x 7H	Exempt
	216-B-10A/B	1948	Yes	16 feet	Timber Crib Box	12W x 12W x 3.5H	Exempt
	216-T-6	1945	Yes	16 feet	Timber Crib Box	12W x 12W x 4H	Exempt
	216-T-7	1947	No	19 feet	Timber Crib Box	12W x 12W x 7H	Exempt
	216-T-8	1949	Yes	16 feet	Timber Crib Box	12W x 12W x 4H	Exempt
	216-T-19	1950	Yes	21 feet	Timber Crib Box	12W x 12W x 9H	Exempt
	216-T-32	1945	No	22 feet	Timber Crib Box	12W x 12W x 4H	Exempt
	216-U-1	1950	No	16 feet	Timber Crib Box	12W x 12W x 4H	Exempt
	216-U-2	1950	No	16 feet	Timber Crib Box	12W x 12W x 4H	Exempt
	216-U-8	1951	Yes	16 feet	Timber Crib Box	16W x 16W x 10H	Exempt
	216-Z-1	1948	Yes	6 feet	Timber Crib Box	12W x 12W x 14H	Exempt
	216-Z-2	1948	No	6 feet	Timber Crib Box	12W x 12W x 14H	Exempt
	216-Z-5	1945	No	14 feet	Timber Crib Box	12W x 12W x 4H	Exempt
C2	216-B-12	1951	Yes	15 feet	Timber Crib Box	16W x 16W x 10H	Exempt

Table 2-1. RL-40 Aging Structures Evaluated. (2 Sheets)

Group	Structure	Date Constructed	Caved-In, Subsidence	Depth of Soil Overburden	Type of Construction	Approximate Size (ft.)	Facility Hazard Classification
C3	216-Z-6	1945	Yes	6 feet	Timber Trench Box	50L x 6.5W x 4H	Exempt
C4	216-Z-7	1946	No	6 feet	Timber Trench Box	150L x 8W x 3H	Exempt
C5	216-Z-9	1955	No	None	Concrete Covered Crib	120L x 90W x 20H	2
T1	241-B-361	1944	No	6 feet	Cylindrical Concrete Tank	20D x 19H	Exempt
	241-T-361	1944	No	6 feet	Cylindrical Concrete Tank	20D x 19H	Exempt
	241-U-361	1951	No	6 feet	Cylindrical Concrete Tank	20D x 19H	Exempt
T2	241-Z-361	1948	No	2 feet	Rectangular Concrete Tank	28L x 15W x 19H	2
T3	241-Z-8	1954	No	6 feet	Cylindrical Steel Tank	40L x 8D	Exempt
O1	PUREX Deep Bed Filters	1954	No	4 feet	Rectangular Concrete Vault	82L x 52W x 13H	2
O2	REDOX Sand Filter	1950	No	None	Rectangular Concrete Vault	85L x 85W x 20H	2
O3	241-CX-70	1951	Yes	11 feet	Cylindrical Concrete Tank	20D x 15H	Exempt

3.0 RISK ASSESSMENT

The aging structures were evaluated against both probability of failure criteria and consequence of failure criteria. Weighted average scores in each group of criteria were combined and normalized to develop a relative ranking of the structures in terms of risk of failure.

A weighted scoring methodology was used to prioritize structures for further evaluation and action planning. Discriminating criteria were developed, which were weighted based on relative influence on risk of failure, and each structure was scored against these criteria. A final score is calculated for each structure and the scores were normalized and sorted to generate a prioritized ranking of the structures. The scoring criteria and weights used were:

- Probability of Failure:
    - Construction Type/Material is Prone to Failure (Weight 40%)
    - Construction Similar to Other Structures that have Failed (Weight 20%)
    - Waste Stream Chemistry (Weight 40%)
- Consequence of Failure:
    - Failing into a Safe Configuration (Weight 30%)
    - Amount/Type of Material that Could be Released (Weight 20%)
    - Proximity to Workers (Weight 20%)
    - Extent of Recovery Effort (Weight 30%)

Table 3-1 summarizes the risk scores that were developed, with Structure 241-Z-361 having the highest risk score and Structure 216-T-6 having the lowest risk score.

Table 3-1. Combined, Normalized, and Ranked Scoring Results.

