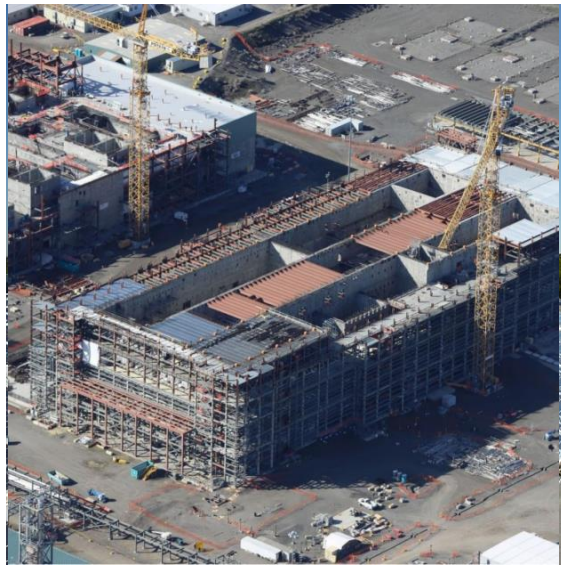
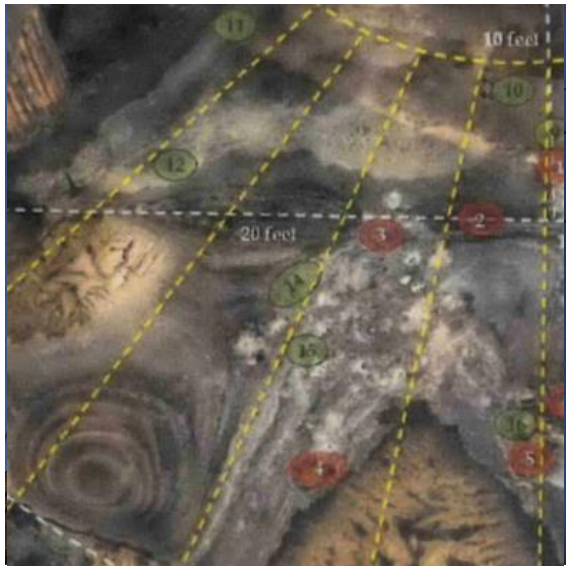
System Plan 8 and the Hanford Tank Mission





Oregon Hanford Cleanup Board

Jeff Burright
March 19, 2018

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Why is this important?

"The treatment of high level waste at Hanford remains the single largest environmental cleanup initiative in the world, and any delay could jeopardize the safety of the residents of the Pacific Northwest."
–U.S. Rep. Doc Hastings, 2000

- A successful tank waste treatment mission will prevent future releases to the soil and eventually the river.
- An unsuccessful tank mission would result in new releases to the environment, serious accidents, poor use of taxpayer resources, or short-sighted decisions about how to dispose of tank waste.
- We are in a race against time.

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Hanford's Tank Waste – 54,000,000 gallons of high-level waste

- 149 "single-shell" tanks (28.5 million gallons)
  - ✓ 55,000 to 1,000,000 gallon capacity
  - ✓ 61 known or suspect leaking tanks – one **actively leaking to the soil**
  - ✓ 17 tanks mostly emptied

- 28 "double-shell" tanks (25.5 million gallons)
  - ✓ 1,000,000 to 1,257,000 gallon capacity
  - ✓ **One out of service after actively leaking into containment**

Hanford's Single-Shell Tanks

Hanford’s Double-Shell Tanks

Double-Shell Tank Construction

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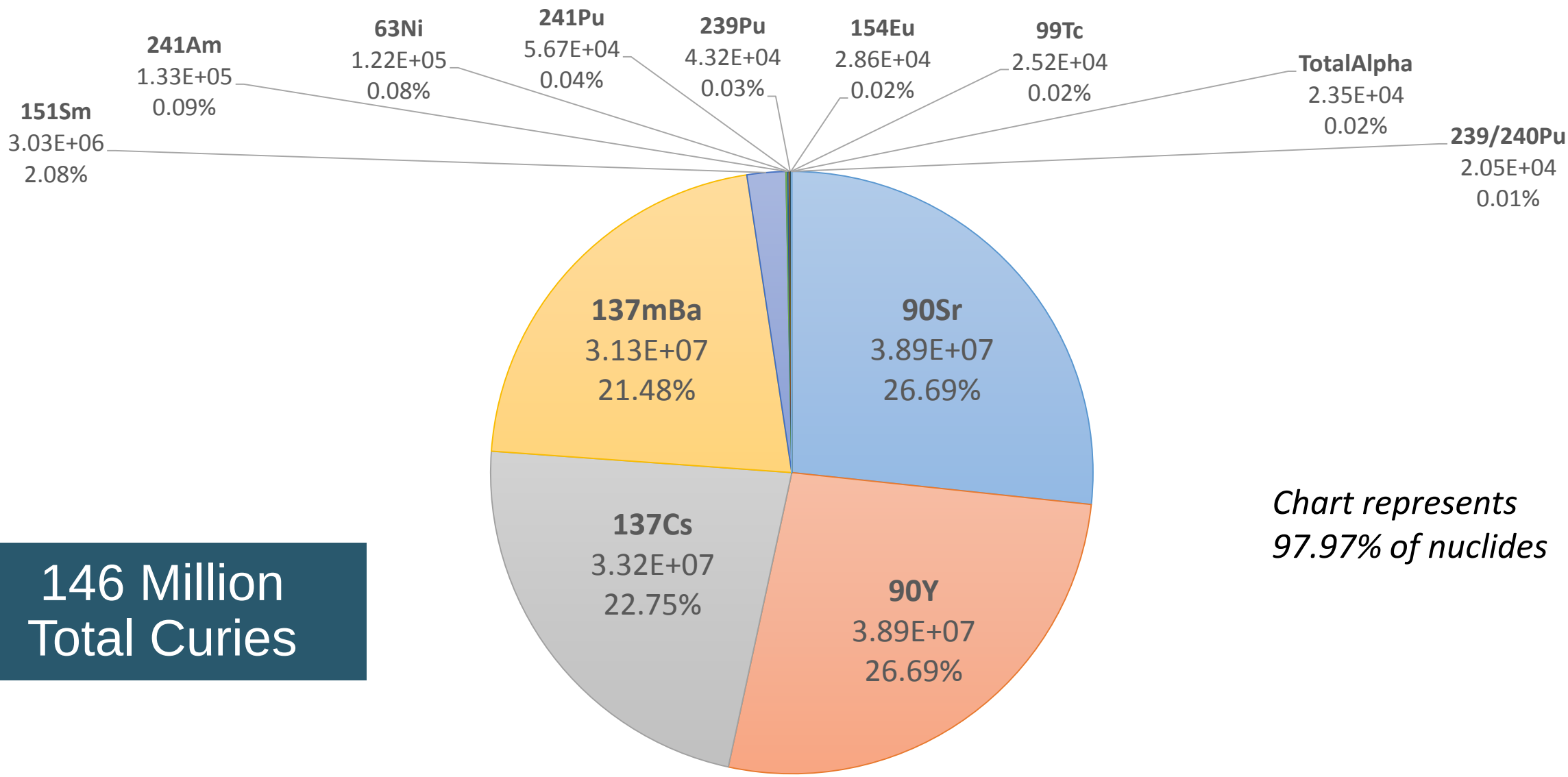
Double-Shell Tank Construction

Hanford's Tank Waste – 54,000,000 gallons of high-level waste

- 149 "single-shell" tanks
  - ✓ Oldest tank has held waste for 73+ years – since 1944
- 28 "double-shell" tanks
  - ✓ 31.5 million gallons total capacity
  - ✓ Newest tank has held waste for 30+ years – since 1986

Tank Radionuclides (Curies)



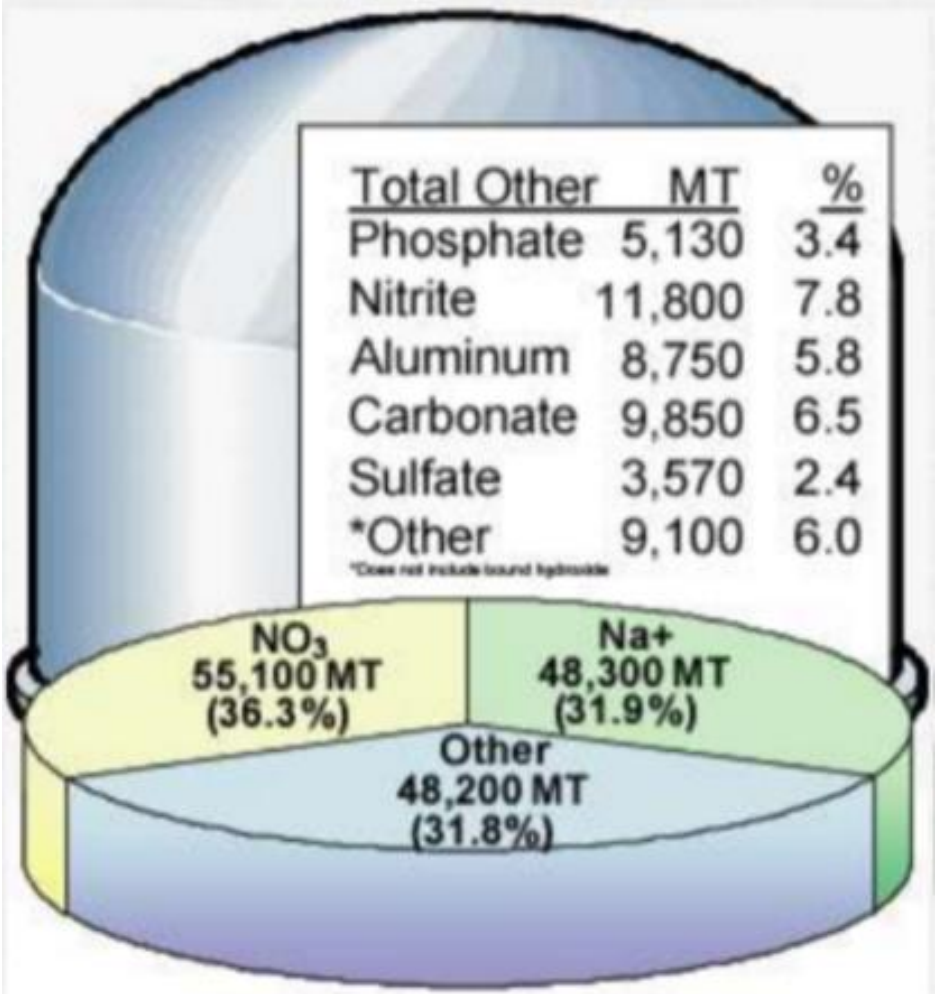
146 Million Total Curies

Chart represents 97.97% of nuclides

Tank Non-Rad Constituents

Total Other	MT	%
Phosphate	5,130	3.4
Nitrite	11,800	7.8
Aluminum	8,750	5.8
Carbonate	9,850	6.5
Sulfate	3,570	2.4
*Other	9,100	6.0

*Does not include bound hydroxide



Total in All Tanks
151,600 Metric Tons

The Mission "Product"

High-Level Waste Canisters

- 2' x 14.75'
- 6,600 pounds of glass each
- 600 canisters produced/year
- ~ 7,200 to 27,800 canisters
- Temporarily stored at Hanford until National Repository opened

Low-Activity Waste Canisters

- 4' x 7.5'
- 13,000 pounds of glass each
- 1,300 containers produced/year
- ~ 58,000 to 96,000 canisters
- Disposed on Hanford Site

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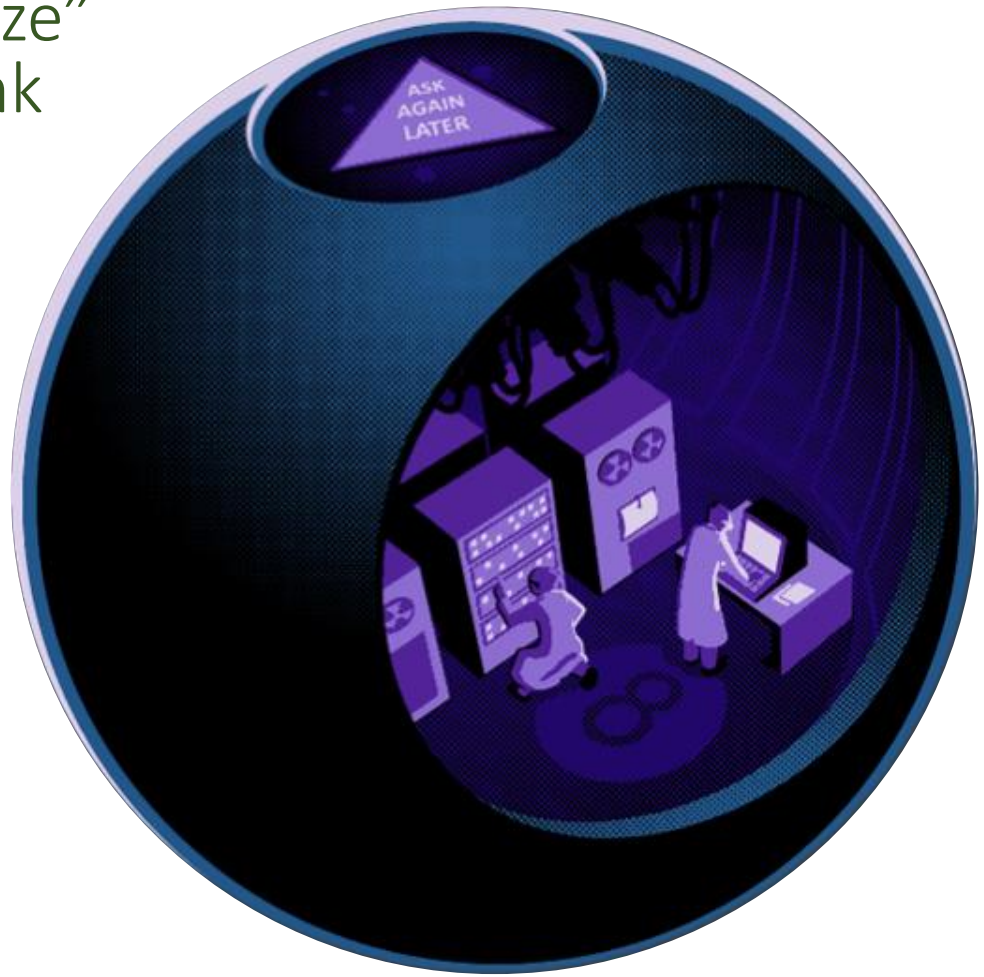
Balance of Facilities
High-Level Waste Facility
Low-Activity Waste Facility
Pretreatment Facility
Analytical Laboratory

What is the System Plan?

- Purpose is to evaluate scenarios and “optimize” the system for retrieval and treatment of tank waste “as quickly as is technically feasible”
- Projects where, how, and when tank waste moves through retrieval & treatment
- Models:
  - Facility operations (waste retrieval/transfer/treatment)
  - Glass formulation (batch recipes)
  - Waste solubility (solid/liquid)
  - Lifecycle cost/schedule.



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How does the System Plan fit the bigger picture?

- Required every 3 years under Consent Decree milestone M-062-40, effective 2010.
- Supports negotiation of enforceable milestones between DOE and Ecology.
  - Negotiation currently ongoing until April 30th*
- Calls attention to facility needs and funding/schedule issues and opportunities

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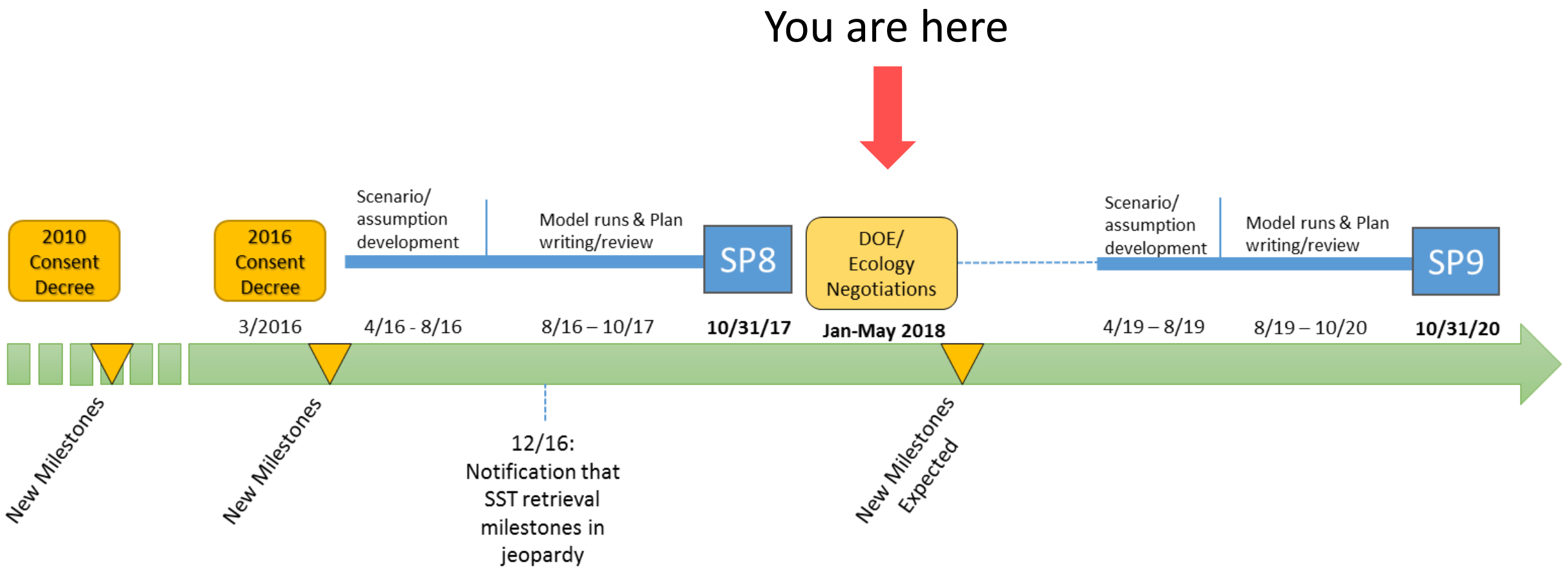
*Subject to extension

Milestones Set the Course



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What are our objectives in Oregon?

