SRR-CWDA-2021-00047
Revision 0

Comment Response Matrix for the First Set of U.S. Nuclear Regulatory Commission Staff Requests for Additional Information on the Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site

May 2021

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REVISION SUMMARY

REV. #	DESCRIPTION	DATE OF ISSUE
0	Initial Issue, providing first round of responses.	May 2021

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ACRONYMS/ABBREVIATIONS

APT	Accelerator Production of Tritium
ARP	Actinide Removal Process
BIO	Biosphere (RAI Topic)
CC	Clarifying Comment
CFR	U.S. Code of Federal Regulations
CPT	Cone Penetrometer Tests
CPTu	Piezocone Penetrometer Tests
DCF	Dose Conversion Factor
DDA	Deliquification, Dissolution, and Adjustment
DF	Decontamination Factor
DOE	U.S. Department of Energy
DSS	Decontaminated Salt Solution
DWPF	Defense Waste Processing Facility
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
FTF	F-Area Tank Farm
FY	Fiscal Year
GCL	Geosynthetic Clay Liner
GIT	Georgia Institute of Technology
GSA	General Separations Area
HDPE	High Density Polyethylene
HEU	Highly Enriched Uranium
HHW	High Heat Waste
HM	H-Modified PUREX Extractions
HTF	H-Area Tank Farm
IAEA	International Atomic Energy Agency
IHI	Inadvertent Human Intruder
INV	Inventory (RAI Topic)
ITP	In-Tank Precipitation
K_d	Distribution Coefficient
LAZ	Lower Aquifer Zone of the Upper Three Runs Aquifer
LHW	Low Heat Waste
LLDL	Lower Lateral Drainage Layer

LLW	Low Level Waste
MCL	Maximum Contaminant Level
MCU	Modular Caustic Side Solvent Extraction Unit
MOP	Member of the Public
MPAD	Most Probable and Defensible
MST	Monosodium Titanate
N/A	Not Applicable or Not Available
NDAA	Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PA	Performance Assessment
PNNL	Pacific Northwest National Laboratory
PUREX	Plutonium Uranium Extraction
QA	Quality Assurance
RAI	Request for Additional Information
RSI	Request for Supplemental Information
SA	Special Analysis
SASW	Spectral Analysis of Surface Wave Tests
SCDHEC	South Carolina Department of Health and Environmental Control
SDF	Saltstone Disposal Facility
SDS	Saltstone Disposal Structure
SDU	Saltstone Disposal Unit
SPF	Saltstone Production Facility
SRNS	Savannah River Nuclear Solutions
SRR	Savannah River Remediation
SRS	Savannah River Site
SS	Site Stability (RAI Topic)
SWPF	Salt Waste Processing Facility
TCCR	Tank Closure Cesium Removal
THOREX	Thorium Extraction
UAZ	Upper Aquifer Zone of the Upper Three Runs Aquifer
ULDL	Upper Lateral Drainage Layer
WCS	Waste Characterization System

EXECUTIVE SUMMARY

The *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site* (SRR-CWDA-2019-00001) was prepared to inform decisions regarding the pertinent requirements of the U.S. Department of Energy's (DOE) Manual 435.1-1, *Radioactive Waste Management Manual,* and *Title 10 Code of Federal Regulations* (CFR) *Part 61, Licensing Requirements for Land Disposal of Radioactive Waste,* Subpart C as required by the *Ronald W. Reagan National Defense Authorization Act for Fiscal* (FY) *Year 2005* (NDAA), Section 3116 (NDAA 3116).

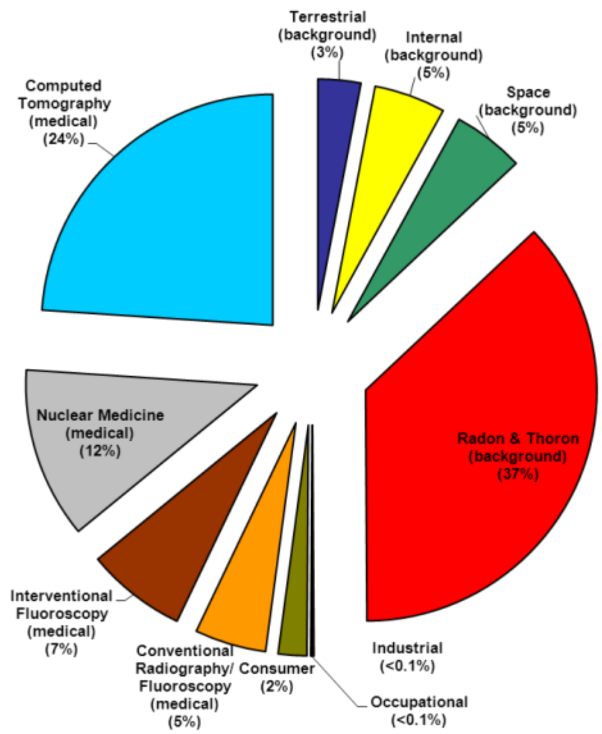
Requirements in both DOE M 435.1-1 and 10 CFR 61 stipulate that a Performance Assessment (PA) should provide reasonable expectation that low-level waste (LLW) disposal will comply with specified performance objectives. DOE M 435.1-1 and 10 CFR 61 both require assessments of impacts to hypothetical receptors, including future members of the public (MOPs) and inadvertent human intruders (IHIs). DOE M 435.1-1 also requires assessments for impacts to water resources. These assessments were performed to address a 1,000-year Compliance Period after facility closure (per DOE M 435.1-1), as well as informational 10,000-year Performance and Long-Term Exploratory (greater than 10,000-years) Periods to identify potential peak doses occurring beyond the regulatory Compliance Period.

The Saltstone Disposal Facility (SDF) PA (SRR-CWDA-2019-00001) serves as the primary long-term risk assessment tool to determine that performance objectives will be met following closure of the SDF. The SDF PA is a performance-based, risk-informed analysis of the fate and transport of saltstone waste following final closure of SDF. The DOE used what is referred to as a "hybrid approach" involving a combination of deterministic and probabilistic models to develop this level of assurance. The foundation of the SDF assessment is the "Compliance Case" model, a deterministic analysis of post-SDF closure that uses the most probable and defensible values for model parameters whenever possible.

In support of the development of the SDF PA, DOE has made a significant investment in parameter research and conceptual model development, using nationally recognized experts in their respective fields including cementitious materials, hydrogeology, and modeling of environmental transport. The fate and transport models in the SDF PA reflect approximately 60 years of study of the subsurface of the General Separations Area (GSA) (i.e., the area centrally located within the Savannah River Site (SRS) that includes the tank farms and the SDF). It is this strong foundation of research and study that contributes to DOE's reasonable expectation/assurance that the performance objectives from DOE M 435.1-1, as well as 10 CFR 61.41 and 10 CFR 61.42, will be met.

To provide perspective on the 25 mrem/yr and 100 mrem/yr dose performance objectives used to demonstrate compliance (DOE M 435.1-1 and 10 CFR 61.41), it is noted that the average annual dose to a United States citizen is approximately 620 millirems (ML033390088), approximately 25 times higher than the 25 mrem/yr performance objective. Figure ES-1 provides a breakdown of the exposure sources that make up the average dose of 620 millirems. If an individual moves from the area surrounding SRS to Denver, Colorado, their annual dose from just cosmic and terrestrial background radiation alone will increase by more than 100 millirem; a value four times higher than the performance objective (NCRP-160). Further, as noted in the U.S. Nuclear Regulatory Commission (NRC) Fact Sheet on *Biological Effects on Radiation*, "there are no data to establish a firm link between cancer and doses below about 10,000 mrem (100 mSv – 100 times the NRC limit)" (ML033390088). A dose of 10,000 mrem/yr represents a dose 400 times greater than the performance objective.

Figure ES-1: Major Sources of Radiation Exposure to the Average US Citizen



[NCRP-160]

In addition to the Compliance Case, two other deterministic modeling cases are prominently discussed in the SDF PA: a "Realistic Case" wherein modeling parameters were selected with a bias towards the most likely or expected conditions regardless of defensibility and a "Pessimistic Case" wherein modeling parameters were selected with a bias towards greater pessimism in the modeling parameter values, thus resulting in higher doses. The deterministic Compliance Case was developed as an intermediate modeling case between these two cases, using a combination of reasonably defensible and best estimate (i.e., most probable and defensible) assumptions and parameter values whenever possible.

As a hybrid approach, the deterministic modeling cases are accompanied by the probabilistic model as well as additional deterministic sensitivity modeling cases, which are provided as tools to inform on the potential impacts on performance associated with various uncertainties in the system as a whole. Collectively, the various models described in the SDF PA support the assessment of the effects of deviations from the Compliance Case assumptions.

The fact that Compliance Case has uncertainties associated with it does not *a priori* make this modeling case incorrect or any less probable. Substituting only pessimistic values for every assumption to account for uncertainty would undercut the intent of the Compliance Case in supporting risk-based decision making and would likely result in little, if any, real risk reduction, needless expenditures, exposure to the current SRS workforce, and delays in risk-reducing waste tank closure activities. The application of the hybrid approach to SDF PA development (i.e., including a probabilistic model and deterministic alternative modeling cases) was to allow for the less probable, but still possible, assumptions to be modeled, improving overall understanding of the SDF system.

The DOE acknowledges that the SDF PA should contain adequate technical bases to support the Compliance Case as it is the case used to establish compliance to performance objectives, and the DOE also acknowledges that the SDF PA should appropriately reflect uncertainties to demonstrate, with reasonable expectation/assurance, that the performance objectives can be met.

The post-closure SDF system will achieve defense-in-depth through multiple barriers to provide a reasonable expectation/assurance that compliance with the performance objectives will be met. DOE clarifies that reasonable expectation/assurance is based on evaluations of how the facility is expected to perform as well as alternative system performance evaluations (i.e., less likely) that encompass uncertainty and variability (uncertainty and sensitivity analyses).

DOE M 435.1-1, *Radioactive Waste Management Manual*, outlines a comprehensive program to maintain PAs. The program is in place to evaluate changes (e.g., new information, changing facility conditions) that could impact the inputs, results, or conclusions of a DOE PA such as the SDF PA. The program requires that PAs be formally reviewed on an annual basis and revised when changes in radionuclide inventories or facility design are identified or new information on key parameters becomes available through continued research and study. On an annual basis, the adequacy of the SDF PA is assessed (e.g., SRR-CWDA-2021-00005) and, when warranted, will be revised and shared with the NRC through the NDAA Section 3116(b) monitoring protocols.

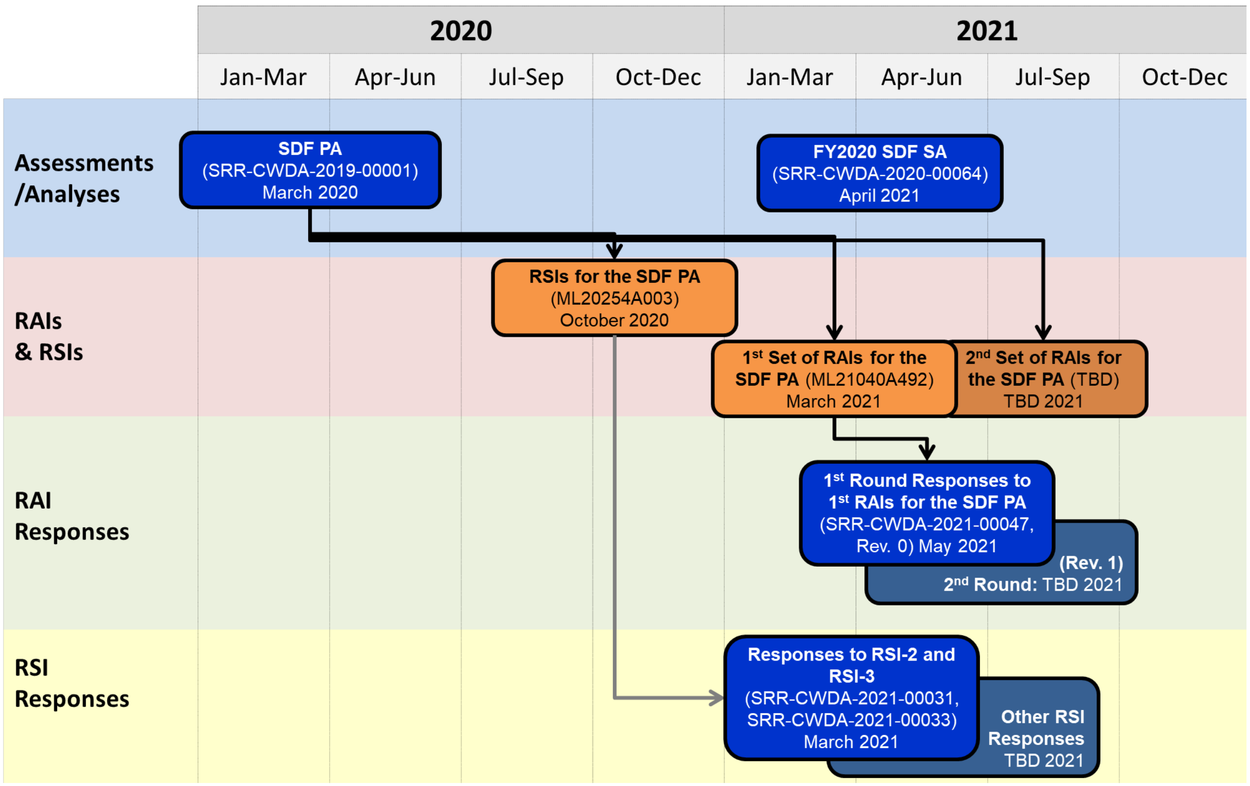
Following the completion of the SDF PA, the NRC provided a set of Requests for Supplemental Information (RSIs) in October 2020 (ML20254A003). Due to the sequential nature of RSIs, wherein some RSIs must be completed as prerequisite to other RSIs, the preparation of the responses to the RSIs is an ongoing activity and has not yet been completed. However, an initial round of technical reports (SRR-CWDA-2021-00031 and SRR-CWDA-2021-00033) have been prepared and were submitted to the NRC on March 30, 2021 to address RSI-2 and RSI-3. These two technical reports document literature reviews and subsequent parameter distribution recommendations to better evaluate uncertainties associate with the long-term performance of the upper lateral drainage layer (ULDL), the high-density polyethylene (HDPE), and the geosynthetic clay liner (GCL) components of the SDF closure cap. These recommended parameter distributions will be used to better evaluate uncertainties in the infiltration rates associated with long-term SDF closure cap performance. Additional RSI responses will be provided to the NRC as they are completed.

Following the RSIs, the NRC also provided a set of Requests for Additional Information (RAIs) and Clarifying Comments (CCs). Based on telephone conversations between the NRC and DOE, more RAIs and CCs are expected in the future. The first set of RAIs and CCs received from the NRC in March 2021 were documented in the letter *Request for Additional Information Regarding the 2020 Savannah River Site Saltstone Disposal Facility Performance Assessment*, dated March 1, 2021 (ML21040A492). Detailed responses to a subset of the RAIs and CCs from ML21040A492 are provided herein. Each of these responses begins with the RAI or CC from the NRC, followed by the DOE response. This report does not provide a complete set of responses.

Several RAIs and CCs require additional time to address so their responses will be provided in a subsequent revision of this response document.

Figure ES-2 provides an overview of the more recent documents associated with DOE and NRC interactions, beginning with the SDF PA. In this figure, the blue documents are those prepared by the DOE and the orange documents are those prepared by the NRC.

Figure ES-2: SDF PA-Related and NRC Documentation Timeline: 2020 and 2021



Additionally, in April 2021 the FY2020 Special Analysis (SA) of the SDF PA was approved (SRR-CWDA-2020-00064, WDPD-21-40). This SA was limited in scope, evaluating the potential impacts for an alternative Saltstone Disposal Unit (SDU) concrete mix and for a cement-free saltstone mix. The FY2020 SA concluded that these new mixes would have a negligible impact on SDF performance and recommended that these mixes be approved for use.

References for the Executive Summary

10 CFR 61, *Licensing Requirements for Land Disposal of Radioactive Waste*, U.S. Nuclear Regulatory Commission, Washington DC, December 2011.

DOE M 435.1-1, Chg. 3, *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington DC, January 2021.

ML033390088, *Backgrounder: Biological Effects of Radiation*, Fact Sheet, U.S. Nuclear Regulatory Commission, Washington DC, March 2017.

ML20254A003, Koenick, S.S., Letter NRC to DOE-SR, *Preliminary Review of the U.S. Department of Energy's Submittal of the 2020 Savannah River Site Saltstone Disposal Facility Performance Assessment*, U.S. Nuclear Regulatory Commission, Washington DC, October 2020.

ML21040A492, Koenick, S.S., Letter NRC to DOE-SR, *Request for Additional Information Regarding the 2020 Savannah River Site Saltstone Disposal Facility Performance Assessment*, U.S. Nuclear Regulatory Commission, Washington DC, March 2021.

NCRP-160, *Ionizing Radiation Exposure of the Population of the United States (2009)*, National Council on Radiation Protection and Measurements, Bethesda, MD, March 2009. (Copyright)

NDAA_3116, *Public Law 108-375, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Section 3116*, *Defense Site Acceleration Completion*, Accessed January 2011.

SRR-CWDA-2020-00064, *FY2020 Special Analysis for the Saltstone Disposal Facility at the Savannah River Site*, Savannah River Remediation, Aiken, SC, Rev. 1, April 2021.

SRR-CWDA-2021-00005, *FY2020 Annual Review Saltstone Disposal Facility (Z Area) Performance Assessment*, Savannah River Site, Aiken, SC, Rev. 0, March 2021.

SRR-CWDA-2021-00031, Hommel, S.P., *Closure Cap Model Parameter Evaluation: Saturated Hydraulic Conductivity of Sand*, Savannah River Site, Aiken, SC, Rev. 1, May 2021.

SRR-CWDA-2021-00033, Hommel, S.P., *Closure Cap Model Parameter Evaluation: High Density Polyethylene (HDPE) and Geosynthetic Clay Liner (GCL) Composite Barrier Performance*, Savannah River Site, Aiken, SC, Rev. 1, May 2021.

WDPD-21-40, *Department of Energy (DOE) Approval of Special Analysis: FY2020 Special Analysis for the Saltstone Disposal Facility at the Savannah River Site, SRR-CWDA-2020-00064 Revision 0, dated January 2021*, U.S. Department of Energy Savannah River Operations Office, Aiken, SC, April 2021.

TECHNICAL TOPIC OF BIOSPHERE (BIO)

BIO-1

BIO-1	**Question:** The NRC staff needs a technical basis for restricting modeled radionuclide deposition to the leafy fraction of plants to assess projected dose from the plant ingestion pathway.
	Basis: Equation 4.4-139 in the 2020 SDF PA limits projected deposition of radionuclides onto plants to the leafy portion of the plants, which is modeled as 22 percent (%) of plant mass consumed. It is not clear to the NRC staff why deposition on non-leafy edible plant parts that are exposed to deposition (e.g., fruits, grains, non-leafy vegetables grown above ground) would not also contribute to dose. Intermediate results from the DOE GoldSim models for the Compliance Case (e.g., for Saltstone Disposal Structure (SDS) 9 and SDS 6) for the 2020 SDF PA indicate that the modeled activity of iodine-129 (I-129) deposited onto leaves exceeds the total root uptake of I-129. The same models show technetium-99 (Tc-99) deposition is equal to approximately half of the total root uptake of Tc-99. Therefore, increases in modeled radionuclide deposition on plants is likely to increase modeled dose from the plant ingestion pathway, which is a significant contributor to the projected peak dose for a member of the public who uses well water within 10,000 years of site closure.
	Path Forward: Provide a technical basis for excluding edible non-leafy portions of plants exposed to deposition from the calculation of dose from the plant ingestion pathway. Alternatively, provide revised dose calculations that account for deposition on both leafy and non-leafy edible plant parts that could be exposed to radionuclide deposition.

DOE Response to BIO-1

Equation 4.4-139 of the SDF PA (SRR-CWDA-2019-00001) does not restrict the modeled deposition of radionuclides onto only the leafy portions of the plants. That equation is used to calculate the ingestion dose to the MOP at the 100-meter well.

Instead, the fraction of produce that is leafy is applied as part of the term P_{in} used to represent all radionuclide uptake for all contaminated plants (leafy and non-leafy) that will be ingested. This term is defined as:

$$P_{in} = \left(LEAF \times F_{leaf} \times F_{wash}\right) + ROOT \qquad \text{Eq. 4.4-149}$$

where:

P_{in} = radionuclide uptake, deposition, and retention rate in plants ((m^2×yr)/kg),

$LEAF$ = radionuclide deposition and retention rate on produce leaves ((m^2×yr)/kg),

F_{leaf} = fraction of produce that is leafy (unitless),

F_{wash} = fraction of material deposited on leaves that is retained after washing (unitless), and

$ROOT$ = radionuclide uptake through produce roots ((m^2×yr)/kg).

For leafy vegetables, the amount of the edible mass of the produce compared to the surface area is relatively high compared to that of other produce. Additionally, the external surfaces of many non-leafy agricultural products are protected by casings which are not consumed (e.g., fruit peels or nut shells). Because of these factors, the equations in the SDF PA did not account for the external deposition of contaminants on the non-leafy produce.

In retrospect, it would have been more defensible to address this. The following provides a revised calculation for P_{in} to account for deposition on both leafy and non-leafy plant parts that could be exposed to radionuclide deposition:

$$P_{in} = \left(LEAF \times F_{leaf} \times F_{wash}\right) + \left(LEAF \times F_{other} \times F_{TL}\right) + ROOT$$

where:

P_{in} = radionuclide uptake, deposition, and retention rate in plants ((m^2×yr)/kg),

$LEAF$ = radionuclide deposition and retention rate on produce leaves ((m^2×yr)/kg),

F_{leaf} = fraction of produce that is leafy (unitless),

F_{other} = fraction of produce that is not leafy and not roots and tubers (unitless),

F_{TL} = "translocation" factor (unitless) to define the fraction of what deposits on the foliage that ends up in the edible portions of the plant,

F_{wash} = fraction of material deposited on leaves that is retained after washing (unitless), and

$ROOT$ = radionuclide uptake through produce roots ((m^2×yr)/kg).

Note that this equation assumes that any contamination that is translocated from the surface to the edible portion of the produce will not be subject to being washed off.

This revised formula now includes a fraction of produce that is neither leafy nor roots and tubers (F_{other}). The first parenthetical in the formula already accounts for the leafy vegetables and the last term ($ROOT$) accounts for any root uptake. To determine the value to use for F_{other}, the assumed crop yield percentages shall be used; these come from Table 2 of SRR-CWDA-2018-00057 (shown here as Table BIO-1.1).

Table BIO-1.1. Assumed Crop Yield Percentages

Produce	**Yield (%)**
Leafy Vegetables	22.2%
Legumes	15.0%
Tubers and Roots	10.0%
Fruit	22.2%
Grain	11.1%
Other Vegetables	19.5%
Total	100%

As shown, the leafy vegetables account for 22.2% of the produce while the tubers and roots account for 10%. Therefore, F_{other} is 67.8% (100% - (22.2% + 10%) = 67.8%).

For the translocation factor (F_{TL}), or the fraction of what deposits on the foliage that ends up in the edible portions of the plant, a value of 0.1 shall be assumed. This value is based on the recommended value described in Sections 6.5.2 and 6.5.6 of NUREG/CR-5512 (ML052220317).

As expected, applying this revised formula results in a slight increase to doses. Within the 1,000-year Compliance Period, this updated formula increases the total dose to the MOP at the 100-meter well from 0.0094 mrem/yr in the SDF PA to 0.0095 mrem/yr. Because these values are significantly below the performance objectives, figures for the 1,000-year results are not provided. Within the 10,000-year Performance Period, the total dose to the MOP at the 100-meter well increased from 1.15 mrem/yr in the SDF PA to 1.18 mrem/yr. These comparisons are shown in Figures BIO-1.1 and BIO-1.2 (for detail).

Within the 1,000-year Compliance Period, this updated formula had a negligible influence on the total dose to the Chronic IHI at the 1-meter well (both doses were 0.30 mrem/yr). Again, because these values are significantly below the performance objectives, figures for the 1,000-year results are not provided. Within the 10,000-year Performance Period, the total dose to the Chronic IHI at the 1-meter well increased from 2.18 mrem/yr in the SDF PA to 2.23 mrem/yr. These comparisons are shown in Figures BIO-1.3 and BIO-1.4 (for detail).

Given the other uncertainties inherent in the Compliance Case, the differences between these two cases are negligible relative to the overall system performance.