Group	Structure	Probability Score	Consequence Score	Combined Risk Score	Normalized Risk Score
T2	241-Z-361	7.4	8.5	63	0.63
C5	216-Z-9	6.2	9.4	58	0.58
C1	216-Z-1	7.2	6.2	45	0.45
C1	216-Z-2	7.2	6.2	45	0.45
T3	241-Z-8	6.2	5.5	34	0.38
C4	216-Z-7	7.2	4.0	29	0.29
C3	216-Z-6	7.2	3.9	28	0.28
O1	PUREX Deep Bed Filters	3.4	8.0	27	0.27
C1	216-T-32	6.4	4.1	26	0.26
C1	216-T-7	6.0	4.2	25	0.25
C1	216-B-7A/B	6.4	3.9	25	0.25
T1	241-T-361	4.2	5.9	25	0.25
T1	241-B-361	4.2	5.5	23	0.23
T1	241-U-361	4.2	5.5	23	0.23
C1	216-B-8	6.4	3.6	23	0.23
O2	REDOX Sand Filter	2.6	8.4	22	0.22
C1	216-U-8	8.0	2.7	22	0.22
C1	216-T-8	6.0	3.5	21	0.21
C1	216-T-19	6.4	3.2	20	0.20
C1	216-Z-5	6.4	3.1	20	0.20
O3	241-CX-70	4.6	4.3	20	0.20
C1	216-B-10A/B	6.4	2.7	17	0.17
C2	216-B-12	5.6	2.9	16	0.16
C1	216-U-1	6.4	2.5	16	0.16
C1	216-U-2	6.4	2.5	16	0.16
C1	216-B-9	8.0	2.0	16	0.16
C1	216-T-6	6.0	2.5	15	0.15

4.0 STRUCTURAL ASSESSMENT

The 11 structures identified in Table 4-1 were the highest ranked structures in each group of structures and were evaluated for structural stability and recommended actions.

Table 4-1. Highest Priority Structures in Each Group for Further Evaluation.

Group	Structure	Normalized Risk Score
T2	241-Z-361	0.63
C5	216-Z-9	0.58
C1	216-Z-2 [1]	0.45
T3	241-Z-8	0.38
C4	216-Z-7	0.29
C3	216-Z-6 [2]	0.28
O1	PUREX Deep Bed Filters	0.27
T1	241-T-361	0.25
O2	REDOX Sand Filter	0.22
O3	241-CX-70	0.20
C2	216-B-12 [2]	0.16

1. 216-Z-1 crib has the same score as 216-Z-2; however, 216-Z-1 has failed.
2. These structures are the only structures in their group and have already experienced some subsidence or cave-in. The extent of the cave-in is unknown and there is continued risk of additional cave-ins; therefore, these structures were evaluated further.

The structural margin of the aging structures was assessed using requirements from current codes and standards that provide acceptable strength limits and provide useful information to assess the strength of structural components. A finite element-based computer code, ANSYS®[1], was used for the analyses. Typical material properties were used, although some assumptions were necessary where information was limited regarding the dimensions, reinforcement details, and prestressing data. Degradation of structural members were simulated for structures with documented evidence of subsidence, corrosion, or water intrusion. Applied loads consisted of dead weight, waste pressure (as applicable), lateral soil pressure, snow, and seismic loads. Live loads were not considered because access is generally controlled administratively; therefore, the structural stability results should not be used to justify worker safety.

The results of the structural assessment of the 11 structures are presented in Table 4-2. Results for five of these 11 structures show that the load demand is greater than the capacity of the structure. This indicates these structures have an elevated risk for failure. Recommended action plans for these five structures are discussed in Section 5.0.

[1] ANSYS is a registered trademark of ANSYS, Inc., Canonsburg, Pennsylvania.

Table 4-2. Summary of Structural Assessment Results

Group	Structure	Acceptable
T2	241-Z-361	No
C5	216-Z-9	No
C1	216-Z-2	Yes
T3	241-Z-8	Yes
C4	216-Z-7	Yes
C3	216-Z-6	No
O1	PUREX Deep Bed Filters	Yes
T1	241-T-361	Yes
O2	REDOX Sand Filter	Yes
O3	241-CX-70	No
C2	216-B-12	No

5.0 RECOMMENDED ACTION PLANS

The structural assessment determined that 241-Z-361, 216-Z-9, 216-Z-6, 241-CX-70, and 216-B-12 have elevated risks of failing and warrant mitigating actions.

5.1 241-Z-361 Settling Tank

The risk assessment scored 241-Z-361 Settling Tank as the structure with the highest risk of all structures considered. Furthermore, the structural evaluation of 241-Z-361 found that it lacked sufficient remaining margin and susceptible to failing.