1. Prevent new releases of tank contents to the environment
2. Retain emergency capacity to respond to additional DST failures
3. Meet obligations for SST waste retrieval
4. Complete treatment of all possible tank waste
5. Choose treatment and disposal pathways for generated and residual wastes that provide long-term protection of human health and the environment

The Universal Qualifier:
"To the maximum extent technically and economically practicable"

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Tank Treatment as a System

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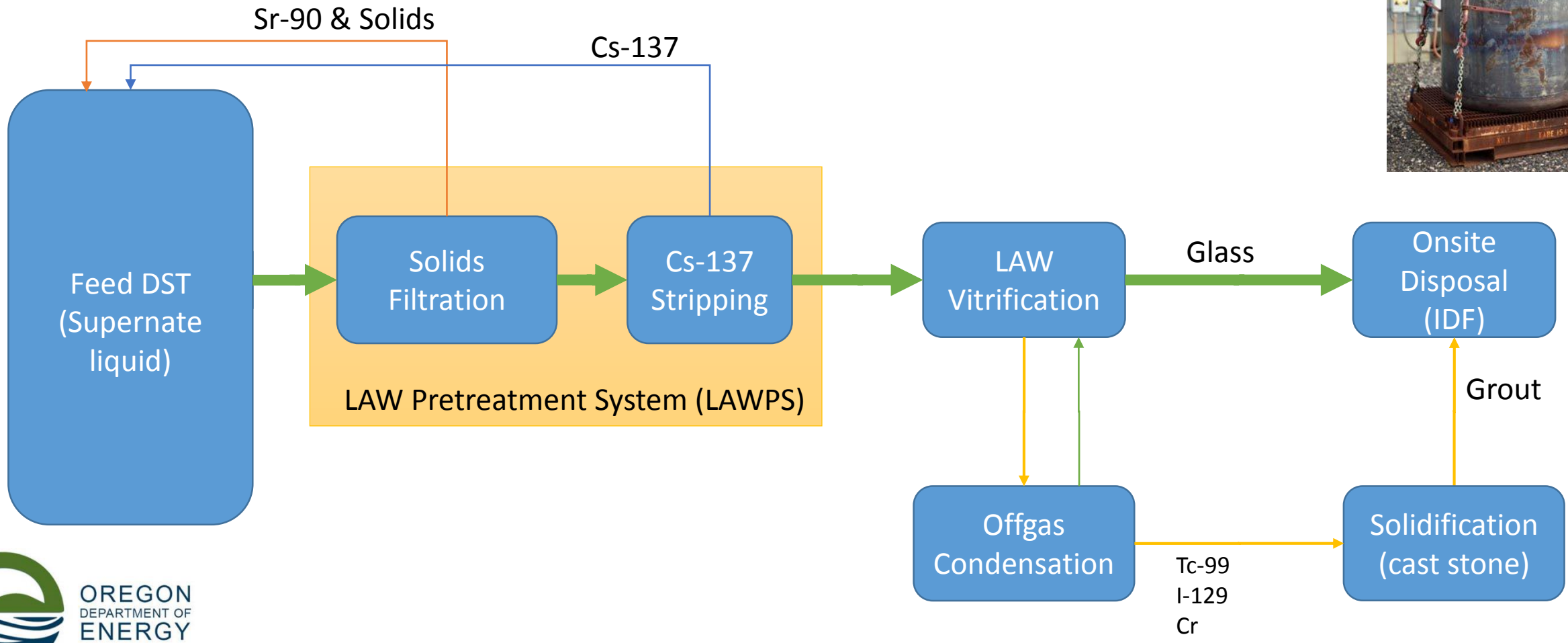
DFLAW Treatment Path (2022-2036)

Net DST space created = ~12.7M gals
11,000 glass containers = 12% of total LAW mission



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HLW Treatment Path (2036 - 2063?)

Feed DST

Supernate

Slurry

Characterization & Staging

Mixing, sampling, batch-making, storage

Pretreat

Offgas

HLW Vitrification

Glass

Offsite Disposal

Offgas condensate

Solidification (cast stone)

Onsite Disposal (IDF)

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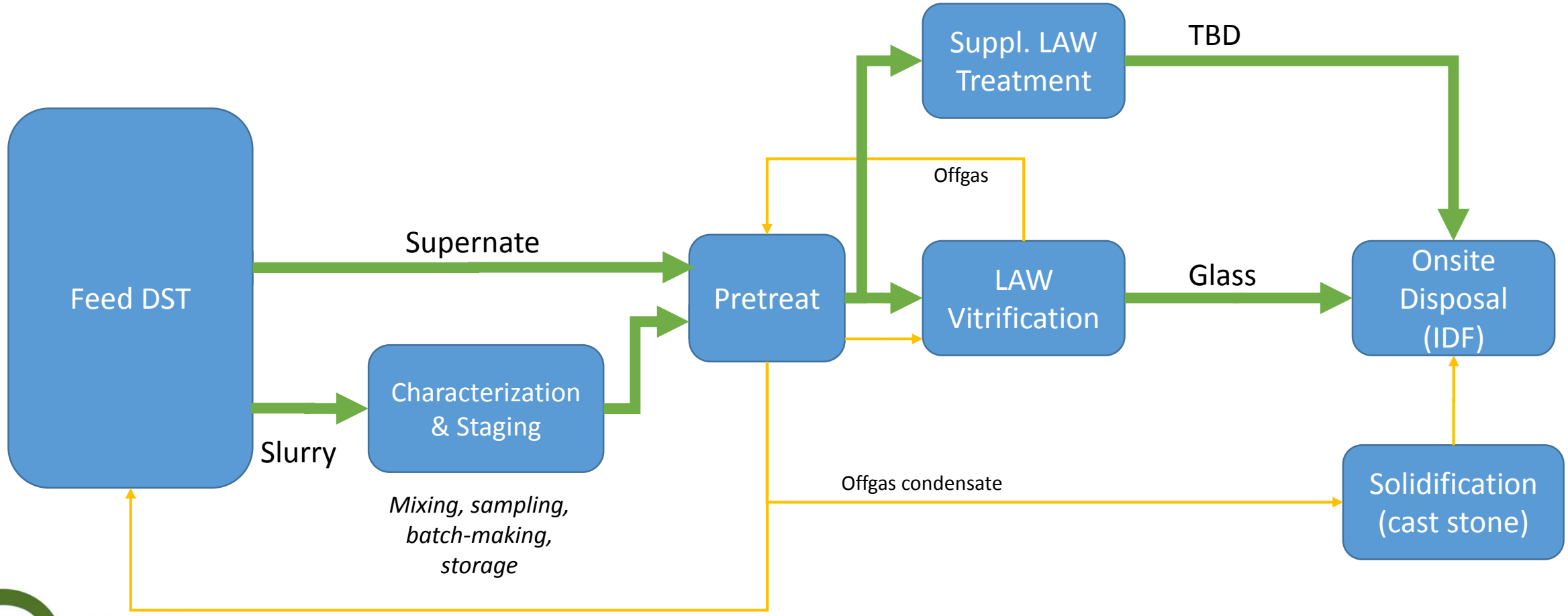
LAW Treatment Path (2036 - 2063?)



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Tank Treatment as a System

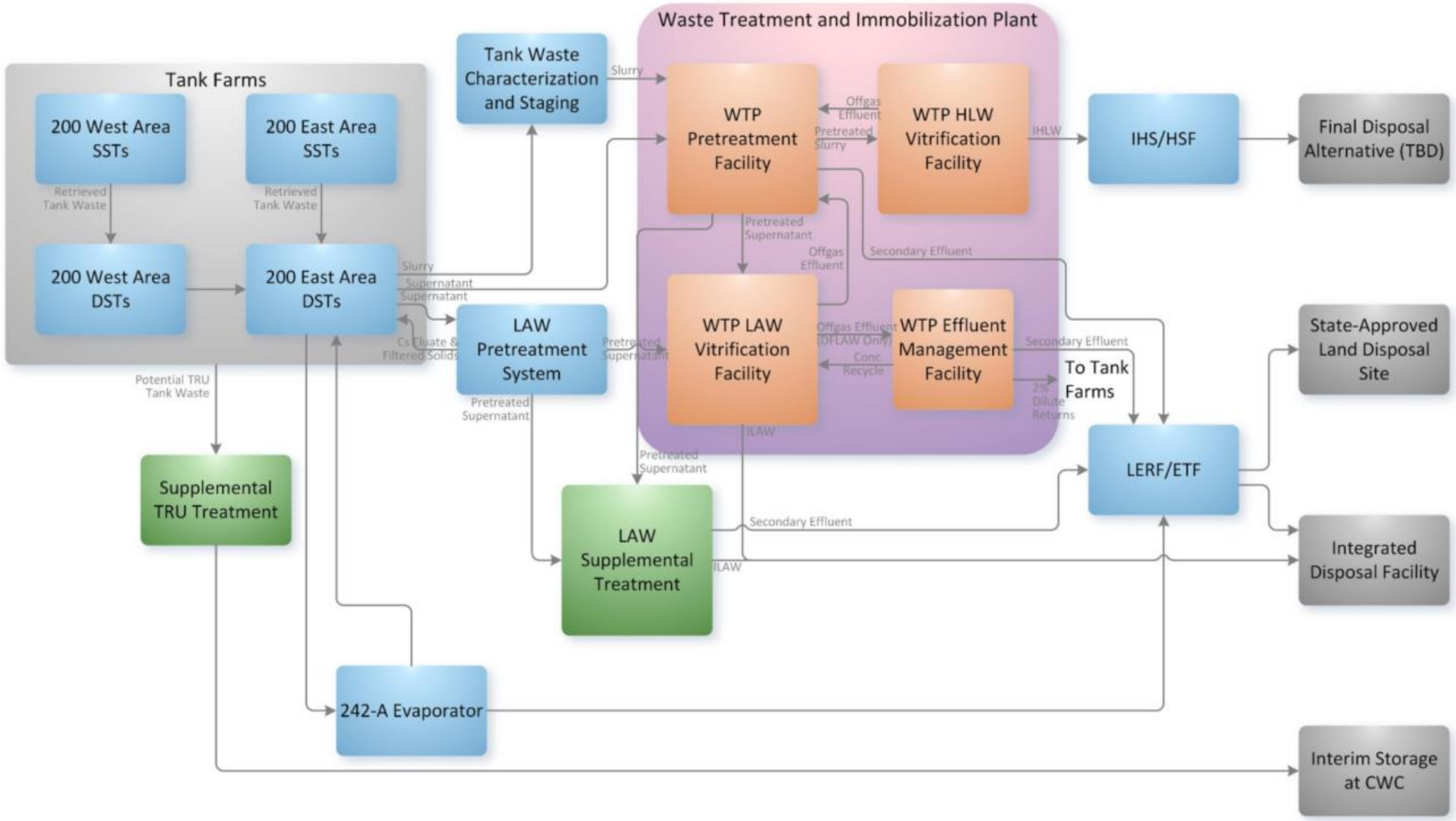
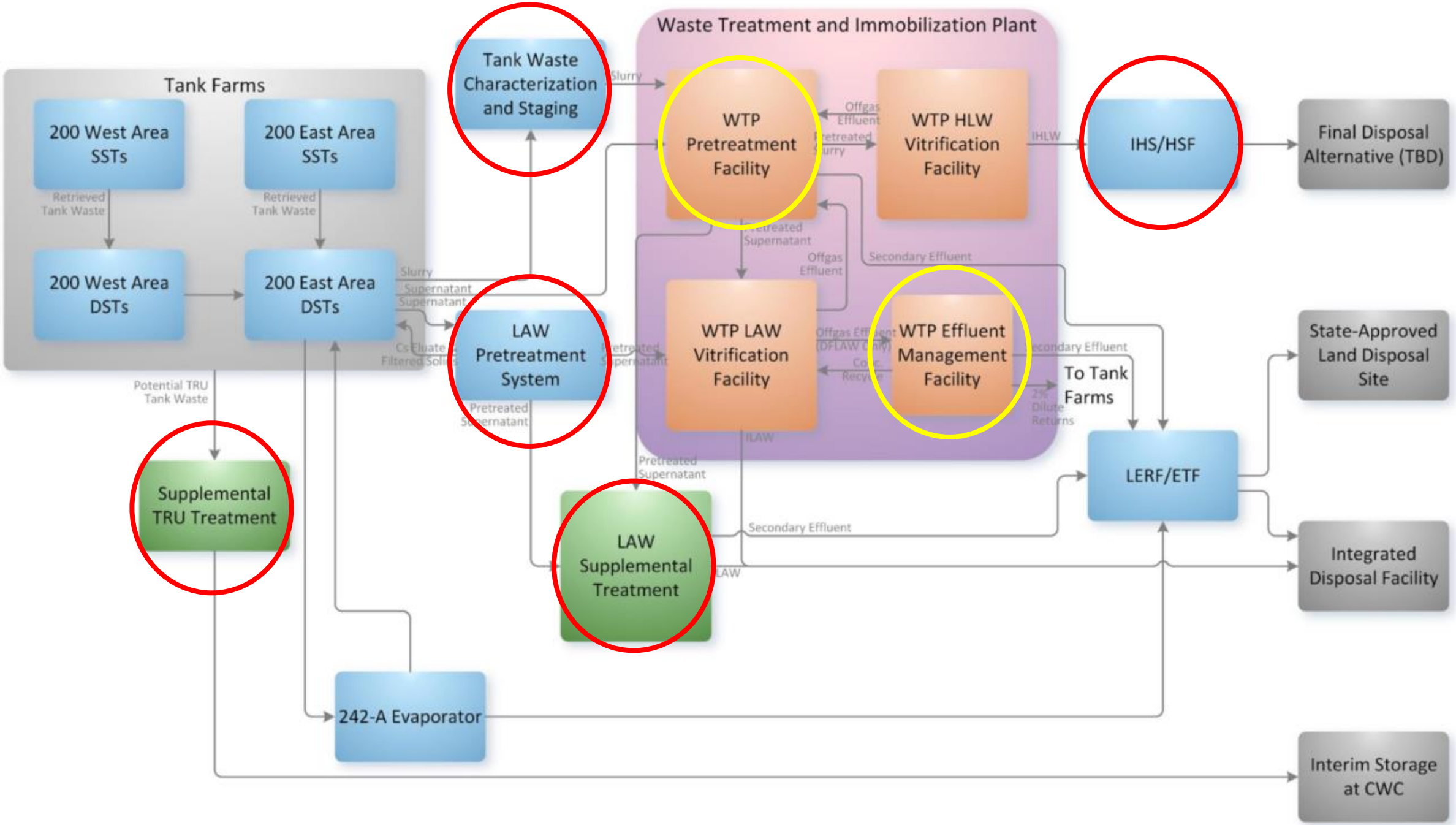
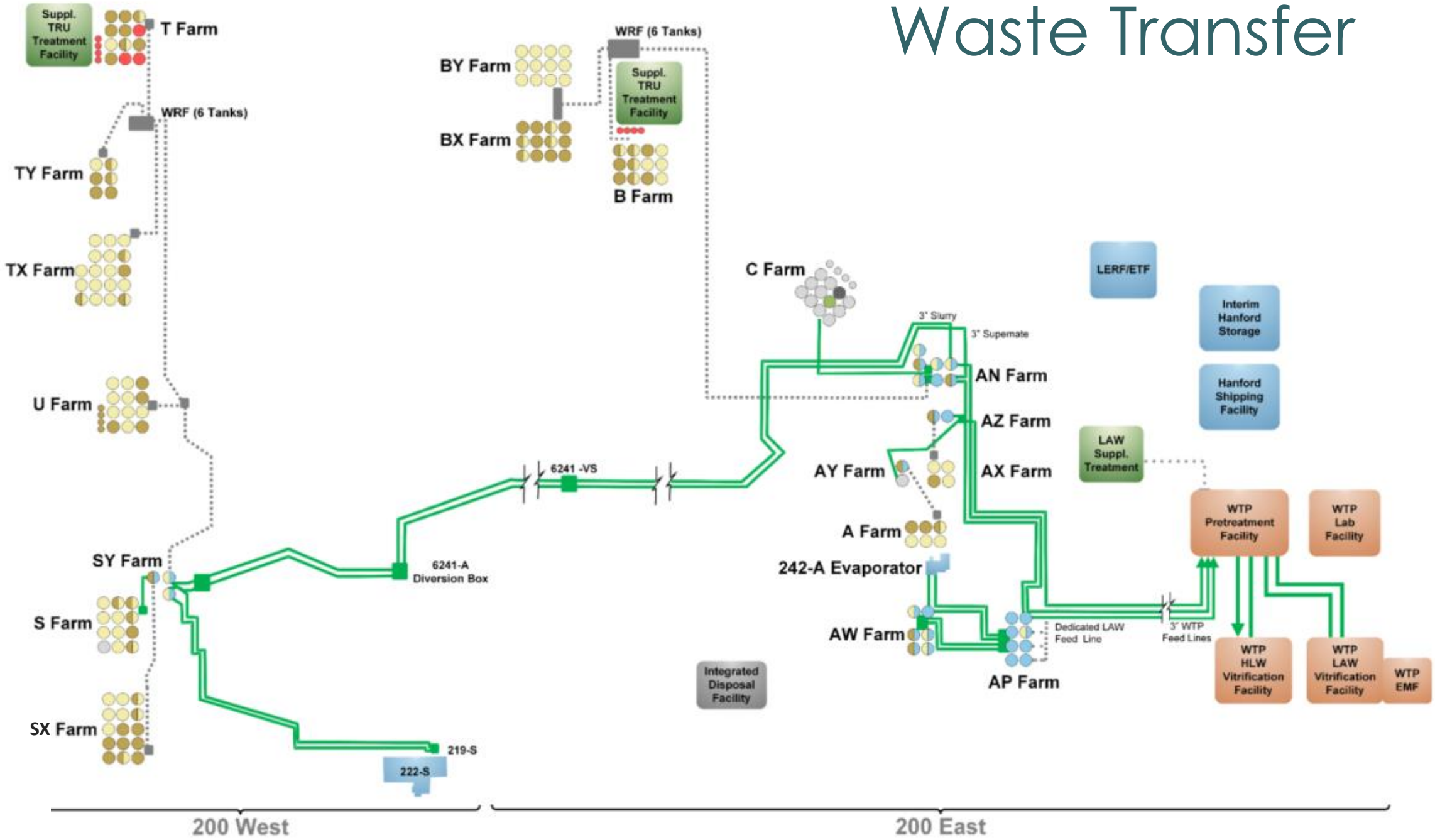


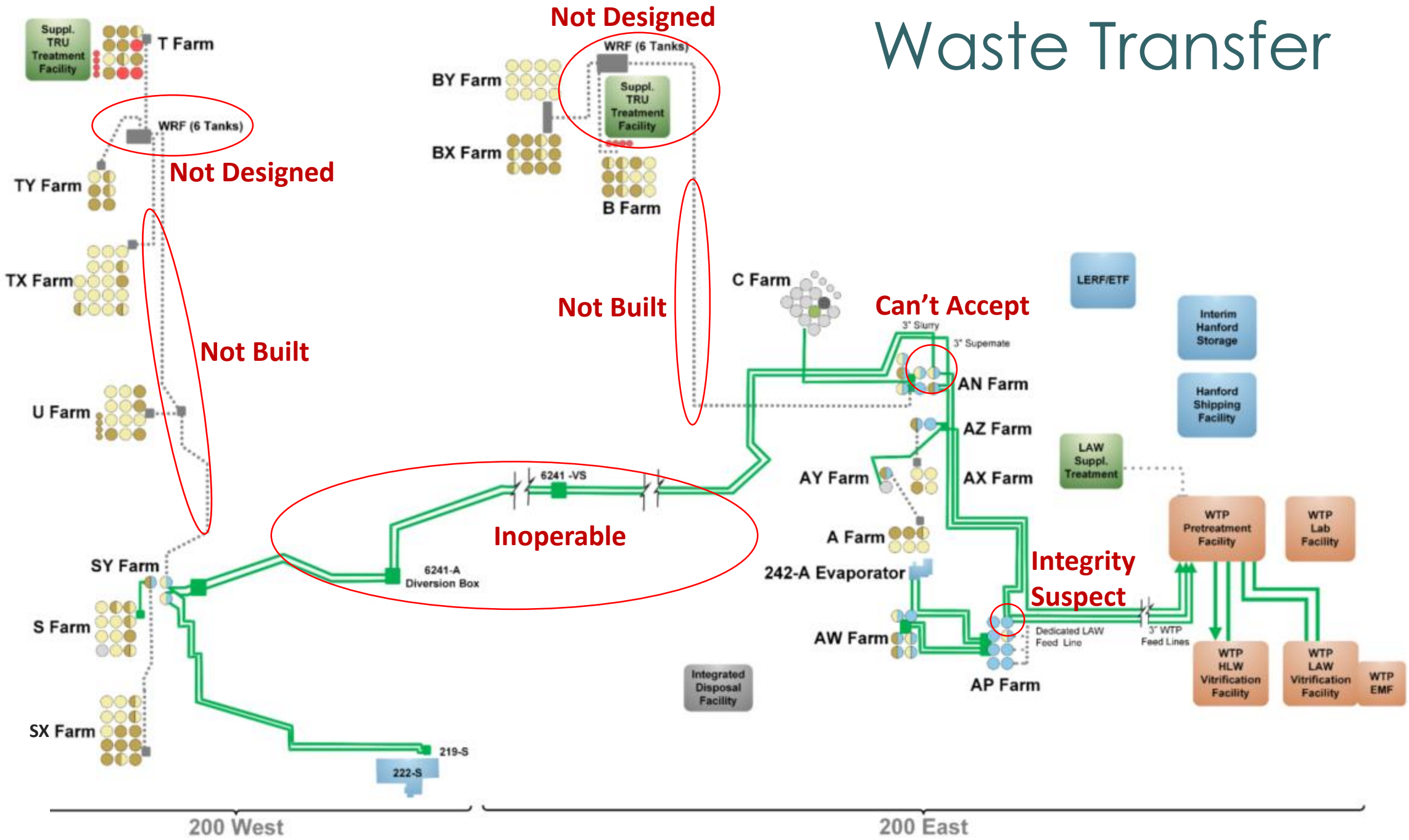
Figure 5-1. Baseline Case – Simplified Flowsheet.