Figure BIO-1.1: Comparison of the100-Meter MOP Peak Ground Water Pathways Dose within 10,000 Years from the PA versus with BIO-1 (Revised Formula)

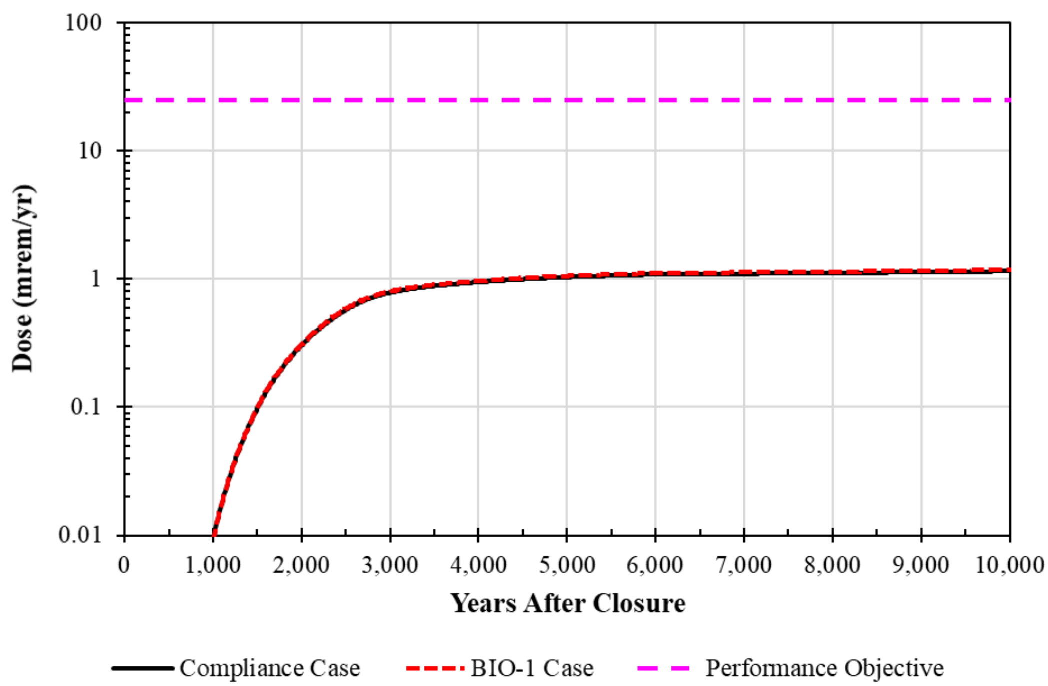


Figure BIO-1.2: Comparison of the100-Meter MOP Peak Ground Water Pathways Dose within 10,000 Years from the PA versus with BIO-1 (Revised Formula) (Detail)

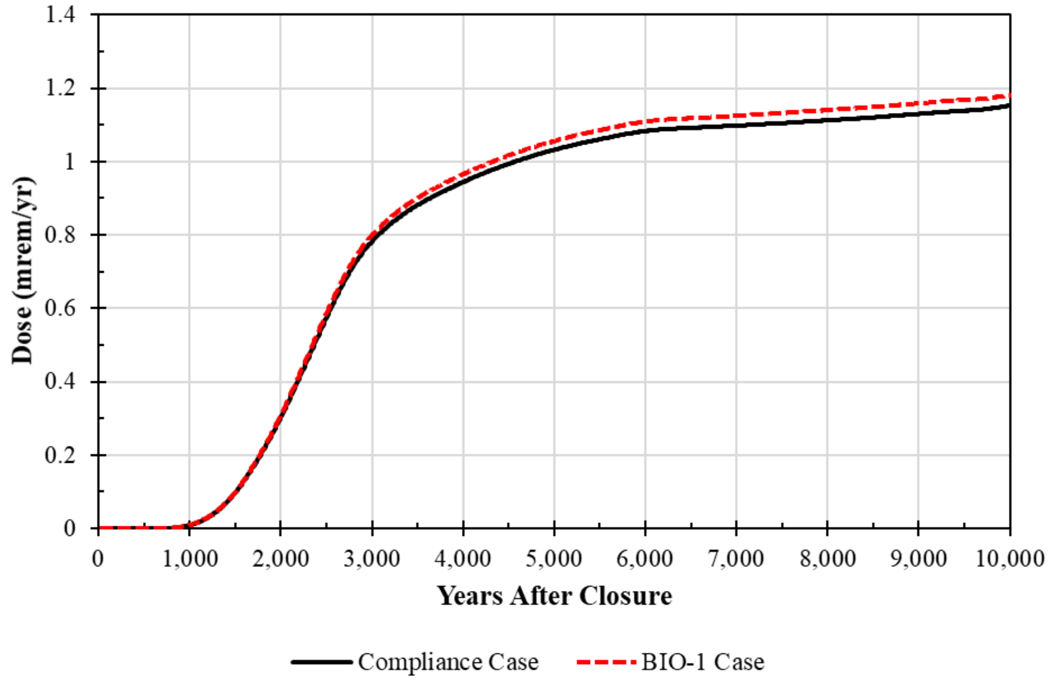


Figure BIO-1.3: Comparison of the Chronic IHI at the 1-Meter Well Dose within 10,000 Years from the PA versus with BIO-1 (Revised Formula)

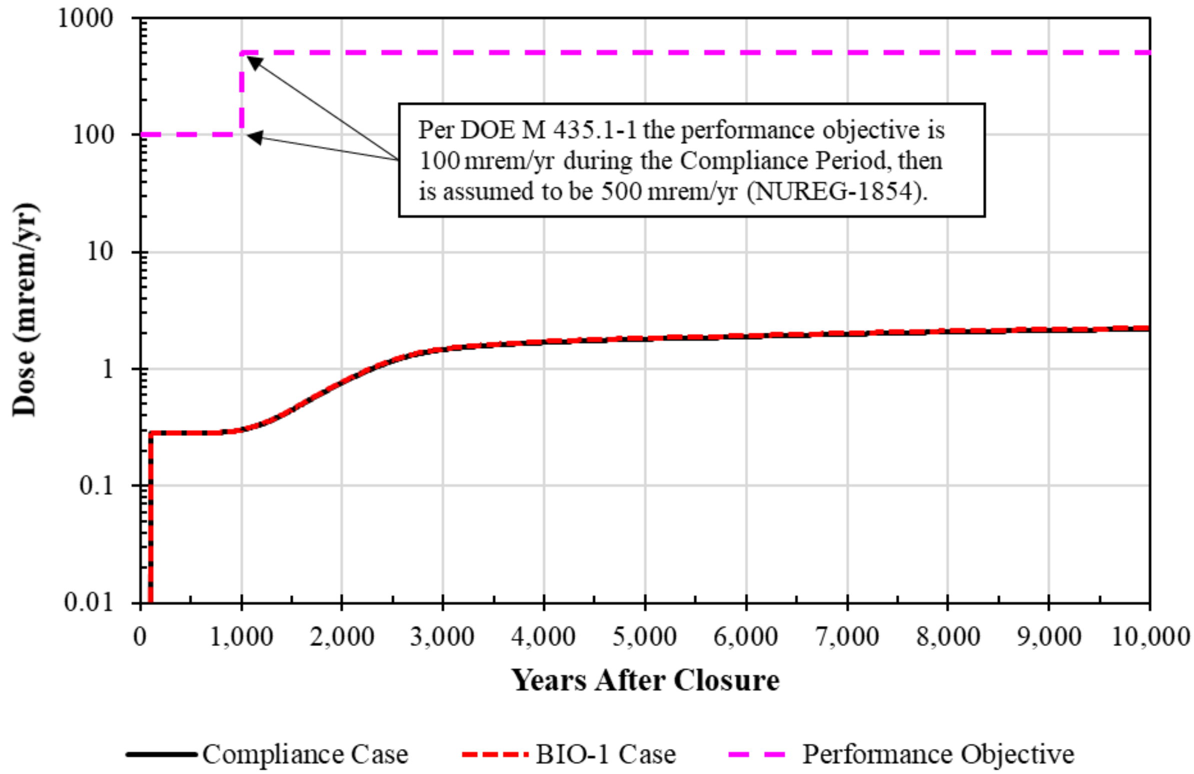
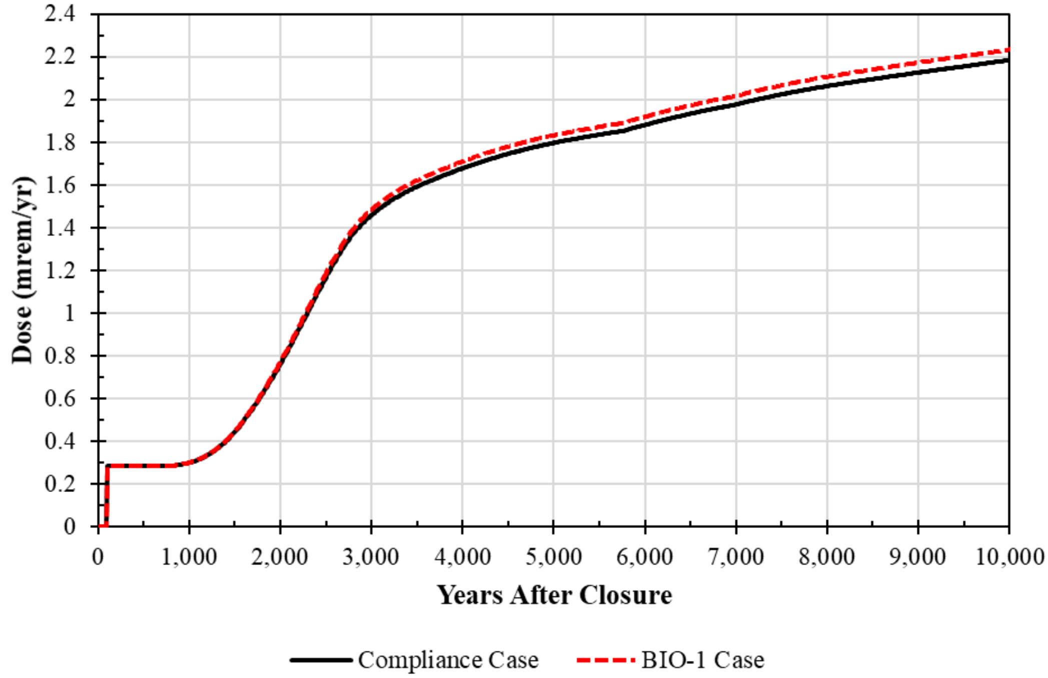


Figure BIO-1.4: Comparison of the Chronic IHI at the 1-Meter Well Dose within 10,000 Years from the PA versus with BIO-1 (Revised Formula) (Detail)



References for Response to BIO-1

ML052220317, Kennedy, W.E., and Strenge, D.L., *Residual Radioactive Contamination from Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalents*, NUREG/CR-5512 Volume 1, PNL-7994, Pacific Northwest Laboratory, Richland, WA, October 1992.

NUREG/CR-5512. See entry for ML052220317.

SRR-CWDA-2018-00057, Dixon, K.D., *Recommended Yield Percentage of Locally Grown Produce in the Savannah River Site Area for Use in Dose Calculations to Support Liquid Waste Performance Assessments*, Savannah River Site, Aiken, SC, Rev. 0, September 2018.

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, March 2020.

BIO-2

BIO-2	**Question:** The NRC staff needs additional information about the development of the soil-to-plant factors used in the 2020 SDF PA to assess projected dose from the plant ingestion pathway.
	Basis: Section 4.4.8.3.4 of the 2020 SDF PA states that soil-to-plant transfer coefficients were developed based on the wet-weight of plants. That statement is consistent with the implementation in the GoldSim dose model for the 2020 SDF PA, which uses the soil-to-plant transfer factors with wet-weight plant consumption factors to calculate radionuclide intake from the plant ingestion pathway. However, the DOE document that the 2020 SDF PA cites as the reference for the soil-to-plant transfer factors (SRR-CWDA-2013-00058, Rev. 2) does not state whether the listed soil-to-plant transfer factors are on a wet- or dry-weight basis. Instead, that document indicates that when wet-weight values were provided in the source documents, dry-to-wet ratios were applied, which implies that the factors were converted from a wet-weight to a dry-weight basis. The NRC staff was unable to reproduce the soil-to-plant transfer factors listed in SRR-CWDA-2013-00058, Rev. 2 based on the cited reference hierarchy for the soil-to-plant transfer factors, the assumed crop yield percentages in Table 9.2-2 of SRR-CWDA-2013-00058, Rev. 2, and the referenced dry-to-wet ratios in the DOE document PNNL-13421, Rev. 0. Combining the dry-to-wet ratios for different plant parts from the DOE document PNNL-13421, Rev. 0 with the fractional yields used in the 2020 SDF PA results in an overall dry-to-wet ratio of 0.3. Because the DOE projects that plant ingestion is 19% of the projected dose for a member of the public at 10,000 years after closure in the Compliance Case and this ratio has a linear effect on the projected dose, the dry-to-wet conversion factor to the soil-to-plant transfer factors could impact the overall uncertainty of the projected dose. Therefore, the NRC staff needs to understand the development of the soil-to-plant transfer factors used in the 2020 SDF PA to evaluate the DOE dose projections.
	Path Forward: Provide illustrative calculations of the soil-to-plant transfer factors for Tc and Iodine listed in Table 4.4-113 of the 2020 SDF PA. The calculations should identify the specific literature sources used (i.e., which documents in the hierarchy provided in SRR-CWDA-2013-00058, Rev. 2 were used) and show any weighting by plant parts or conversions between a wet- and dry-weight basis.

DOE Response to BIO-2

Table 4.4-113 from the SDF PA (SRR-CWDA-2019-00001) references SRR-CWDA-2013-00058 as the source for the soil-to-plant transfer factors. As described in Section 9.1 of SRR-CWDA-2013-00058, the selection of the soil-to-plant transfer factors was made based on a hierarchy of references. Specifically, this hierarchy is as follows:

- If values were available from the International Atomic Energy Agency (IAEA-472), those values would be used.
- If not, then
  - If values were available from Pacific Northwest National Laboratory (PNNL-13421), those values would be used.
  - If not, then
    - If values were available from Oak Ridge National Laboratory (ORNL-5786), those values would be used.
    - If not, then

- If values were available from NUREG/CR-5512 (ML052220317), those values would be used.
- If not, then
  - If values were available from WSRC-STI-2007-00004, those values would be used.
  - If not, then values were used from SRR-CWDA-2010-00128.

If the soil-to-plant transfer factors from the respective reference(s) were reported as dry-weight values (as opposed to fresh weight or wet-weight values), then the values were converted into wet-weight values by multiplying the values by dry-to-wet weight conversion factors. Section 9.2 of SRR-CWDA-2013-00058 incorrectly stated that "When wet-weight values were provided, dry-to-wet ratios from PNNL-13421 were applied." This is a mistake in the report and it should have stated: "When *dry-weight* values were provided, the dry-to-wet *weight conversion factors* from PNNL-13421 were applied." This step is necessary because when produce is consumed, the amount consumed is based on the fresh or wet weight of the produce.

The dry-to-wet weight conversion factors used to develop the soil-to-plant transfer factors in the SDF PA (SRR-CWDA-2019-00001) came from Table 2.1 of PNNL-13421 and are shown here as Table BIO-2.1.

Table BIO-2.1. Dry-to-Wet Weight Conversion Factors for Food Products

Plant Type	**Conversion Factor**
Leafy vegetables	0.20
Other vegetables	0.25
Other/root vegetables	0.25
Fruit	0.18
Grain	0.91

Next, the resulting wet-weight values were scaled according to assumed crop yield percentages. The assumed crop yield percentages were recommended from Table 2 of SRR-CWDA-2018-00057 (shown here as Table BIO-2.2).

Table BIO-2.2. Assumed Crop Yield Percentages

Produce	**Yield (%)**
Leafy Vegetables	22.2%
Legumes	15.0%
Tubers and Roots	10.0%
Fruit	22.2%
Grain	11.1%
Other Vegetables	19.5%
Total	100%

The following provides step-by-step explanations for how this information was used to develop the recommended iodine and technetium soil-to-plant transfer factors provided in Table 4.4-113 of the SDF PA (SRR-CWDA-2019-00001).

Example 1: Development of the Iodine Soil-to-Plant Transfer Factor

From IAEA-472, for temperate environments, the iodine soil-to-plant transfer factors were found in Table 17. These values are reproduced here as Table BIO-2.3.

Table BIO-2.3. Soil-to-Plant Transfer Factors for Iodine from IAEA-472

Row #	IAEA-472 Table	Element	Plant group	Plant compartment	Soil Group	Mean
1	TABLE 17	I	Cereals	Grain	All	6.3E-04
2	TABLE 17	I	Cereals	Grain	Sand	5.8E-03
3	TABLE 17	I	Cereals	Grain	Loam	3.6E-04
4	TABLE 17	I	Cereals	Grain	Clay	5.7E-04
5	TABLE 17	I	Cereals	Stems and shoots	All	5.2E-02
6	TABLE 17	I	Cereals	Stems and shoots	Sand	4.3E-01
7	TABLE 17	I	Cereals	Stems and shoots	Loam	3.6E-02
8	TABLE 17	I	Cereals	Stems and shoots	Clay	4.5E-02
9	TABLE 17	I	Leafy Vegetables	Leaves	All	6.5E-03
10	TABLE 17	I	Leafy Vegetables	Leaves	Sand	4.0E-02
11	TABLE 17	I	Leafy Vegetables	Leaves	Loam	4.1E-03
12	TABLE 17	I	Leafy Vegetables	Leaves	Clay	4.6E-03
13	TABLE 17	I	Non-Leafy vegetables	Fruit	All	1.0E-01
14	TABLE 17	I	Leguminous Vegetables	Seeds and pods	All	8.5E-03
15	TABLE 17	I	Leguminous Vegetables	Seeds and pods	Sand	3.5E-03
16	TABLE 17	I	Leguminous Vegetables	Seeds and pods	Loam	4.4E-04
17	TABLE 17	I	Leguminous Vegetables	Seeds and pods	Clay	2.5E-04
18	TABLE 17	I	Root crops	Roots	All	7.7E-03
19	TABLE 17	I	Root crops	Roots	Sand	2.3E-02
20	TABLE 17	I	Root crops	Roots	Loam	4.7E-03
21	TABLE 17	I	Root crops	Roots	Clay	4.5E-03
22	TABLE 17	I	Tubers	Tubers	All	1.0E-01
23	TABLE 17	I	Pasture	Stems and shoots	All	3.7E-03
24	TABLE 17	I	Pasture	Stems and shoots	Sand	1.8E-03
25	TABLE 17	I	Pasture	Stems and shoots	Clay	8.7E-03

Note: Table 17 of IAEA-472 is missing the label for I; however, given that the elements are listed alphabetically and there is an unlabeled dataset between Fe and K, the unlabeled data is assumed to correspond to iodine.

From the data set in Table BIO-2.3, representative values were selected for specific plant categories:

- Grains = 6.3E-04 (from Table BIO-2.3, Row 1),
- Leafy Vegetables = 6.5E-03 (from Table BIO-2.3, Row 9),
- Fruits = 1.0E-01 (from Table BIO-2.3, Row 13),
- Legumes = 8.5E-03 (from Table BIO-2.3, Row 14), and
- Roots and Tubers = 7.7E-03 (from Table BIO-2.3, Row 18).

Note that IAEA-472 provided soil-to-plant transfer factor values as minimum, mean, and maximum values. Of these, the mean is assumed to be the best representation of the soil-to-plant transfer factors. IAEA-472 also provided various values based on different soil types (All, Sand, Clay, or Loam). Because the soils may be modified by future farmers (e.g., adding manure), it is unclear what the appropriate soil type would be. Therefore, the "All" soil group was assumed because this represents the most general soil group value and it considers the largest number of analyzed samples. The selected values are summarized in Table BIO-2.4

Table BIO-2.4. Initial Selection of Soil-to-Plant Transfer Factors for Iodine

Element	Plant Category	Value
I	Grains	6.3E-04
I	Leafy Vegetables	6.5E-03
I	Fruit	1.0E-01
I	Legumes	8.5E-03
I	Roots and Tubers	7.7E-03

The IAEA-472 are all dry-weight values (as described in Section 2.2 of IAEA-472). Therefore, the dry-to-wet weight conversion factors from Table BIO-2.1 were applied to the each of the representative values in Table BIO-2.4 to determine the appropriate wet-weight soil-to-plant transfer factors for iodine. Table BIO-2.5 summarizes the results from this step.

Table BIO-2.5. Soil-to-Plant Transfer Factors for Iodine with Dry-to-Wet Mass Conversion

Element	Plant Category	Dry Weight Value	Dry-to-Wet Weight Conversion Factor	Wet Weight Value (Dry Weight Value × Dry-to-Wet Weight Conversion Factor)
I	Grains	6.3E-04	0.91	5.7E-04
I	Leafy Vegetables	6.5E-03	0.20	1.3E-03
I	Fruit	1.0E-01	0.18	1.8E-02
I	Legumes	8.5E-03	0.25	2.1E-03
I	Roots and Tubers	7.7E-03	0.25	1.9E-03

Next, Table BIO-2.6 shows the initial assignments of crop yield percentages (from Table BIO-2.2) relative to each of the plant categories for iodine. At this point it is noted that because this data set does not include a soil-to-plant transfer factor for "Other Vegetables," the sum of the crop yields does not equal 100%. This indicates that the initial crop yield percentages do not account for all of the potential crops, which means that the initial crop yield percentages must be adjusted to account for the full 100% that should be possible.

Table BIO-2.6. Selected Wet-Weight Soil-to-Plant Transfer Factors for Iodine with Initial Crop Yield Percentages

Element	Plant Category	Wet Weight Value (from Table BIO-2.5)	Initial Crop Yield Percentages (from Table BIO-2.2)
I	Grains	5.7E-04	11.1%
I	Leafy Vegetables	1.3E-03	22.2%
I	Fruit	1.8E-02	22.2%
I	Legumes	2.1E-03	15%
I	Roots and Tubers	1.9E-03	10%

Because the literature on the use and application of soil-to-plant transfer factors sometimes specifies different treatment for Leafy Vegetables, the plant categories were split into two sets: Leafy Vegetables and Non-Leafy Produce, where the Non-Leafy Produce is assumed to include all plant categories except for the Leafy Vegetables.

Because the Leafy Vegetables crop yield is known to account for 22.2% of all crops, this crop yield percentage was held constant. This means that the remaining initial crop yield percentages in Table BIO-2.6 needed to be scaled up, such that the total percentage of all crop yields equals 100%. Because the Leafy Vegetables account for 22.2%, the Non-Leafy Produce must account for the remaining 77.8% of crop yields (100% - 22.2% = 77.8%). From Table BIO-2.6, the sum of the crop yields for Grains, Fruit, Legumes, and Roots and Tubers is 58.3%. Therefore, the total soil-to-plant transfer factor for iodine is:

$$(22.2\% \times 1.3\text{E-}03) + (77.8\% \times [11.1\% \times 5.7\text{E-}04 + 22.2\% \times 1.8\text{E-}02 + 15\% \times 2.1\text{E-}03 + 10\% \times 1.9\text{E-}03] / 58.3\%) = 6.38\text{E-}03$$

Note that in the file wherein this value was calculated, additional significant figures were used, such that the resulting total was slightly higher (6.39E-03). This value of 6.39E-03 for iodine matches the value shown in Table 4.4-113 from the SDF PA (SRR-CWDA-2019-00001).

Example 2: Development of the Technetium Soil-to-Plant Transfer Factor

From IAEA-472, for temperate environments, the technetium soil-to-plant transfer factors were found in Table 18. These values are reproduced here as Table BIO-2.7.

Table BIO-2.7. Soil-to-Plant Transfer Factors for Technetium from IAEA-472

Row #	IAEA-472 Table	Element	Plant group	Plant compartment	Soil Group	Mean
1	TABLE 18	Tc	Cereals	Grain	All	1.3E+00
2	TABLE 18	Tc	Maize	Grain	All	3.8E+00
3	TABLE 18	Tc	Maize	Stems and shoots	All	6.4E+00
4	TABLE 18	Tc	Leafy Vegetables	Leaves	All	1.8E+02
5	TABLE 18	Tc	Leafy Vegetables	Leaves	Sand	1.1E+02
6	TABLE 18	Tc	Leafy Vegetables	Leaves	Loam	2.5E+02
7	TABLE 18	Tc	Leguminous Vegetables	Seeds and pods	All	4.3E+00
8	TABLE 18	Tc	Leguminous Vegetables	Seeds and pods	Sand	1.3E+00
9	TABLE 18	Tc	Leguminous Vegetables	Seeds and pods	Loam	2.6E+01
10	TABLE 18	Tc	Root crops	Roots	All	4.6E+01
11	TABLE 18	Tc	Tubers	Tubers	All	2.3E-01
12	TABLE 18	Tc	Tubers	Tubers	Sand	3.9E-01
13	TABLE 18	Tc	Tubers	Tubers	Loam	9.4E-02
14	TABLE 18	Tc	Pasture	Stems and shoots	All	7.6E+01

From the data set in Table BIO-2.7, representative values were selected for specific plant categories:

- Grains = 3.8E+00 (from Table BIO-2.7, Row 2),
- Leafy Vegetables = 1.8E+02 (from Table BIO-2.7, Row 4),
- Fruits = no technetium data was available in IAEA-472 for fruit,
- Legumes = 4.3E+00 (from Table BIO-2.7, Row 7), and
- Roots and Tubers = 4.6E+01 (from Table BIO-2.7, Row 10).

These selections are summarized in Table BIO.2-8.

Table BIO-2.8. Initial Selection of Soil-to-Plant Transfer Factors for Technetium

Element	Plant Category	Value
Tc	Grains	3.8E+00
Tc	Leafy Vegetables	1.8E+02
Tc	Fruit	N/A
Tc	Legumes	4.3E+00
Tc	Roots and Tubers	4.6E+01

The IAEA-472 are all dry-weight values (as described in Section 2.2 of IAEA-472). Therefore, the dry-to-wet weight conversion factors from Table BIO-2.1 were applied to the each of the representative values in Table BIO-2.8 to determine the appropriate wet-weight soil-to-plant transfer factors for technetium. Table BIO-2.9 summarizes the results from this step.