5.1.1 Description of Structure

Tank 241-Z-361 is a rectangular, reinforced-concrete structure with inner dimensions of 26 ft by 13 ft and a height varying from 17 ft to 18 ft due to a sloping bottom. The tank had a total capacity less than 40,500 gallons. The walls of the tank are 12 in. thick and lined with 3/8-in. steel. The top of the tank was approximately 2 ft below grade. Several vent risers extend from the top of the tank to above the ground. Figure 5-1 shows the interior of 241-Z-361.

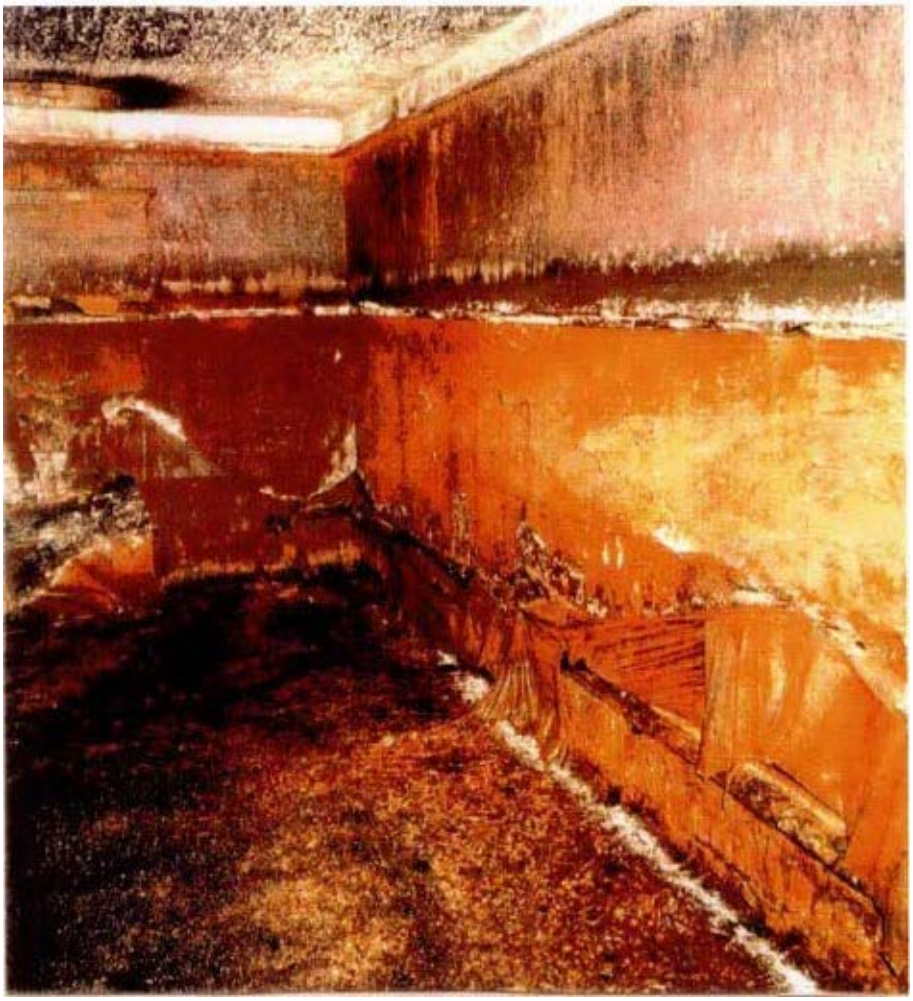

Figure 5-1. Interior of 241-Z-361 Settling Tank.

The 241-Z-361 Tank is approximately 350 ft south of the 234-5Z Building [Plutonium Finishing Plant (PFP)]. Figure 5-2 shows the location of the 241-Z-361 Tank. The structure is a Hazard Category 2 Facility. Between 1949 to 1973, the tank handled all neutralized, low-salt, aqueous waste from PFP. In 1973, 241-Z-361 was removed from service and all inlet and outlet lines were capped in 1975. In 1985, all lines were sealed. At the time of deactivation, the liquid level within the tank was left at the overflow point. In May 1975, approximately 21,000-gallons of supernate liquid was pumped from one of the risers and trucked to a Tank Farm for storage. This left approximately 200-gallons of standing liquid and 20,000-gallons of sludge remaining in 241-Z-361. After the pumping in May 1975, a layer of sludge approximately 2.4 meters or 8 ft thick remained with estimated volume of 75 m^3 or 98 yd^3, containing approximately 29 kg of plutonium (HNF-8735). Figure 5-3 shows sludge levels of 94 in. deep within the tank when tank sampling and characterization was performed in 1999 (HNF-4371). It is estimated that this sludge may contain a range of 26 kg to 75 kg of plutonium (HNF-8735).