Waste Transfer



Waste Transfer



The New Baseline

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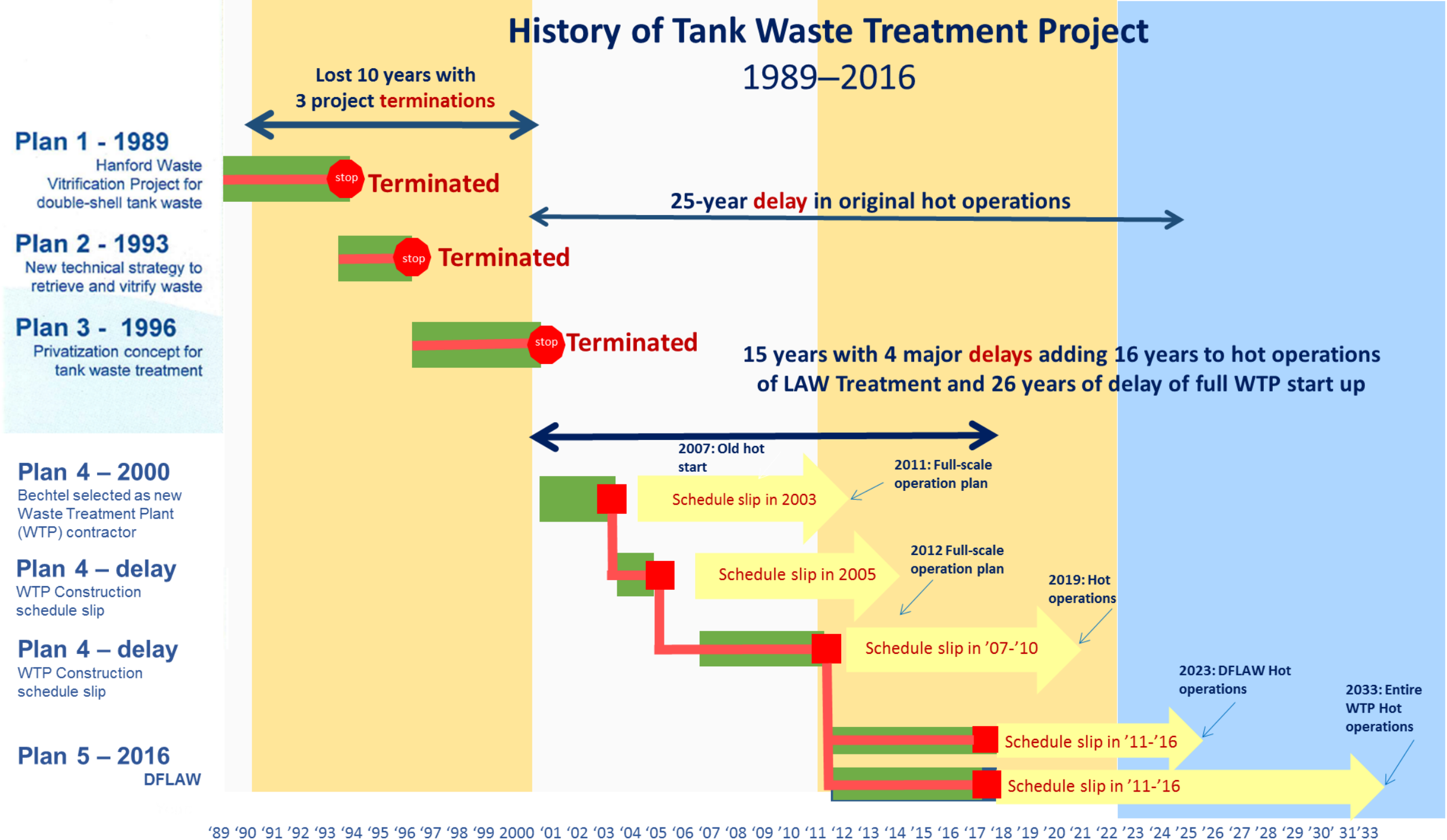
History of Tank Waste Treatment Project
1989–2016



The new baseline: a longer road ahead

- Why? WTP is delayed.
- Why? Pre-treatment is hard.
- Why do we want Pre-treatment? It saves us HLW glass volume.
- Why is that important? No HLW repository exists, and the last limit for Yucca was only 70,000 tons of heavy metal HLW
  - Baseline Scenario will make ~24,000 tons glass (unclear how much is heavy metal); all US commercial & defense HLW = 86,000 tons today).
- Why else? Pre-treatment allows separation of LAW for onsite disposal.
- What does it all mean? Increased risk of tank failure, seismic events, aging infrastructure failure.

"It always takes longer than you think. It always costs more than you think."
-Bob Vila

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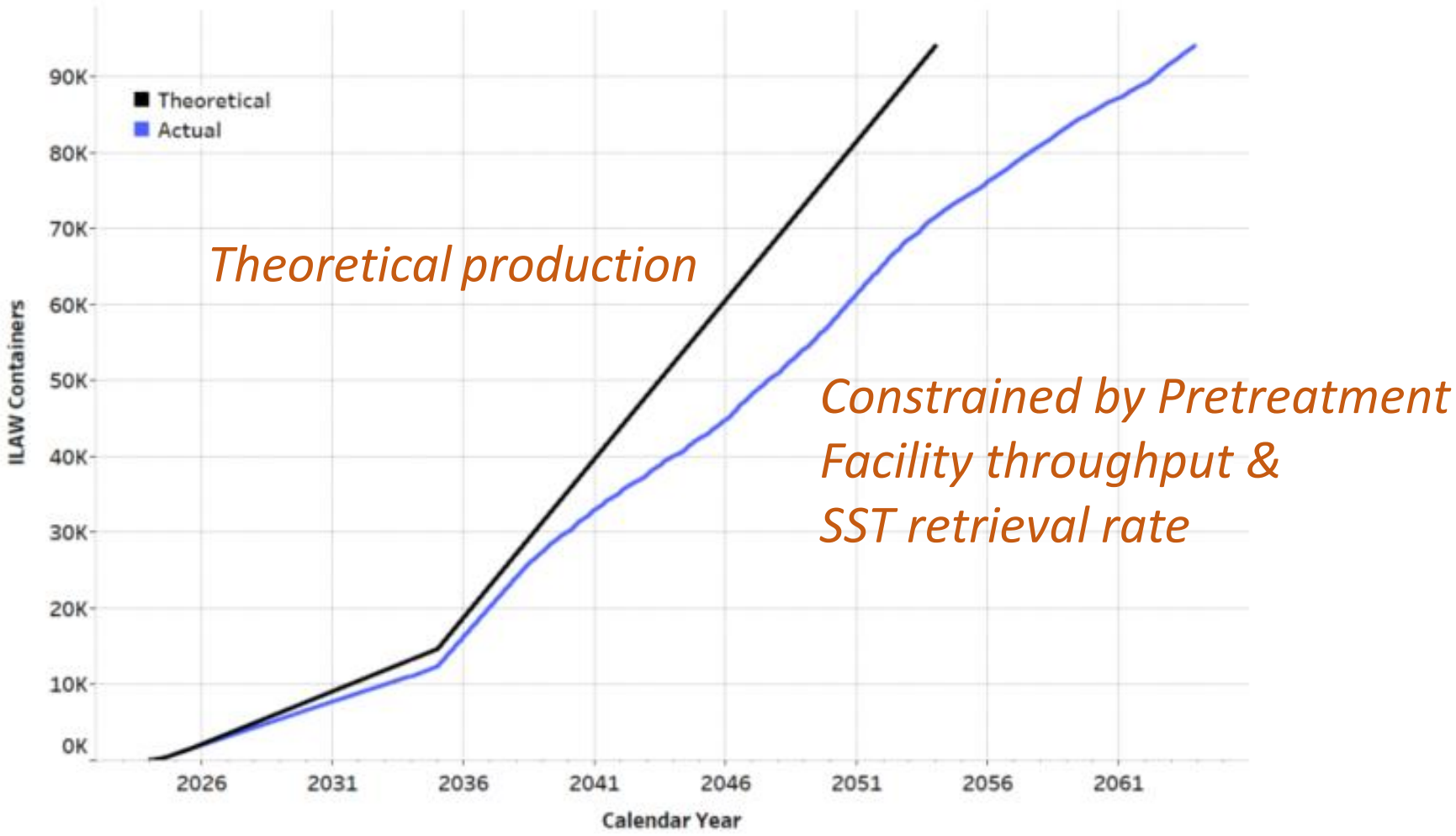
LAW Glass Production

Figure 5-16. Baseline Case – Projected Combined Immobilized Low-Activity Waste Production.



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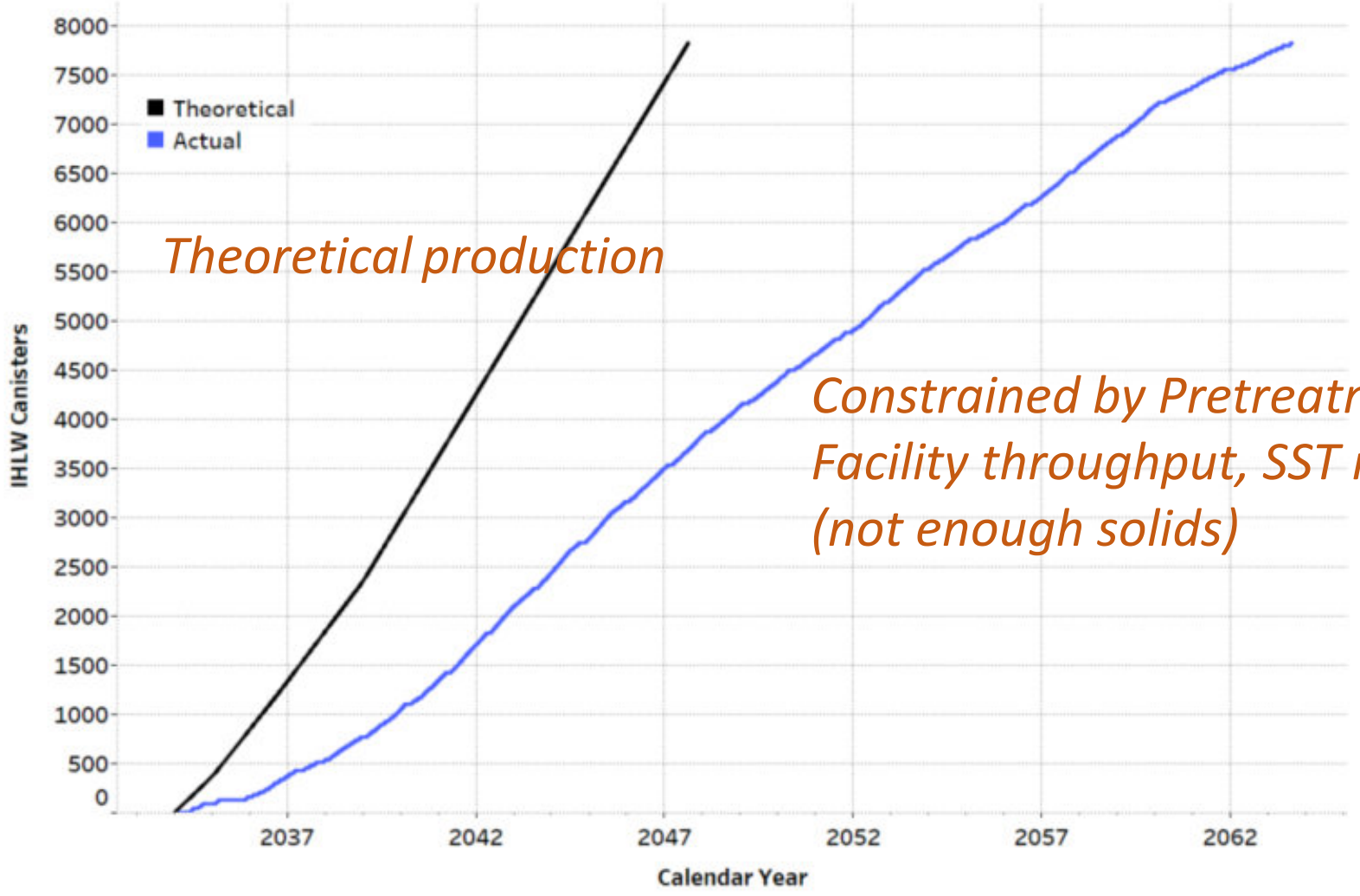
HLW Glass Production

Figure 5-15. Baseline Case – Projected Immobilized High-Level Waste Production.



Theoretical production

Constrained by Pretreatment Facility throughput, SST retrieval (not enough solids)

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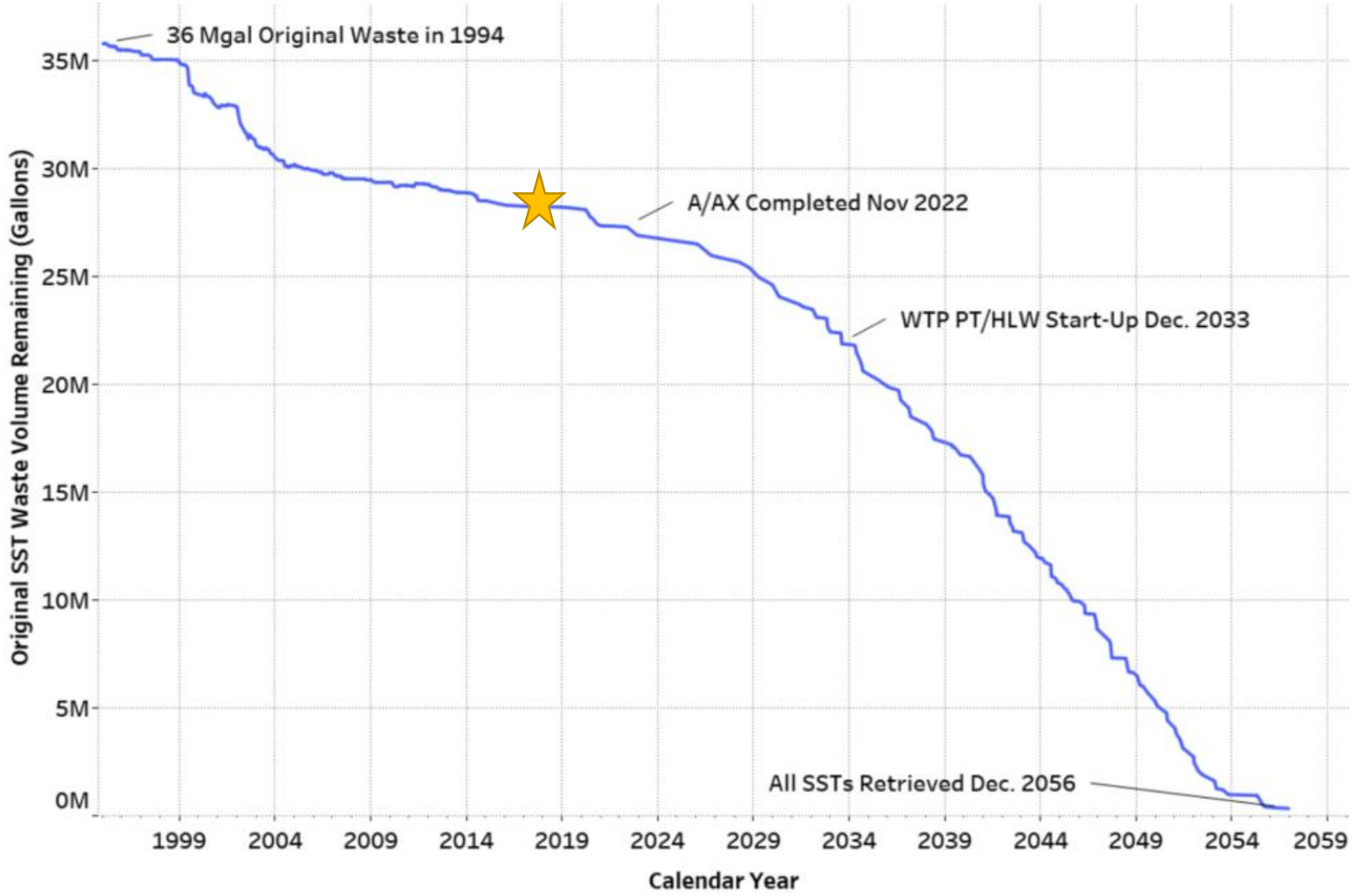
SST Retrievals

Figure 5-4. Baseline Case – Single-Shell Tank Retrieval Progress.



