Washington State Department of Ecology's Evaluations of the 241-AY-102 Hanford's First Leaking Double Shell Tank – 14342

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ABSTRACT

The Hanford Nuclear Reservation includes 177 underground tanks, organized in 18 "tank farms" storing over 200 million liters (56 million gallons) of mixed high-level (HLW). The waste contains millions of curies of radioactive materials, acids, solvents, cyanides, and toxic heavy metals. These 177 tanks still contain waste well past their design life. Sixty-seven of the 149 Single Shell Tanks (SSTs) are estimated to have leaked over 3.8 million liters (one million gallons) of mixed HLW over the last 65 years. SST leaks and groundwater contamination have long been a part of "the Hanford story." New to Hanford, is that one of the 28 Double Shell Tanks (DSTs) is leaking.

The Washington State Department of Ecology (Ecology) was notified August 8, 2012, by the United States Department Of Energy-Office of River Protection (USDOE-ORP) that their Tank Farm Contractor, Washington River Protection Solutions (WRPS), had discovered an "anomaly" in the secondary containment or annular space of DST 241-AY-102. Sampling results indicated that the anomaly was HLW, contents from AY-102's primary tank.

Ecology has requested that USDOE-ORP remove the contents of the tank and return the tank to service after repairs are certified by an Independent, Qualified, Registered Professional Engineer or close the tank as soon as possible. Ecology will set operational and closure criteria for this and other DSTs in the Hanford Facility Dangerous Waste permit under its state-designated Resource Conservation and Recovery Act authority (Washington Administrative Code 173-303, Dangerous Waste). Ecology is also considering future modifications to the DST Permit.

BACKGROUND

The Hanford Nuclear Reservation or Hanford Site (Figure 1) is managed by the U.S. Department of Energy (USDOE). It is lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State. The Hanford Site encompasses approximately 1,450 km^2 (560 mi^2) north of the confluence of the Yakima and Columbia Rivers.

Established in 1943, the Hanford Site was originally designed, built, and operated to produce plutonium for nuclear weapons. The major waste generating processes at Hanford included:

- Bismuth Phosphate/Lanthanum Fluoride
- Reduction-Oxidation (REDOX)
- Plutonium-Uranium Extraction (PUREX)
- Uranium Recovery (UR)
- Plutonium Finishing Plant (PFP)
- Uranium Trioxide (UO_3)
- Strontium/Cesium separations and recovery
- Rare Earth metals recovery
- Americium Recovery
- Various Neptunium, Thorium, Lithium/Tritium process operations.