Figure 5-2. Location of 216-Z-6 Crib, 216-Z-9 Crib, and 241-Z-361 Settling Tank.

V. SOURCE/RELEASE CHARACTERIZATION

Estimated Volume: Approx. 2,000,000 gal of waste water per year for 22 yr

Product:	No	Waste:	Yes	Lead Hazard:	No
Liquid:	minimal free liquid remains	Flammable:	Unlikely	Asbestos:	? maybe flange gaskets
Sludge:	94 in. deep in tank	Corrosive:	pH range 4-7		
Solid:	Yes	Reactive:	No		
Empty:	No	Toxic:	? Uncertain		
Other:	Radioactive (alpha emitter), Plutonium and Americium (from Plutonium decay)				

Figure 5-3. 241-Z-361 Characterizations with Sludge Depth (Inches).

A structural review of 241-Z-361 was performed based on a 1999 video inspection of the interior of the tank. The review identified effects on the tank's interior roof, including cracking indications attributed to the atmosphere and etching of the cement paste off the lower surface of the roof slab. The video showed that the inner steel plate liner was dissolved or removed over most of the area exposed to the tank liquid contents and etching of the sidewall as seen by exposed aggregate. The images did not allow an estimation of the distance that this effect. It may extend into the wall thickness but indicates a potential loss in wall structural capability. The principal concern for this site is collapse of the tank structure resulting in a release of the sludge.

5.1.2 Summary of Structural Assessment

Given the level of deterioration observed in the video inspection, all concrete walls and the roof were reduced in thickness by 1 in., and rebar area was reduced by 10% to simulate the observed degradation. Results showed a maximum displacement of 0.085 in. occurs at the center of the long side of the tank, the maximum axial stress is 1,159 psi tension, and -1863 psi compression (both extreme values occur on the lower end of the long wall). The 241-Z-361 Tank does not have adequate margin against failure because moment and shear limits are exceeded at the bottom of the long walls. This will likely cause local failure; however, the failure is not expected to progress causing sudden catastrophic failure due to the redundancy available in the box structure.

5.1.3 Recommended Action Plan

While only local failure and not catastrophic failure is likely, 241-Z-361 scored the highest risk of all facilities considered. The principal concerns are the obvious deterioration of the structure, the large radiological inventory in the tank, and the close proximity to workers. The minimal soil overburden of only 2 ft when compared to the tank height of up to 19 ft means that breaching of the tank and exposure of the contents to the environment is highly probable if the tank fails. This makes near term stabilization a high priority. This concern is compounded by the importance of maintaining safe working conditions for those involved in any activities near the tank. Given the difficulties of retrieving the remaining waste with a tank that is damaged, a multi-phase approach is recommended.

- Phase 1– Interim stabilization (e.g., grouting) that does not prevent future remediation due to the deteriorating and overstressed condition of the structure and the difficulty of working in the vicinity, OR
    - Phase 1 Alternative Option – Design and install a confinement cap or enclosure over the tank as soon as feasible. The primary function of the enclosure would be to mitigate an airborne radiological release if the tank fails catastrophically before remediation work can be completed.
- Phase 2 – Perform an engineering study to develop long term options for remediation and a path to closure. This may include additional activities to stabilize the tank while planning, engineering and construction is completed, or the necessary funding is made available. Such activities could include externally reinforcing the tank walls as a temporary measure.

5.2 216-Z-9 Waste Storage Crib

The 216-Z-9 Waste Storage Crib has the second highest risk score of the facilities considered. Like the 241-Z-361 Settling Tank, its structural evaluation determined it lacks sufficient remaining margin; therefore, susceptible to failing.

5.2.1 Description of Structure

The 216-Z-9 Crib is a tailings crib (enclosed trench) built in 1955. The crib is located approximately 500 ft east of PFP (see Figure 5-2) and received solvent and aqueous waste from the recovery of uranium and plutonium by extraction (RECUPLEX) process between 1955 and 1962, including carbon tetrachloride, dibutyl phosphate, and dibutyl phosphonate. The structure is a Hazard Category 2 Facility. The 216-Z-9 Crib received approximately 1,000,000-gallons of liquid wastes containing plutonium. In 1976 and 1977, the trench floor was mined to extract plutonium to reduce the risk of environmental contamination and the potential for a criticality. However, the crib still contains a significant inventory of plutonium (estimated to be 48 kg) and other chemical and radiological constituents that would be at risk of release in the event of a collapse. The present estimate of 48 kg remaining is based on the best information available in RHO-ST-21, *Report On Plutonium Mining Activities At 216-Z-9 Enclosed Trench*.