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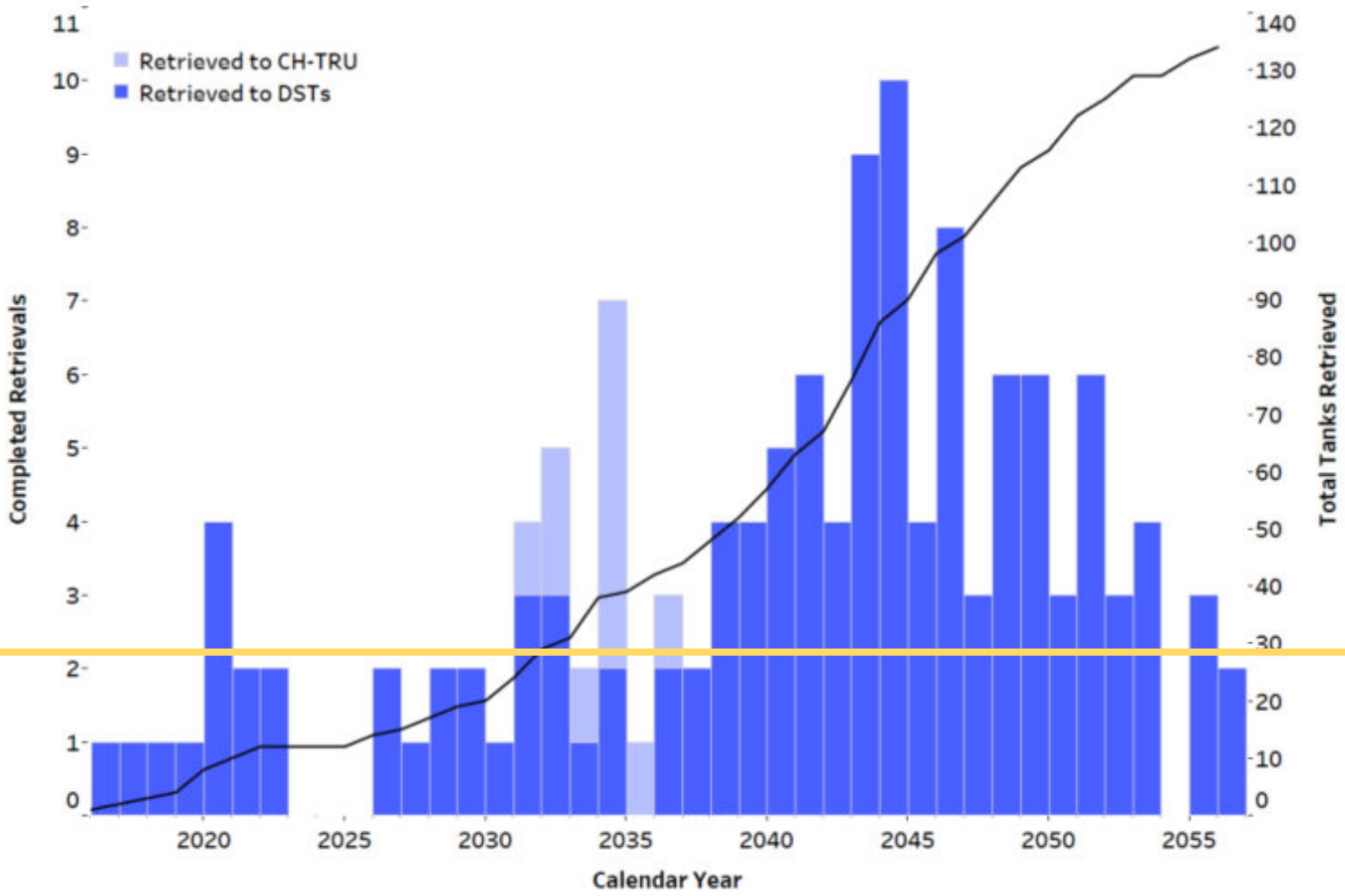
SST Retrieval Rate

Figure 5-5. Baseline Case – Total Single-Shell Tank Retrievals Completed per Calendar Year.



C-Farm approx. retrieval rate (16 tanks in ~9 years)

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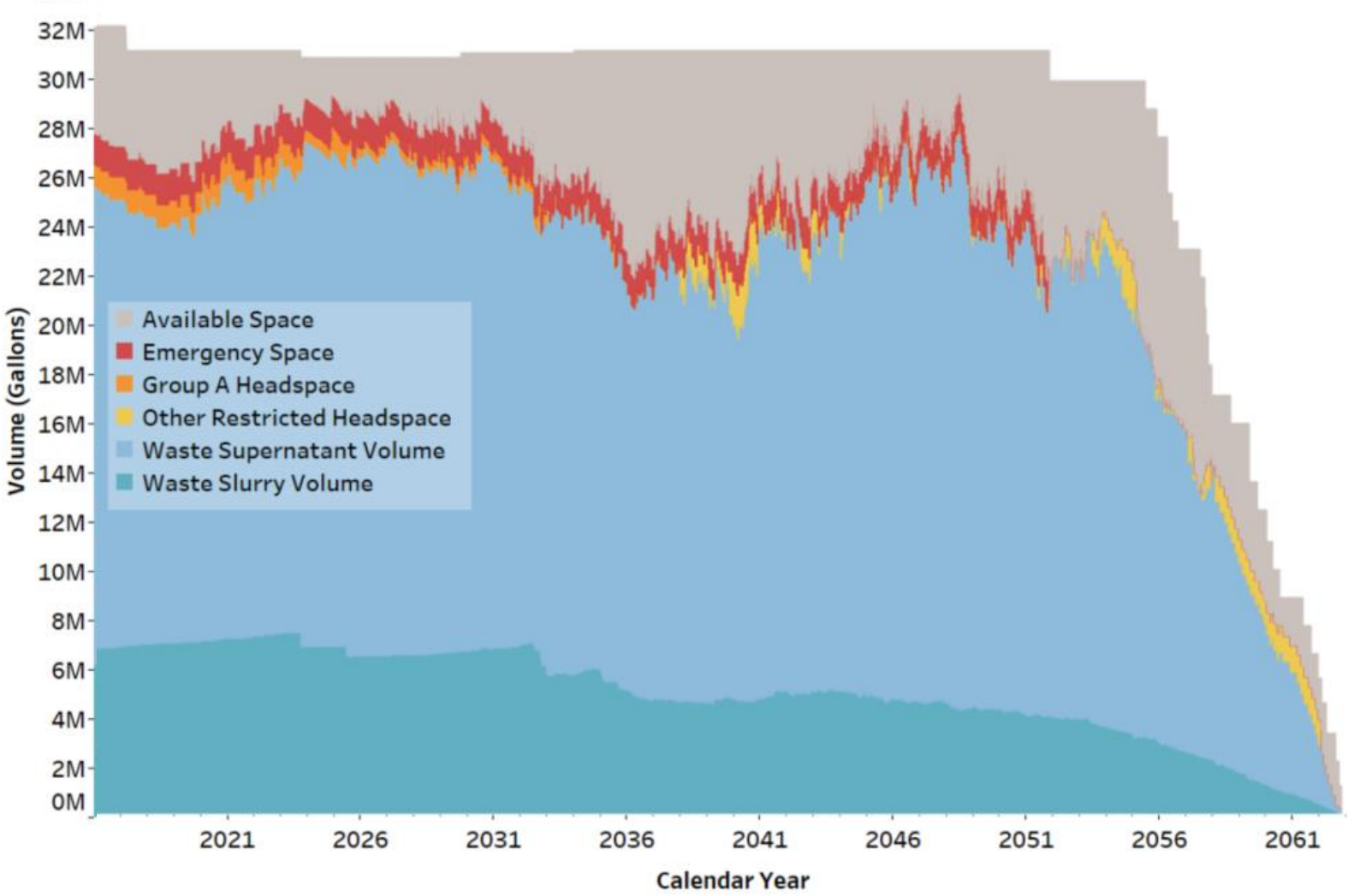
DST Utilization

Figure 5-8. Baseline Case – Double-Shell Tank Space Utilization.



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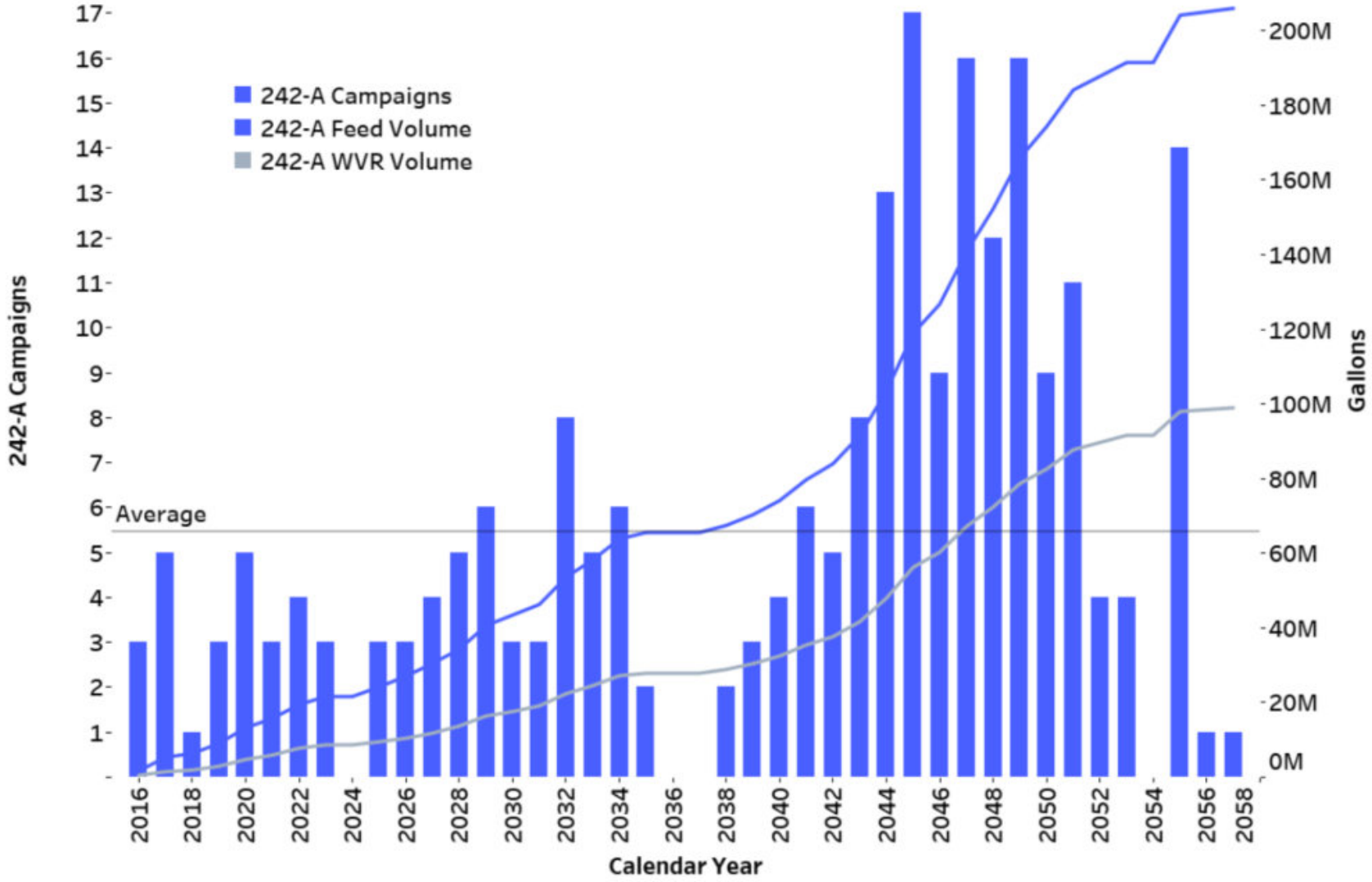
Evaporation

Figure 5-11. Baseline Case – Projected Operation of the 242-A Evaporator.



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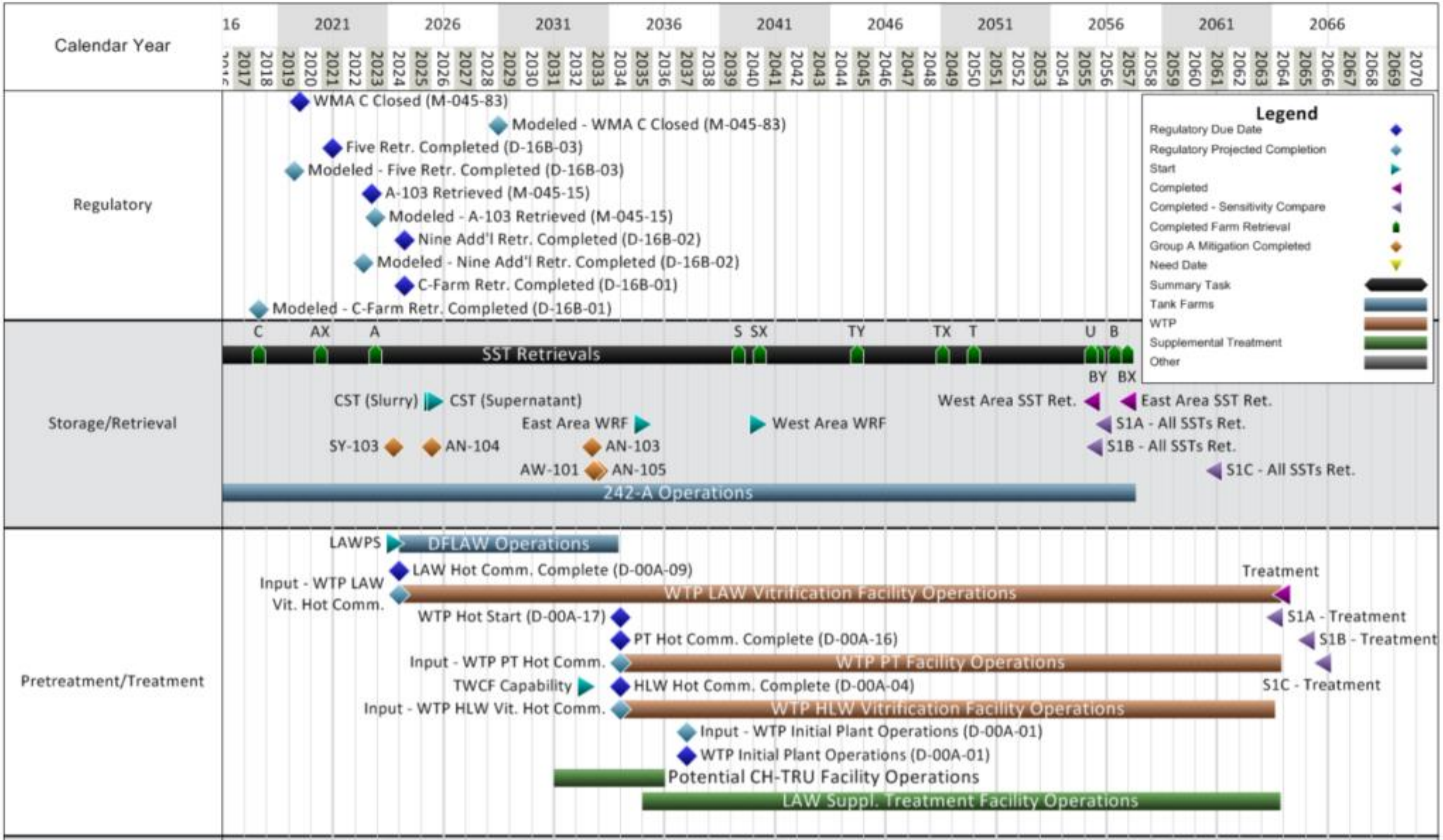
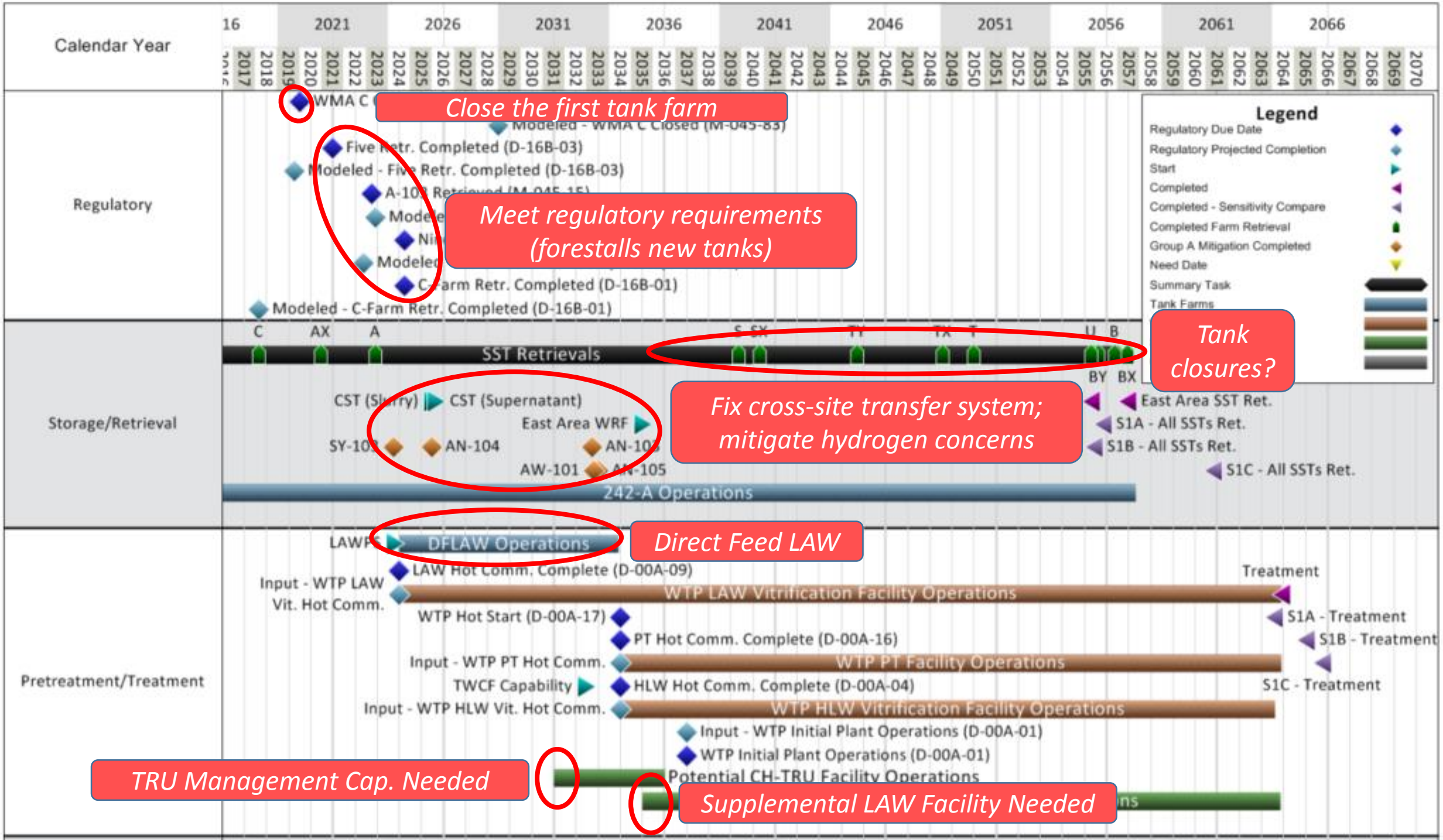
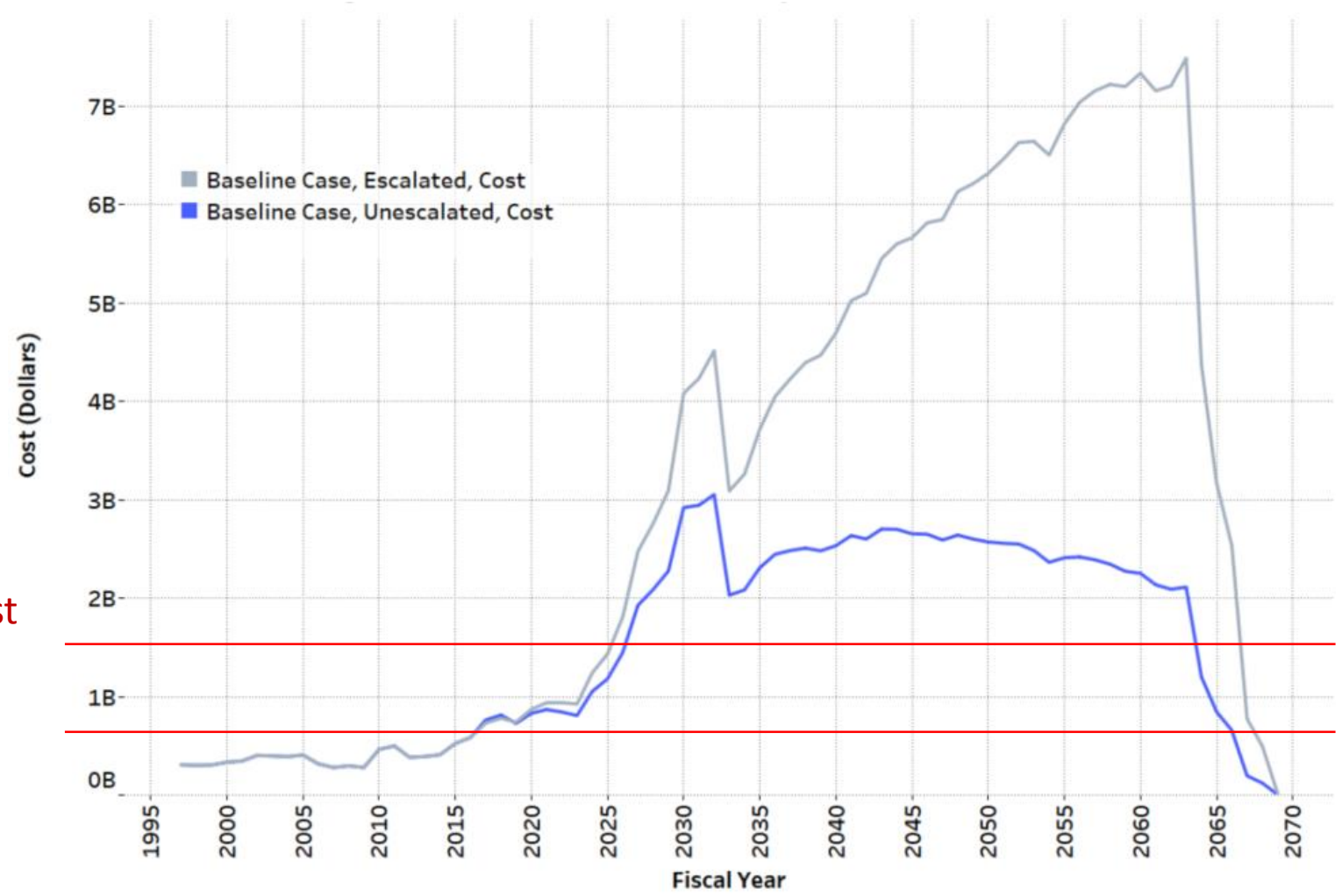