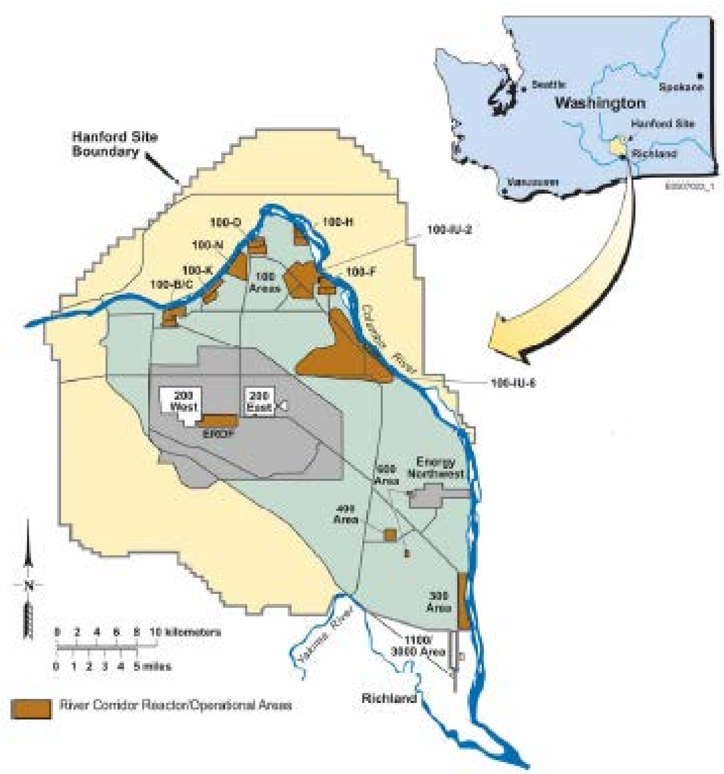

Figure 1 – Lo

Hanford's processing and reprocessing generated several hundred thousand metric tons of liquid chemical and radioactive wastes. Included were HLW, transuranic (TRU) waste, and Low-Level and Mixed Low-Level Wastes (LLW/MLLW) wastes. The waste management process initially involved routing the HLW and TRU wastes for neutralization with sodium hydroxide and sodium carbonate and storing the resulting waste mixture in large underground tanks. From 1943 through early 1964, 149 SSTs were built to store waste in the 200 Areas of Hanford (Figure 2).

In the mid-1950s, leaks were detected and suspected in some SSTs. To address concerns about SST designs, Hanford adopted a new DST design, which would allow for detection of leaks and effective corrective actions before the waste could reach the surrounding soil. Between 1968 and 1986, 28 DSTs were constructed (Figure 3). Additional DST tanks were designed and sites in both 200 East and West were excavated. However, funding became constrained and these tanks were not constructed.

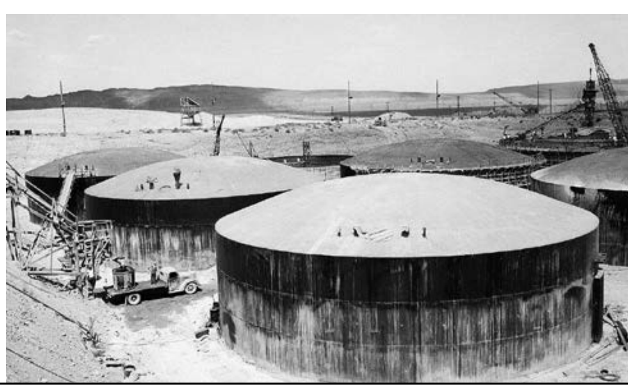

Figure 2 – Construction of the BY Farm SSTs in 1949

Figure 3 – Construction of the AW Farm DSTs in 1979

Today these 177 SSTs and DSTs are well past their design life and continue to age. However, over 200 million liters (56 million gallons) of high-level waste containing millions of curies of radioactive materials, acids, caustic soda, solvents, cyanides, and toxic heavy metals remain. Sixty-seven SSTs are estimated to have leaked over 3.8 million liters (one million gallons) of HLW over the last 65 years. Ten of the twelve single-shell tank farms have negatively affected groundwater. Groundwater concentrations under two tank farms are 100 times higher than safe drinking water regulatory limits.

INTRODUCTION

The Hanford Site is divided into a number of operational areas. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas on the National Priorities List (NPL) pursuant to the Comprehensive Response, Compensation, and Liability Act of 1980 (CERCLA). Prior to this placement, the Tri-Parties, EPA, Ecology, and the United States USDOE entered into a legal agreement. This Tri-Party Agreement (TPA) is formally known as the Hanford Federal Facility Agreement and Consent Order (HFFACO) covers environmental compliance and cleanup operations. The TPA recognizes the State of Washington as the lead Agency for all Treatment, Storage, and Disposal (TSD) Units, which include Hanford's SST and DST systems.

The Washington State Department of Ecology (Ecology) was notified August 8, 2012, by the United States Department Of Energy-Office of River Protection (USDOE-ORP) that their Tank Farm Contractor, Washington River Protection Solutions, LLC (WRPS) had discovered an "anomaly" in the secondary containment or annular space of DST 241-AY-102 (AY-102). The 241-AY-102 is the oldest DST at Hanford and the first to be constructed between 1968 and 1969. Figure 4 shows the anomalies found during the August visual inspections.