The 216-Z-9 Crib is almost entirely underground with a reinforced-concrete-slab roof that is 9-in. thick at grade level. The roof is approximately 120 ft long by 90 ft wide and is lined on the underside with acid-resistant bricks. The underground walls slant inward to a rectangular bottom that is approximately 60 ft by 30 ft. It is approximately 20 ft deep. The concrete roof is supported by footings around the perimeter and six 23-ft tall concrete columns lined with clay pipe located at the corners of the floor area and midway along each of the 60-ft sides. In addition, a girder-tension I-beam support system was installed on the roof for additional support over areas with increased weight and where holes had been drilled in the concrete cover. Recent visual inspections show that some of the clay tile on the supports and liner bricks on the roof have fallen off (see Figure 5-4).

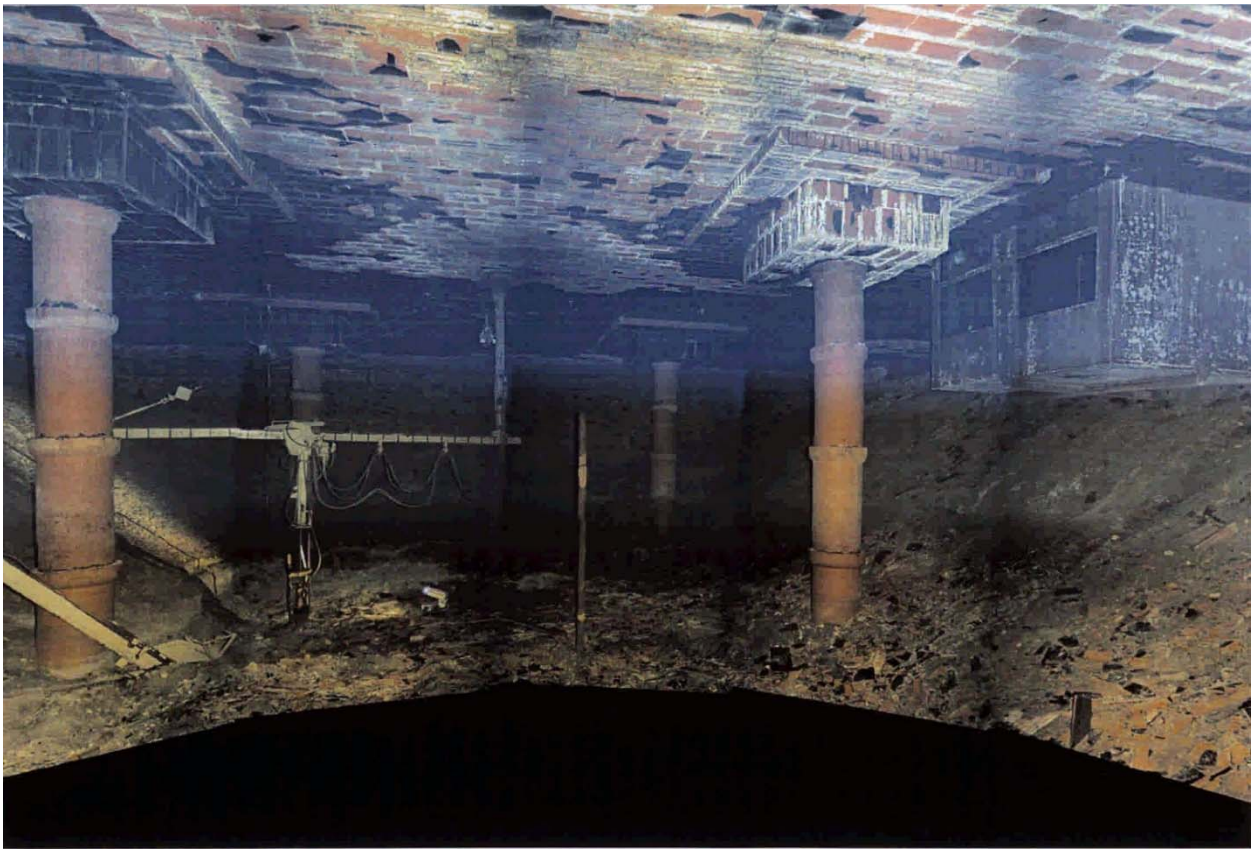

Figure 5-4. Interior of 216-Z-9 Crib.