Calendar Year
16
2021
2026
2031
2036
2041
2046
2051
2056
2061
2066
Regulatory
WMA C Closed (M-045-83)
Modeled - WMA C Closed (M-045-83)
Five Retr. Completed (D-16B-03)
Modeled - Five Retr. Completed (D-16B-03)
A-103 Retrieved (M-045-15)
Modeled - A-103 Retrieved (M-045-15)
Nine Add'l Retr. Completed (D-16B-02)
Modeled - Nine Add'l Retr. Completed (D-16B-02)
C-Farm Retr. Completed (D-16B-01)
Modeled - C-Farm Retr. Completed (D-16B-01)
Legend
Regulatory Due Date
Regulatory Projected Completion
Start
Completed
Completed - Sensitivity Compare
Completed Farm Retrieval
Group A Mitigation Completed
Need Date
Summary Task
Tank Farms
WTP
Supplemental Treatment
Other
Storage/Retrieval
C
AX
A
S
SX
TY
TX
T
U
B
SST Retrievals
BY
BX
CST (Slurry)
CST (Supernatant)
West Area SST Ret.
East Area SST Ret.
East Area WRF
West Area WRF
S1A - All SSTs Ret.
SY-103
AN-104
AN-103
S1B - All SSTs Ret.
AW-101
AN-105
S1C - All SSTs Ret.
242-A Operations
Pretreatment/Treatment
LAWPS
DFLAW Operations
LAW Hot Comm. Complete (D-00A-09)
Treatment
Input - WTP LAW Vit. Hot Comm.
WTP LAW Vitrification Facility Operations
WTP Hot Start (D-00A-17)
S1A - Treatment
PT Hot Comm. Complete (D-00A-16)
S1B - Treatment
Input - WTP PT Hot Comm.
WTP PT Facility Operations
TWCF Capability
HLW Hot Comm. Complete (D-00A-04)
S1C - Treatment
Input - WTP HLW Vit. Hot Comm.
WTP HLW Vitrification Facility Operations
Input - WTP Initial Plant Operations (D-00A-01)
WTP Initial Plant Operations (D-00A-01)
Potential CH-TRU Facility Operations
LAW Suppl. Treatment Facility Operations


Calendar Year
Regulatory
Storage/Retrieval
Pretreatment/Treatment
Close the first tank farm
Meet regulatory requirements (forestalls new tanks)
Tank closures?
Fix cross-site transfer system; mitigate hydrogen concerns
Direct Feed LAW
TRU Management Cap. Needed
Supplemental LAW Facility Needed
Legend
Regulatory Due Date
Regulatory Projected Completion
Start
Completed
Completed - Sensitivity Compare
Completed Farm Retrieval
Group A Mitigation Completed
Need Date
Summary Task
Tank Farms
Five Retr. Completed (D-16B-03)
Modeled - Five Retr. Completed (D-16B-03)
Modeled - C-Farm Retr. Completed (D-16B-01)
SST Retrievals
CST (Supernatant)
East Area WRF
AN-104
AW-101
242-A Operations
East Area SST Ret.
S1A - All SSTs Ret.
S1B - All SSTs Ret.
S1C - All SSTs Ret.
DFLAW Operations
LAW Hot Comm. Complete (D-00A-09)
Input - WTP LAW Vit. Hot Comm.
WTP LAW Vitrification Facility Operations
Treatment
WTP Hot Start (D-00A-17)
PT Hot Comm. Complete (D-00A-16)
Input - WTP PT Hot Comm.
WTP PT Facility Operations
TWCF Capability
HLW Hot Comm. Complete (D-00A-04)
Input - WTP HLW Vit. Hot Comm.
WTP HLW Vitrification Facility Operations
Input - WTP Initial Plant Operations (D-00A-01)
WTP Initial Plant Operations (D-00A-01)
Potential CH-TRU Facility Operations

The Funding "Bow Wave"

2018 ORP
Total Budget Request



Budget minus
WTP Construction

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“What If” Scenarios

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“What ifs” in System Plan 8

- What if we start vitrifying HLW early without pre-treatment?
- What if we never finish the WTP Pretreatment Facility?
- What if retrieval and/or treatment go slower than we expect?
- What if we don’t retrieve waste in some tanks?
- What if we build some new double-shell tanks?
- What if we change the order of SST retrieval?
- What if the WTP facility is 5 years late?
- What if we grout the condensed steam offsite?

Scenario 2: Early Direct Feed HLW

Start treating HLW in 2024 via direct feed to melters from TWCS facility (before PT facility finished)

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
↓ 3 years	↓ 5 years	↓ $7 Bil. ($35B escal.)	↑ 3,600 HLW ↓ 1,400 LAW	• "Hybrid Mode" (PT Facility + TWCS) could save 14 years on HLW portion of mission.	• Extra $4.7B needed now thru 2033 • 242-A Evaporator in higher demand • TWCS needed in 6 years • More melters fail • More HLW storage • No WAC for DFHLW glass

Scenario 3: Early DFHLW + no PT Facility

Pretreatment facility never finished; HLW vitrification fed directly from TWCS; LAW vitrification fed directly from LAWPS; No Supplemental LAW facility.

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
↑ 8 years	↑ 63 years	↑ $40 Bil. ($537 B escal.)	↑ 56,000 HLW (190K tons) ↓ 34,000 LAW		• TWCS needed in 6 years • More HLW onsite storage • No WAC for DFHLW glass • More melters fail

Scenario 4: "Risk-Informed" Retrieval

49 SSTs would be closed without retrieval (2% of total Curie inventory); Based on C-106 precedent; TRU tanks not retrieved

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
↓ 6 years	↓ 2 years	↓ $8 Bil. ($26 B escal.)	↓ 600 HLW ↓ 8,500 LAW	• 4.9 million gals more waste remain vs. baseline (300K) • 1.48M Ci left in tanks	• 49 selected tanks not vetted for dose/hazard risks in System Plan • Unassessed risk of regulatory costs, lawsuits, etc. for tank closure

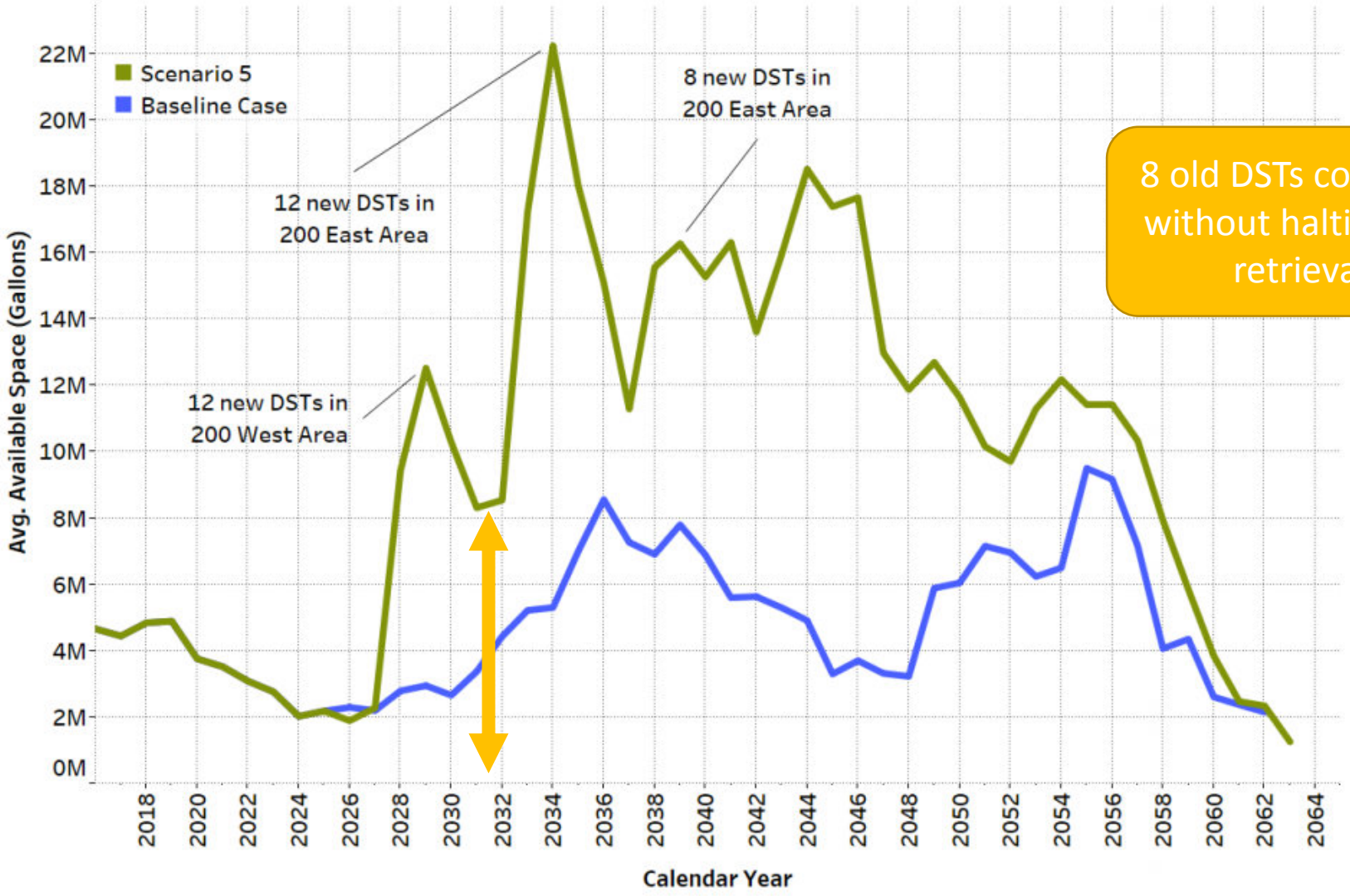
Scenario 5: Accelerated Retrieval Completion

Total of 32 additional DSTs built in 2028 (12), 2033 (12), and 2038 (8) for purposes of SST retrieval space. Assumes 8 years to build tanks.

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
↓ 10 years	↑ 1 year	↑ $6 Bil. ($8 B escal.)	=	• SST retrieval rate same as baseline, but DST capacity reduces delay by 62% • 242-A Evaporator shut down 8 years earlier, run lighter	• Extra $4B needed from 2020-2035 may delay WTP completion

What does 32 new DSTs buy us?

Figure 5-92. Scenario 5 Comparison – Double-Shell Tank Available Space.



8 old DSTs could fail without halting SST retrieval

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Scenario 6: TPA Compliant

- Calculates required capacities needed to meet TPA milestones for SST retrieval (2040) and all tank waste treatment (2047)
- Requires **58** new DSTs plus **2.5x** use of 242-A evaporator
- Requires **2x** Pretreatment Facility treatment rate
- LAW Supplemental facility would need **7** vit melters (Baseline = 4)
- Requires almost **10x** ramp-up of SST retrieval after 2028 (108 tanks in 13 years)
- Purpose of including this was to show how infeasible it is.

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Scenario 7: Reduced Throughput

Retrieval and treatment rates lower than expected.
7A*: Reduced retrieval rate only (2.5 times slower)
7B: Reduced treatment rate only (50% instead of 70% facility availability)

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
↑ 18 years	↑ 17 years	↑ $37 Bil. ($186 B escal.)	= HLW ↑ 1,400 LAW	• Assumes no new DSTs • Slower SST retrieval based on actual C-Farm experience.	• Assumes no DST failure • Increases aging infrastructure failure risks

Scenario 8: Early U Tank Farm Retrieval

Retrieve U Farm after A/AX farm (instead of S farm).

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
1 year	1 year	$1 Bil. ($2 B escal.)	HLW 800 LAW	• 16 tank retrievals instead of 8 in same time span • 4 leakers vs. 1 • U farm closed 8 years earlier than next farm after A/AX	• Higher sludge levels in U-farm may risk taking up DST capacity

Scenario 9: Offsite Effluent Treatment

Assumes total 7 Mil gals of condensate effluent treated offsite and disposed offsite or at IDF.

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
1 year	6 mos.	$1 Bil. ($4 B escal.)	HLW 8,300 LAW	• DOE sent 3 gals treated supernate to Texas in 2017 • Retrieves 4 more SSTs during DFLAW • Glass melters last longer • Group A tanks remed. 7 yrs early	• 60% of Tc-99 grouted "offsite" instead of in immobilized LAW. • Uncertain regulatory, transportation, environmental risks.

Scenario 10: Retrieval Contingency

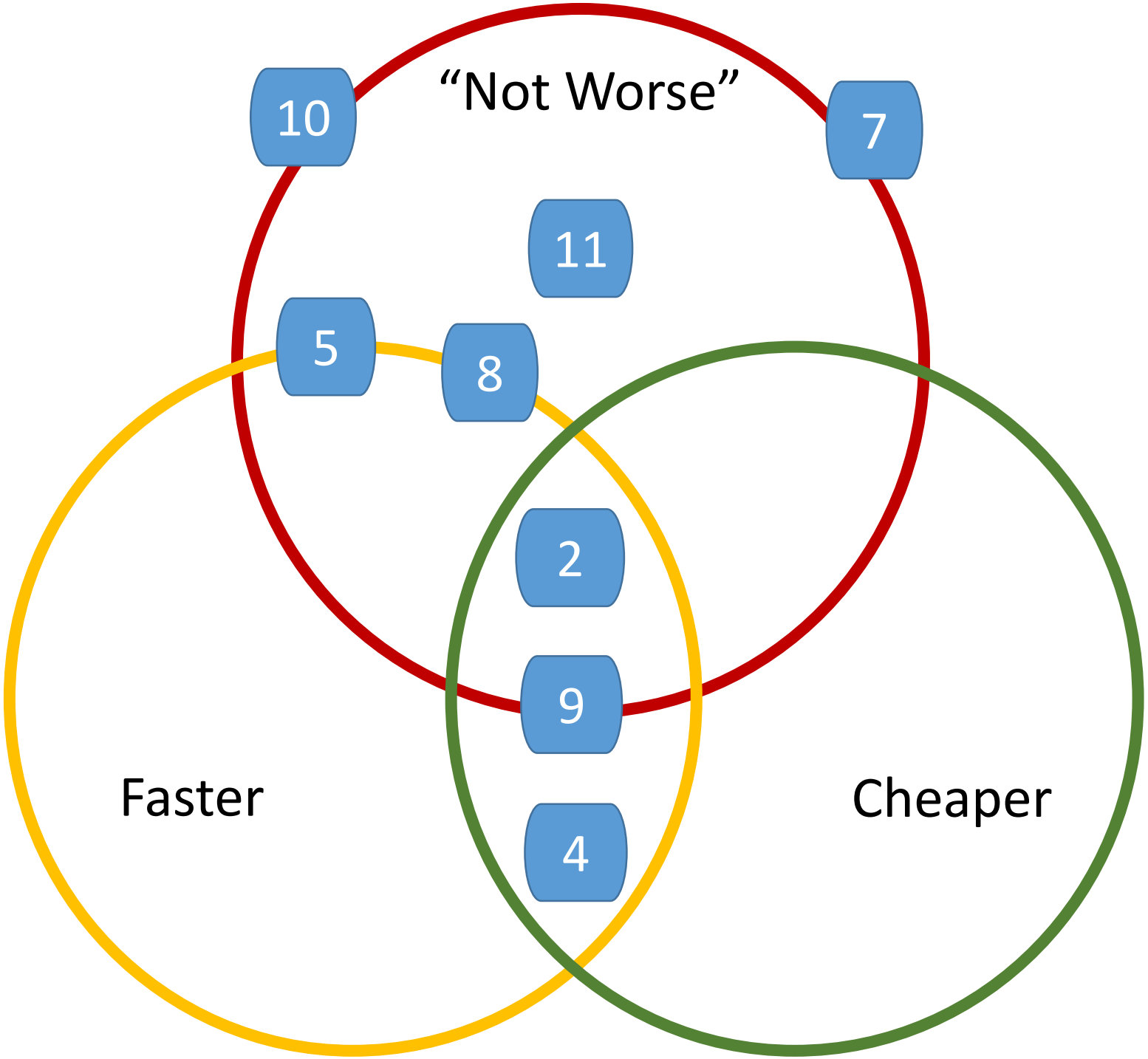
Assumes Waste Treatment Plant and Direct-Feed LAW start 5 years behind schedule. 12 new DSTs built by 2033 to meet Baseline SST retrieval targets.

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
1 year	5 years	$5 Bil. ($35 B escal.)	= HLW 1,800 LAW	• Extra DST space delays Group A tank mitigation by only 2 years • Reduced load on 242-A Evaporator	• Extra $4-5B needed from 2020-2033 may delay WTP completion • Mission delay increases aging infrastructure risk

Scenario 11: DFHLW with liquids-only PT-Fac.