Table BIO-2.9. Soil-to-Plant Transfer Factors for Technetium with Dry-to-Wet Mass Conversion

Element	Plant Category	Dry Weight Value	Dry-to-Wet Weight Conversion Factor	Wet Weight Value (Dry Weight Value × Dry-to-Wet Weight Conversion Factor)
Tc	Grains	3.8E+00	0.91	3.5E+00
Tc	Leafy Vegetables	1.8E+02	0.20	3.6E+01
Tc	Fruit	N/A	N/A	N/A
Tc	Legumes	4.3E+00	0.25	1.1E+00
Tc	Roots and Tubers	4.6E+01	0.25	1.2E+01

Next, Table BIO-2.10 shows the initial assignments of crop yield percentages (from Table BIO-2.2) relative to each of the plant categories for technetium. At this point it is noted that because this data set does not include a soil-to-plant transfer factor for "Fruit" or for "Other Vegetables," the sum of the crop yields does not equal 100%. This indicates that the initial crop yield percentages do not account for all of the potential crops, which means that the initial crop yield percentages must be adjusted to account for the full 100% that should be possible.

Table BIO-2.10. Selected Wet-Weight Soil-to-Plant Transfer Factors for Technetium with Initial Crop Yield Percentages

Element	Plant Category	Wet Weight Value (from Table BIO-2.9)	Initial Crop Yield Percentages (from Table BIO-2.2)
Tc	Grains	3.5E+00	11.1%
Tc	Leafy Vegetables	3.6E+01	22.2%
Tc	Fruit	N/A	N/A
Tc	Legumes	1.1E+00	15%
Tc	Roots and Tubers	1.2E+01	10%

Because the literature on the use and application of soil-to-plant transfer factors sometimes specifies different treatment for Leafy Vegetables, the plant categories were split into two sets: Leafy Vegetables and Non-Leafy Produce, where the Non-Leafy Produce is assumed to include all plant categories except for the Leafy Vegetables.

Because the Leafy Vegetables crop yield is known to account for 22.2% of all crops, this crop yield percentage was held constant. This means that the remaining initial crop yield percentages in Table BIO-2.10 needed to be scaled up, such that the total percentage of all crop yields equals 100%. Because the Leafy Vegetables account for 22.2%, the Non-Leafy Produce must account for the remaining 77.8% of crop yields (100% - 22.2% = 77.8%). From Table BIO-2.10, the sum of the crop yields for Grains, Legumes, and Roots and Tubers is 36.1%. Therefore, the total soil-to-plant transfer factor for technetium is:

$$(22.2\% \times 3.6E{+}01) + (77.8\% \times [11.1\% \times 3.5E{+}00 + 15\% \times 1.1E{+}00 + 10\% \times 1.2E{+}01] / 36.1\%) = 1.18E{+}01$$

Note that in the file wherein this value was originally calculated, additional significant figures were used, such that the resulting total was slightly lower (1.17E+01). This value of 1.17E+01 for technetium matches the value shown in Table 4.4-113 from the SDF PA (SRR-CWDA-2019-00001).

References for DOE Response to BIO-2

IAEA-472, *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments*, Technical Reports Series No. 472, International Atomic Energy Agency, Vienna, January 2010. (Copyright)

ML052220317, Kennedy, W.E., and Strenge, D.L., *Residual Radioactive Contamination from Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalents*, NUREG/CR-5512 Volume 1, PNL-7994, Pacific Northwest Laboratory, Richland, WA, October 1992.

ORNL-5786, Baes, C.F., Sharp, R.D., Sjoreen, A.L., and Shor, R.W., *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*, Oak Ridge National Laboratory, Oak Ridge, TN, September 1984.

PNNL-13421, Staven, L.H., Napier, B.A., Rhoads, K., and Strenge, D.L., *A Compendium of Transfer Factors for Agricultural and Animal Products*, Pacific Northwest National Laboratory, Richland, WA, June 2003.

SRR-CWDA-2010-00128, *Performance Assessment for the H-Area Tank Farm at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 1, November 2012.

SRR-CWDA-2013-00058, Hommel, S.P., *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 2, January 2019.

SRR-CWDA-2018-00057, Dixon, K.D., *Recommended Yield Percentage of Locally Grown Produce in the Savannah River Site Area for Use in Dose Calculations to Support Liquid Waste Performance Assessments*, Savannah River Site, Aiken, SC, Rev. 0, September 2018.

WSRC-STI-2007-00004, Lee, P.L. and Coffield, T.W., *Baseline Parameter Update for Human Health Input and Transfer Factors for Radiological Performance Assessments at the Savannah River Site*, Savannah River National Laboratory, Aiken, SC, Rev. 4, June 2008.

BIO-3

<table>
<tr><td rowspan="3">BIO-3</td><td>Question: The NRC staff needs additional information about the effect of uncertainty in certain transfer factors to evaluate dose projections for both a member of the public and inadvertent human intruder (IHI).</td></tr>
<tr><td>Basis: The 2020 SDF PA does not represent the uncertainty in transfer factors because the DOE Fiscal Year (FY) 2014 Special Analysis Document for the SDF did not demonstrate that those factors contributed significantly to uncertainty in dose projections (SRR-CWDA-2013-00058, Rev. 2). However, the relative significance of uncertainty in individual parameters on the uncertainty in dose projections can change when a model changes. For example, the soil-to-plant and feed-to-meat transfer factors were both identified as contributing significantly to the uncertainty in the Tc-99 dose in Sector B in the DOE FY 2013 Special Analysis Document for the SDF. Similarly, the water-to-fish bioconcentration factor was identified as significantly contributing to uncertainty to dose in several sectors in the FY 2013 Special Analysis Document. Although none of those transfer factors were identified among the top eight contributors to uncertainty in the projected dose for any sector in the FY 2014 Special Analysis Document, their identification in the FY 2013 Special Analysis Document demonstrates that model changes can affect which parameters have the most significant effect on dose. Model changes between the FY 2014 Special Analysis Document and the 2020 SDF PA could have a similar effect.

Furthermore, several parameters that were identified as important to performance in the FY 2014 Special Analysis and the 2020 SDF PA (e.g., infiltration rate, Tc solubility) were modeled differently in the 2020 SDF PA than they were in the FY 2014 Special Analysis Document, increasing the chance that the relative importance of uncertainty in parameters would change. Therefore, parameters that were not identified as one of the top eight contributors to uncertainty in dose projections in the FY 2014 Special Analysis Document could be worth including in the uncertainty analysis in the 2020 SDF PA based on consideration of the uncertainty in the parameter values, the dominant radionuclides, and the major exposure pathways.

As stated in the description of Monitoring Factor 10.08 in the NRC Monitoring Plan for the SDF, Rev. 1, transfer factors typically have significant uncertainty. No additional information related to transfer factors was introduced between the FY 2013 Special Analysis Document, when several transfer factors were identified as significantly affecting the uncertainty in dose, and the 2020 SDF PA. Therefore, it appears that transfer factors related to the dominant radionuclides and main dose pathways could significantly affect uncertainty in the dose projections in the 2020 SDF PA.

The DOE identified water ingestion, plant ingestion, and fish ingestion as the main contributors to dose to the member of the public in the Compliance Case in the 2020 SDF PA. Although calculation of the dose from water ingestion does not involve an environmental transfer factor, calculation of the projected dose from plant ingestion and fish ingestion do involve environmental transfer factors. Therefore, the DOE should evaluate the effect of the uncertainty in transfer factors related to the plant and fish ingestion pathways in the 2020 SDF PA model for Tc-99 and I-129 for the member of the public. Similarly, the DOE identified water ingestion and plant ingestion as major dose pathways for the IHI in the 2020 SDF PA. Therefore, the DOE should evaluate the effect of the uncertainty in transfer factors related to the plant ingestion pathway for Tc-99 and I-129 for the projected dose to the IHI.</td></tr>
<tr><td>Path Forward: Provide an analysis of the effect of uncertainty in the soil-to-plant transfer factor for Tc-99 and I-129 on the uncertainty in the projected dose for the member of the public and IHI. Provide an analysis of the effect of uncertainty in the water-to-fish transfer factors for Tc-99 and I-129 on the projected dose for the member of the public.</td></tr>
</table>

DOE Response to BIO-3

To be determined. Preparation of this response has been deferred to a future revision of this RAI response document.

TECHNICAL TOPIC OF INVENTORY (INV)

INV-1

<table>
<tr><td rowspan="3">INV-1</td><td>Question: The NRC staff needs additional information about the development of the chemical inventories of Iodine reported in Tables 3.3-8, 3.3-9, and 3.3-10 of the 2020 SDF PA and how they relate to the radiological inventories of I-129 reported in Tables 3.3-5, 3.3-6, and 3.3-7 of the 2020 SDF PA.</td></tr>
<tr><td>Basis: The chemical inventories of Iodine reported in Tables 3.3-8, 3.3-9, and 3.3-10 of the 2020 SDF PA are too small to account for the radiological inventories of I-129 reported in Tables 3.3-5, 3.3-6, and 3.3-7 of the 2020 SDF PA. Both the chemical inventories of Iodine and the radiological inventories of I-129 reported in the 2020 SDF PA are shown below in Table INV-1.

Using a specific activity of 6.5×10^9 Becquerels per kilogram (Bq/kg) (0.18 Curies per kg [Ci/kg]) (10 CFR Part 71, Appendix A), the NRC staff also calculated the mass of Iodine corresponding to the reported radiological inventory of I-129. Based on the values in Table INV-1, it appears that the reported chemical inventories of Iodine are insufficient to account for the radiological inventories of I-129 even if there are no other Iodine isotopes present (i.e., if other isotopes were present the chemical inventories would need to be even greater than shown in the last column of Table INV-1).

Table INV-1: Radiological and Chemical Inventories for the SDF Reported in the 2020 SDF PA Compared to the Chemical Inventory Calculated by the NRC Staff Based on the Reported Radiological Inventories

<table>
<tr><th></th><th>Radiological Inventory Reported in the 2020 SDF PA (Ci)</th><th>Chemical Inventory Reported in the 2020 SDF PA (kg)</th><th>Chemical Inventory Calculated by the NRC Staff Based on Reported Radiological Inventory, Assuming I-129 is the Only Iodine Isotope Present (kg)</th></tr>
<tr><td>Realistic</td><td>15.7</td><td>3.58</td><td>87.3</td></tr>
<tr><td>MPAD</td><td>16.6</td><td>3.68</td><td>92.4</td></tr>
<tr><td>Pessimistic</td><td>24.2</td><td>3.71</td><td>135</td></tr>
</table>

The NRC staff uses radiological inventory of Iodine to assess the projected dose to a member of the public and an IHI. In addition, the NRC staff uses chemical inventory of Iodine to assess the potential effect of stable Iodine on I-129 uptake and dose.</td></tr>
<tr><td>Path Forward: Provide the technical basis and any calculations supporting the chemical inventories of Iodine in Tables 3.3-8, 3.3-9, and 3.3-10 of the 2020 SDF PA. Explain the apparent inconsistency between the reported chemical and radiological inventories and provide updated values, if necessary. The projected chemical inventories of Iodine should address contributions of other Iodine isotopes, including stable Iodine, based on available information.</td></tr>
</table>

DOE Response to INV-1

The approach for estimating the initial inventories for iodine was based on an assumed concentration of 0.116 mg/L as described in Section 3.3 of SRR-CWDA-2018-00041.

In reviewing the estimates in response to INV-1, some issues have now been identified in the SDF-WIDE Model. Version 1.10 of the SDF-WIDE Model (*SDF-WIDE_Model_v.1.10*) was used to support the development of the chemical inventory assignments including iodine. First, the estimate for future iodine inventories incorrectly used the WCS[1] estimate for I-129 inventories, which is consistent with the approach used for estimating other radionuclides and chemicals, but is not consistent with the recommended inventory estimate for I-129 from SRR-CWDA-2015-00077. Next, although the GoldSim modeling software automatically performs unit conversions, the analyst applied a unit conversion factor within GoldSim when converting the I-129 values into chemical iodine values. As such, the unit conversion was applied twice, resulting in an underestimate of the total future inventory for iodine. Finally, for the canyon additions (described in Section 4.2.1 of SRR-CWDA-2018-00041), only radiological constituents (e.g., I-129) were added to the inventory estimates based on the H-Canyon influents. To correct this, non-radiological inventory values were estimated and added to the chemical inventory of iodine to account for the H-Canyon transfers.

Regardless, the assumed approach only relied upon one iodine isotope (I-129) to estimate the inventory for total iodine. Therefore, even if these issues had been identified and corrected, the total iodine inventory would have been an underestimate.

The following discussion provides a revised approach for the inventory assignments for total iodine.

Iodine-129 (I-129) is expected to be present in saltstone long after closure of the SDF because it has a relatively long half-life (1.57E+07 years per SRR-CWDA-2018-00018). The isotope of iodine with the next longest half-life after I-129 is I-125 with a half-life of less than 60 days (per SRR-CWDA-2018-00018). As such, no other radioactive isotopes of iodine are expected to be present after SDF closure. Therefore, only I-129 and stable iodine (I-127) are needed to estimate total iodine.

With only I-129 and I-127 isotopes expected to be present, and with I-129 inventories having already been defined (via SRR-CWDA-2015-00077 and SRR-CWDA-2018-00041), the next step in estimating the total iodine in the system is developing an estimate of I-127.

Stable iodine is not typically measured from SRS liquid waste system, so data on I-127 concentrations is not available with one exception: estimates of I-127 weight percentages (based on isotopic mass measurements) are available from the residual waste samples collected from the walls or floors of Tanks 6, 12, and 16. These samples were collected prior to those tanks being grouted. The residual waste measurements are summarized in Table INV-1.1, which also shows the ratios of I-127 weight percentages to I-129 weight percentages.

These ratios vary from a minimum of <0.0037 to a maximum of 3.36, suggesting that the ratio of I-127 to I-129 can vary significantly in residual tank wastes. Since the residual tank waste is unlikely to be representative of the decontaminated salt solution used in saltstone production, it is not appropriate to use residual tank waste concentrations of I-129 for estimating the I-127 concentrations for the SDF inventories.

[1] WCS = Waste Characterization System

Table INV.1-1. Residual Tank Waste Measurements of Iodine Isotopes

Tank	Reference	Table in Ref.	Sample	Anion	Average	Unit
Tank 6	SRNL-STI-2012-00365	Table 7	Composite Sample 1	I-127	1.32E-04	wt%
Tank 6	SRNL-STI-2012-00365	Table 7	Composite Sample 1	I-129	7.57E-05	wt%
Tank 6	SRNL-STI-2012-00365	Table 7	Composite Sample 1	**Ratio**	**1.74**	I-127/ I-129
Tank 6	SRNL-STI-2012-00365	Table 8	Composite Sample 2	I-127	2.66E-04	wt%
Tank 6	SRNL-STI-2012-00365	Table 8	Composite Sample 2	I-129	8.90E-05	wt%
Tank 6	SRNL-STI-2012-00365	Table 8	Composite Sample 2	**Ratio**	**2.99**	I-127/ I-129
Tank 6	SRNL-STI-2012-00365	Table 9	Composite Sample 3	I-127	3.56E-04	wt%
Tank 6	SRNL-STI-2012-00365	Table 9	Composite Sample 3	I-129	1.06E-04	wt%
Tank 6	SRNL-STI-2012-00365	Table 9	Composite Sample 3	**Ratio**	**3.36**	I-127/ I-129
Tank 16	SRNL-STI-2014-00321	Table 11	Primary Liner Sample 1-P	I-127	<6.30E-07	wt%
Tank 16	SRNL-STI-2014-00321	Table 11	Primary Liner Sample 1-P	I-129	1.28E-04	wt%
Tank 16	SRNL-STI-2014-00321	Table 11	Primary Liner Sample 1-P	**Ratio**	**<0.0049**	I-127/ I-129
Tank 16	SRNL-STI-2014-00321	Table 12	Primary Liner Sample 2-P	I-127	<6.32E-07	wt%
Tank 16	SRNL-STI-2014-00321	Table 12	Primary Liner Sample 2-P	I-129	<4.01E-06	wt%
Tank 16	SRNL-STI-2014-00321	Table 12	Primary Liner Sample 2-P	**Ratio**	**<0.16**	I-127/ I-129
Tank 16	SRNL-STI-2014-00321	Table 13	Primary Liner Sample 3-P	I-127	<6.29E-07	wt%
Tank 16	SRNL-STI-2014-00321	Table 13	Primary Liner Sample 3-P	I-129	1.68E-04	wt%
Tank 16	SRNL-STI-2014-00321	Table 13	Primary Liner Sample 3-P	**Ratio**	**<0.0037**	I-127/ I-129
Tank 12	SRNL-STI-2015-00241	Table 9	Composite Sample 1	I-127	1.22E-04	wt%
Tank 12	SRNL-STI-2015-00241	Table 9	Composite Sample 1	I-129	2.69E-03	wt%
Tank 12	SRNL-STI-2015-00241	Table 9	Composite Sample 1	**Ratio**	**0.045**	I-127/ I-129
Tank 12	SRNL-STI-2015-00241	Table 10	Composite Sample 2	I-127	2.26E-04	wt%
Tank 12	SRNL-STI-2015-00241	Table 10	Composite Sample 2	I-129	2.85E-03	wt%
Tank 12	SRNL-STI-2015-00241	Table 10	Composite Sample 2	**Ratio**	**0.079**	I-127/ I-129
Tank 12	SRNL-STI-2015-00241	Table 11	Composite Sample 3	I-127	8.25E-05	wt%
Tank 12	SRNL-STI-2015-00241	Table 11	Composite Sample 3	I-129	2.19E-03	wt%
Tank 12	SRNL-STI-2015-00241	Table 11	Composite Sample 3	**Ratio**	**0.038**	I-127/ I-129

Alternatively, in the *Radiochemistry of Iodine* (NAS-NS-3062), the National Academy of Sciences National Research Council estimated that for each gram (g) of uranium that is irradiated for fission, 3.13E-08 g of I-129 and 9.78E-09 g of I-127 are generated. This suggests that for every gram of I-129, there should be 0.31 grams of I-127 (9.78E-09 g / 3.13E-08 g = 0.31). This estimate is similar to information presented by Robert Hill of Argonne National Laboratory during a 2010 presentation of transmutation (ML110120261). In the presentation, Hill identifies the isotopic composition of iodine in a neutron field as being approximately 23% I-127 and approximately 77% I-129, such that the ratio of I-127 to I-129 is approximately 0.30 (23 / 77 = 0.30). As such, the 0.31 ratio from NAS-NS-3062 shall be assumed for estimating the I-127 inventory.

Tables INV.1-2 through INV.1-4 provide the updated I-129, I-127, and total iodine inventories for the Realistic inventory estimates, the Most Probable and Defensible (MPAD) inventory estimates, and the Pessimistic inventory estimates.

Table INV.1-2. Updated Realistic SDF Inventory Estimates for I-129, I-127, and Total Iodine Inventories at SDF Closure

SDU	I-129 (Ci) [a]	I-129 (g) [b]	I-129 (kg) [c]	I-127 (g) [d]	I-127 (kg) [c]	Total Iodine (kg) [e]
1	2.01E-01	1.14E+03	1.14E+00	3.52E+02	3.52E-01	1.49E+00
2A	7.31E-02	4.13E+02	4.13E-01	1.28E+02	1.28E-01	5.42E-01
2B	6.83E-02	3.86E+02	3.86E-01	1.20E+02	1.20E-01	5.06E-01
3A	1.85E-01	1.05E+03	1.05E+00	3.24E+02	3.24E-01	1.37E+00
3B	1.80E-01	1.02E+03	1.02E+00	3.15E+02	3.15E-01	1.33E+00
4	2.77E-01	1.57E+03	1.57E+00	4.86E+02	4.86E-01	2.05E+00
5A	1.39E-01	7.86E+02	7.86E-01	2.44E+02	2.44E-01	1.03E+00
5B	8.68E-02	4.91E+02	4.91E-01	1.52E+02	1.52E-01	6.43E-01
6	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
7	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
8	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
9	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
10	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
11	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
12	2.10E+00	1.19E+04	1.19E+01	3.68E+03	3.68E+00	1.55E+01
Total	**1.59E+01**	**9.00E+04**	**9.00E+01**	**2.79E+04**	**2.79E+01**	**1.18E+02**

Notes: (a) From the SDF PA (SRR-CWDA-2019-00001), Table 3.3-5.
(b) Converted from Ci to g using a specific activity of 1.7681E-04 Ci/g from SRR-CWDA-2018-00018.
(c) Converted from g to kg by dividing the value by 1,000.
(d) Estimated based on I-129 mass (g) × 0.31 (discussed above).
(e) I-129 + I-127 = total iodine.

Table INV.1-3. Updated MPAD SDF Inventory Estimates (Compliance Case Values) for I-129, I-127, and Total Iodine Inventories at SDF Closure

SDU	I-129 (Ci) [a]	I-129 (g) [b]	I-129 (kg) [c]	I-127 (g) [d]	I-127 (kg) [c]	Total Iodine (kg)[e]
1	2.01E-01	1.14E+03	1.14E+00	3.52E+02	3.52E-01	1.49E+00
2A	7.31E-02	4.13E+02	4.13E-01	1.28E+02	1.28E-01	5.42E-01
2B	6.83E-02	3.86E+02	3.86E-01	1.20E+02	1.20E-01	5.06E-01
3A	1.92E-01	1.09E+03	1.09E+00	3.37E+02	3.37E-01	1.42E+00
3B	1.88E-01	1.06E+03	1.06E+00	3.30E+02	3.30E-01	1.39E+00
4	2.77E-01	1.57E+03	1.57E+00	4.86E+02	4.86E-01	2.05E+00
5A	1.39E-01	7.86E+02	7.86E-01	2.44E+02	2.44E-01	1.03E+00
5B	8.68E-02	4.91E+02	4.91E-01	1.52E+02	1.52E-01	6.43E-01
6	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
7	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
8	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
9	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
10	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
11	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
12	2.20E+00	1.24E+04	1.24E+01	3.86E+03	3.86E+00	1.63E+01
Total	**1.66E+01**	**9.40E+04**	**9.40E+01**	**2.91E+04**	**2.91E+01**	**1.23E+02**

Notes: (a) From the SDF PA (SRR-CWDA-2019-00001), Table 3.3-6.
(b) Converted from Ci to g using a specific activity of 1.7681E-04 Ci/g from SRR-CWDA-2018-00018.
(c) Converted from g to kg by dividing the value by 1,000.
(d) Estimated based on I-129 mass (g) × 0.31 (discussed above).
(e) I-129 + I-127 = total iodine.

Table INV.1-4. Updated Pessimistic SDF Inventory Estimates for I-129, I-127, and Total Iodine Inventories at SDF Closure

SDU	I-129 (Ci) [a]	I-129 (g) [b]	I-129 (kg) [c]	I-127 (g) [d]	I-127 (kg) [c]	Total Iodine (kg)[e]
1	2.01E-01	1.14E+03	1.14E+00	3.52E+02	3.52E-01	1.49E+00
2A	7.31E-02	4.13E+02	4.13E-01	1.28E+02	1.28E-01	5.42E-01
2B	6.83E-02	3.86E+02	3.86E-01	1.20E+02	1.20E-01	5.06E-01
3A	2.70E-01	1.53E+03	1.53E+00	4.73E+02	4.73E-01	2.00E+00
3B	2.82E-01	1.59E+03	1.59E+00	4.94E+02	4.94E-01	2.09E+00
4	2.77E-01	1.57E+03	1.57E+00	4.86E+02	4.86E-01	2.05E+00
5A	1.39E-01	7.86E+02	7.86E-01	2.44E+02	2.44E-01	1.03E+00
5B	8.68E-02	4.91E+02	4.91E-01	1.52E+02	1.52E-01	6.43E-01
6	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
7	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
8	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
9	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
10	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
11	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
12	3.29E+00	1.86E+04	1.86E+01	5.77E+03	5.77E+00	2.44E+01
Total	**2.44E+01**	**1.38E+05**	**1.38E+02**	**4.28E+04**	**4.28E+01**	**1.81E+02**

Notes: (a) From the SDF PA (SRR-CWDA-2019-00001), Table 3.3-7.
(b) Converted from Ci to g using a specific activity of 1.7681E-04 Ci/g from SRR-CWDA-2018-00018.
(c) Converted from g to kg by dividing the value by 1,000.
(d) Estimated based on I-129 mass (g) × 0.31 (discussed above).
(e) I-129 + I-127 = total iodine.

From the SDF PA Table 3.3-9, the previous MPAD estimate for the total iodine inventory was 3.68 kg. From Table INV-1.3 (above), the updated MPAD estimate for the total iodine inventory is now estimated to be 123 kg. This is increases in the MPAD inventory by a factor of 33.47 (123 kg / 3.68 kg).

With these updated inventory values for total iodine, the resulting groundwater concentrations are expected to be impacted. To estimate the impacts to the total iodine concentrations for the Compliance Case, the peak groundwater concentrations from the SDF PA may be scaled up by the respective increase to the MPAD inventory (i.e., a factor of 33.47). Within the SDF PA (SRR-CWDA-2019-00001), the peak groundwater concentrations are in Tables 5.2-7 through 5.2-9 (for peaks in 1,000 years) and Tables 5.2-16 through 5.2-18 (for peaks in 10,000 years). The iodine concentrations from these tables are shown in Tables INV-1.5 and INV-1.6, along with the estimated increases to the concentrations.