5.2.2 Summary of Structural Assessment

Since the original slab design of 216-Z-9 does not include beams, the evaluation was performed using methods for flat slab design. This consisted of analyzing the column strips and middle strips based on design drawings that include details of the slab reinforcement. Based on available information, degradation in the roof has been observed; therefore, degradation was simulated by reducing the concrete thickness by 1 in. Results show that a maximum vertical displacement of 0.4 in. occurs at the roof between the column line and perimeter ledge. The 216-Z-9 Crib does not have adequate margin against failure due to the bending moment capacity is less than the demand moment for the outer middle strip and outer column strip (overstress in the slab and column flexure).

5.2.3 Recommended Action Plan

The 216-Z-9 Crib presents a significant challenge to stabilize. The crib is relatively large with no soil overburden such that the contents will be exposed to the environment if the roof collapses. The large size adds to the complexity of mitigation and remediation efforts. This makes near term stabilization a high priority. This concern is compounded by the importance of maintaining safe working conditions for those involved in any activities near the tank. Given the size and difficulty of retrieving the soil and waste, a multi-phase approach is recommended.

- Phase 1– Interim stabilization (e.g., grouting) that does not prevent future remediation due to the deteriorating and overstressed condition of the structure and the difficulty of working in the vicinity, OR
    - Phase 1 Alternative Option – Install a confinement enclosure over the roof to mitigate a radiological release if the structure fails before full remediation work can be completed.
- Phase 2 – Assess if the roof can be structurally strengthened as an interim measure to reduce the likelihood of the roof partially or full collapsing.
- Phase 3 – Perform an engineering study to develop long terms options for remediation and a path to closure. This may include additional activities to again mine the soil in the structure or fix the soil and contamination in place such that the roof can be safely removed.

5.3 216-Z-6 Crib

The 216-Z-6 Crib has a risk score that was low to medium compared to the other structures. However, the structural evaluation found that 216-Z-6 lacks remaining margin; therefore, susceptible to failing.

5.3.1 Description of Structure

The 216-Z-6 Crib was constructed in 1945 to the north of the PFP (see Figure 5-2). The unit consists of a rectangular wooden box set in the base of an excavation that was then back filled covering the crib. The 216-Z-6 Crib is approximately 50 ft long by 6.5 ft wide by 4 ft tall at the tallest point. The crib received process waste from the 231-Z Building via an over-ground line from the 231-W-151 Sump. The site was only used for one month prior to being abandoned due to plugging of the surrounding soil by process sludge and precipitates. The site was deactivated by capping the transfer line west of the 231-W-151 Sump and removing the above-grade piping. The 216-Z-6 Crib was surface stabilized in February 1990. Previous cave-in events have occurred at the site with potential for future collapse.

5.3.2 Summary of Structural Assessment

Due to the previous cave-in events, 216-Z-6 is expected to have experienced some degradation. To account for this degradation in the analysis, the calculated demand stress was increased by 20%. The results show that a maximum displacement of 0.11 in. occurs at the center of the roof, the maximum axial stress due to axial forces and bending moments in the timber is 1,961 psi in tension, and the maximum shear stress is 1,064 psi – where peak stresses were evaluated based on a material strength for Douglas Fir timber with 12% moisture content. The 216-Z-6 Crib does not have adequate margin against failure because the shear stress exceeds the failure limit.

5.3.3 Recommended Action Plan

Since 216-Z-6 is located close to workers at PFP and with the elevated risk of failure, efforts should be initiated to stabilize the site. The soil overburden of 6 ft. is greater than the crib height

of 4 ft, but not sufficient to completely preclude radiological exposure in a failure event. The recommended approach to 216-Z-6 is to grout the crib to the extent practical to prevent any more collapse or cave-ins. This approach is mainly driven by the crib's close proximity to workers at PFP.

- The most obvious access point for grouting is the existing vent pipe. The vent pipe should be inspected with a remote camera to ensure it is free and open into the crib. At the same time, the crib should be inspected to determine that grouting remains necessary despite past cave-ins.
- Prior to grouting, a review should be conducted to ensure all connected piping has been cut and capped. Potholing maybe necessary if historical data is lacking or in question.
- Since cave-ins at 216-Z-6 have occurred in the past, limited grouting may only be possible. The intent of grouting 216-Z-6 is to structurally strengthen it, so if only partial grouting is possible, this still may lower the risk of future cave-ins.