Direct-Feed HLW for entire mission; no solids treatment from Pretreatment Facility (batch directly from TWCS).
DOE "Grand Challenge" alternative

Complete SST Retrieval	Complete Treatment	Cost	# Glass Canisters	Extras	Risks
↑ 6 years	↑ 16 years	↑ $25 Bil. ($138 B escal.)	↑ 20,000 HLW ↓ 24,800 LAW	• Model could be further optimized	• Melters fail more often • More IHLW storage • Aging infrastructure • TWCS facility design more complicated



N/A

3

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Risks and Vulnerabilities

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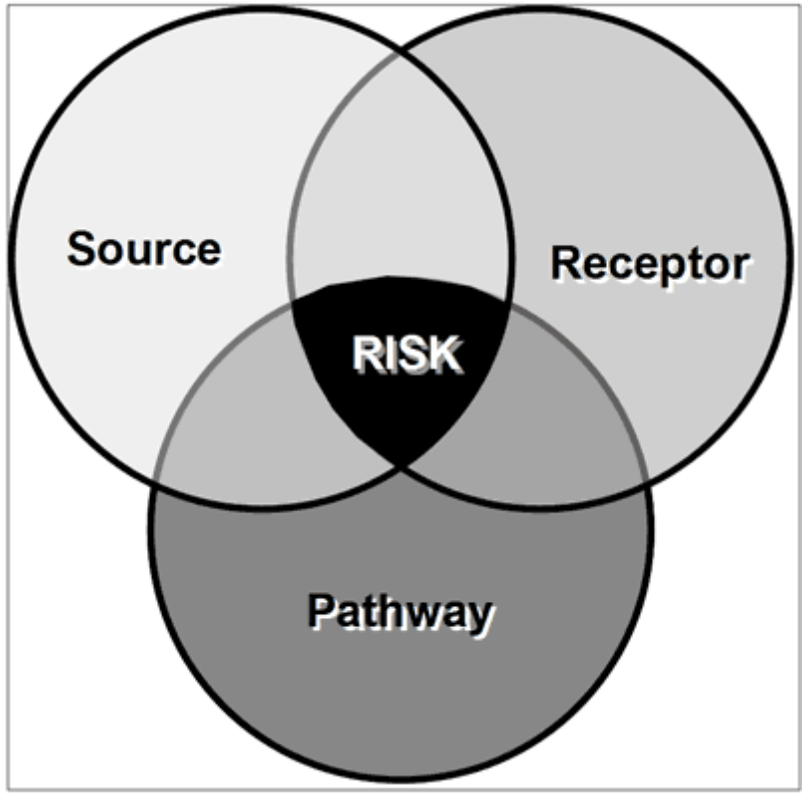
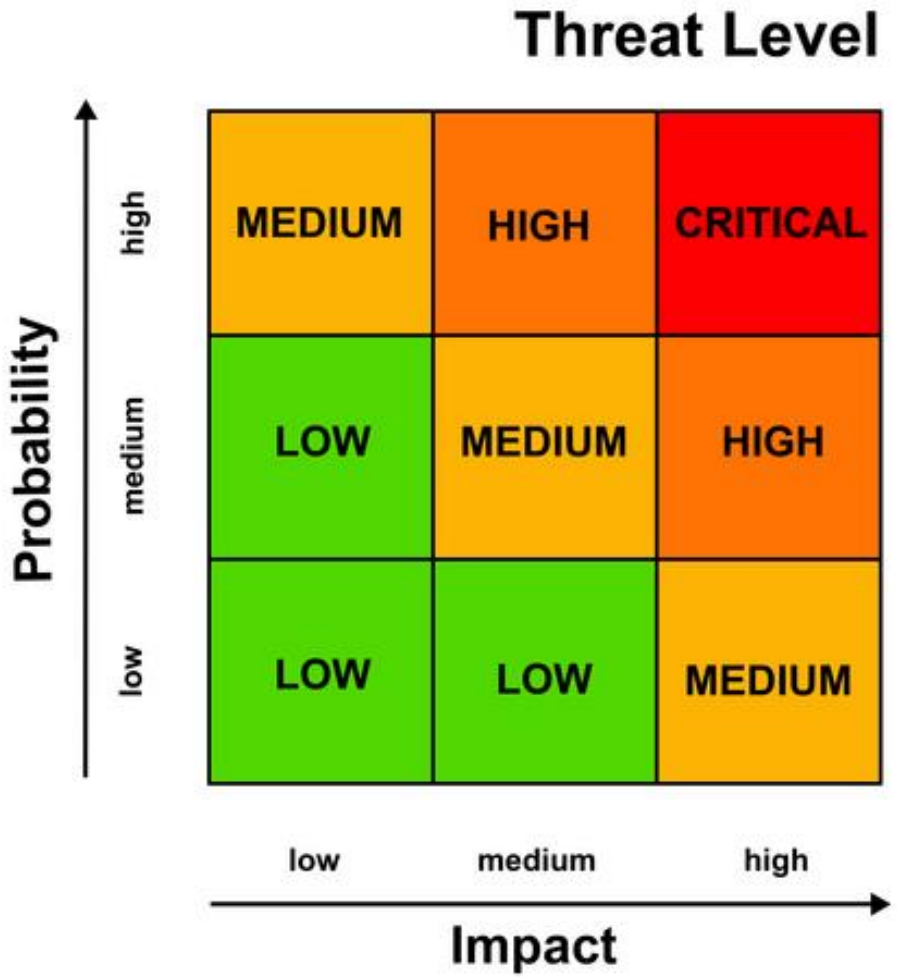
What do we mean by risk?





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System Plan 8 Risks & Vulnerabilities

- Unexpected infrastructure failures not modeled
  - Assumes all DSTs survive the longer mission
  - 242-A Evaporator is a single-point failure risk
  - Some SSTs may be too corroded for liquid-based retrieval

- Costs not included in the analysis
  - Disposal of LAW vs. HLW
  - Potential expansion of onsite disposal facility (IDF)
  - Infrastructure failure response (AY-102 cost $100M)
  - Environmental releases (potential costs of failure)

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Other Mission-Influencing Risks

- Unrealistic funding profile
  (WTP costs and the “bow wave”)
- Combination Scenarios could change results
- “Risk-informed” retrieval (Scenario 4) increases regulatory & health risks and closure costs
- Tank vapor issues could slow retrievals by 50%
- Recent changes to Direct-Feed LAW
  could change how the system operates

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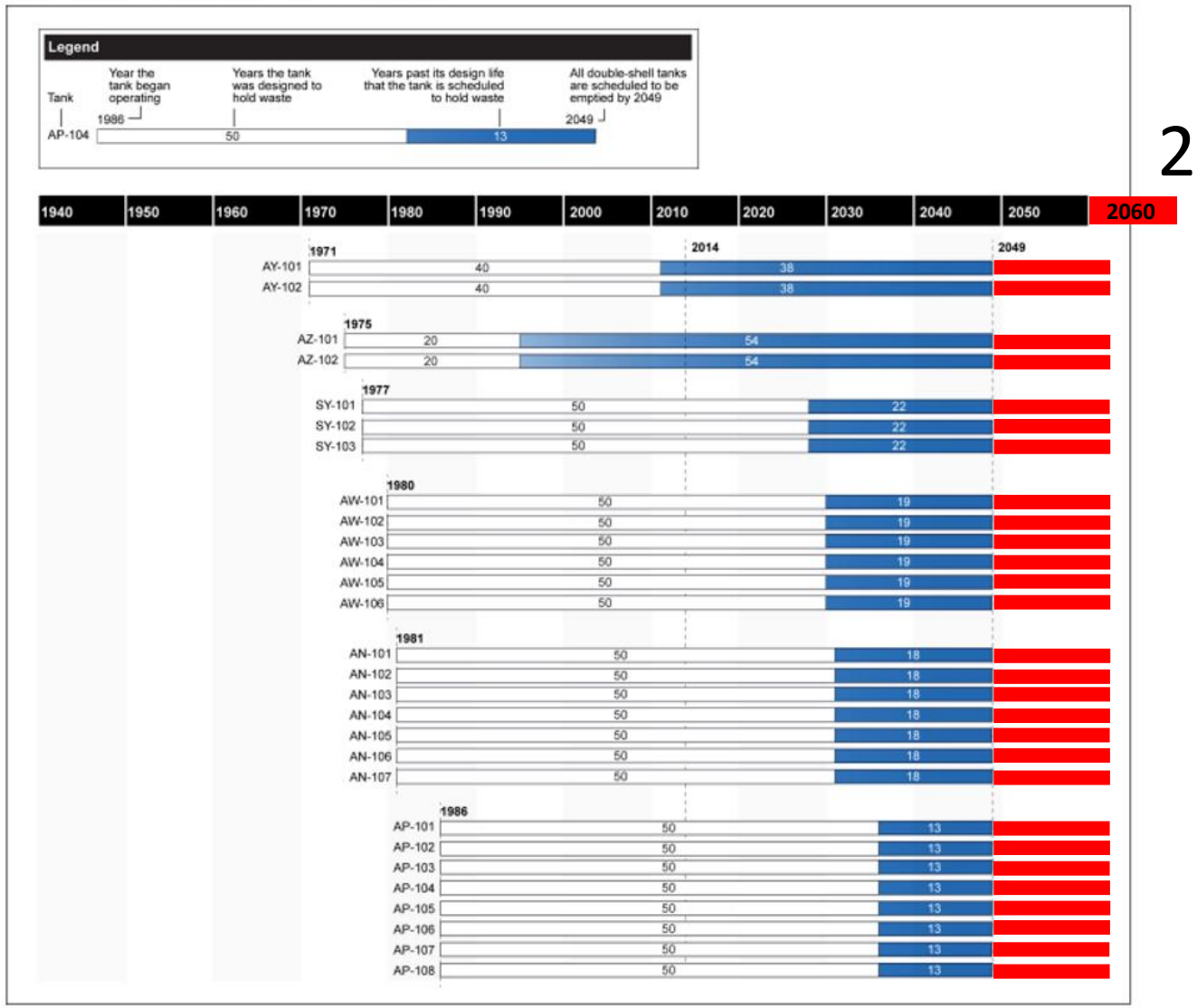
A Longer DST Mission

- Baseline Scenario extends DST mission 14 years
- Reduced WTP efficiency (50% instead of 70%) would extend the mission 32 years

Figure 7: Timeline of Hanford Double-shell Tanks



Source: GAO analysis of DOE data. | GAO-15-40

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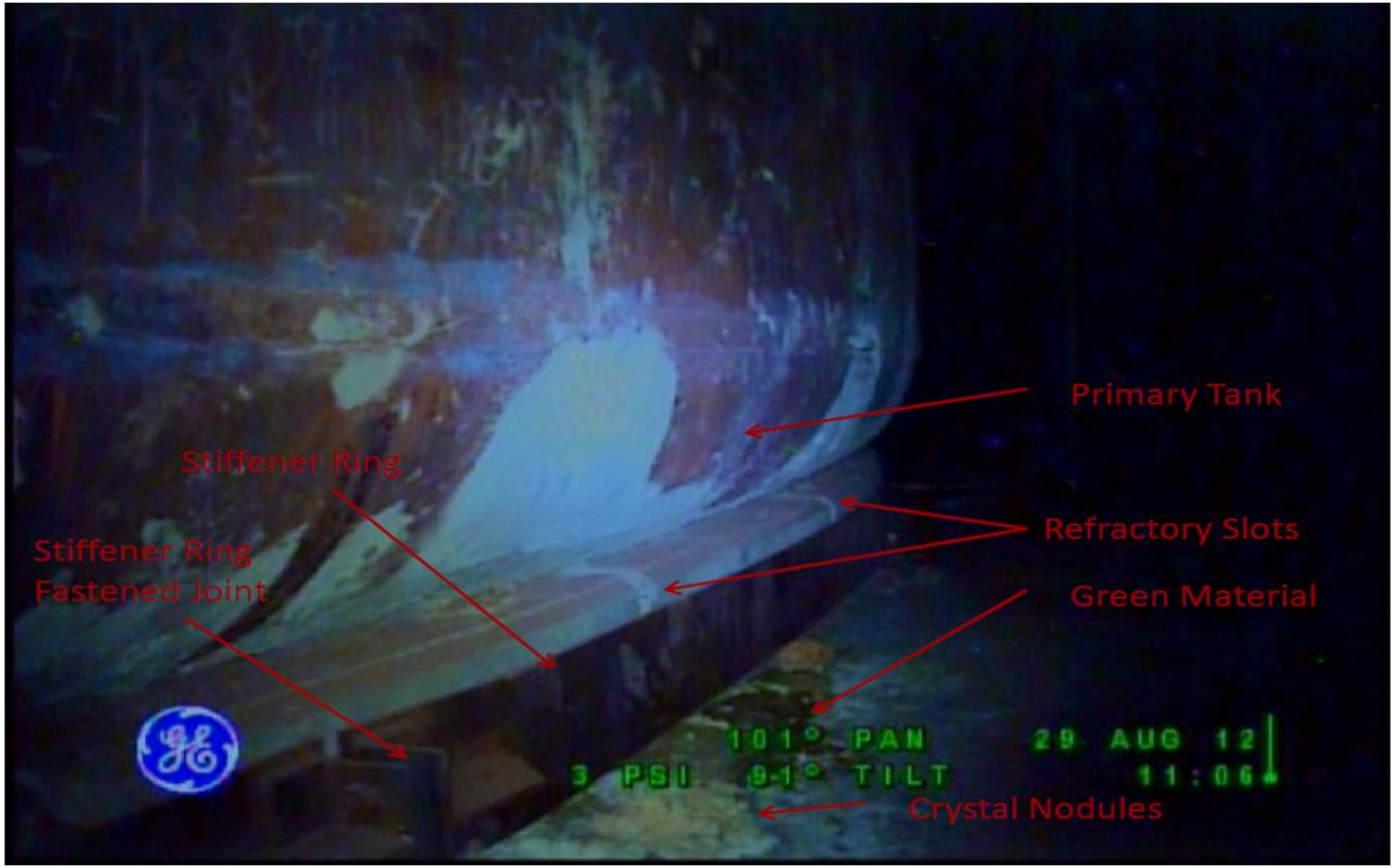
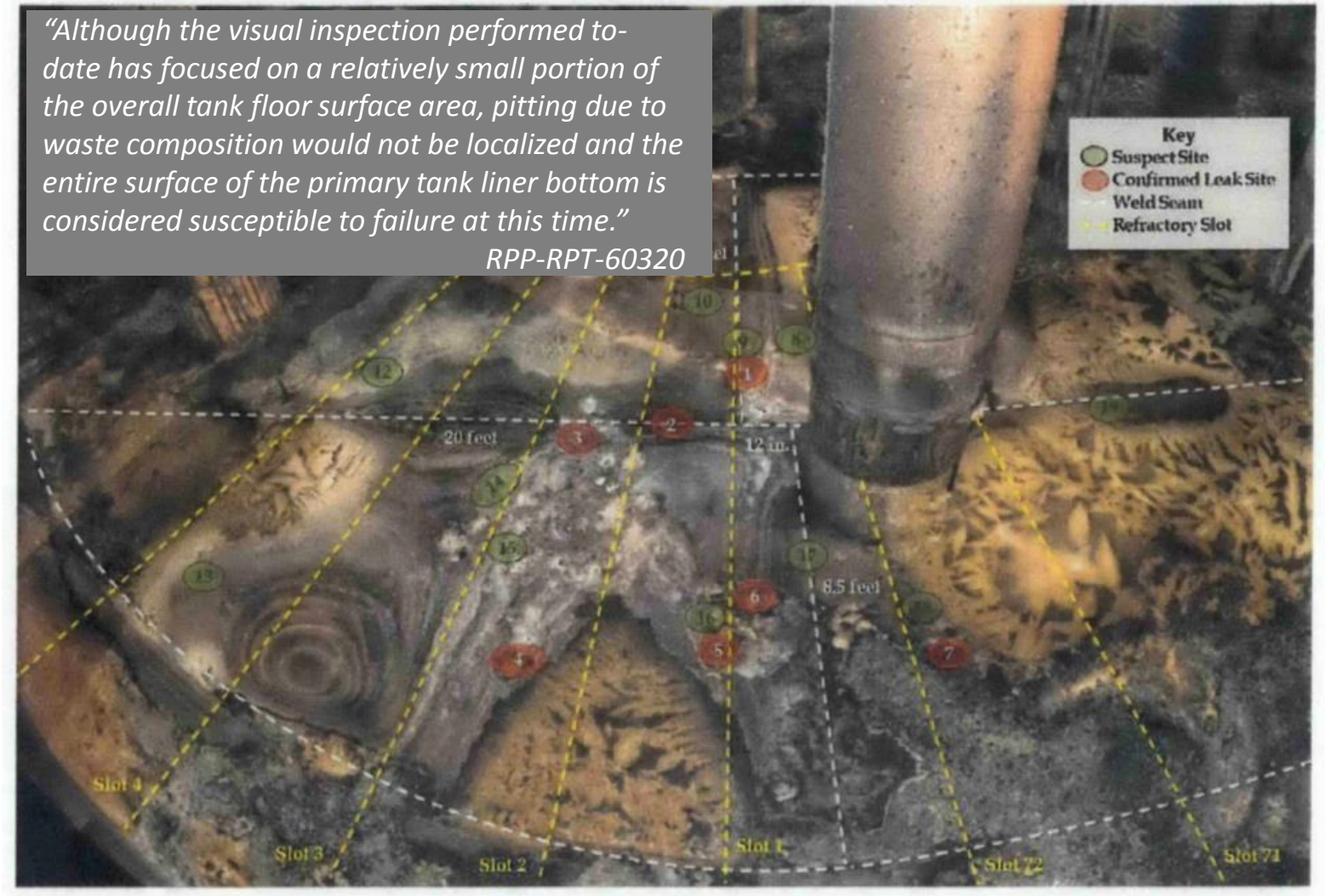
Double-Shell Tank Leak – AY-102



Temperature, Chemistry, and Time

- AY-102 Leak Assessment Report found multiple leaks on seams and center-plate.
- Failure cause identified as "service-induced pitting corrosion due to historic waste composition and operating conditions"
  - Dilute waste water with relatively low pH remained in contact with the liner for first seven years
  - High heat (100-150°F) waste from C-106 added in 1990s
  - Tank was 41 years into its 40-year design life.