Figure 4 – Inspection Photographs taken from Riser 90 on 8/10/2012

USOE-ORP and WRPS had hoped and initially postulated that the anomalies were due to soil/sediment/water intrusion into the 241-AY-102 annular space, and not that the tank was leaking. To determine the actual cause of the "anomalies", WRPS initiated a Leak Assessment Investigation in accordance with their TFC-ENG-CHEM-D-42 Procedure. Sample collection and analysis was simultaneously planned and performed. Ecology repeatedly requested to be involved with the leak loss investigation and sampling Data Quality Objectives processes. However, these requests went unanswered by both USDOE-ORP and WRPS. The investigation and sampling efforts continued without communication to Ecology of findings and preliminary results until October 31, 2012. On November 7, RPP-ASMT-53793, *Tank AY-102 Leak Assessment Report* [1], was released to Ecology and the public.

During the months that sampling results and leak loss information were pending, Ecology was inundated with requests and questions from many members of the public, including the media and stakeholders. Ecology DST Engineering staff initiated an in-depth review of 241-AY-102. This review consisted of: brief construction information, previous tank waste characteristics, historical waste chemistry and tank integrity characterization, historical operations and process information, and previous tank integrity issues. This assessment was completed in September and presented to several members of the public and various stakeholders. Ecology also sent this information to USDOE-ORP and WRPS personnel involved with the leak assessment investigation. They, in turn, incorporated much of the information into the *Tank AY-102 Leak Assessment Report* [1]. Ecology's early evaluation indirectly concluded that the tank was in fact leaking due to the following observations:

- First DST constructed at Hanford in 1968-69 [2]
- Put into service in 1975 and last waste transfer in was in 2003
- Intrusion into the annular space from the Leak detection pit was highly unlikely given the piping configuration [3]
- Integrity of the secondary tank had shown signs of corrosion and mineralization and the integrity of the primary tank had shown even more signs of corrosion and mineralization [2, 4]
- The ventilation had been off for approximately 7 years [5, 6]
- Crystals and mineralization (yellow and white) had formed in the haunch region, but remained un-sampled and had grown larger as of 2012 visual inspections [2, 4]
- The waste chemistry in AY-102 was out of specification in 12/1999 for pH and hydroxide, and later for nitrite parameters [2, 3, 7]
- Additions of sodium hydroxide in 2/2001, 5/2005, and 7/2005 were required to bring the tank back into specification [2]
- One addition of sodium nitrite in 11/2001 was required to bring the tank back into specification [2]
- The waste within the 241-AY-102 DST is both radiologically and very thermally "hot" [3, 2]
- The anomalies reported were most likely waste due to a tank leak at the base of the primary tank.

Current Conditions

Based on past process and operational history and past sampling and analysis efforts, the current conditions of the 241-AY-102 DST are: [3, 8, 9]

- Age
    - This tank is 17 years past its design life.
- Waste Content
    - Total Waste Volume 3550 kL (938 kgal)
    - Supernatant Volume 2979 kL (787 kgal) – BBI reports 2705 kL

    - Sludge Volume 571 kL (151 kgal) – BBI reports 451 kL
    - BBI reports 120 kL of Sludge Interstitial Liquids
- Waste Conditions
    - Surface Level (1/6/2014) 741.2 cm (291.8.1 inches)
    - Temperature (1/6/2014) 34.8°C - 52.3°C (94.6.2°F - 126.2°F) from Riser 29;
    - Waste Group Designation B (potential induced flammable gas release hazard, but not spontaneous buoyant displacement flammable gas release hazard)
    - No other tank contains the same mix of wastes - Closest is 241-AY-101
    - One of the most radioactive HLW tanks at Hanford
    - Sludge in 2002 read 200 Rad/hr on sample bottle
    - Most Cesium is associated with dry solids not leached by washing (aluminosilicates)
    - Dilute layer of supernatant tops the convective currents of solids in the tank resulting in thermal gradients in the tank
    - Very thermally hot (primary and annulus ventilation shut-down for upgrades in 2000 resulted in an increased the temperature)
- Unknown if waste chemistry currently meets Chemistry (Corrosion) Control Program Specifications
- Unknown condition of secondary tank liner and breach.