Table INV.1-5. Updated Chemical Peak Iodine Concentrations along the 100-Meter Boundary in 1,000 Years

		Peaks from the SDF PA			Updated Peaks	
Aquifer [a]	Sector	Conc. (µg/L)	Year of Peak	SDF PA Table	Conc. (µg/L) [b]	Year of Peak
UAZ	Sector A	1.7E-09	1,000	Table 5.2-7	5.7E-08	1,000
UAZ	Sector B	4.4E-09	1,000	Table 5.2-7	1.5E-07	1,000
UAZ	Sector C	2.5E-07	1,000	Table 5.2-7	8.4E-06	1,000
UAZ	Sector D	1.7E-07	1,000	Table 5.2-7	5.7E-06	1,000
UAZ	Sector E	1.8E-08	1,000	Table 5.2-7	6.0E-07	1,000
UAZ	Sector F	2.6E-06	1,000	Table 5.2-7	8.7E-05	1,000
UAZ	Sector G	4.2E-06	1,000	Table 5.2-7	1.4E-04	1,000
UAZ	Sector H	5.1E-08	1,000	Table 5.2-7	1.7E-06	1,000
LAZ	Sector A	6.5E-09	1,000	Table 5.2-8	2.2E-07	1,000
LAZ	Sector B	2.2E-08	1,000	Table 5.2-8	7.4E-07	1,000
LAZ	Sector C	3.4E-07	1,000	Table 5.2-8	1.1E-05	1,000
LAZ	Sector D	2.2E-07	1,000	Table 5.2-8	7.4E-06	1,000
LAZ	Sector E	7.3E-08	1,000	Table 5.2-8	2.4E-06	1,000
LAZ	Sector F	6.7E-06	1,000	Table 5.2-8	2.2E-04	1,000
LAZ	Sector G	7.8E-06	1,000	Table 5.2-8	2.6E-04	1,000
LAZ	Sector H	4.4E-08	1,000	Table 5.2-8	1.5E-06	1,000
Gordon	Sector A	8.4E-12	1,000	Table 5.2-9	2.8E-10	1,000
Gordon	Sector B	1.9E-11	1,000	Table 5.2-9	6.4E-10	1,000
Gordon	Sector C	2.5E-11	1,000	Table 5.2-9	8.4E-10	1,000
Gordon	Sector D	1.3E-11	1,000	Table 5.2-9	4.4E-10	1,000
Gordon	Sector E	3.2E-13	1,000	Table 5.2-9	1.1E-11	1,000
Gordon	Sector F	3.8E-11	1,000	Table 5.2-9	1.3E-09	1,000
Gordon	Sector G	3.4E-11	1,000	Table 5.2-9	1.1E-09	1,000
Gordon	Sector H	<1E-20	1,000	Table 5.2-9	<3.3E-20	1,000

Notes: (a) UAZ = Upper Aquifer Zone of the Upper Three Runs Aquifer, LAZ = Lower Aquifer Zone of the Upper Three Runs Aquifer.
(b) Peak from the SDF PA × 33.47 as discussed above.

Table INV.1-6. Updated Chemical Peak Iodine Concentrations along the 100-Meter Boundary in 10,000 Years

		Peaks from the SDF PA			Updated Peaks	
Aquifer [a]	Sector	Conc. (μg/L)	Year of Peak	SDF PA Table	Conc. (μg/L) [b]	Year of Peak
UAZ	Sector A	1.3E-05	10,000	Table 5.2-16	4.4E-04	10,000
UAZ	Sector B	3.5E-05	10,000	Table 5.2-16	1.2E-03	10,000
UAZ	Sector C	2.3E-03	10,000	Table 5.2-16	7.7E-02	10,000
UAZ	Sector D	5.9E-04	10,000	Table 5.2-16	2.0E-02	10,000
UAZ	Sector E	3.7E-05	10,000	Table 5.2-16	1.2E-03	10,000
UAZ	Sector F	3.4E-04	10,000	Table 5.2-16	1.1E-02	10,000
UAZ	Sector G	5.1E-04	10,000	Table 5.2-16	1.7E-02	10,000
UAZ	Sector H	3.0E-05	10,000	Table 5.2-16	1.0E-03	10,000
LAZ	Sector A	6.5E-05	10,000	Table 5.2-17	2.2E-03	10,000
LAZ	Sector B	2.5E-04	10,000	Table 5.2-17	8.4E-03	10,000
LAZ	Sector C	3.3E-03	10,000	Table 5.2-17	1.1E-01	10,000
LAZ	Sector D	1.1E-03	10,000	Table 5.2-17	3.7E-02	10,000
LAZ	Sector E	1.2E-03	9,990	Table 5.2-17	4.0E-02	9,990
LAZ	Sector F	1.0E-03	9,990	Table 5.2-17	3.3E-02	9,990
LAZ	Sector G	1.1E-03	9,990	Table 5.2-17	3.7E-02	9,990
LAZ	Sector H	2.9E-05	10,000	Table 5.2-17	9.7E-04	10,000
Gordon	Sector A	3.2E-07	10,000	Table 5.2-18	1.1E-05	10,000
Gordon	Sector B	1.5E-06	10,000	Table 5.2-18	5.0E-05	10,000
Gordon	Sector C	6.1E-06	10,000	Table 5.2-18	2.0E-04	10,000
Gordon	Sector D	2.8E-06	10,000	Table 5.2-18	9.4E-05	10,000
Gordon	Sector E	2.5E-08	10,000	Table 5.2-18	8.4E-07	10,000
Gordon	Sector F	3.5E-07	10,000	Table 5.2-18	1.2E-05	10,000
Gordon	Sector G	2.9E-07	10,000	Table 5.2-18	9.7E-06	10,000
Gordon	Sector H	1.8E-17	10,000	Table 5.2-18	6.0E-16	10,000

Notes: (a) UAZ = Upper Aquifer Zone of the Upper Three Runs Aquifer, LAZ = Lower Aquifer Zone of the Upper Three Runs Aquifer.
(b) Peak from the SDF PA × 33.47 as discussed above.

Because iodine does not have a specified maximum contaminant level (MCL) value from the State Primary Drinking Water Regulation (South Carolina Department of Health and Environmental Control [SCDHEC] R.61-58), the increase in the groundwater concentrations of iodine has no impact on the performance of the SDF.

References for DOE Response to INV-1

ML110120261, Hill, R., *Transmutation* (presentation), Argonne National Laboratory, December 2010.

NAS-NS-3062, Kahn, M. and Kleinberg, J., *Radiochemistry of Iodine*, National Academy of Sciences National Research Council, September 1977.

SCDHEC R.61-58, *State Primary Drinking Water Regulation,* Bureau of Water, South Carolina Department of Health and Environmental Control, Columbia, SC, September 2014.

SRNL-STI-2012-00365, Oji, L.N., DiPrete, D.P., Coleman, C.J., Hay, M.S., and Shine, E.P., *Analysis of the Tank 6F Final Characterization Samples-2012*, Savannah River National Laboratory, Aiken, SC, Rev. 2, January 2013.

SRNL-STI-2014-00321, Oji, L.N., DiPrete, D.P., Coleman, C.J., Hay, M.S., and Shine, E.P., *Tank 16H Residual Sample Analysis Report*, Savannah River National Laboratory, Aiken, SC, Rev. 1, October 2014.

SRNL-STI-2015-00241, Oji, L.N., Shine, E.P., DiPrete, D.P., Coleman, C.J., and Hay, M.S., *Tank 12H Residuals Sample Analysis Report*, Savannah River National Laboratory, Aiken, SC, Rev. 0, June 2015.

SRR-CWDA-2015-00077, *Evaluation of I-129 Concentration Data to Improve Liquid Waste Inventory Projections*, Savannah River Site, Aiken, SC, Rev. 2, February 2018.

SRR-CWDA-2018-00018, *Database Compilation of Radionuclides Standardized with Half-Lives in Seconds and Specific Activity in Ci/g*, Savannah River Site, Aiken, SC, Rev. 0, April 2018.

SRR-CWDA-2018-00041, Dixon, K.D., *Determination of Inventory for FY2019 Performance Assessment Modeling*, Savannah River Site, Aiken, SC, Rev. 3, July 2019.

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 0, March 2020.

INV-2

INV-2	**Question:** The NRC staff needs a justification for the DOE assumption that transfers made after 2015 did not significantly affect tank farm concentrations measured after June 2015. In addition, the NRC staff needs information about the uncertainty that the DOE assumption would contribute to the projected SDF inventory of I-129 at closure.
	Basis: Section 4.3 of the DOE document SRR-CWDA-2015-00077, Rev. 2 states that "Any concentration from June of 2015 or newer was assumed to still be valid, regardless of any transfer activity occurring since that time." However, the DOE did not provide a justification for that assumption. Almost half of the samples (i.e., 20 of the 43) listed in Table 4-3 of that DOE document were taken in or after June 2015. Therefore, the projected inventory of the SDF could be affected by the DOE assumption that those concentrations were valid. The sensitivity analysis documented in Section 5.8.5.3 of the 2020 SDF PA shows that changes to the I-129 inventory have an approximately linear effect on the projected dose to a member of the public from I-129. Because I-129 is one of the two radionuclides that dominate the projected dose for a member of the public from the SDF, the NRC staff needs information about the uncertainty attributable to the DOE assumption that measured tank farm concentrations taken in or after June 2015 are valid to understand the uncertainty in the projected dose to a member of the public.
	Path Forward: Provide a justification for the DOE assumption that transfers made after 2015 did not significantly affect tank farm concentrations measured after June 2015. Provide an estimate of the uncertainty that the DOE assumption would contribute to the projected SDF inventory of I-129 at closure.

DOE Response to INV-2

The purpose of the analysis described in the *Evaluation of I-129 Concentration Data to Improve Liquid Waste Inventory Projections* (SRR-CWDA-2015-00077) was to project the final amount (in curies) of I-129 that are currently in the tank farms (i.e., F-Area Tank Farm (FTF) and H-Area Tank Farm (HTF)) and to use the estimate to project the total inventory (Ci) of I-129 for final disposal within the Saltstone Disposal Facility (SDF).

Estimating any changes in concentrations on a tank-by-tank basis requires knowing the initial concentrations in the waste tank prior to any incoming transfers and knowing the concentrations for all incoming waste. Unfortunately, at no point in time has the concentration of I-129 been known for every single waste tank, so there is no single point in time that may effectively be used as a starting baseline for such an evaluation. Instead, the sample analyses used to measure I-129 concentrations in the waste tanks only provide concentrations relative to the particular date from which the sample was collected from the waste tank and only remains unchanged if no additional waste or treatment materials (e.g., water) are added to the waste tank. So, because ongoing transfers of waste and treatment materials into or out of the waste tanks are needed to support various operations at SRS, simplifying assumptions allowed the scope of the evaluation in SRR-CWDA-2015-00077 to be practical and feasible.

The I-129 concentration data used to inform the evaluations described in SRR-CWDA-2015-00077 spans a period of 57 years (from May 1960 to September 2017). However, the evaluations in SRR-CWDA-2015-00077 do not account for any transfers that took place after June of 2015. This means that potential transfers in the 27 months from June 2015 to September 2017 were assumed to be inconsequential.

To support this assumption, Figures INV-2.1 through INV-2.51 have been provided to show the tank levels for each of the SRS waste tanks from Fiscal Year (FY) 2015 through FY2020. These tanks level history figures are annotated to provide summary information about incoming and outgoing transfers. These figures all come directly from summary reports of Savannah River Remediation LLC (SRR) Operations Performance for each fiscal year:

- FY2015: SRR-LWP-2015-00049,
- FY2016: SRR-LWP-2016-00049,
- FY2017: SRR-LWP-2018-00019,
- FY2018: SRR-LWP-2019-00001,
- FY2019: SRR-LWP-2020-00013, and
- FY2020: SRR-LWP-2020-00045.

Upon reviewing these figures, the 51 tanks at SRS may be organized based on their transfer histories.

Tanks in the first group (tanks that have been stabilized with grout) will not see any transfers of waste as the tanks are filled with grout and have no space available for waste.

- Tanks that have been stabilized with grout
    - Tank 5
    - Tank 6
    - Tank 12
    - Tank 16
    - Tank 17
    - Tank 18
    - Tank 19
    - Tank 20

Tanks in the second group (tanks with no (or very limited) transfers) are not expected to have seen any significant change to their inventories during the six-year period being observed.

- Tanks with no (or very limited) transfers
    - Tank 1
    - Tank 2
    - Tank 9[2]
    - Tank 14
    - Tank 24[3]
    - Tank 27
    - Tank 28

2 Tank 9 had some minor volume changes due to reel tape calibrations, mining, and water additions.

3 Tank 24 received one small transfer from Tank 42 in July 2020.

- Tank 29[4]
- Tank 31
- Tank 33
- Tank 34
- Tank 36
- Tank 42[5]
- Tank 44
- Tank 45
- Tank 46
- Tank 47
- Tank 48

Tanks in the third group (tanks that received waste from other SRS facilities) are discussed below. Tank to tank transfers associated with these tanks are predominantly performed to maintain the waste levels in these tanks and to ensure that they may continue receiving waste from the other SRS facilities.

- Tanks that received waste from other SRS Facilities
  - Tank 11 (as of 2019) received Decontaminated Salt Solution (DSS) from Tank Closure Cesium Removal (TCCR)
  - Tank 22 received Defense Waste Processing Facility (DWPF) Recycle
  - Tank 30 received 3H evaporator concentrate
  - Tank 37 received 3H evaporator concentrate
  - Tank 38 received 2H evaporator concentrate
  - Tank 39 received fresh waste from H-Canyon
  - Tank 50[6] received decontaminated salt solution from Actinide Removal Process (ARP)/Modular Caustic Side Solvent Extraction Unit (MCU)/Salt Waste Processing Facility (SWPF) and from TCCR (via Tank 11), and received low level waste from other facilities (e.g., Effluent Treatment Facility [ETF])

Tanks in the fourth group (tanks that feed waste to other SRS facilities) are also discussed below. Similar to the third group, tank to tank transfers associated with this fourth group of tanks are predominantly performed to maintain the waste levels in these tanks and to ensure that they may continue feeding waste to the other SRS facilities.

- Tanks that feed waste to other SRS Facilities
  - Tank 10 (as of 2018) feeds TCCR
  - Tank 32 feeds the 3H Evaporator
  - Tank 40 feeds DWPF
  - Tank 43 feeds the 2H Evaporator
  - Tank 49 feeds ARP/MCU/SWPF
  - Tank 50[6] feeds the Saltstone Production Facility (SPF)

[4] Tank 29 had two small transfers in November and December 2015 to Tank 32

[5] Tank 42 had a small transfer from Tank 30 in December 2014 and three small transfers to various tanks in July and August 2020

[6] Tank 50 is the only tank in two groups as it both received waste from and feeds waste to other SRS facilities

For the final group (tanks that support transfers and other operations), because these tanks do not take in waste from sources external to the tank farms and are not sending waste to facilities outside the tank farms, any transfers associated with these waste tanks have a net zero effect on the total I-129 curies in the tank farms. As such, these transfers do not affect the inventory estimates used for the SDF inventory determination.

- Tanks that support transfers and other operations
  - Tank 3 (transfers to and from Tank 7 and receives rainwater)
  - Tank 4 (one large transfer to Tank 22 in December 2016)
  - Tank 7 (transfers to and from Tanks 3 and 38)
  - Tank 8 (transfers to and from Tanks 21 and 51)
  - Tank 13 (transfers to and from Tanks 15, 30, 37, 39, and 51)
  - Tank 15 (transfers to and from Tank 13)
  - Tank 21 (transfers to and from Tanks 8, 23, 35, 39, 41, 43, and 49)
  - Tank 23 (transfers to and from Tanks 21, 35, and 41)
  - Tank 25 (transfers to and from Tank 26 and acts as "Jet catch tank")
  - Tank 26 (transfers to and from Tanks 25, 32, 35, and 51)
  - Tank 35 (transfers to and from Tanks 21, 23, 37, and 41)
  - Tank 41 (transfers to and from Tanks 21, 22, 23 and 35, sometimes receives DWPF recycle)
  - Tank 51 (supports sludge batch preparations)

Tanks 10 and 11 (TCCR)

Tanks 10 and 11 were used to support the TCCR System. Both tanks sat idle for most of the six-year period being considered.

Tank 10 remained idle at approximately 214,000 gallons until November 2018 when dissolution activities began to support preparation for transferring waste to TCCR. In 2019 and 2020, waste from Tank 10 was sent to TCCR. This is expected to have removed some of the I-129, although the exact amount is not known because the effectiveness of the salt dissolution is unclear.

Tank 11 remained idle at approximately 137,000 gallons until November 2018 when the tank was effectively emptied (to Tank 51) to approximately 20,000 gallons to support TCCR receipts which started in early 2019. Because no decontamination factor (DF) is assumed for I-129 and because TCCR was only fed from Tank 10, it is assumed that any I-129 inventory removed from Tank 10 to feed TCCR is received by Tank 11. As such, TCCR operations (from Tank 10 to TCCR to Tank 11) are assumed to have a net zero effect on the total I-129 in the waste tank system.

Tank 22 (DWPF Recycle)

Tank 22 routinely receives waste from DWPF recycle. Section 4.4 of SRR-CWDA-2015-00077 indicates that sludge waste is expected to be sent to DWPF for vitrification. Because of this, Section 5.1 of SRR-CWDA-2015-00077 indicates that "realistic" inventories for future SDF modeling purposes do not include any sludge inventories. However, for compliance models, the sludge inventory is included. The DWPF recycle is low activity waste that is generated during the vitrification process of the high activity sludge waste stream. Since sludge waste generally has lower I-129 concentrations relative to supernate or interstitial liquids (due to the high solubility of

I-129), the sludge waste stream sent to DWPF is generally low in I-129 and any recycle returning from DWPF is also expected to be have relatively low concentrations of I-129.

The most recent I-129 samples from Tank 22 were a Pre-Salt Batch 8 sample taken in June 2014 (<5.4E-01 pCi/mL from SRNL-L3100-2014-00124) and a depth sample taken in June 2016 (<9.49E+01 disintegrations per minute per milliliter (dpm/mL) which converts to approximately <4.28E+01 pCi/mL from SRNL-L3100-2016-00221). Both these samples were below the applicable detection limits, so the reported concentrations are actually the detection limits for I-129 that correspond to the respective sample. However, based on the equivalent Cs-137 concentrations of 4.45E+06 pCi/mL (SRNL-L3100-2014-00124) and 9.70E+07 dpm/mL (SRNL-L3100-2016-00221) which converts to 4.37E+07 pCi/mL, the I-129 concentrations were estimated to be approximately 1.9E+00 pCi/mL and 1.4E+01 pCi/mL, respectively (using Equation 3-6 from SRR-CWDA-2015-00077). Regardless, Table 4-4 of SRR-CWDA-2015-00077 shows that the detection limit from the most recent I-129 sample (4.28E+01 pCi/mL) was assumed for Tank 22 even though the actual concentration was estimated to be below this detection limit. This value is likely to be more than double the actual concentration of Tank 22, thus the I-129 inventory in Tank 22 is probably an overestimate.

In order to maintain sufficient space in Tank 22 for the incoming receipts of DWPF recycle, waste from Tank 22 is typically transferred to either Tank 38 or Tank 43 where it is used as feed to the tank farm evaporator systems.

Tanks 30, 32, 37, 38, and 43 (Evaporator Systems)

Tanks 32 and 43 feed waste from the tank farms to the 3H and 2H Evaporators, respectively, while Tanks 30, 37, and 38 all receive concentrated supernate from the 2H and 3H Evaporators. It is assumed that any I-129 within the waste that is passed into the evaporator system will be returned to the waste tanks within the concentrated supernate received from the evaporator system. So, although the concentrations may change, the total inventory of I-129 remains the same. Therefore, it is assumed that the evaporators have a net zero effect on the total I-129 in the waste tank system.

Tank 39 (Fresh H-Canyon Receipts)

Tank 39 receives fresh waste from H-Canyon. While SRR-CWDA-2015-00077 does not discuss explicit transfers of fresh waste from H-Canyon to Tank 39, receipts of fresh waste (300,000 gal/yr) from FY2018 through FY2025 were credited in the SDF inventory per Section 4.2.1 of SRR-CWDA-2018-00041.

For context, the following summarizes the actual receipts of fresh waste to the tank farms from H-Canyon from FY2015 through FY2020:

- FY2015 (SRR-LWP-2015-00049): 22,000 gallons to Tank 39 and 12,000 gallons to Tank 50. Additionally, 3,000 gallons from 299-H was received by Tank 39.
    - FY2015 total: 22,000 gal + 12,000 gal + 3,000 gal = 37,000 gal.
- FY2016 (SRR-LWP-2016-00049): 70,000 gallons to Tank 39 and 11,000 gallons to Tank 50. Additionally, 5,000 gallons from 299-H was received by Tank 39.
    - FY2016 total: 70,000 gal + 11,000 gal + 5,000 gal = 86,000 gal.

- FY2017 (SRR-LWP-2018-00019): 70,000 gallons to Tank 39 and 11,000 gallons to Tank 50. Additionally, 1,000 gallons from 299-H was received by Tank 39.
    - FY2017 total: 70,000 gal + 11,000 gal + 1,000 gal = 82,000 gal.
- FY2018 (SRR-LWP-2019-00001): 63,000 gallons to Tank 39 and 10,000 gallons to Tank 50. Additionally, 5,000 gallons from 299-H was received by Tank 39.
    - FY2018 total: 63,000 gal + 10,000 gal + 5,000 gal = 78,000 gal.
- FY2019 (SRR-LWP-2020-00013): 87,000 gallons to Tank 39 and 12,000 gallons to Tank 50 and 14,000 gallons to Tank 51. Additionally, 5,000 gallons from 299-H was received by Tank 39.
    - FY2019 total: 87,000 gal + 12,000 gal + 14,000 gal + 5,000 gal = 118,000 gal.
- FY2020 (SRR-LWP-2020-00045): 106,000 gallons to Tank 39 and 1,000 gallons to Tank 50 and 10,000 gallons to Tank 40. Additionally, 1,000 gallons from 299-H was received by Tank 39.
    - FY2020 total: 106,000 gal + 1,000 gal + 10,000 gal + 1,000 gal = 118,000 gal.

Therefore, over this six-year period, 519,000 gallons have been received from H-Canyon (37,000 gal + 86,000 gal + 82,000 gal + 78,000 gal + 118,000 gal + 118,000 gal = 519,000 gal).

Figure INV-2.52 shows the complete history of the fresh waste receipts from the F- and H-Canyons to the SRS tank farms through calendar year 2019. This figure shows that the rate of fresh waste receipts was relatively steady from 1954 to approximately 1988, with fresh waste receipts of approximately 2.65E+06 gallons per year (gal/yr) during this period. From 1988 to 2010 the rate slowed considerably, mostly due to space limitations. And from 2010 to 2019, the waste receipts have slowed even further, averaging a rate of 1.25E+05 gal/yr.

Collectively, this information suggests that assuming 300,000 gal/yr of fresh waste receipts (per SRR-CWDA-2018-00041) is a bounding assumption, and actual waste receipts will be less than this assumption.

The types of fresh waste received at the SRS tank farms from the F- and H-Canyons may be characterized based on one of three potential extraction processes applied to generate the waste: plutonium uranium extraction (PUREX), H-Modified PUREX (HM) extraction, and thorium extraction (THOREX) (SRR-CWDA-2014-00003, Section 2.5.1.1). The waste products from these processes differ slightly in composition, but each is a result of a liquid-liquid organic extraction process with ion exchange. PUREX removes plutonium and uranium isotopes from irradiated fuel rods. Similar to PUREX, HM is slightly modified to process limited amounts of other isotopes such as neptunium and californium. THOREX is a method to remove thorium isotopes. Each of these processes result in acidic waste streams, so the waste is neutralized with sodium hydroxide and corrosion is inhibited with sodium nitrite before being sent to the tank farms. The neutralization reaction creates the salts and precipitates the solids (SRR-CWDA-2014-00003, Section 2.5.1.1). Figure INV-2.53 shows the annual fresh waste receipts based on each of the extraction processes. This figure shows that since 2007, all waste receipts at the tank farms have been HM wastes (either High Heat Waste [HHW] or Low Heat Waste [LHW]). Because all of the waste sent to Tank 39 since 2007 is HM waste, it is expected that the waste receipts since 2007 have all been generally similar in concentration.

In June 2015, analysis of Tank 39 showed I-129 detection limit concentrations of either <5.36E+01 pCi/mL (for a surface sample) or <2.91E+01 (for a depth sample) (converted from dpm/mL values in SRNL-L3100-2016-00221). Because these were detection limit values and corresponding Cs-137 concentrations were known, Equation 3-6 from SRR-CWDA-2015-00077 can be used to estimate I-129 concentrations of approximately 25 pCi/mL (for both the surface sample and the depth sample).

Then in January 2017, additional samples were taken and analyzed from Tank 39 (SRNL-L3100-2017-00007). This time, the values were measured above the detection limits, with values of 30.0 pCi/mL (converted from 66.6 dpm/mL) for the surface sample and 24.9 pCi/mL (converted from 55.5 dpm/mL). Based on these samples, Table 4-4 of SRR-CWDA-2015-00077 assigned Tank 39 a supernate concentration of 3.00E+01 pCi/mL. While the volume in Tank 39 may change, it is reasonable to expect this concentration to be representative of the incoming HM waste stream to Tank 39. Because this value (3.00E+01 pCi/mL) is lower than the assumed I-129 concentration for the H-Canyon waste receipts (5.23E+02 pCi/mL per Section 4.2.1 of SRR-CWDA-2018-00041) which was used to estimate future waste additions for the inventory of the SDF PA, it is likely that the assumed concentration for incoming I-129 is overpredicting the incoming waste concentration. As such, any waste additions of I-129 based on the assumption in Section 4.2.1 of SRR-CWDA-2018-00041 are likely to result in an overprediction of I-129 in the future waste inventory estimates for the SDF.