Figure 3-21. High-Definition Video from Riser 54 in September 2017 (Leak Sites)



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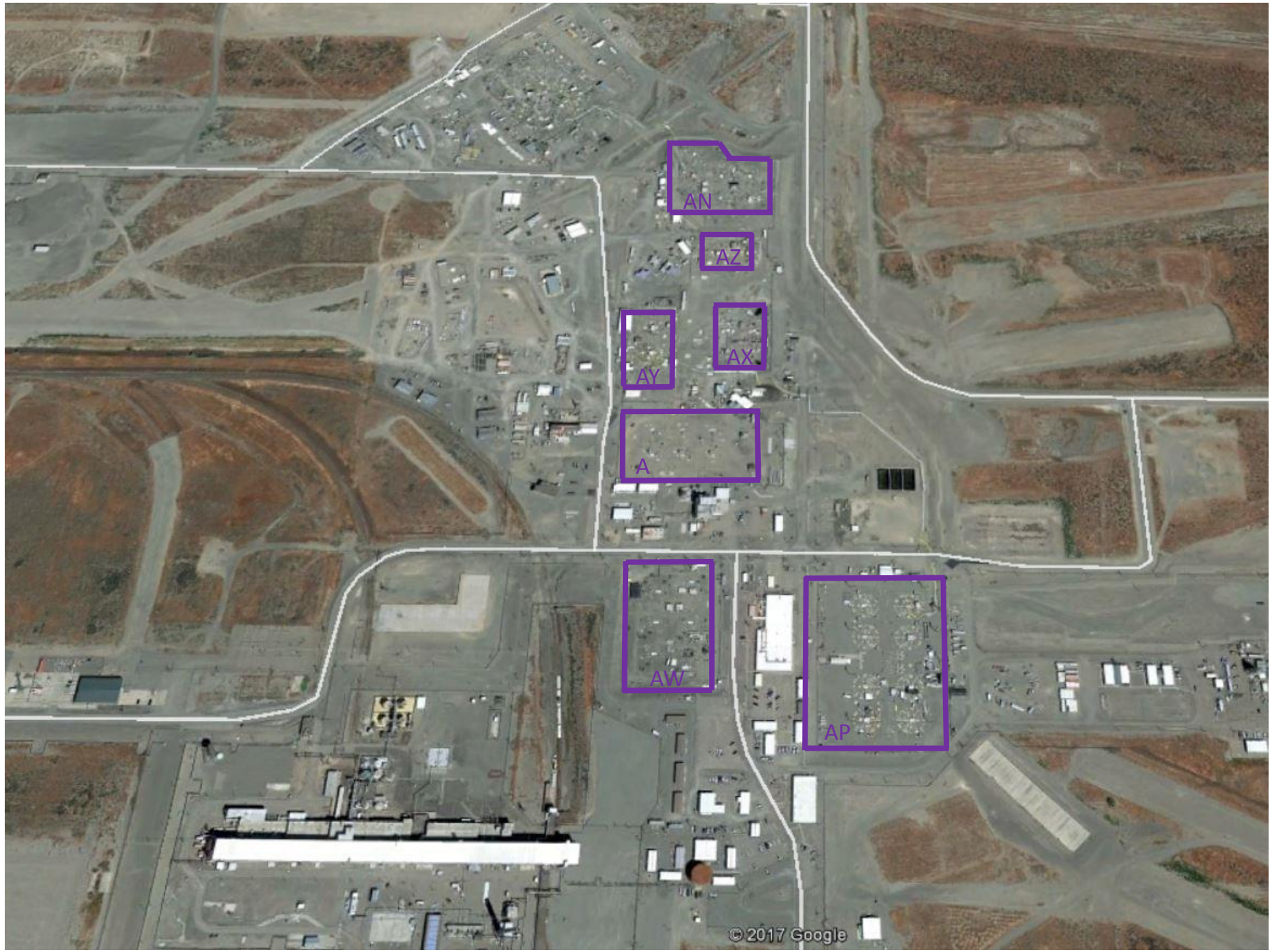
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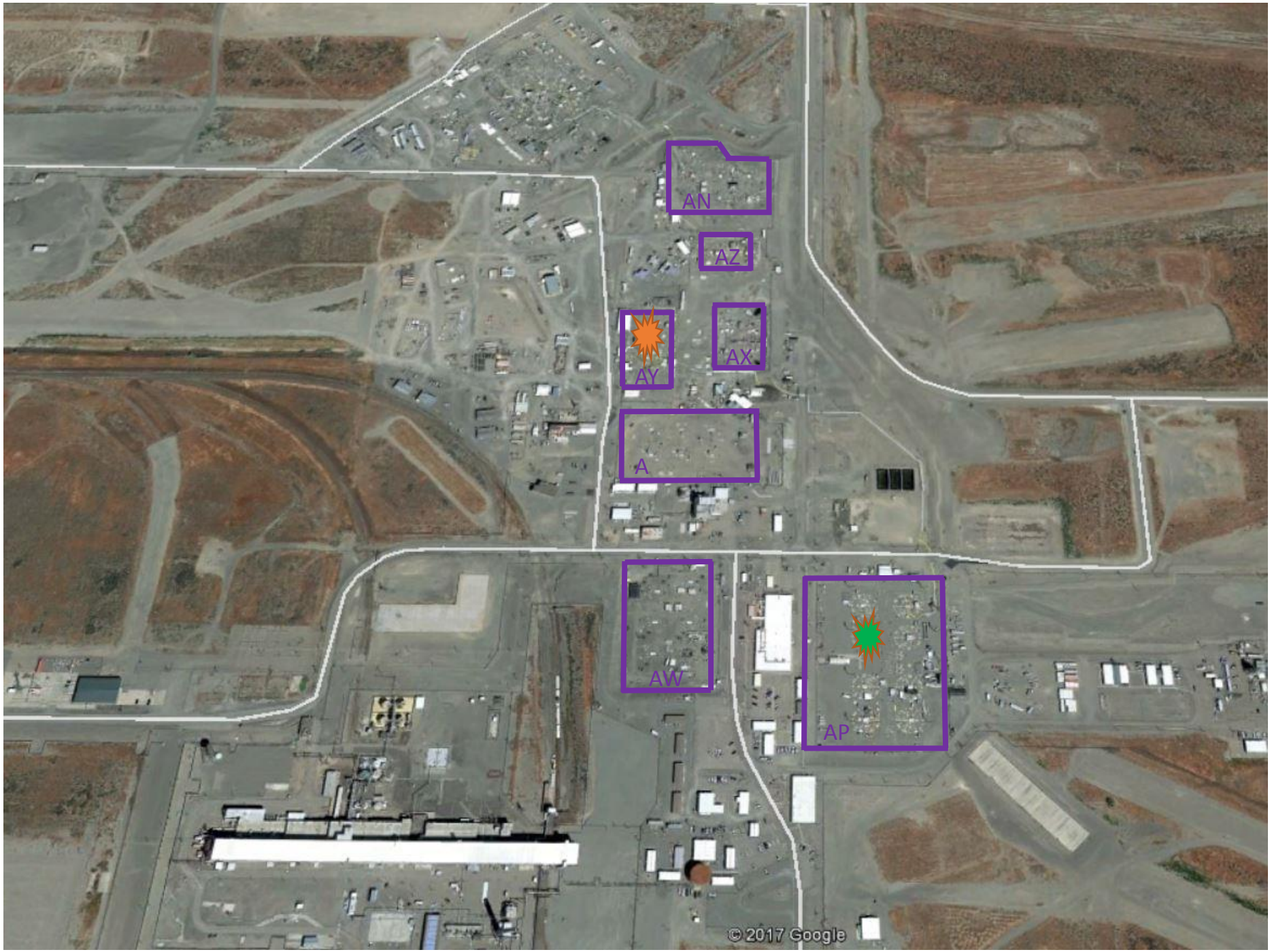
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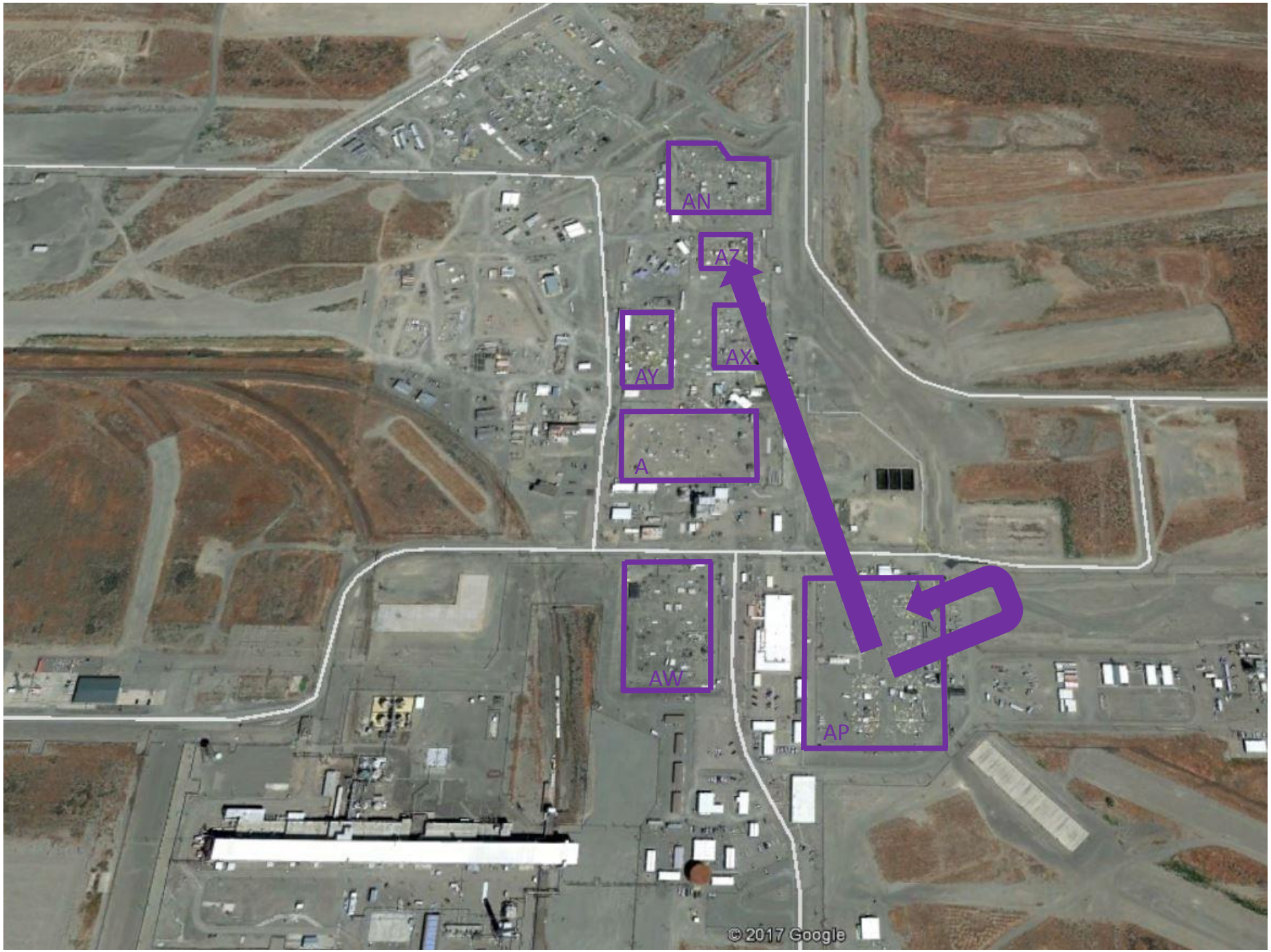
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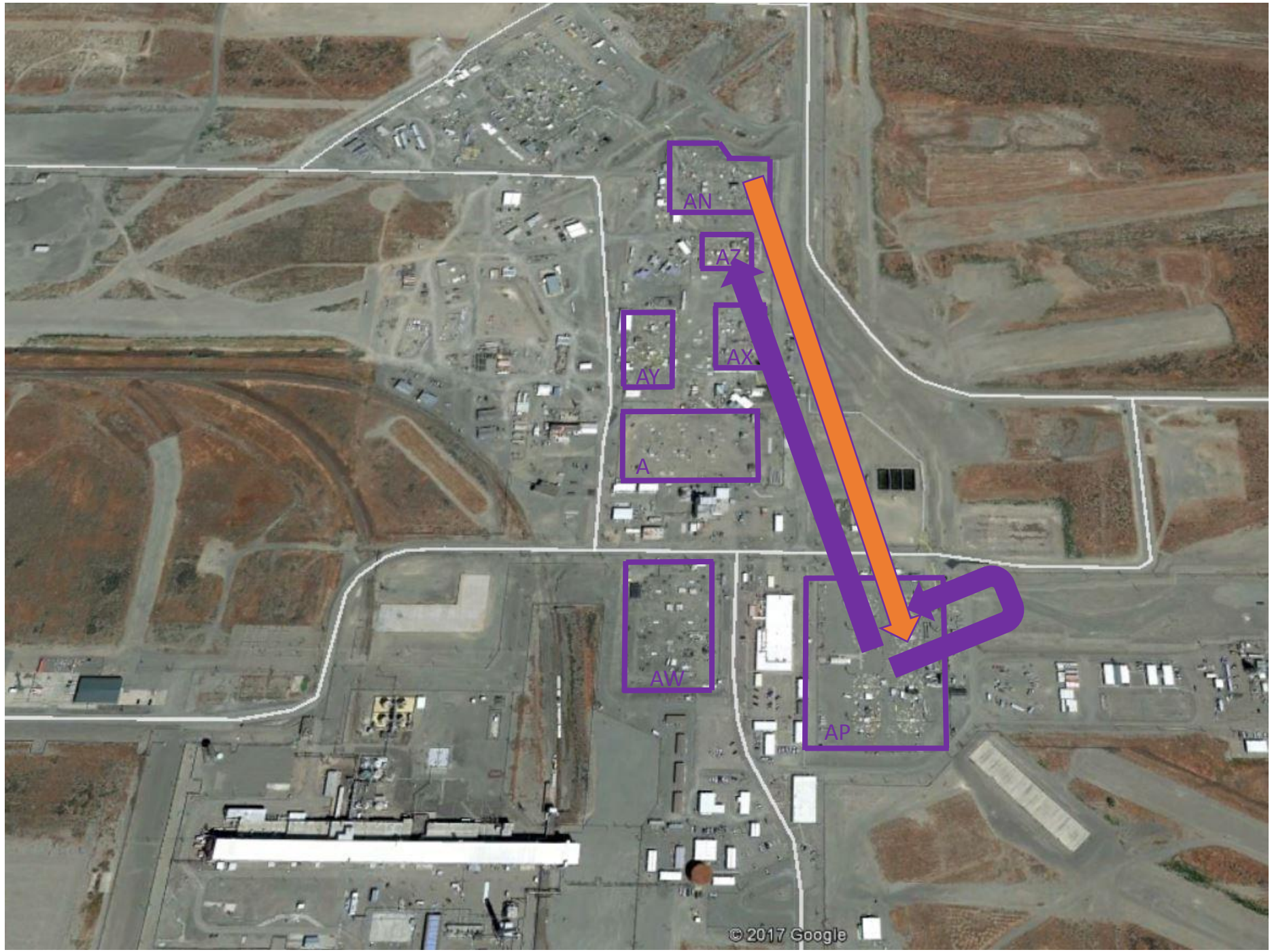
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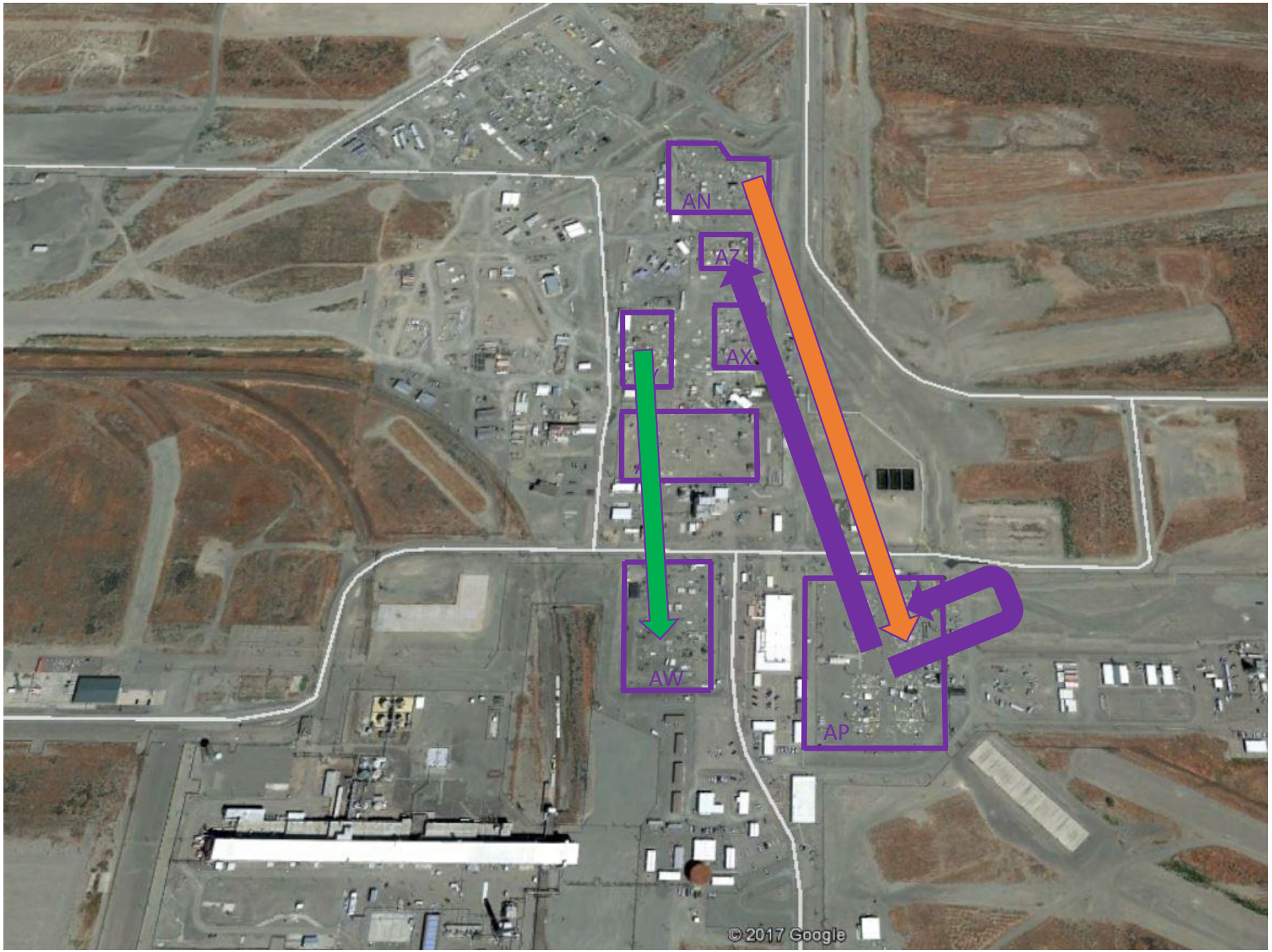
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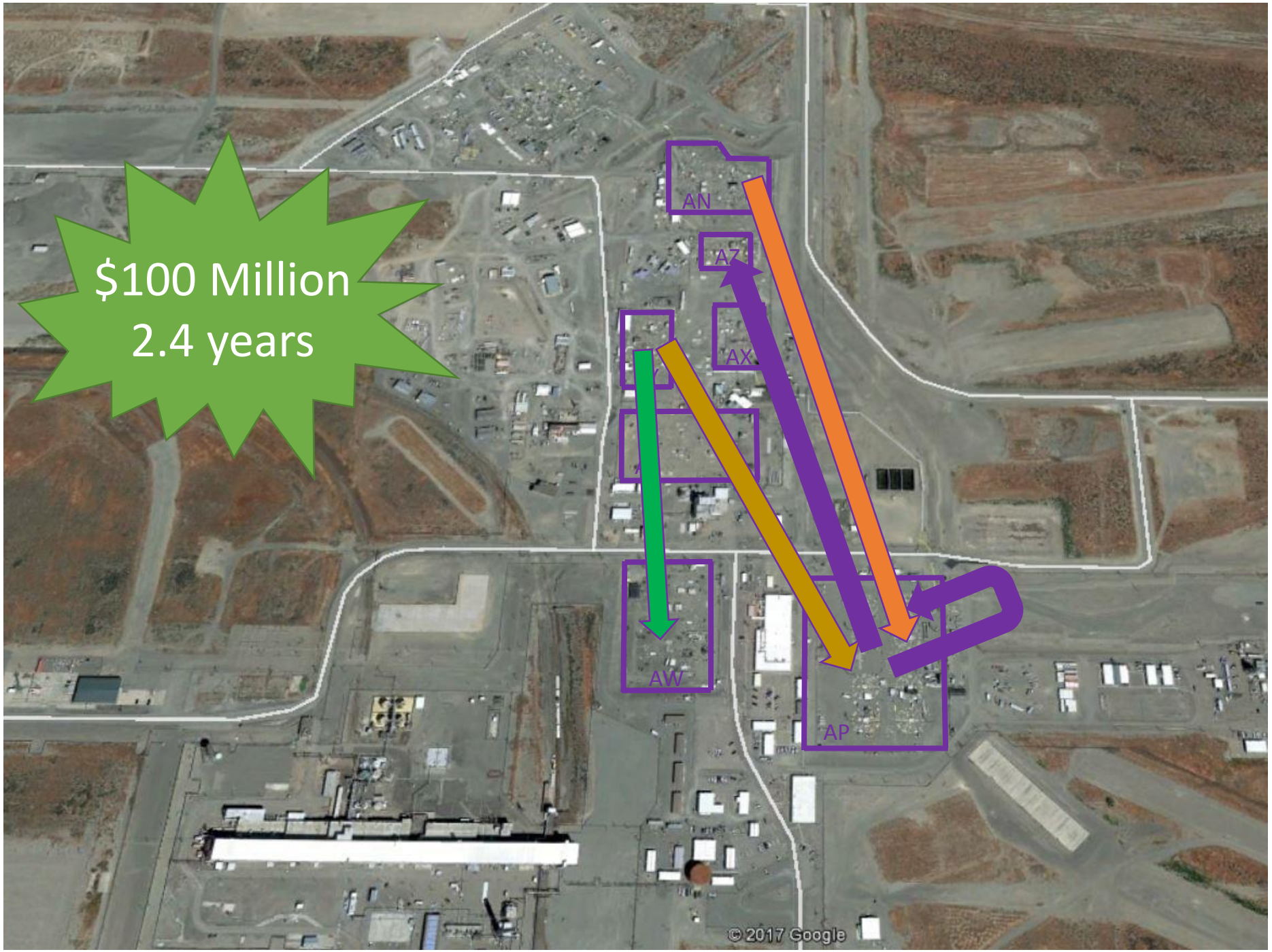
$100 Million
2.4 years
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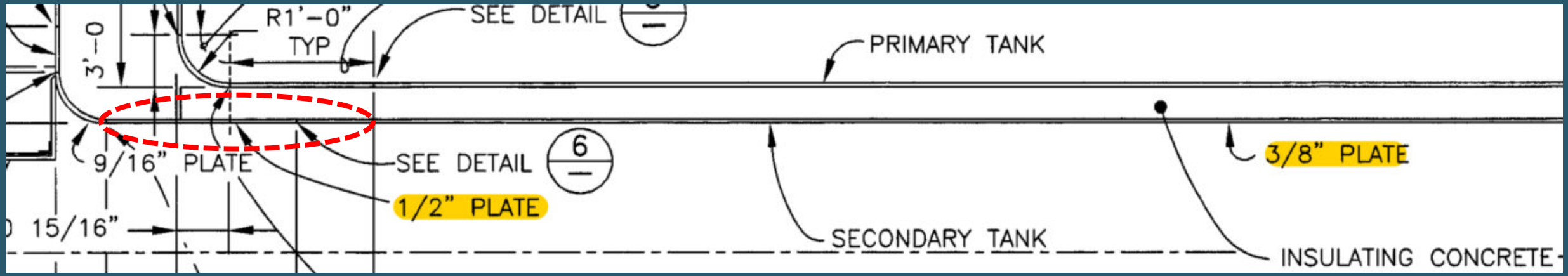
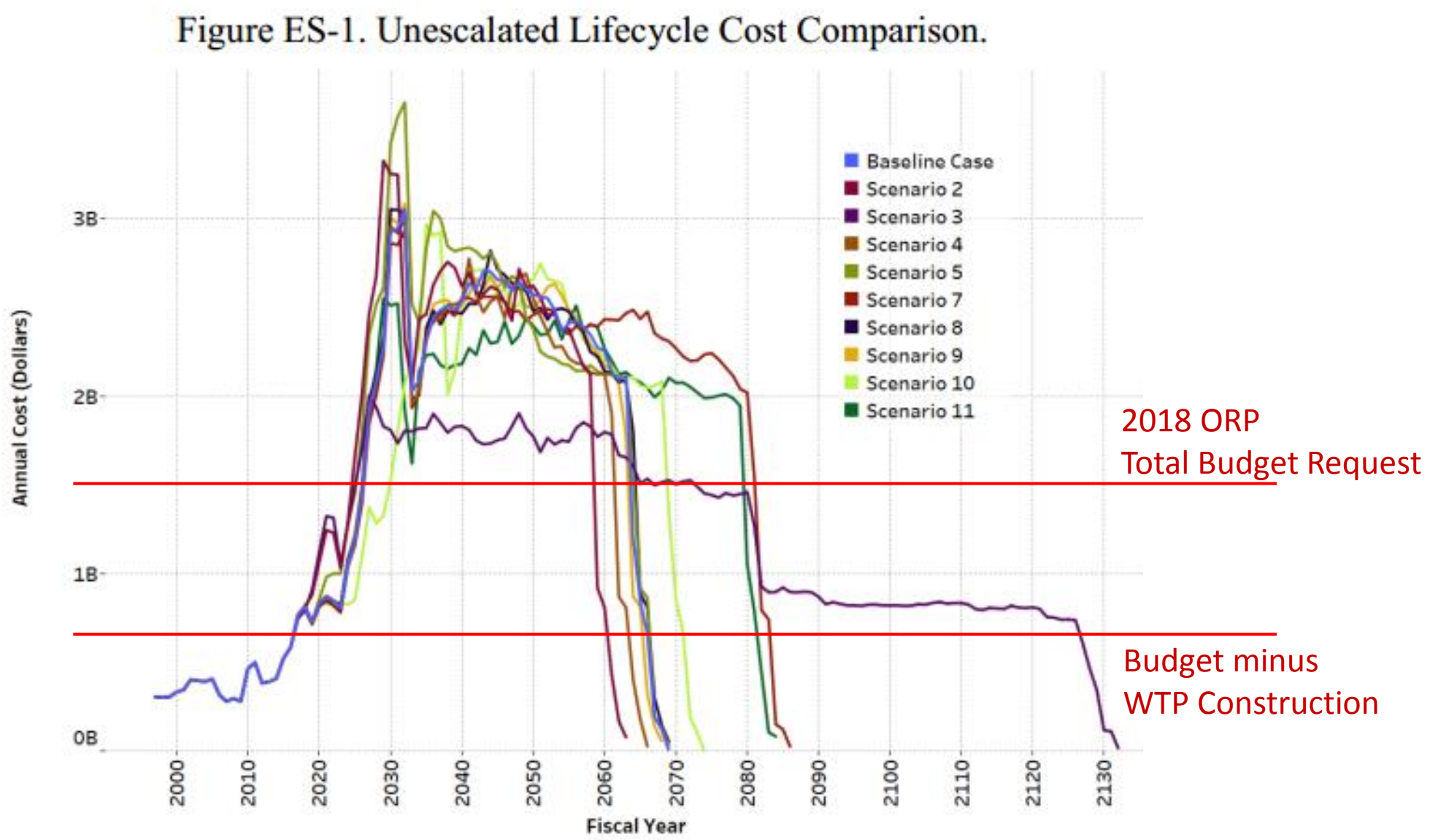
© 2017 Google