5.4 241-CX-70 Semiworks Process Waste Tank

The 241-CX-70 Semiworks Process Waste Tank had a risk score that was low to medium compared to the other structures considered. However, the structural evaluation found that 241-CX-70 lacks remaining margin; therefore, susceptible to failing.

5.4.1 Description of Structure

The 241-CX-70 Tank was constructed in 1951 to the west of the 241-C Tank Farm and northwest of the plutonium-uranium extraction (PUREX) plant, see Figure 5-5. The tank received high level process waste from the Strontium Semiworks Facility pilot plant up until 1957. In 1979, the liquid inventory remaining from the 1950s was pumped out, leaving 10,300-gallons of very soft sludge. In 1988, most of the remainder of the waste was sluiced and retrieved leaving a residual of approximately 500-gallons of liquid and 250-gallons of solid. In 1992 all remaining liquids and solids were drummed and transferred to the Central Waste Complex. The tank was dried and is considered empty.

The tank is a vertical, below grade 15-ft tall concrete tank with a diameter of 20 ft and a 30,000-gallons capacity. It has a 1/4-in. thick stainless-steel plate liner. The sides and top are 1 ft thick concrete and the bottom thickness varies from 2 ft at the edges to 9 in. at the center. The tank is approximately 11-ft below grade.

A cave-in occurred on the west side of the tank in May 2004. The cave-in was approximately 7 ft deep. In 2009 a backfill was performed to cover the 2004 cave-in site. Additional cave-ins occurred in October 2016 and February 2017. The February 2017 subsidence was approximately 9 ft by 9 ft by 7 ft deep. These cave-ins were backfilled in March 2017.