However, in preparing this RAI response, it was learned that an error occurred in the preparation of the inventory estimates for both I-129 and Tc-99. SRR-CWDA-2015-00077 (for I-129) and SRR-CWDA-2015-00123 (for Tc-99) recommended total inventory values from the tank farms to be used in estimating the future disposal inventories at the SDF. Unfortunately, these recommended values did not include the additional inventory from H-Canyon effluents, so the recommended tank farm inventories should have been applied *prior* to adding the additional inventory from H-Canyon effluents. However, the recommended tank farm inventories were applied at a step in the inventory development process that was *after* the H-Canyon additions had been applied. This means that the I-129 and Tc-99 inventory estimates used in the SDF PA did not include the H-Canyon additions in the inventory estimates.

Using the 5.23E+02 pCi/mL for I-129 and 1.17E+05 pCi/mL for Tc-99 with the 300,000 gal/yr per Section 4.2.1 of SRR-CWDA-2018-00041, an additional 4.85 Ci of I-129 and an additional 1,090 Ci of Tc-99 should have been assumed with the total inventory estimates based on the approach described in SDF PA inventory report (SRR-CWDA-2018-00041). For the Compliance Case, these changes would have increased the inventories assigned to each of the 375-foot diameter SDUs (SDUs 6 through 12) from 2.20 Ci of I-129 to 2.87 Ci of I-129 (or an increase of a factor of 1.31) and from 4.43E+03 Ci of Tc-99 to 4.58E+03 Ci of Tc-99 (or an increase of a factor of 1.03).

However, if more reasonable assumptions[7] for the incoming concentration and volume had been applied (as informed by more recent operating experience), this increase would be negligible.

[7] The "reasonable assumptions" used 12,500 gal/yr of future H-Canyon Receipts and an I-129 concentration of 3.00E+01 pCi/mL and a Tc-99 concentration of 2.46E+04 pCi/mL. These concentrations were converted from the Tank 39 concentration (dpm/mL) values in SRNL-L3100-2016-00221.

Tank 40 (DWPF Feed)

Tank 40 is a "sludge tank" meaning the waste in this tank is predominantly sludge material. This sludge waste is routinely sent to DWPF to support the vitrification of higher activity waste. Because I-129 is highly soluble, the concentrations of I-129 in the sludge waste are expected to be relatively low. Even though this waste is routinely sent to DWPF and removed from the tank farms, it is anticipated that only a negligible amount of I-129 will be removed from the Tank Farms via these transfers to DWPF. Additionally, some of the lower activity waste that is produced during the vitrification process is returned to the tank farms as DWPF recycle (received by Tank 22).

Tank 49 (ARP/MCU/SWPF Feed)

Tank 49 is used as a salt batching tank, accepting feed from multiple waste tanks, then transferring that feed to various facilities for decontamination of the salt solution. Prior to the suspension of the MCU operations, waste from Tank 49 has been sent through ARP and through MCU. Starting in FY2021 waste from Tank 49 will be transferred to SWPF. Regardless of the facility, it is expected that any I-129 inventory that is sent through the decontamination process will be returned to the tank farms into Tank 50. Therefore, it is assumed that the decontamination process will have a net zero effect on the total I-129 in the waste tank system.

Tank 50 (SPF Feed)

Tank 50 receives waste after it has undergone decontamination (via ARP, MCU, SWPF, or TCCR). Tank 50 also routinely receives low-activity waste from ETF.

Waste from the ETF primarily originates from the tank farms; it is treated at ETF and the contaminated portion is returned to the tank farms, such that the material is already accounted for in the tank farm waste (see Section 4.2.2 of SRR-CWDA-2018-00041). It is noted that the ETF also receives some low activity material from outside the Tank Farm; however, this is assumed to be negligible relative to the total amount of material in the tank farms and is not included in the final SDF inventory estimates.

Most of the waste received into Tank 50 is DSS. From Tank 50, the DSS is removed from the tank farms and fed to the SPF where it will be mixed with dry feeds to produce saltstone for the SDF. Because I-129 is highly soluble, and because none of the other operations or facilities associated with the tank farms are expected to remove any significant amounts of I-129 from the tank farms, it is expected that most of the I-129 in the tank farms will eventually pass through Tank 50 (or other SPF feed tank, should other tanks be used in the future).

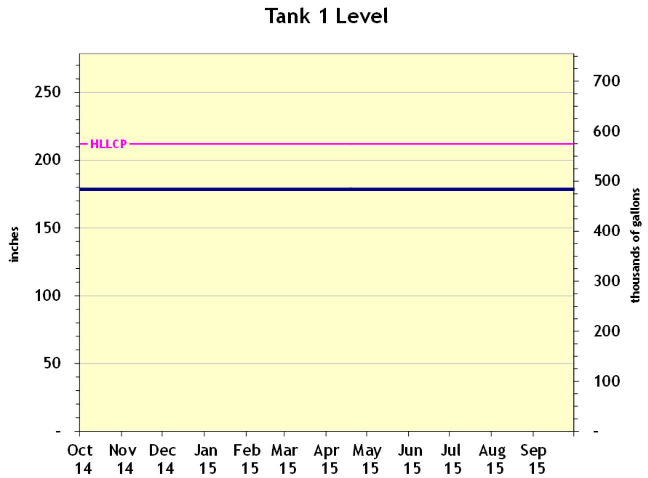
Regardless of the source, the waste in Tank 50 is routinely sampled and characterized (e.g., SRNL-STI-2019-00381), so the concentrations of I-129 in Tank 50 are well understood. Figure INV-2.54 shows the historical concentrations of I-129 in Tank 50. Initially, the concentrations were highly variable, ranging between approximately 2 pCi/mL and 100 pCi/mL. However, once the DSS became the dominant waste stream (around 2012), the I-129 concentrations have generally varied between approximately 10 pCi/mL and 40 pCi/mL.

Summary

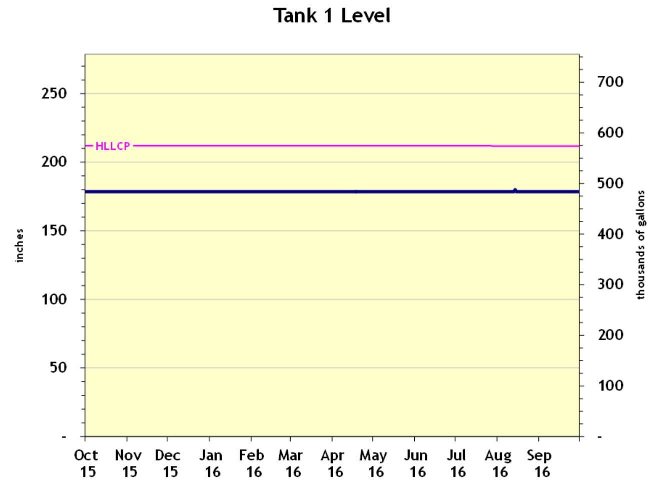
Any I-129 sent from the tank farms to any of the SRS facilities (other than the SPF or DWPF) is assumed to be returned to the tank farms after processing (e.g., evaporation, decontamination, etc.), such that those processes have a net zero effect on the total I-129 inventory estimates for the tank farm, regardless of the concentrations. Due to the high solubility of I-129, relatively little I-129 is expected to be present in sludge waste. This means the waste sent to DWPF is expected to have a minimal impact on the total I-129 inventory estimate. Although the I-129 concentrations may change over time within specific tanks due to transfers and ongoing tank farm activities, the overall inventory estimate for the tank farms will only increase due to the addition of fresh waste receipts being sent to Tank 39, or decrease as the waste is removed from the tank farms via transfers to the SPF. Although the increases from the H-Canyon receipts were not appropriately accounted for in the SDF PA inventory estimates (for both the I-129 and Tc-99 inventories), the use of reasonable assumptions indicates that the total future disposal inventories for the SDF will likely only increase the total I-129 inventory in the tank farms by a factor of less than 1.03 from now through FY2025.

Figure INV-2.1. Tank 1 Volume History, FY2015 through FY2020

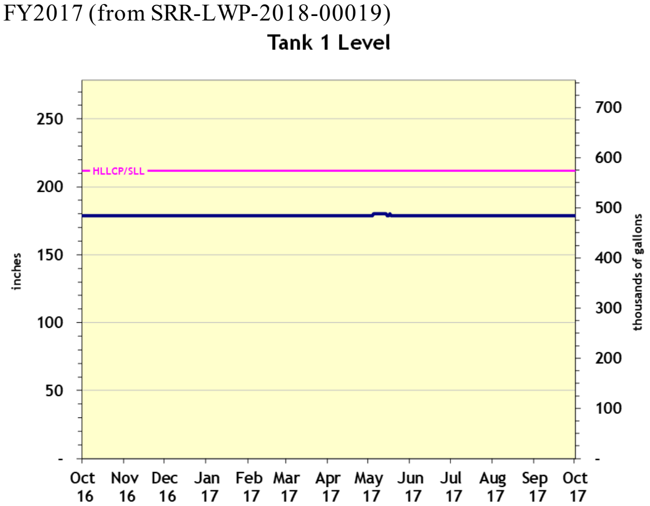
FY2015 (from SRR-LWP-2015-00049)



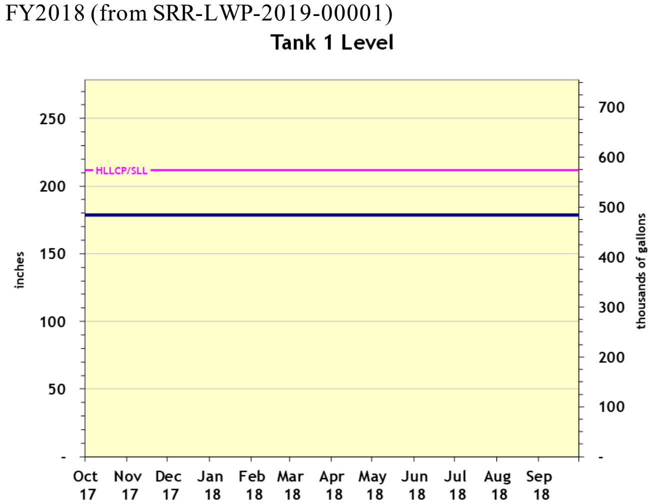
FY2016 (from SRR-LWP-2016-00049)



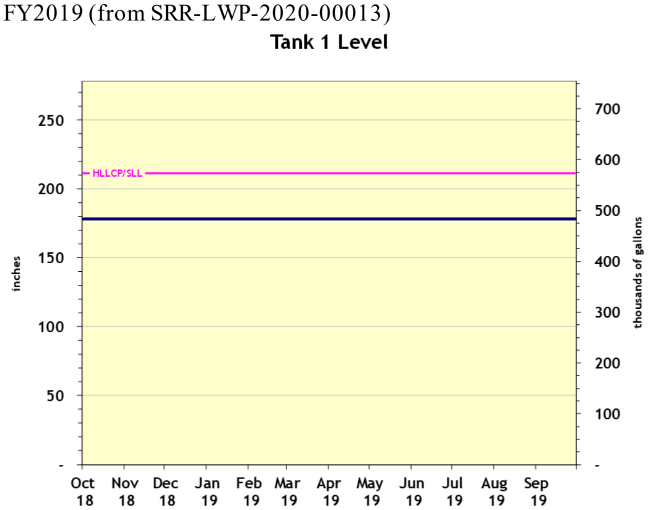
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

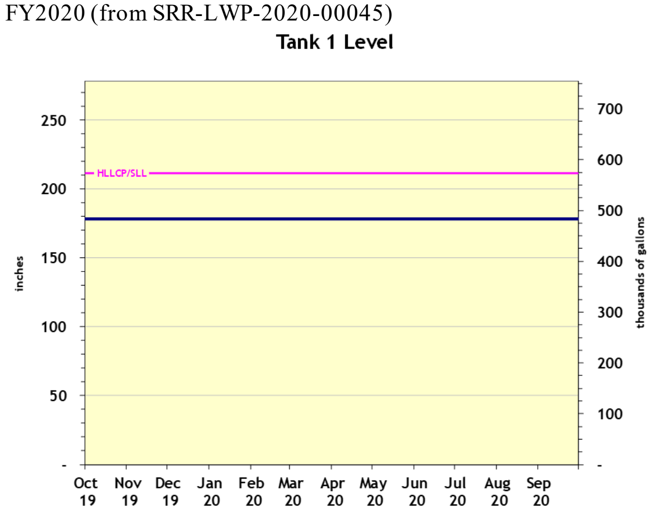
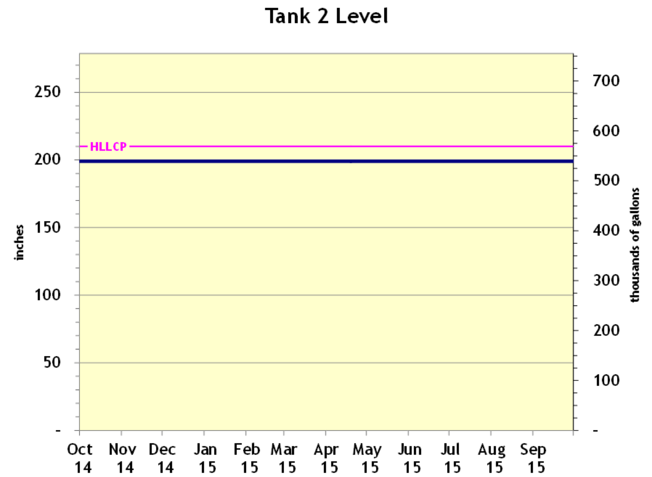
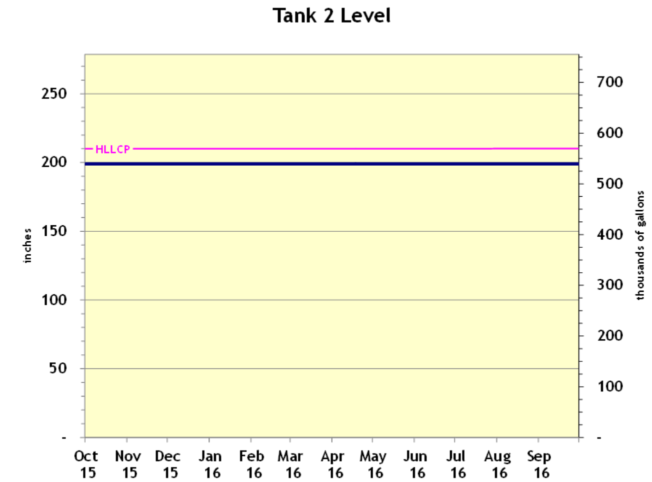


Figure INV-2.2. Tank 2 Volume History, FY2015 through FY2020

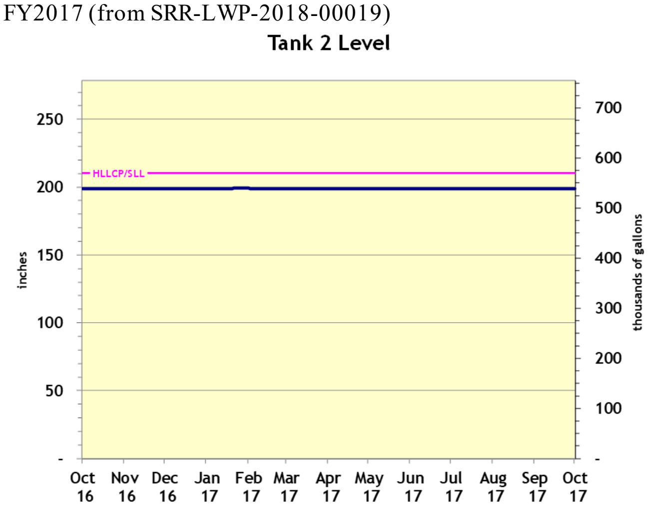
FY2015 (from SRR-LWP-2015-00049)



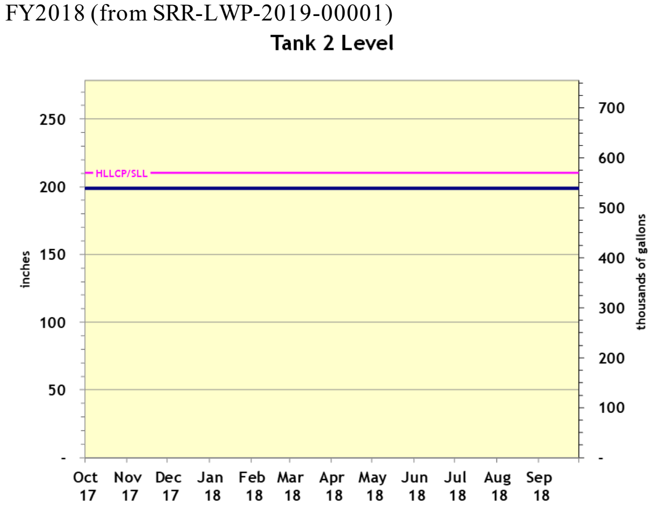
FY2016 (from SRR-LWP-2016-00049)



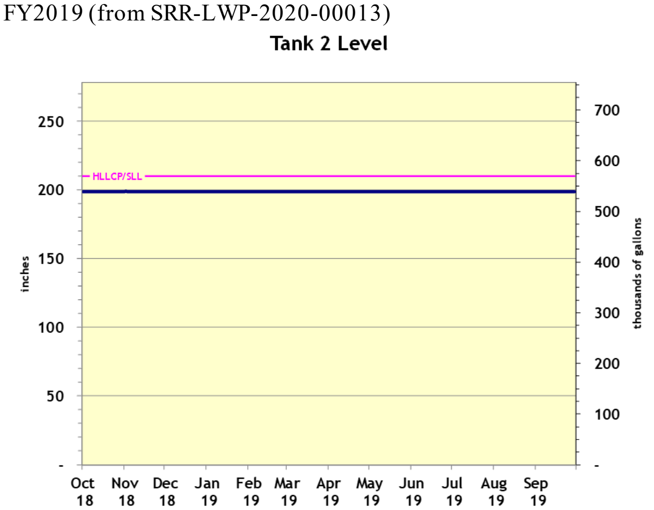
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

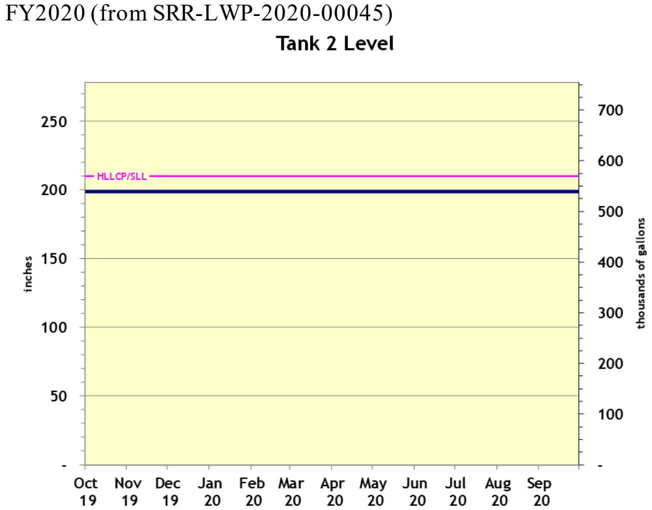
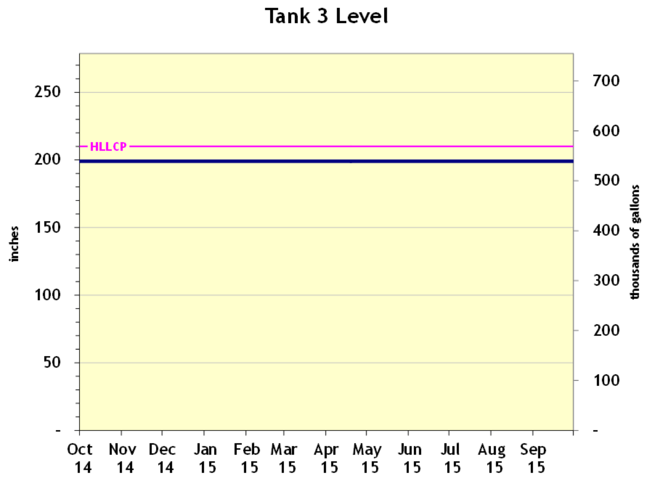
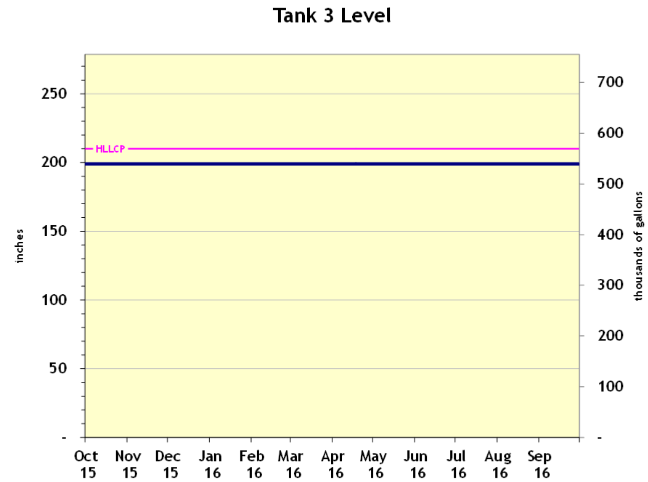


Figure INV-2.3. Tank 3 Volume History, FY2015 through FY2020

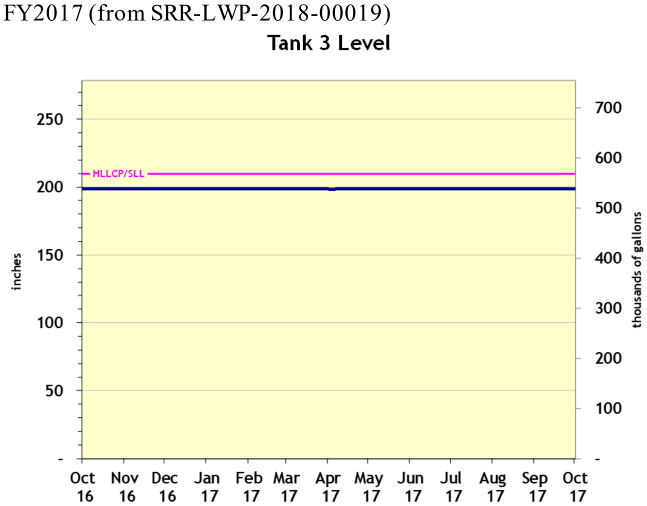
FY2015 (from SRR-LWP-2015-00049)



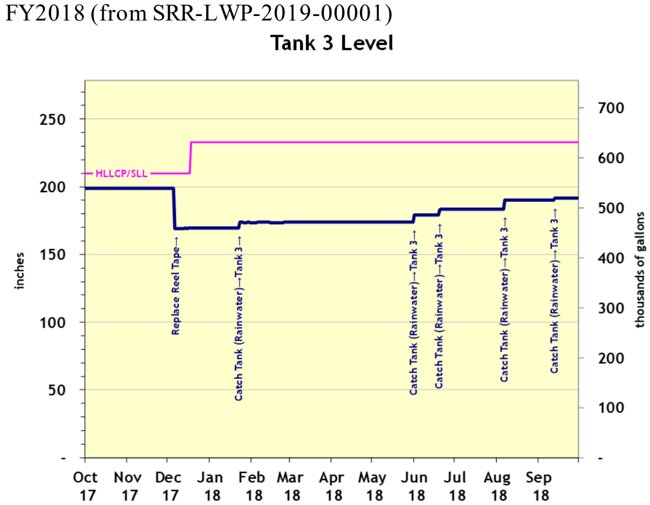
FY2016 (from SRR-LWP-2016-00049)



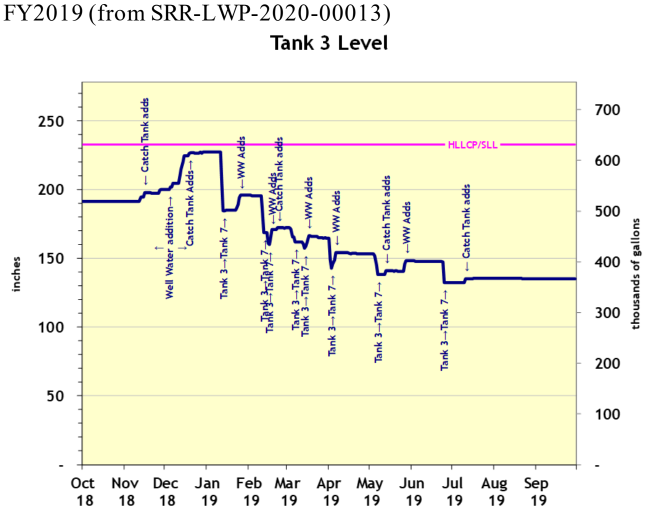
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