Construction

DST Primary tanks were never “certified” by an IQRPE to contain hazardous or hazardous and nuclear wastes per current regulatory requirements during design, construction, and testing phases (during and after construction). Nor were these tanks designed and constructed to contain toxic, nuclear waste for over 22 years, let alone the past 39-years. However, DSTs were designed using the 1965 ASME Boiler and Pressure Vessel Codes and fabricated and constructed using the ASTM A515, grade-60 carbon steel. [2] Each AY DST consists of a primary carbon steel tank and secondary carbon steel liner anchored to a steel reinforced concrete shell. The primary tank was stress relieved at 811 Kelvin (1000 degrees Fahrenheit) for 3-4 hours to eliminate welding and fabrication stresses, minimizing the potential for stress corrosion cracking. [2] Figure 5 is a photograph of the AY-102 Construction effort.

Figure 5 – Worker welding flashing to the risers and surrounding rebar in the haunch region

The AY-102 primary tank rests on a 20 centimeters (8 inch) Kaolite[1] 2200-LI clay refractory pedestal located between the primary and secondary tank floors. The pad (radially) has air vents or drain slots allowing for the circulation of air at the bottom of the primary tank and the draining of any leakage from the primary tank into the annular space of the secondary tank. In 1970, it was discovered that a portion of the Kaolite pedestal was damaged due to moisture from a rain event entering the tank prior to and during heating of the tank for stress relief. [1] In 1970, the outer 53 centimeters (21 inches) of Kaolite material was chiseled away and replaced with reinforced shrink-compensating concrete and secured with a steel ring. Figures 6 and 7 illustrate work on the pedestal.

Figure 6 – Workers creating ventilation slots in the Kaolite pedestal once the primary tank has been lifted with cribbing

Figure 7 – Workers in the annular space removing 21 inches of Kaolite material under

Process Operations

For the first seven years, AY-102 contained heated, raw Columbia River water. The tank remained heated to ensure it could receive self-boiling waste from PUREX at a moment's notice. In 1975, the tank accidently received B-Plant aging waste. In 1977, the tank was used to route HLW to the 242-A Evaporator and later that year the tank received more aging Sr-90/Cs-137 Recovery waste from B-Plant. From 1978 to 1980, AY-102 sent Double-Shell Slurry Feed to A Farm and 241-BX-104 and received waste from 241-A-102. Miscellaneous waste from PUREX, non-complexant Sr-90/Cs-137 Encapsulation waste, dilute 100-N Reactor wastes, and salt well liquids were sent to AY-102 between 1981 and 1985. From 1985 to 1996, AY-102 received Sr/Cs Encapsulation vessel clean-out and process waste, 100-N Reactor waste, T-Plant tank and decontamination waste, 200/300/400-Area laboratory wastes, and transfers from 241-AW-102/106, and 241-AP-103/104/106/108. In 1997, complexant waste from 241-AY-101 was sent to AY-102. Between 1998 and 1999 AY-102 received almost 97 percent of the high-heat sludge retrieved from 241-C-106. In 1998, AY-102 became a condensate receiver tank. In 2003 AY-102 received C-106 flush water and 244-AR Vault liquid. These process operations caused large variability in tank levels and tank temperatures. [3, 10]

[1] Kaolite is a trade name of Babcock & Wilcox, Co., Refractories Division, Augusta, Georgia

Historical Sampling

Historical sampling includes both Waste Chemistry [3] sampling and Tank Integrity sampling [2] efforts as indicated in the Table below:

241-AY-102 Historical Sampling Efforts		
Type	Date	Detail
Tank Integrity	1992	First Visual Inspections in Risers 79 and 84
Waste Chemistry	1994	Grab samples
Waste Chemistry	1995	Grab samples
Vapor	1998	*Vapor samples found in the Tank Waste Information Network System (TWINS)* [8]
Tank Integrity	1999	Ultrasonic Testing (UT) in Riser 89
Waste Chemistry	2000	Four core samples results in: *Tank 241-AY-102 Cores 270, 271, 272, and 273 Analytical Results for the Final Report* [11] and letter report *Solubility Screening Tests for Tank 241-AY-102 in Appendix B, Attachment 8* of [12], *Results of Retrieval Testing of Sludge from Tank 241-AY-102* [13], and *Final Analytical Results for Tank 241-AY-102 Grab and Core Samples* [14]
Waste Chemistry	2000	Four Supernatant grab samples from Riser 64 – samples "too hot" for transport to 222-S Lab – no analyses or archive
Waste Chemistry	2001	Four grab samples and seven core samples from Riser 64 and one core sample from Riser 57, results in: *Tank 241-AY-102 FY 2002 Core Samples Analytical Results for the Final Report* [15]
Tank Integrity	2001	Second Generation Visual Inspections in Risers 79, 80, 84, and 86
Tank Integrity	2001	Primary In-Tank Video in Riser 51
Waste Chemistry	2002	Six grab samples from Riser 54, results in: *Tank 241-AY-102 FY 2002 Grab Samples Analytical Results for the Final Report* [16]
Waste Chemistry	2003	One core sample from Riser 65 letter report, results in: *Tank 241-AY-102 FY 2003 Core Samples Analytical Results for the Final Report, Reissue 3* [17]
Tank Integrity	2003	Corrosion Product Sample Collection in Riser 80
Tank Integrity	2003	Visual Inspection in Riser 80 for Corrosion Product Sample Collection
Waste Chemistry	2003	*Core samples found in the Tank Waste Information Network System (TWINS)* [8]
Vapor	2004	*Vapor samples found in the Tank Waste Information Network System (TWINS)* [8]
Waste Chemistry	2005	*Core samples found in the Tank Waste Information Network System (TWINS)* [8]
Waste Chemistry	2005	*Grab samples found in the Tank Waste Information Network System (TWINS)* [8]
Tank Integrity	2006	Visual Inspections in Risers 77, 79, 80, 82, 84, 86, 88, and 89
Tank Integrity	2006	Primary In-Tank Inspection in Riser 65
Tank Integrity	2007	UT in Risers 77, 79, 80, 82, 84, 86, 88, and 89
Tank Integrity	2009	Corrosion Probe and Coupons
Tank Integrity	2012	Visual Inspections and Video in all 10 Annulus Risers
Tank Integrity	2012	UT in Risers

According to the AY integrity [2] and characterization reports [3], the sampling and inspections performed provided the following conclusions about the tank:

"…discovered what appeared to be flow markings and corrosion that would suggest moisture accumulation in the AY-102 annulus. In addition to the findings in the AY-102 annulus, corrosion streaks were also found with very similar characteristics to the streaks found in AY-101. This suggested that water intrusion from an outside source still exists. An ongoing Technical Safety Requirement (TSR) Plan [was] under development [in 2007] to prevent this water intrusion." [2]

Corrosion has been observed in the annulus since 2001, as documented in RPP-RPT-34311, *Double-Shell Tank Integrity Inspection Report for 241-AY Tank* Farm, 2007. [2] The AY Integrity Report also states:

"This finding resulted in the issuance of an occurrence report, RPP-CHG-TANKFARM-2001 -0106. As a result of this occurrence report a corrosion sample was collected from the annulus tank wall through Riser 80 in February 2003. The sample was scanned by Operational Health Physics and found to contain no radioactivity". [18]

"The waste chemistry in AY-102 was also out of specification since December 1999 for pH and Hydroxide, and later Nitrite parameters." Several additions of sodium hydroxide and one addition of sodium nitrite to AY-102 took place in February 2001, May 2005, July 2005, and November 2001, respectively, to bring the tank back into specification. [3]

DESCRIPTION/DISCUSSION

Assessment of the Anomalies…Intrusion or Leak?

An initial sample was collected August 10, 2012 via duct tape on a weight from AY-102's Riser 90 annular space. Figure 8 is a photograph of this sample. Preliminary results on August 14th indicated that the anomaly was likely contamination due to a leak in the tank due to the high potassium signature. [19] These preliminary results were not shared with Ecology.

Figure 8 – Initial sample collected from the annulus space (Riser 90)

Figure 9 – 241-AY-102 Sampling Effort

Samples of the anomaly were collected via a crawler in late September from Riser 83 and early October of 2012 from Riser 90, and sent to the 222-S Laboratory for chemical and radionuclide analyses. Results included signatures of strontium-90, cesium-137, and potassium which indicated that waste from the 241-AY-102 was present within the secondary tank liner (annulus). [19] Figure 9 depicts one of the sampling efforts.