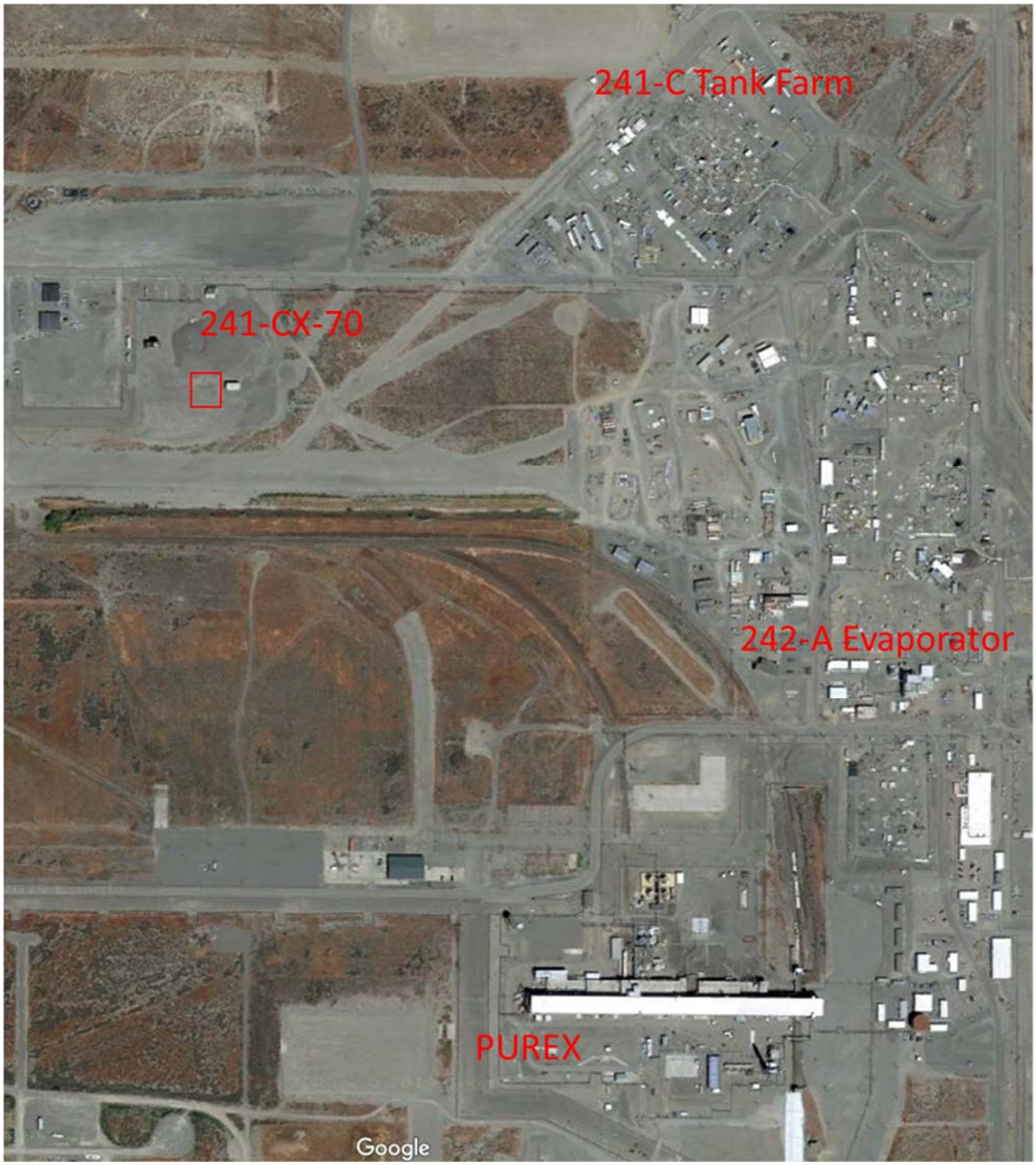

Figure 5-5. Location of 241-CX-70 Semiworks Process Waste Tank.

5.4.2 Summary of Structural Assessment

Results showed that a maximum deflection of 0.12 in. occurs at the center of the roof. The 241-CX-70 Tank does not have adequate margin against failure because local yielding of the top radial rebar in the roof at the wall junction and in the wall at the top (the yielding may cause relieving of local stresses and limit damage progression).

5.4.3 Recommended Action Plan

The 241-CX-70 Tank has an elevated risk of failure and evaluation. Efforts should be initiated to stabilize the site. The soil overburden of 11 ft is less than the tank height of 15 ft, which is not sufficient to completely preclude breaching the tank in the event of failure. Since the tank has already been emptied, retrieval activities are not required, and efforts to stabilize the tank with grout are simplified. Recommended actions include:

- Before grouting, the tank should be inspected with a remote camera to ensure it is still empty and grouting is feasible.
- Connected piping should be reviewed to ensure all connections are cut and capped. Potholing maybe necessary if historical data is lacking or in question.
- Grouting should be performed to the extent possible. Complete grouting of the tank and risers may not be necessary since the intent of grouting is to structurally strengthen the tank and lower the risk of a cave-in.

5.5 216-B-12 Crib

The risk assessment scored 216-B-12 Crib low compared to the other structures considered. However, the structural evaluation found that 216-B-12 lacks remaining margin; therefore, susceptible to failing.

5.5.1 Description of Structure

The 216-B-12 Crib was constructed in 1951 to the northwest of the 221-B Building (B Plant), See Figure 5-6. The site includes three wooden crib structures built in series to cascade from one to the next in the event of an overflow. The structures each have overall dimensions of 16 ft by 16 ft by 10 ft tall. The cribs are covered by approximately 15 ft of soil overburden. From November 1952 to December 1957, the 216-B-12 Crib received 221-U (U Plant) and 224-U condensate waste transported from the 200 West Area via the Cross-Site Transfer Line (Line V219 and 200-E-160-PL). The crib was reactivated in May 1967 to receive condensate waste from B Plant via pipeline 200-E-160-PL and later via pipeline 200-E-162-PL. The crib remained in service until November 1973 when a crib collapse was discovered. Following this discovery, the area was backfilled to grade and actions were taken to deactivate the crib. The 216-B-12 Crib was isolated in March and April 1974 by deactivating the inlet and transfer lines and sealing the vent risers below grade. The 216-B-12 Crib was surface stabilized in 1993.

Figure 5-6. Location of 216-B-12 Crib.

5.5.2 Summary of Structural Assessment

Since subsidence has been observed in other structures within Group C1, degradation was included in the 216-B-12 analysis by increasing the calculated demand stresses by 20%. The results showed that a maximum displacement of 1.6 in. occurs at the center of the roof, the maximum axial stress due to axial forces and bending moments in the timber is 6,568 psi in compression, and the maximum shear stress is 3,511 psi – where peak stresses were evaluated based on a material strength for Douglas Fir timber with 12% moisture content. The 216-B-12 Crib does not have adequate margin against failure because the bending and shear stresses are above failure limit.

5.5.3 Recommended Action Plan

The large amount of soil overburden, 15 ft, relative to the structure's height, 10 ft, implies that failure would result in soil subsidence only and the consequences of a failure are likely to be very minimal or none. This conclusion is supported by past partial subsidence and numerous other partial failures of other deeply buried structures, where consequences were minimal. No action is recommended at this time other than continued surveillance and maintenance of adequate administrative controls to ensure worker safety.

6.0 REFERENCES

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