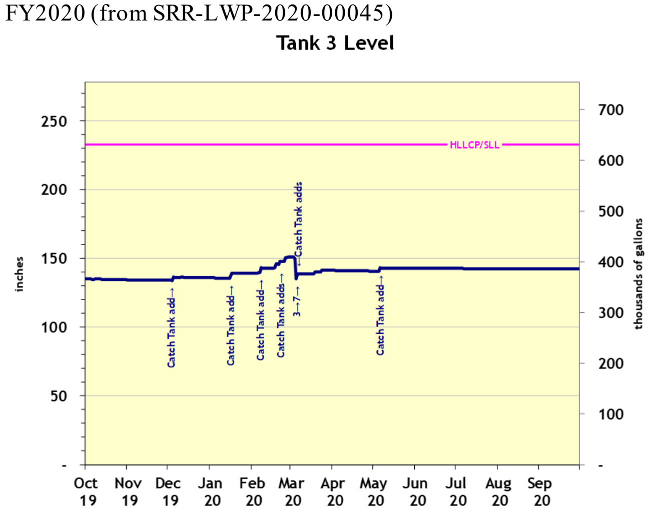
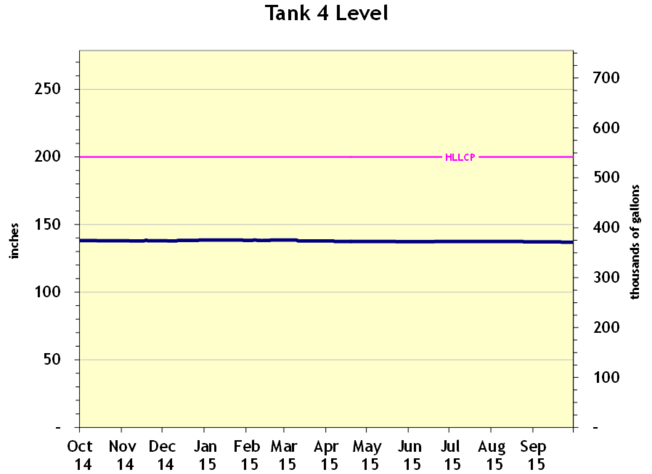
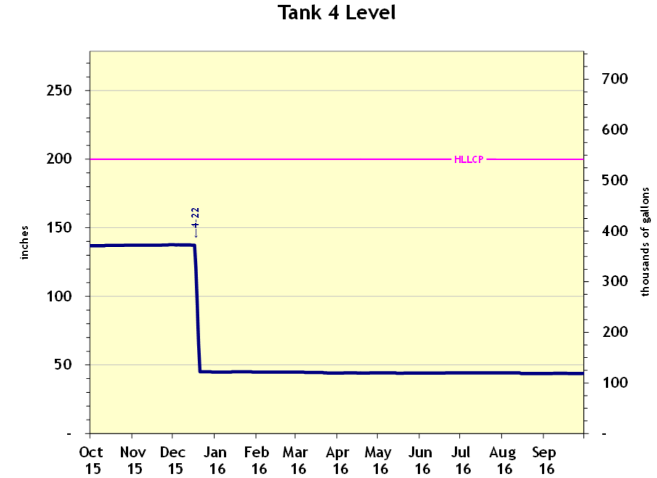


Figure INV-2.4. Tank 4 Volume History, FY2015 through FY2020

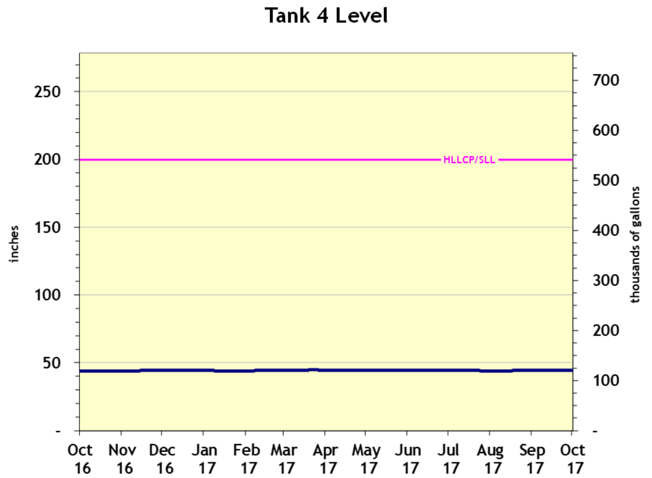
FY2015 (from SRR-LWP-2015-00049)



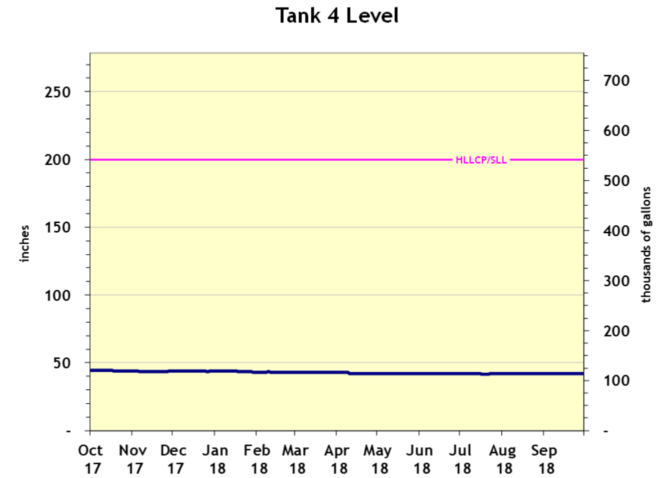
FY2016 (from SRR-LWP-2016-00049)



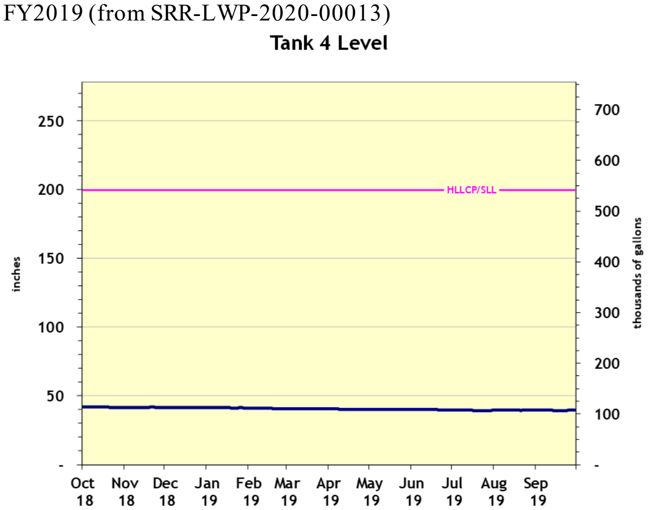
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

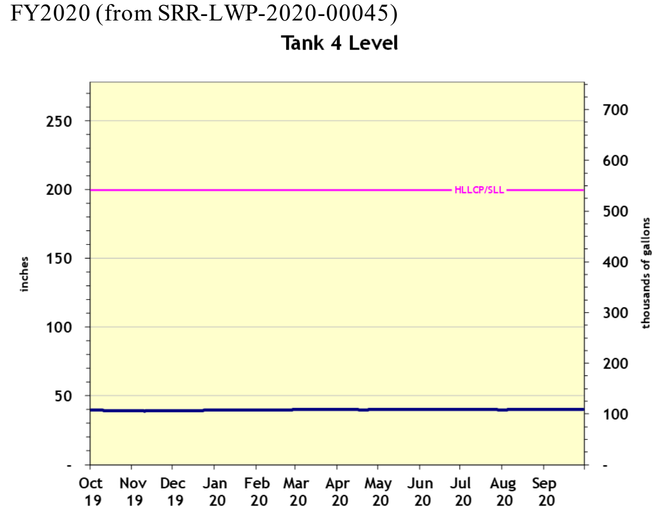


Figure INV-2.5. Tank 5 Volume History, FY2015 through FY2020

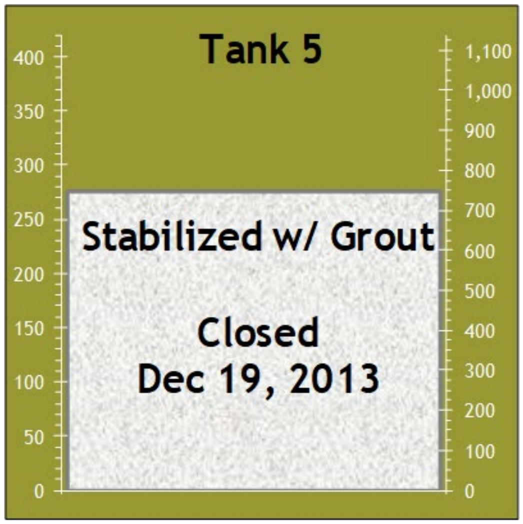


Figure INV-2.6. Tank 6 Volume History, FY2015 through FY2020

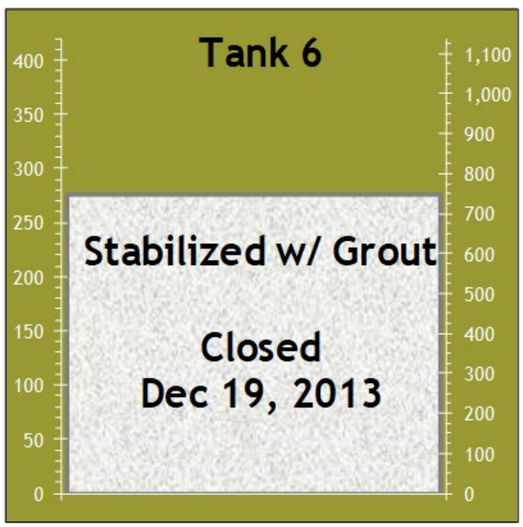


Figure INV-2.7. Tank 7 Volume History, FY2015 through FY2020

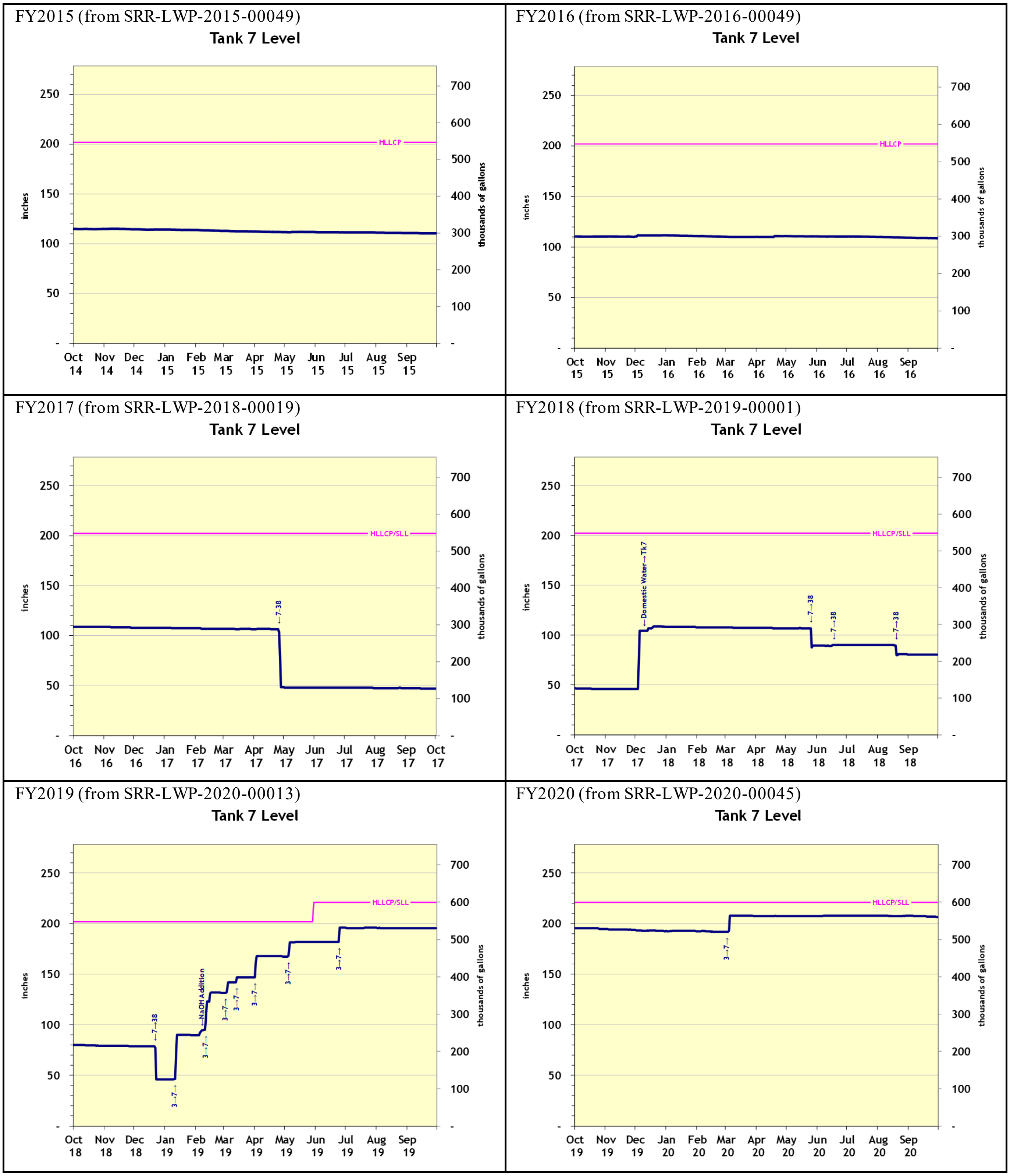


Figure INV-2.8. Tank 8 Volume History, FY2015 through FY2020

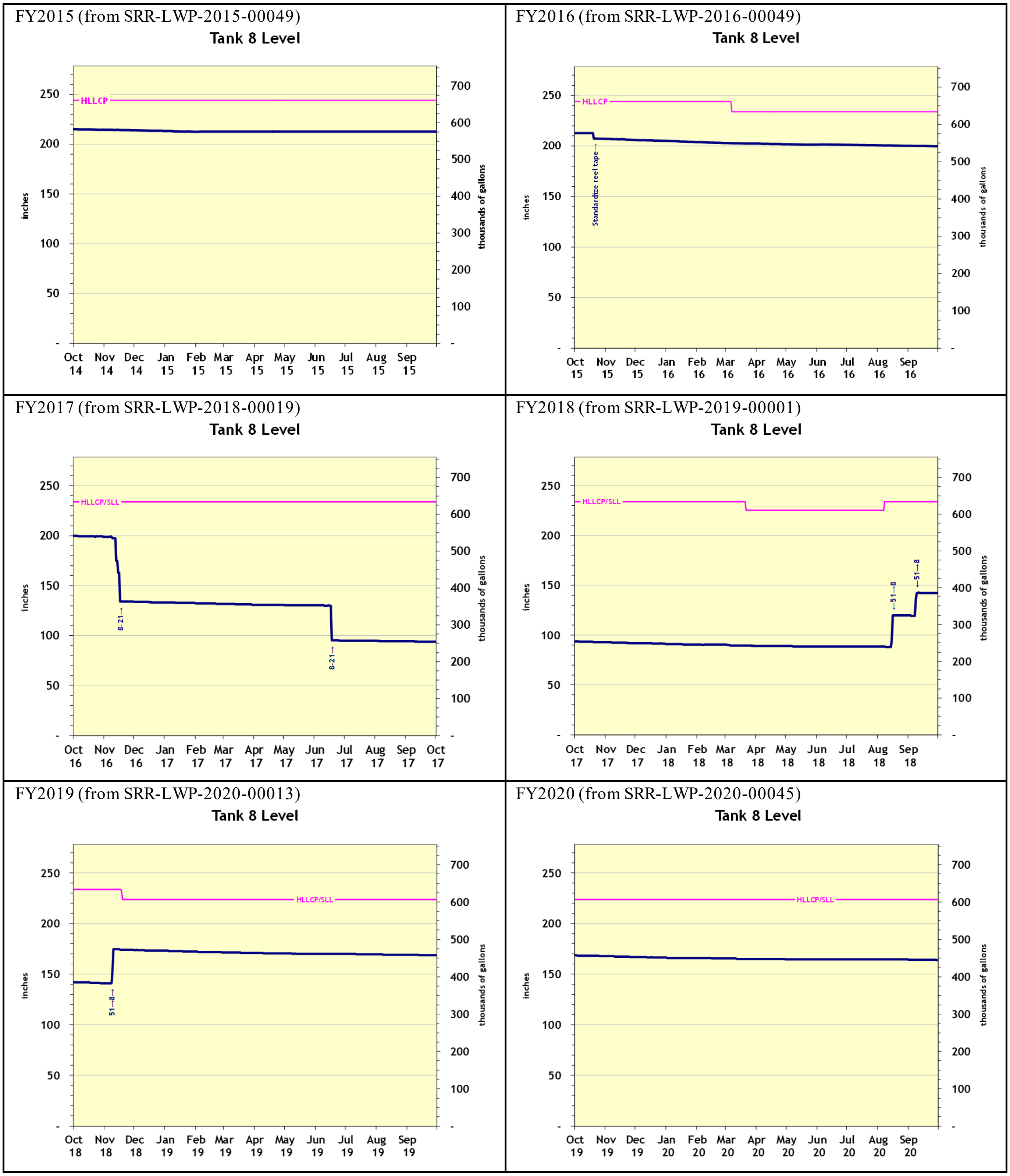
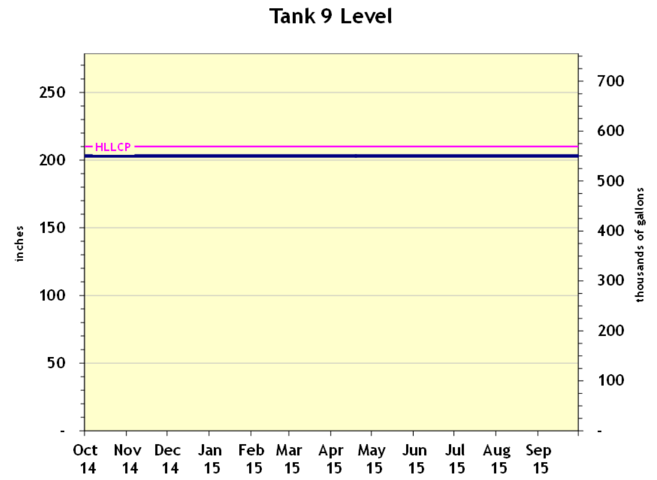
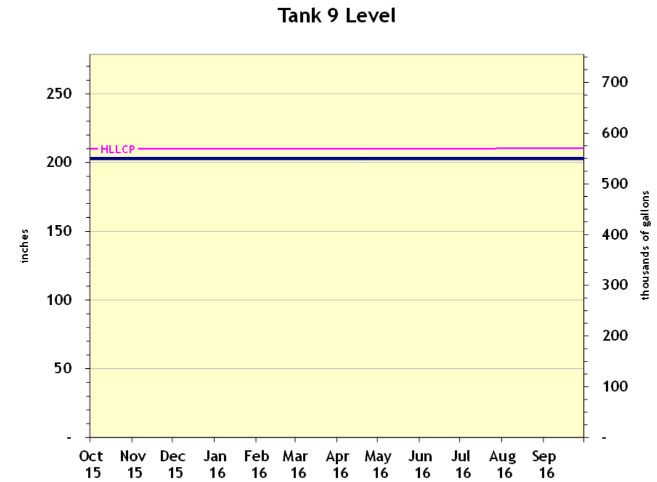


Figure INV-2.9. Tank 9 Volume History, FY2015 through FY2020

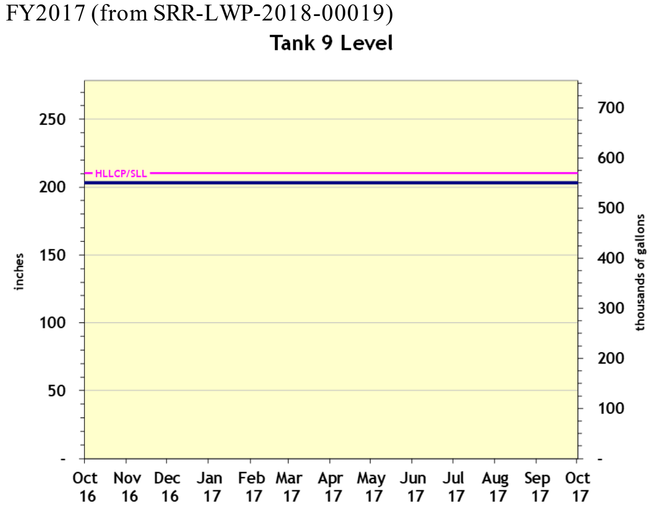
FY2015 (from SRR-LWP-2015-00049)



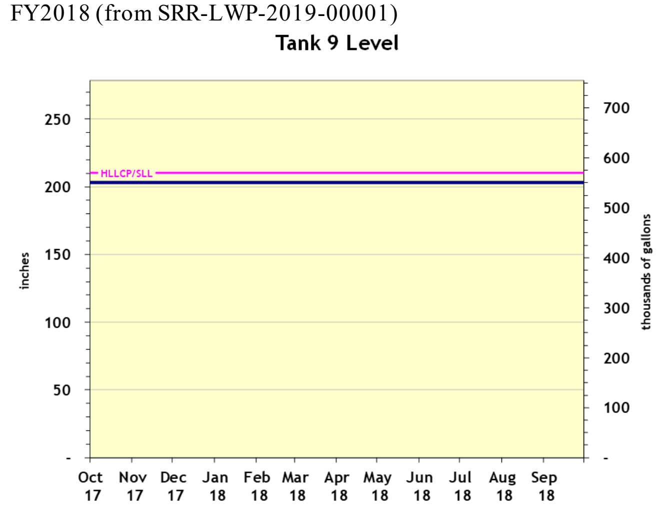
FY2016 (from SRR-LWP-2016-00049)



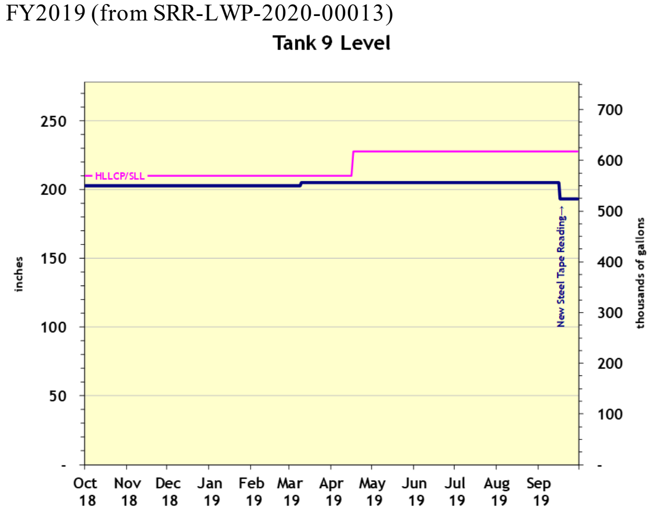
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