Tank AP-102 Outer Shell Suspect

- Letter from WA Ecology 8/14/17: Concern that secondary tank bottom for AP-102 has likely failed.
- Ultrasonic testing of the annulus found an area where > 70% thinning has occurred (3/8" of a 1/2" plate)
- Majority of the secondary bottom is 3/8" and can't be directly inspected.
- Likely cause is corrosion from excessive liquids in the leak detection pit and groundwater infiltration beneath the tank.
- Ecology requires a plan for inspecting integrity of AP-102 by March 31, 2018. Final integrity assessment report due by September 30, 2018.



What Alternatives Can We Afford?



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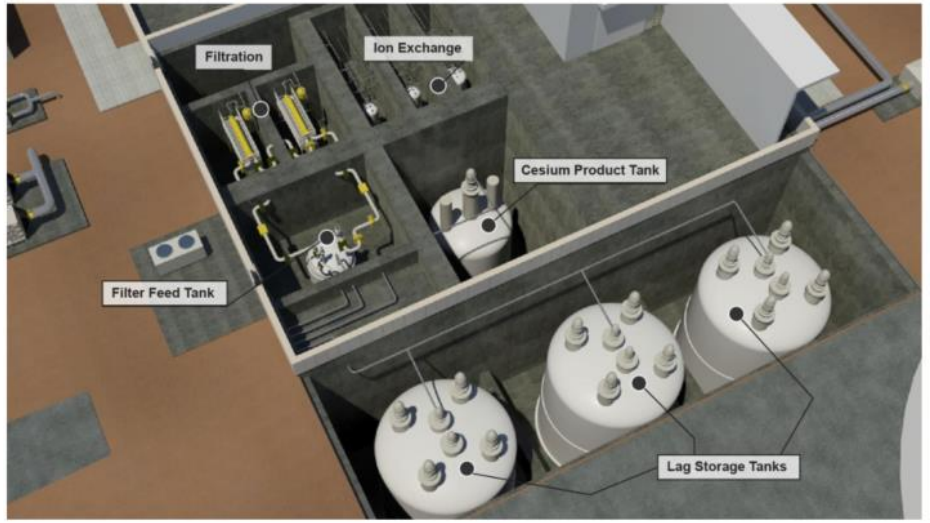
Complications Ensue: LAWPS Redesign and TSCR

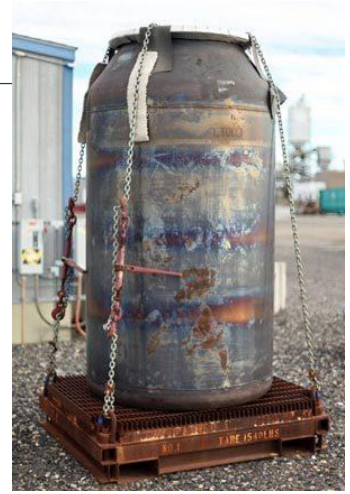
- In December 2017, DOE withdrew its permit application for LAWPS
- Concerns from DOE HQ Independent Review Team that LAWPS is over-designed, won't be ready in time/on budget
- Proposal to break LAWPS functions into smaller chunks
  - Tank-Side Cesium Removal: non-reusable resin
  - Tank-side filtration: 100x change in filter size (0.1 to 10 micron)
  - Repurpose 2 DSTs for feed and return
- "Optimized" LAWPS design may return

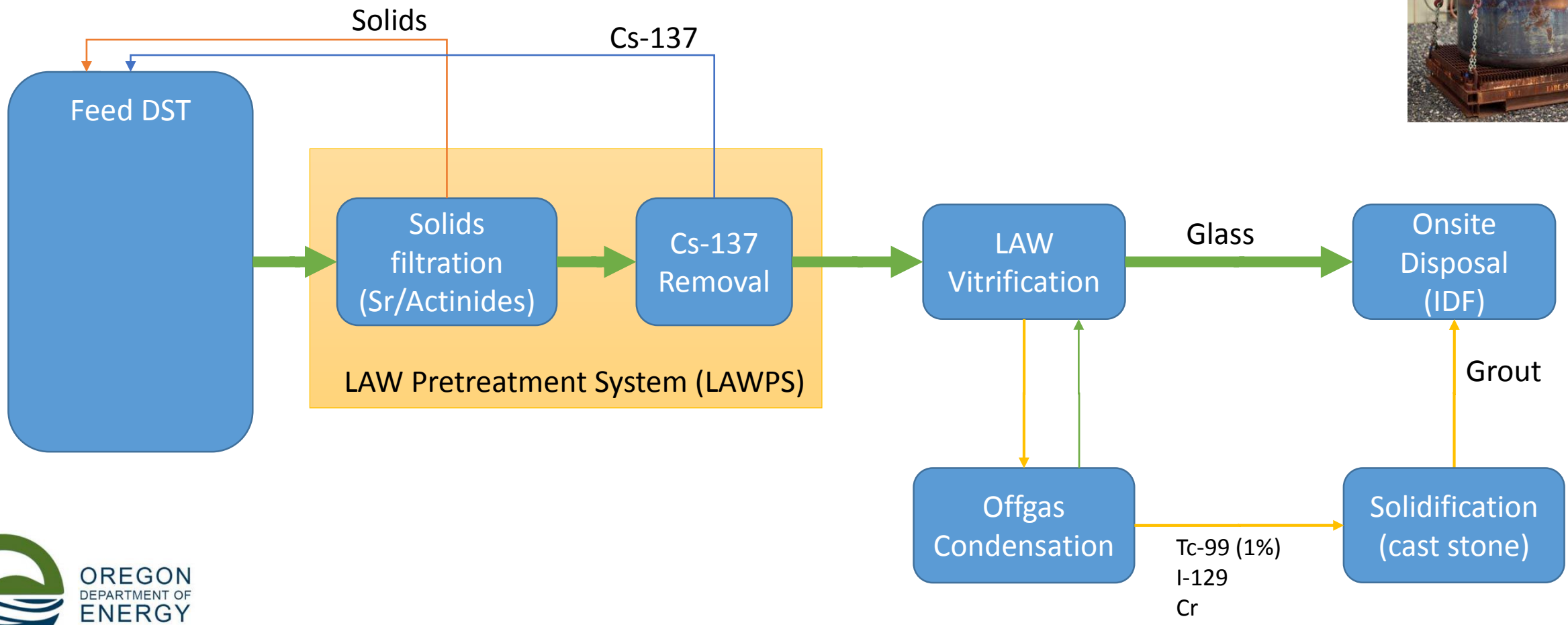
Figure 3-14. Low Activity Waste Pretreatment System Cut Away View.



"Old" DFLAW Treatment Path

Net DST space created = ~12.7M gals
11,000 glass containers = 12% of total LAW mission





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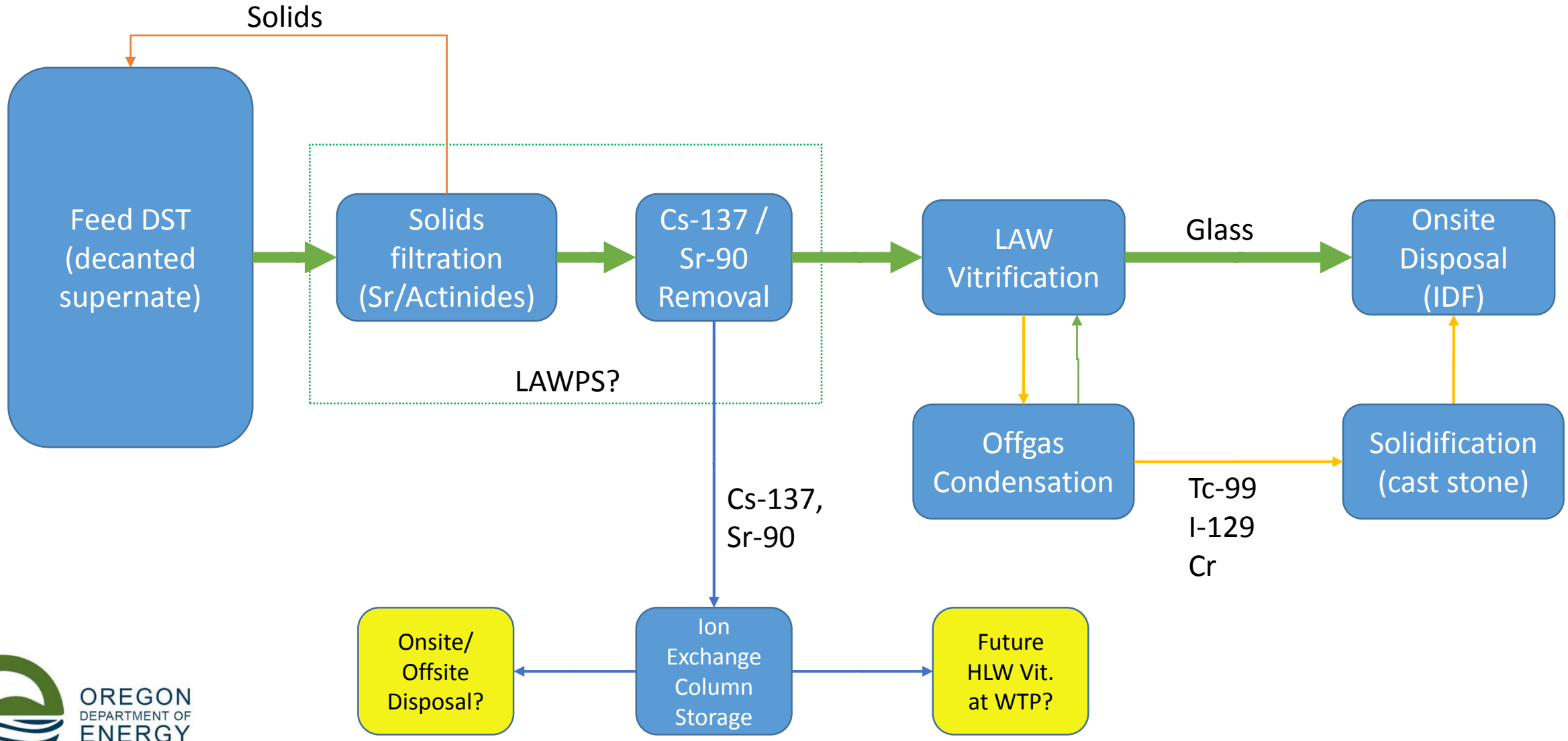
New DFLAW Treatment Path?



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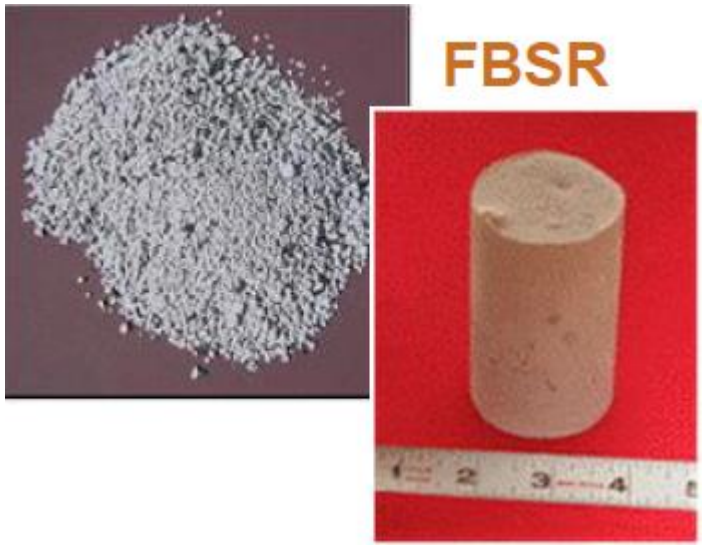
Mobile Cs/Sr removal in Japan

NAS Supplemental LAW Analysis

- National Defense Authorization Act 2017 tasked National Academies of Science to evaluate alternatives for Supplemental LAW (~50% of LAW inventory)
- Federal group looking at assumptions in past analyses of LAW waste forms, including grout & steam reforming.
- NAS visited Hanford February 2018
- Report to Congress expected in 2019

Cast Stone



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Summary and Next Steps

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Summary

- It's a longer road no matter what we do. This affects risk.
- We are managing a failing system as much as we are producing glass.
- A good decision should account for all system costs and risks.
  - "Stress test" for risk resilience
- Some options to reduce time/cost/risk, but no budget to pursue

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Summary

- DFLAW plan is changing (fastest way to buy DST space). This may affect future waste treatment/storage/disposal.
- 8 years to build new tanks – when is the right time to start?
- Offsite effluent treatment may make sense.
- Leaving waste in some SSTs may look like it buys time/money, but legal/ health costs & risks are not accounted.

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What's Next?

- Tank mission milestone negotiations ongoing now.
  - ODOE & HAB letters requesting consultation before final decisions are made
- NAS analysis of Supplemental LAW ongoing now.
- Tank Side Cesium Removal and new solids filtration under development (spring/summer 2018)
- WTP and PT Facility may go into "preservation mode" to facilitate DFLAW (i.e., divert funds)
- LAWPS future path to be determined . . .

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Discussion