Visual inspections began to focus on the waste near Riser 80.3, to the exclusion of the waste near Riser 90. Visual inspection of the waste was performed on a weekly basis. After approximately six months, USDOE-ORP requested and Ecology approved changing the inspection frequency to one inspection every two weeks. Ecology DST Engineering Staff entered the 241-AY Farm to participate in the visual inspections 10/25/2012, 11/12/2012, 12/27/2012, 1/28/2013, and 3-14-2013. Figures 10 – 13 show the progression of the leak of waste near Riser 83.

Figure 10 – 241-AY-102 Waste in the Annulus near Riser 83 (October 2012)

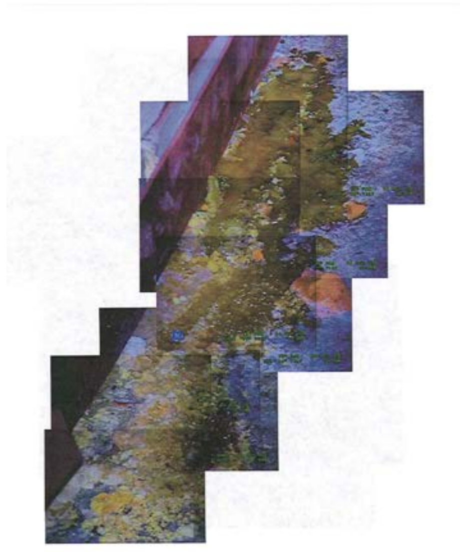

Figure 11 – 241-AY-102 Waste in the Annulus near Riser 83 (November 2012)

The 241-AY-102 leak assessment report [1] concluded that 241-AY-102 was leaking from the bottom of the tank and the leak was likely due to poor welding practices and flooding caused by precipitation during construction. The flooding of the tank deteriorated the Kaolite pedestal that the primary tank is placed upon and most likely caused uneven settling and stresses upon the primary tank, possibly aggravating weak welds and joints.

Ecology, WA Department of Health, and the State of Oregon participated in an Integrated Project Team (IPT) along with WRPS at the request of USDOE-ORP. The scope of the IPT was to: 1.) Recommend immediate actions to ensure risks are minimized until a path forward is determined, and 2.) Recommend a path forward for the AY-102 DST. The IPT met weekly beginning November 8, 2012. Various subject matter experts associated with tank farm operations, system

Figure 12 – 241-AY-102 Waste in the Annulus near Riser 83 (July 2013)

Figure 13 – 241-AY-102 Waste in the Annulus near Riser 83 (Jan 2014)

configuration, ventilation, pumping, sampling and analysis, integrity, tank chemistry, and emergency pumping. During the meetings and documented in various letters, Ecology requested that the USDOE-ORP remove the contents of the AY-102 DST to comply with state-delegated Resource Conservation and Recovery Act authority (Washington Administrative Code 173-303, Dangerous Waste) requirements.

The IPT was informally concluded in early February 2013 when a technology down-select workshop was conducted. The workshop participants determined that the sludge in AY-102 should be sluiced out, similar to various 241-C Farm retrieval efforts.

CONCLUSIONS

On May 6, 2013, USDOE-ORP sent Ecology letter 13-TF-0024 stating that AY-102 did not need to be pumped at this time. Ecology responded with letter 13-NWP-056 on May 24, 2013 and again requested a pumping plan to remove all contents from AY-102 by June 14, 2013. This letter also noted inconsistencies in USDOE-ORP's application of 40 CFR 265.196, 40 CFR 265.193, and compliance with HNF-3484, Double-Shell Tank Emergency Pumping Guide, an enforceable portion of the DST Dangerous Waste Permit. USDOE-ORP submitted RPP-PLAN-55220, The 241-AY-102 Pumping Plan, [20] to Ecology via letter 13-TF-0049. USDOE-ORP noted that a pump was installed at AY-102 to remove supernatant from the tank. However, USDOE-ORP has not removed the supernatant from the tank. The letter also stated that USDOE-ORP is procuring the needed equipment to remove the sludge from the tank. However, Ecology is aware that not all of the equipment has been designed or fabricated and the Pumping Plan [20] is under revision by WRPS. Ecology sent comments to USDOE-ORP on the Pumping Plan [20] via letter 14-NWP-001, expressing disappointment with the Pumping Plan. Ecology anticipates an acceptable pumping plan from USDOE-ORP by February 15, 2014. Additional observations from Ecology regarding this event include:

- The waste present in the annular space appears to cycle through “wetter” and “drier” periods. During the “wetter” periods, additional waste migrates further along the area of the annular floor and additional volume of waste appears to be added. However, no pattern or relationship to tank humidity, ventilation, ambient air temperature, seasonal climate parameters, etc. has been discovered as of date.
- Since the tank is leaking from the bottom, it is unlikely it can be repaired and certified by an IQRPE and will need to be closed.
- Waste in the annular space in the Kaolite refractory pedestal (secondary containment) most likely cannot be cleaned or removed.
- It is uncertain if waste has left the secondary containment and migrated into the environment. The Hanford Expert Panel on Corrosion has been tasked with performing tests of waste simulants on aged steel to determine a range of responses that might determine what the secondary liner may experience due to contact with the waste.
- Both the primary and secondary tank bottoms suffered from wrinkling, bulging, and poor welding practices. It is likely that the secondary liner will release waste into the environment. Releases from the secondary liner would be undetected by the leak detection pit.
- Overall, DST space is extremely limited. USDOE-ORP cannot continue SST Retrieval and remove the waste from this leaking DST.
- 241-AY-102 can no longer be considered the Feed Tank for the Waste Treatment Plant.

- Additional "older DSTs" SY-101-, -102,-103, AY-101, AZ-101 and -102 also have questionable service life left before they begin leaking due to their past operational histories, lack of past ventilation, corrosion found during UT and visual inspections, and the contents they continue to store.
- The DST *Dangerous Waste* Permit Part B will need modification to include changes in the DST Integrity Program, changes to DST continuous leak detection and monitoring, emergency leak detection and response, etc.
- More DST space is needed and new tanks should be designed and constructed immediately because: 1) lack of operational DST space will cease retrieval operations as indicated in various "System Plan" documents [21, 22]; 2) the "Group A" DSTs do not receive or route waste as a precaution to prevent flammability [23]; 3) 67 the SSTs and now a DST are leaking and most likely negatively impacting the environment; and 4) the Waste Treatment Plant (WTP) is not expected to meet its consent decree deadlines.

Ecology has made it clear that USDOE-ORP and WRPS' initial evaluations regarding various aspects of this event do not constitute regulatory decisions. Ecology will set operational and closure criteria for this and other DSTs in the Hanford Facility *Dangerous Waste* permit under its delegated Resource Conservation and Recovery Act authority (Washington Administrative Code 173-303, *Dangerous Waste*). Ecology continues to request that the contents of 241-AY-102 DST be removed so that the tank can be repaired and certified by an Independent, Qualified, Registered Professional Engineer or closed.

As Hanford tanks continue to age, the potential for impacts to environment from leaks, catastrophic failure, and releases increase daily. Clean-up costs will soar exponentially once the waste leaves the tanks. The technical ability to remediate the waste once it is in the groundwater and soil is limited. The best approach is to retrieve the waste while still in the tanks and immobilize it at the WTP. Since the WTP operations are delayed and for the reasons mentioned above, Hanford needs additional, new, safer DSTs constructed to contain the waste from failing SSTs and DSTs. This need has been recognized by both the States of Washington and Oregon and even noted indirectly by the Government Accountability Office.

> "DOE's tank management strategy involves continuing to use Hanford's tanks to store waste until the waste is removed and disposed of and the tanks are permanently closed, a period measured in decades…The lingering uncertainties over tank condition and contents, combined with the tanks' advancing age…raise serious questions about the tanks' long-term viability."

– Government Accountability Office
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