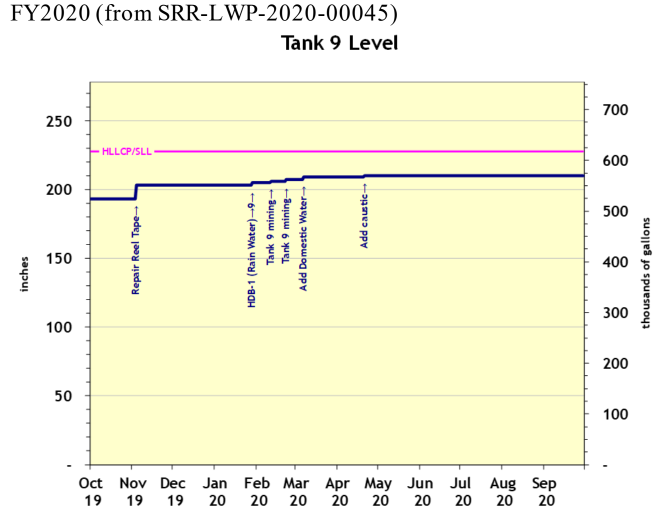


Figure INV-2.10. Tank 10 Volume History, FY2015 through FY2020

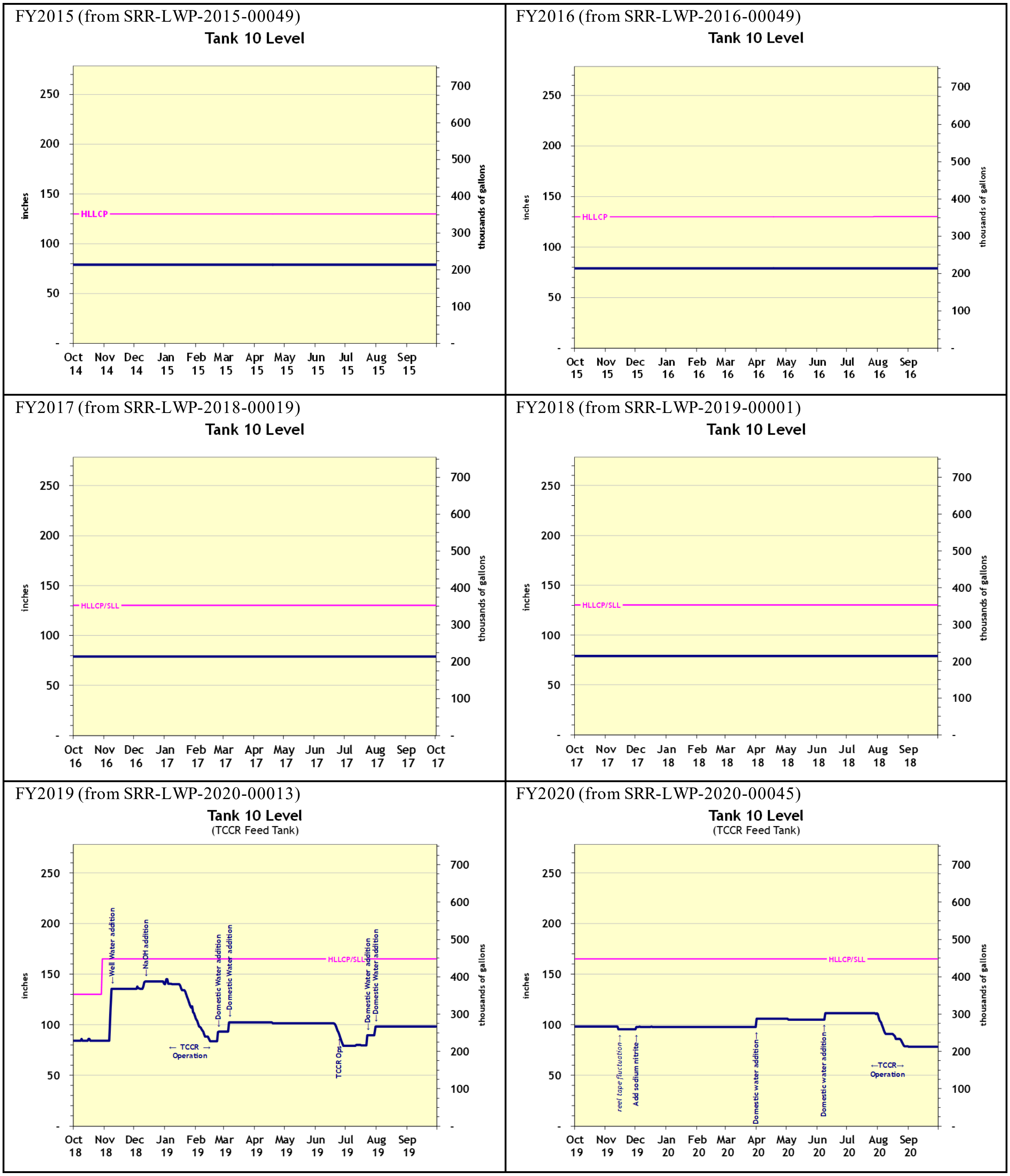


Figure INV-2.11. Tank 11 Volume History, FY2015 through FY2020

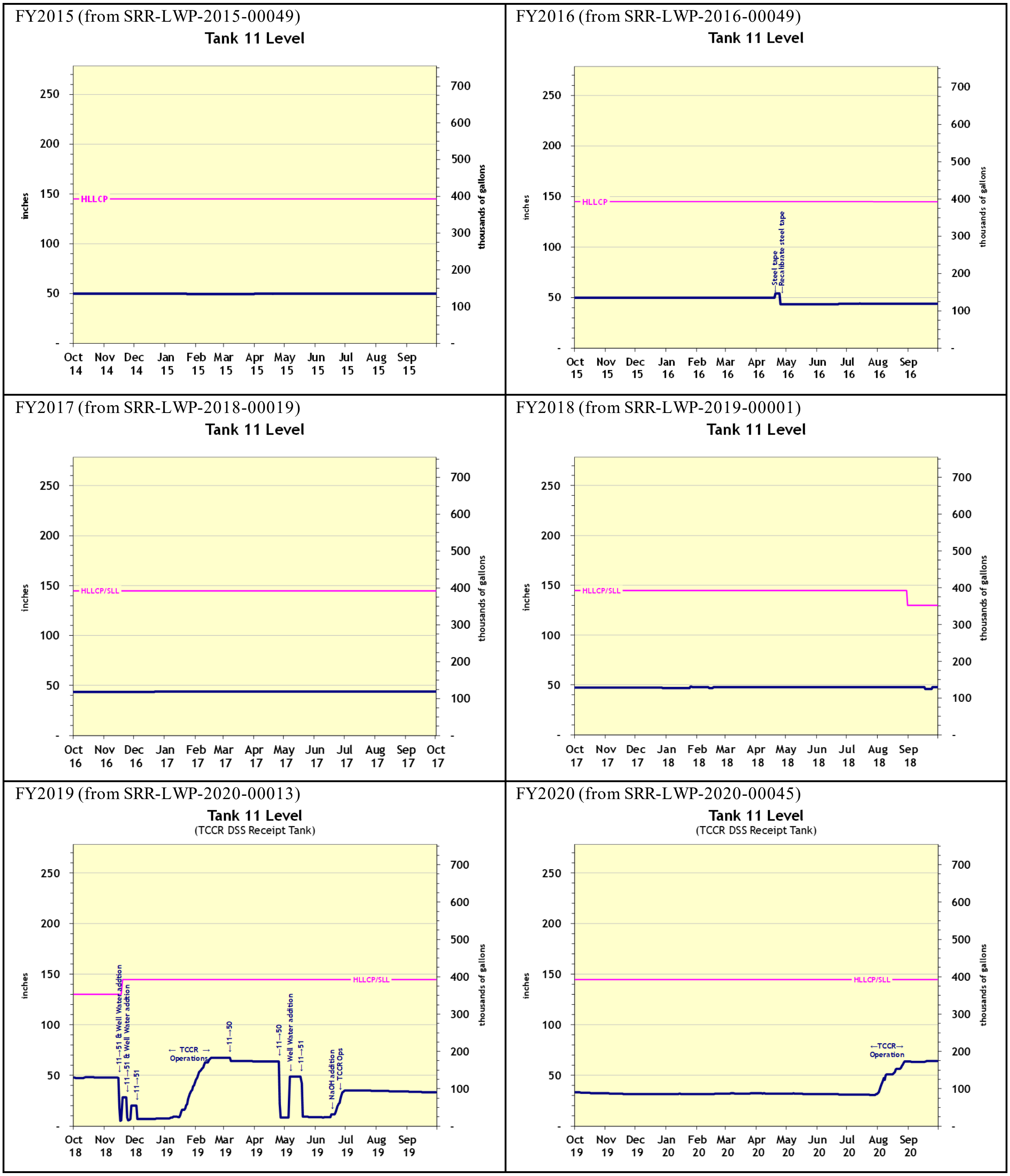


Figure INV-2.12. Tank 12 Volume History, FY2015 through FY2020

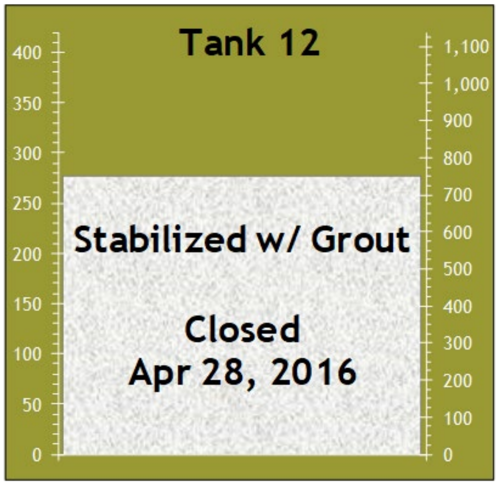


Figure INV-2.13. Tank 13 Volume History, FY2015 through FY2020

Figure INV-2.14. Tank 14 Volume History, FY2015 through FY2020

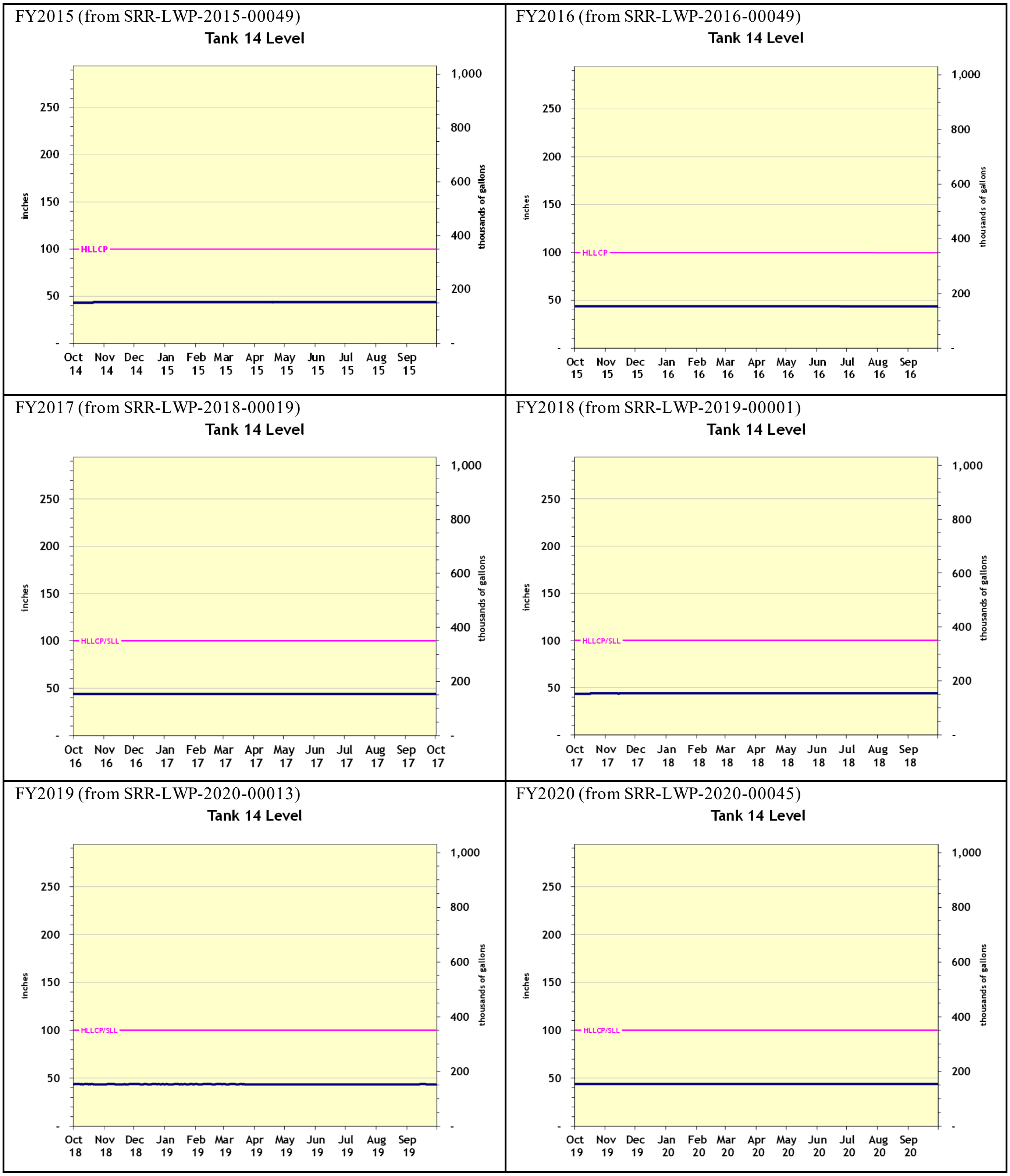


Figure INV-2.15. Tank 15 Volume History, FY2015 through FY2020

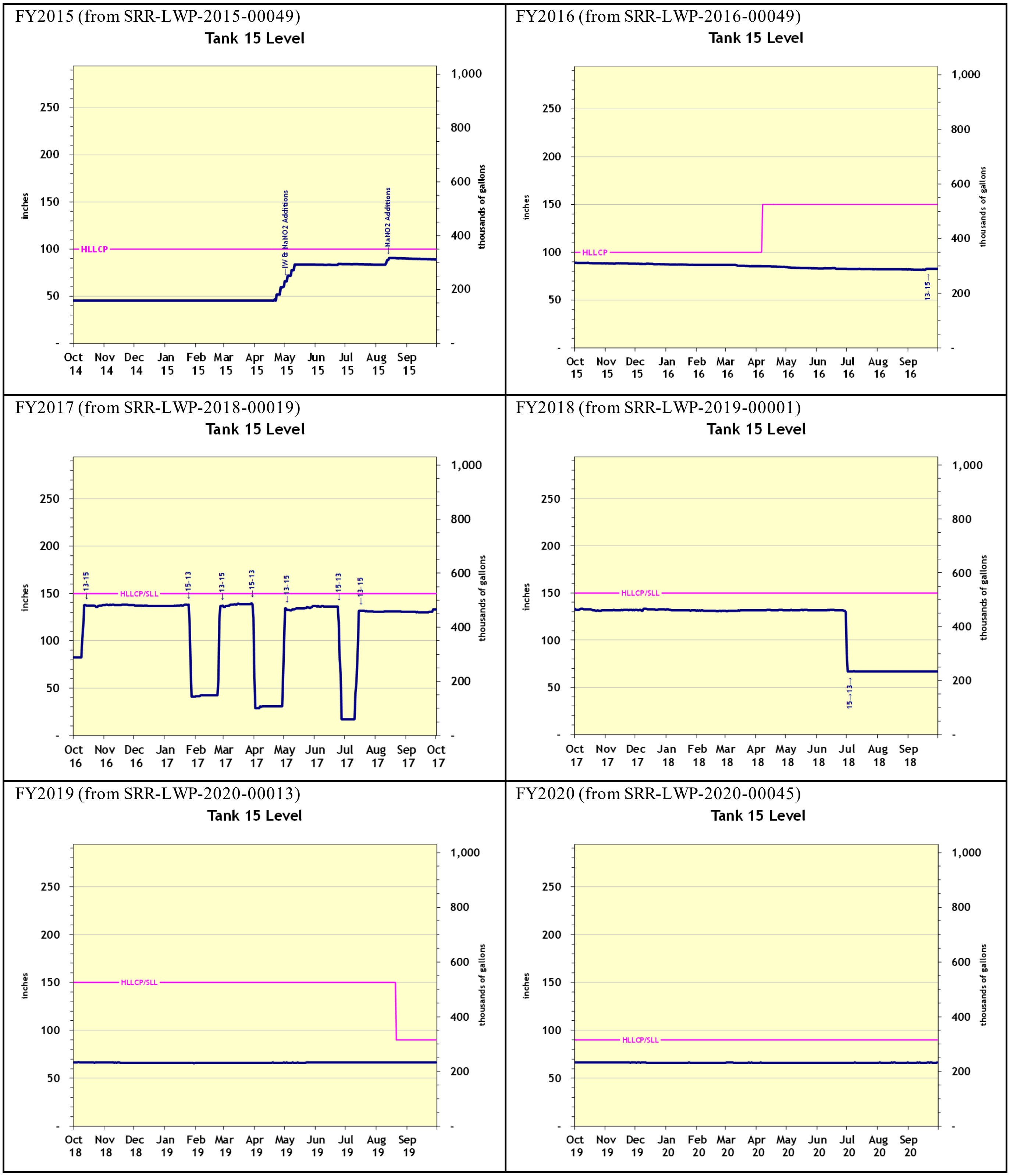


Figure INV-2.16. Tank 16 Volume History, FY2015 through FY2020

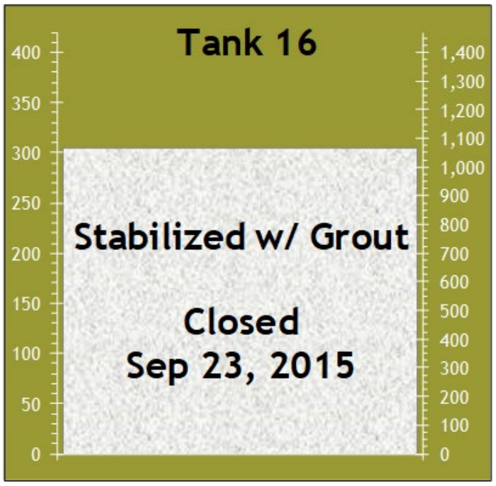


Figure INV-2.17. Tank 17 Volume History, FY2015 through FY2020

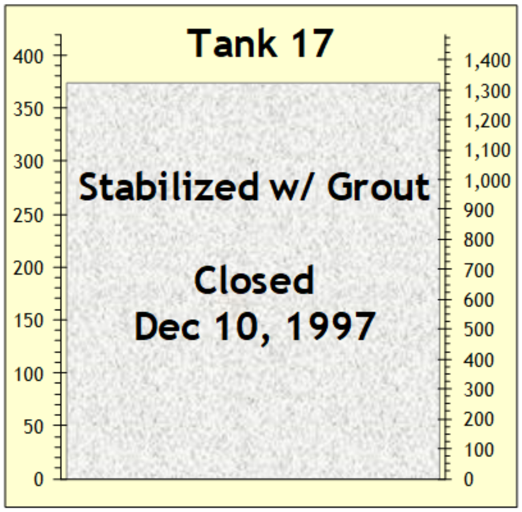


Figure INV-2.18. Tank 18 Volume History, FY2015 through FY2020

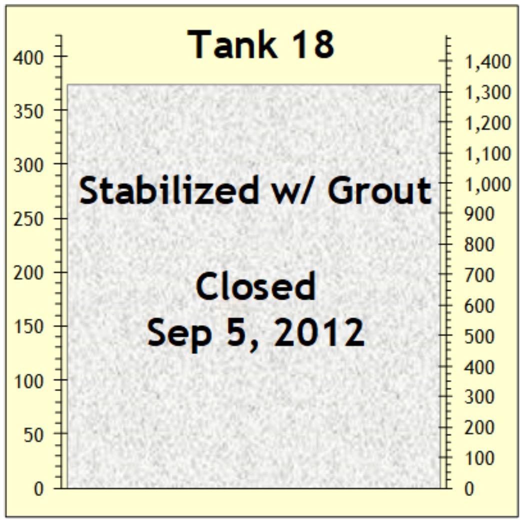


Figure INV-2.19. Tank 19 Volume History, FY2015 through FY2020

Figure INV-2.20. Tank 20 Volume History, FY2015 through FY2020

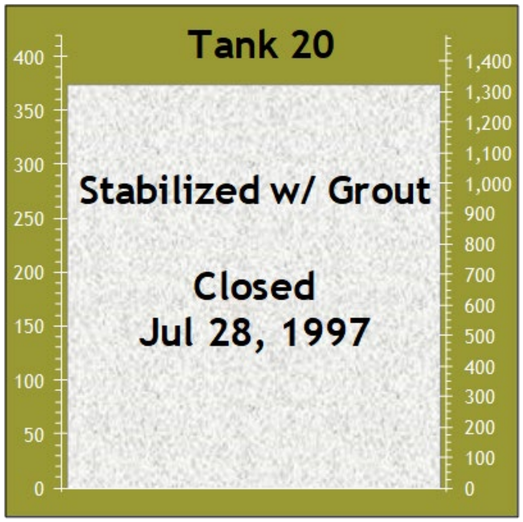
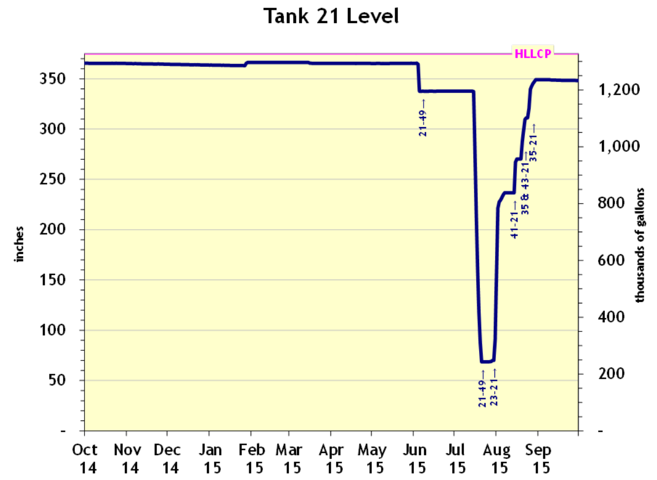
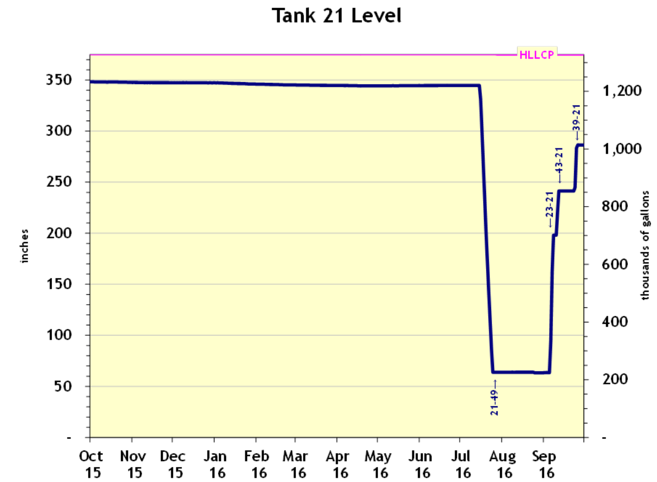


Figure INV-2.21. Tank 21 Volume History, FY2015 through FY2020

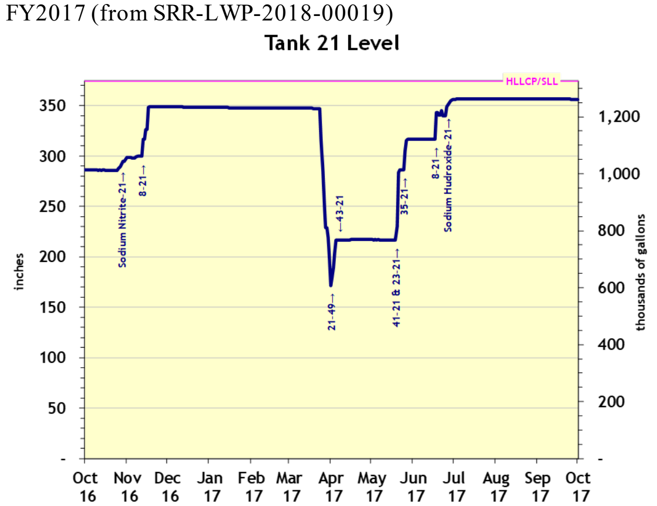
FY2015 (from SRR-LWP-2015-00049)



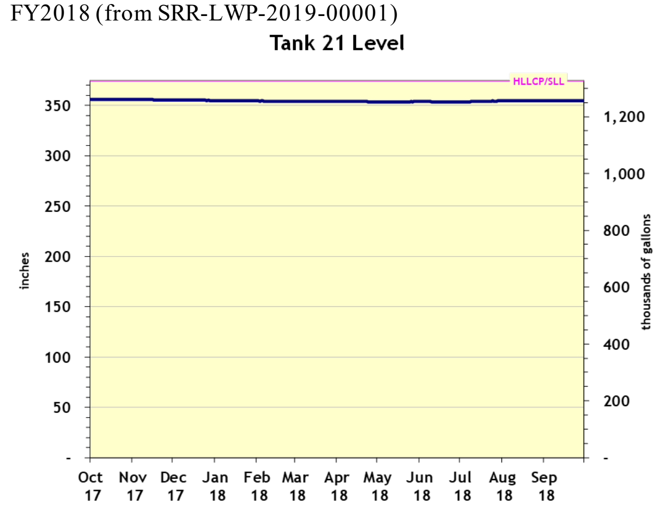
FY2016 (from SRR-LWP-2016-00049)



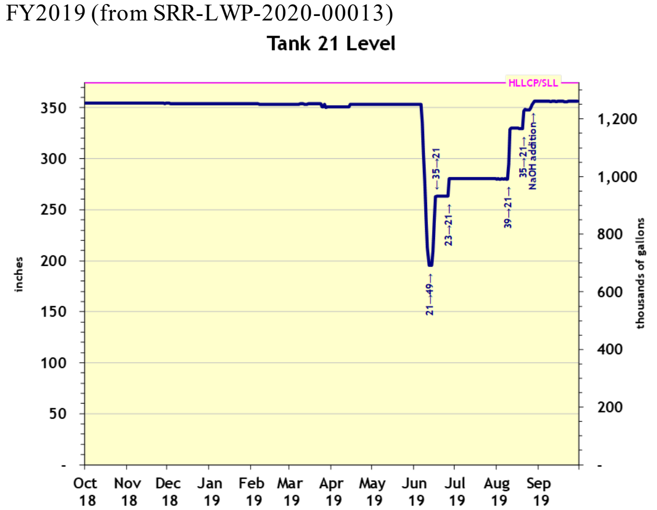
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

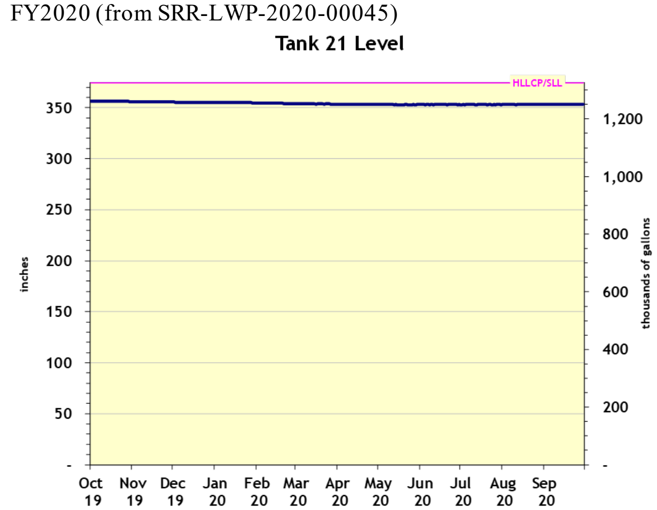


Figure INV-2.22. Tank 22 Volume History, FY2015 through FY2020

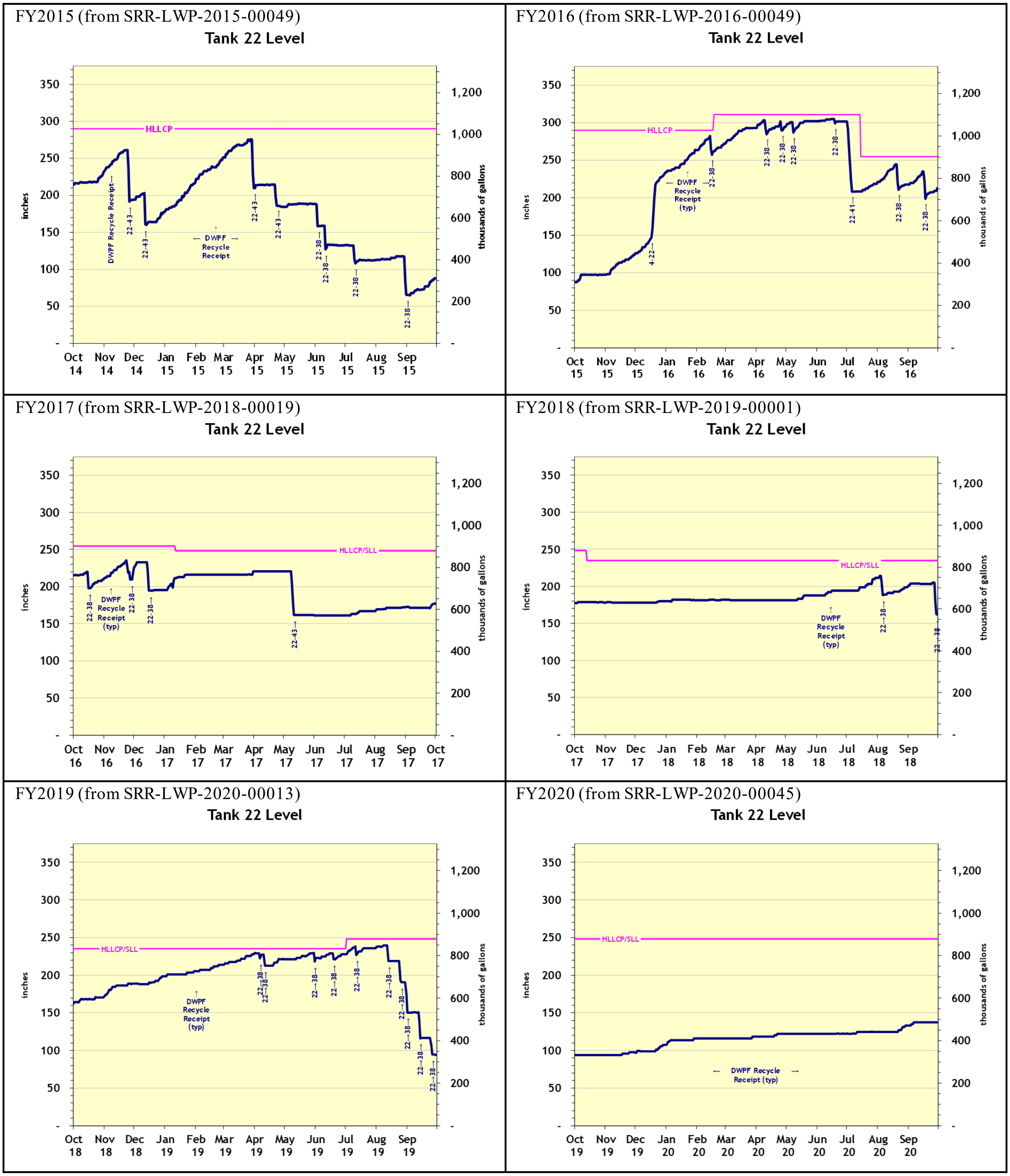
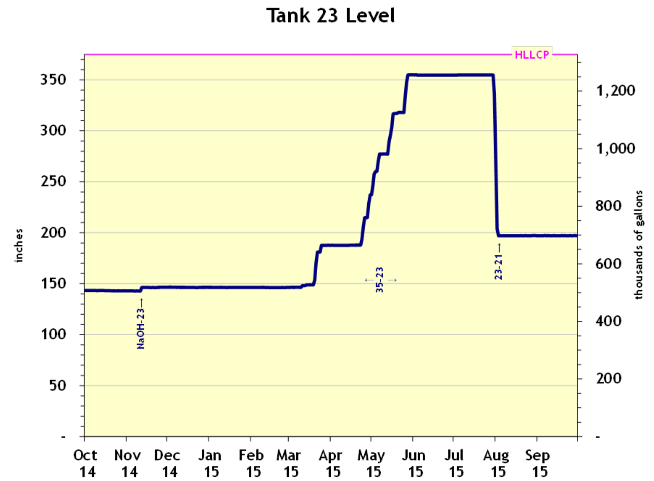
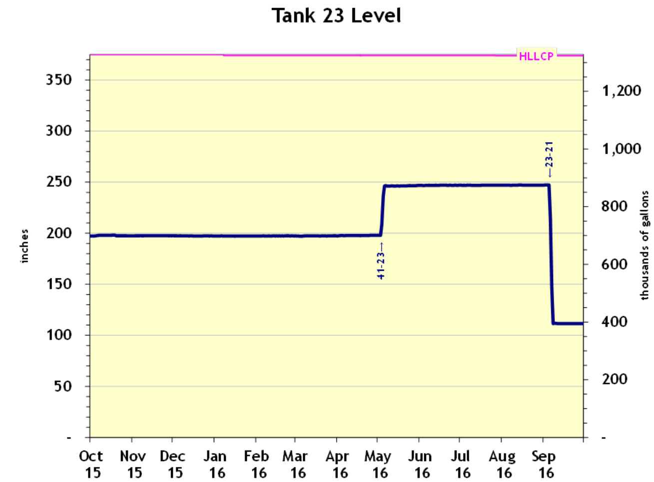


Figure INV-2.23. Tank 23 Volume History, FY2015 through FY2020

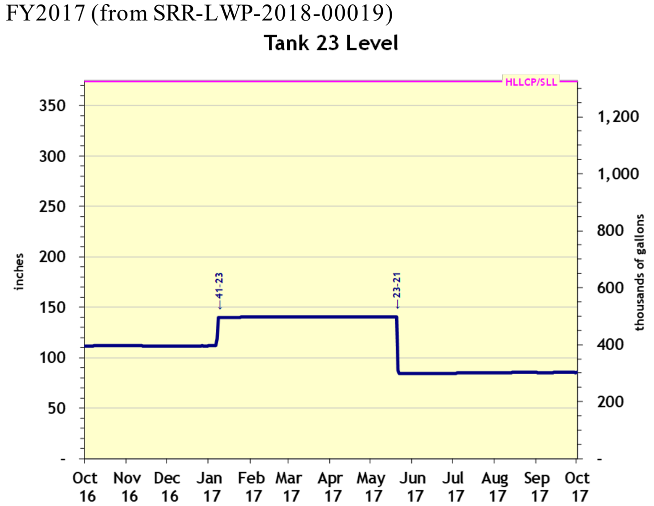
FY2015 (from SRR-LWP-2015-00049)



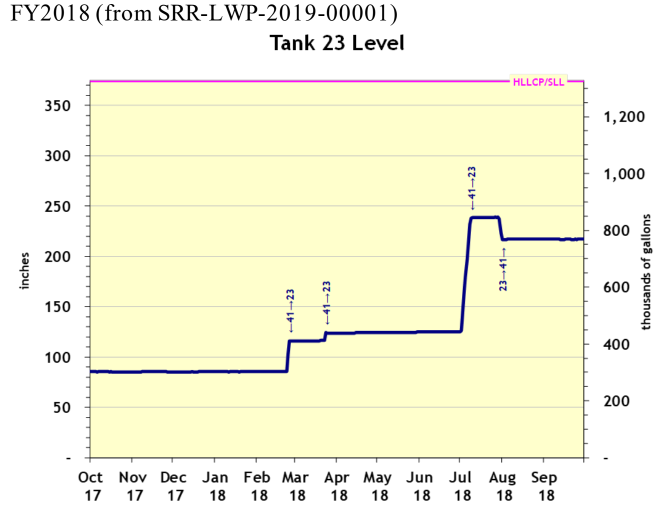
FY2016 (from SRR-LWP-2016-00049)



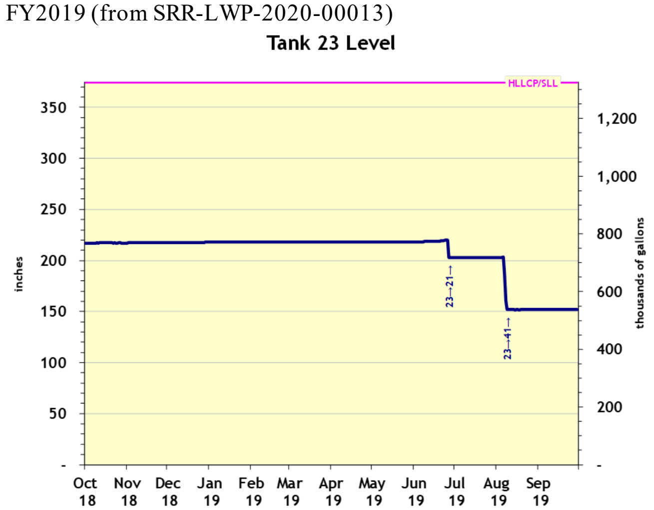
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

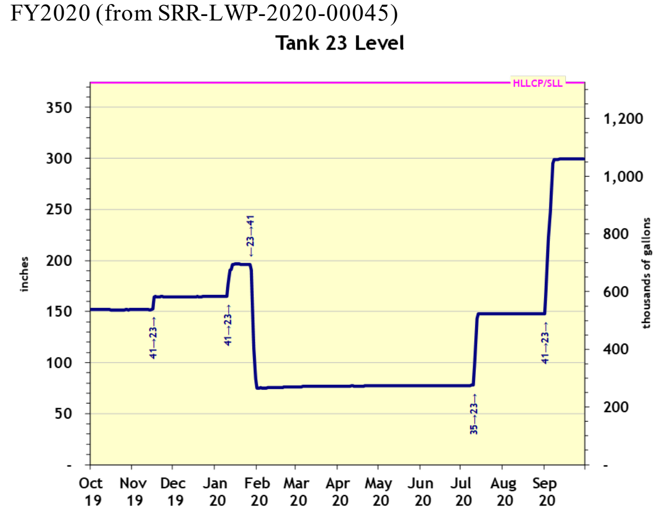
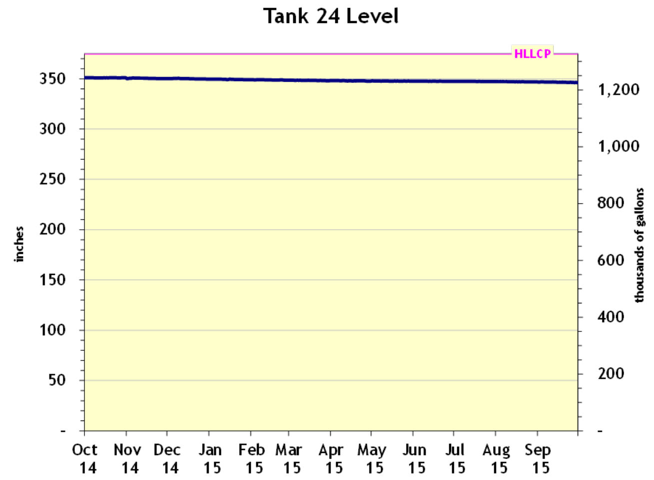
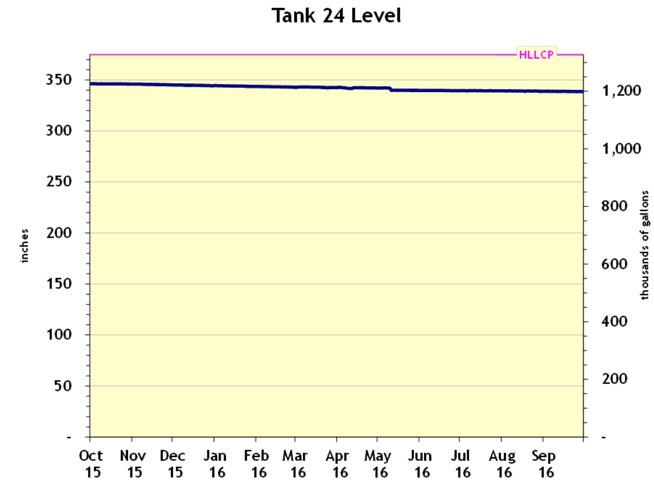


Figure INV-2.24. Tank 24 Volume History, FY2015 through FY2020

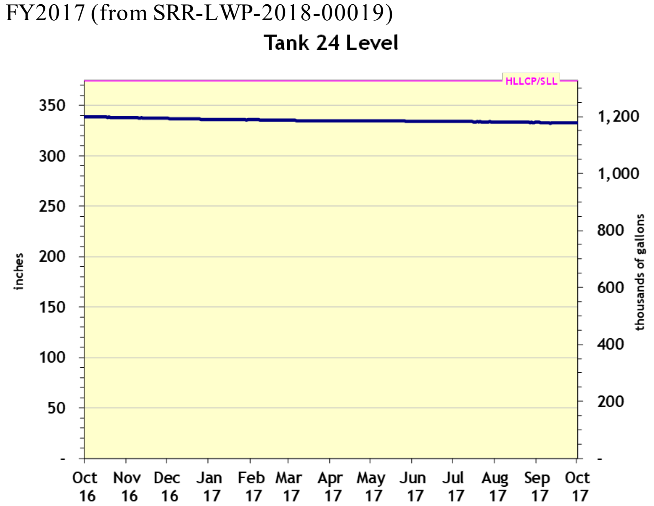
FY2015 (from SRR-LWP-2015-00049)



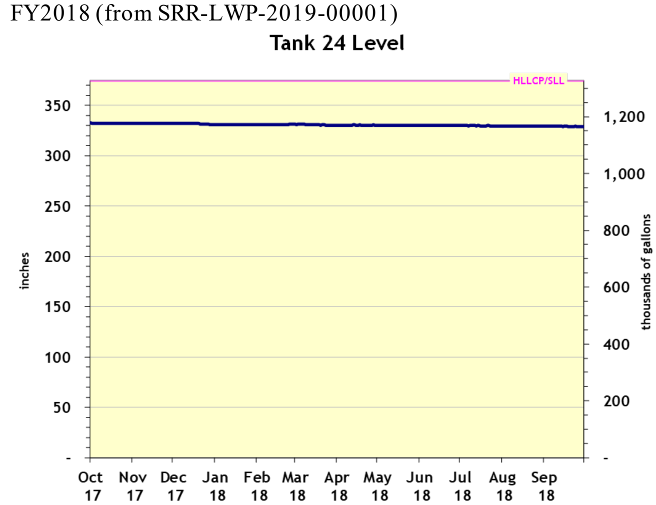
FY2016 (from SRR-LWP-2016-00049)



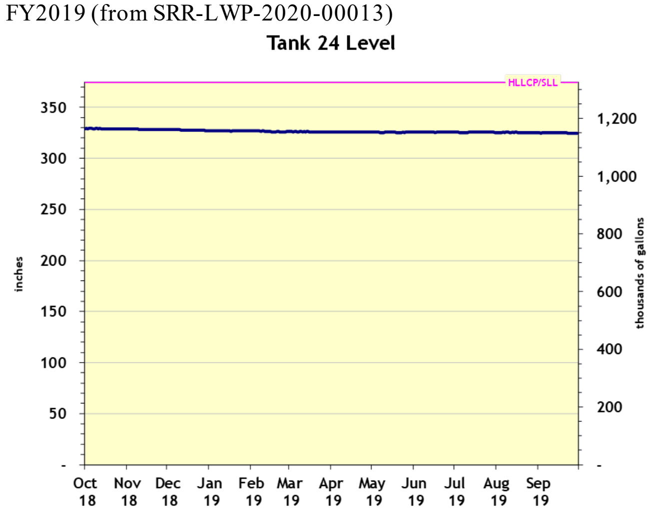
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

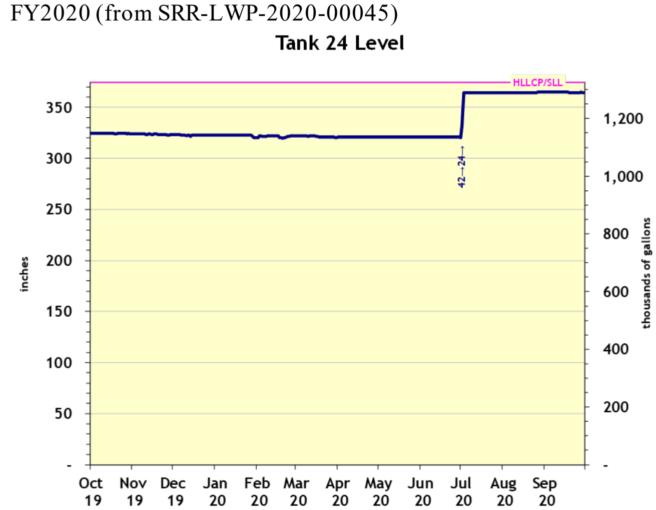


Figure INV-2.25. Tank 25 Volume History, FY2015 through FY2020

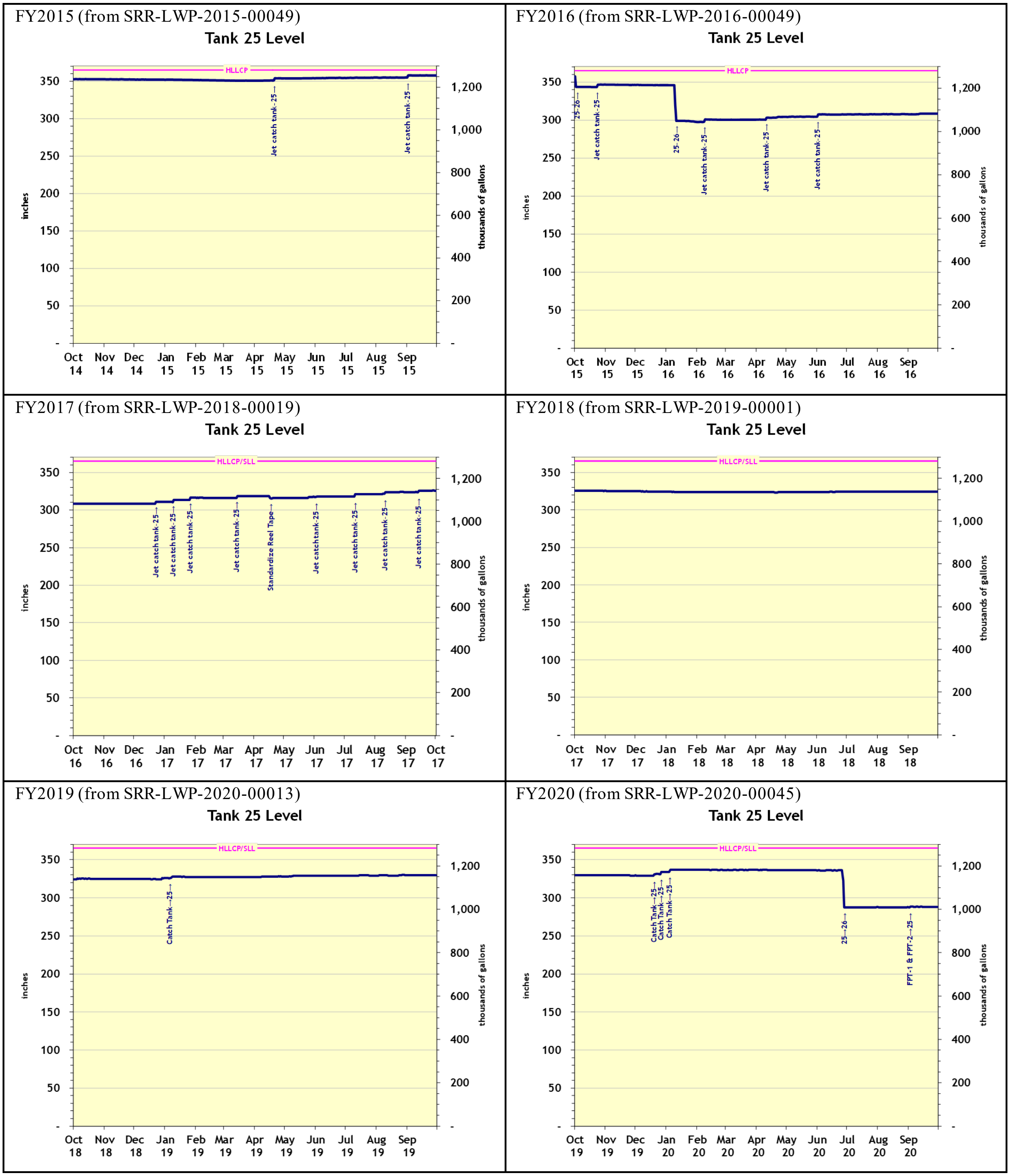
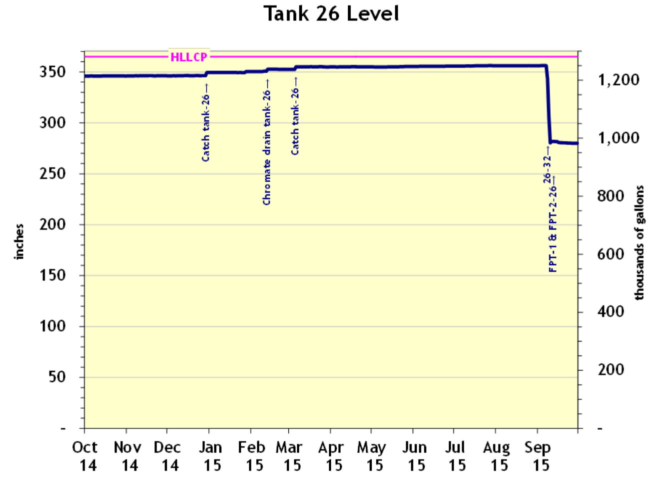
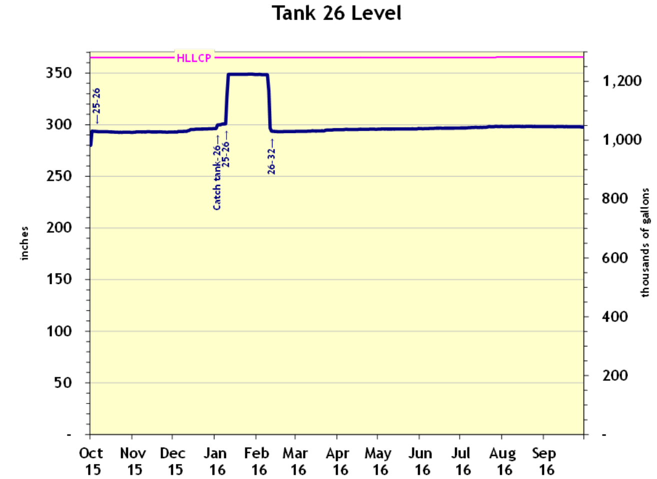


Figure INV-2.26. Tank 26 Volume History, FY2015 through FY2020

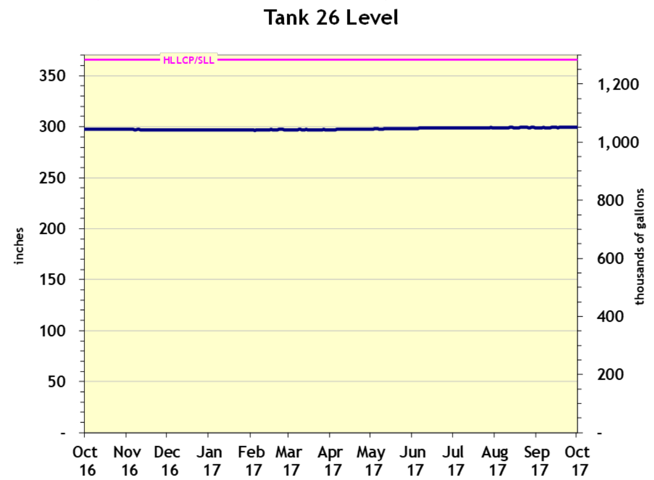
FY2015 (from SRR-LWP-2015-00049)



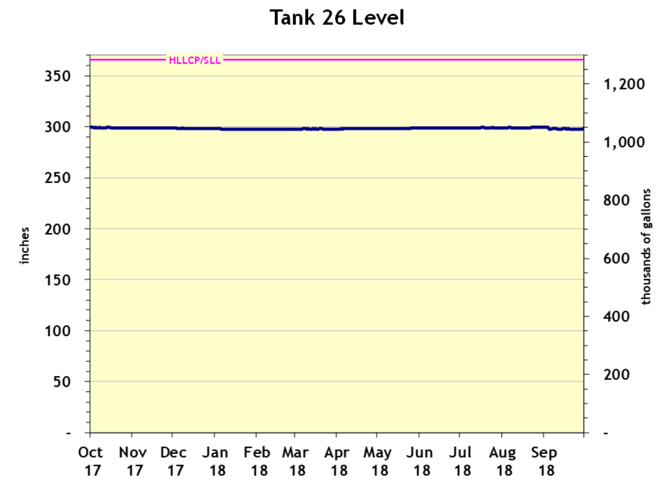
FY2016 (from SRR-LWP-2016-00049)



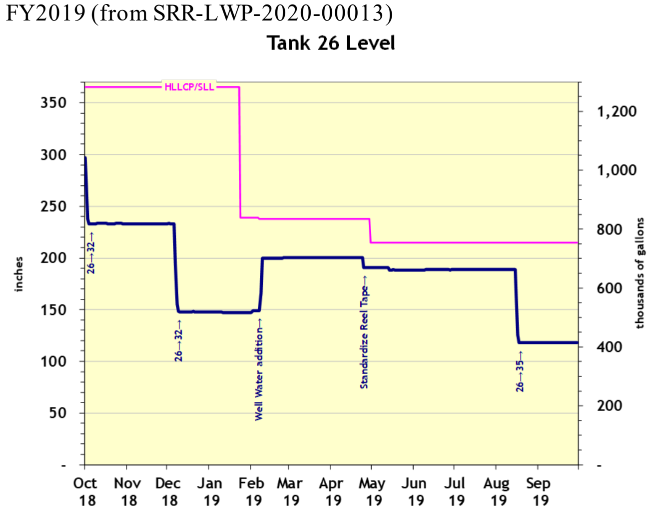
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

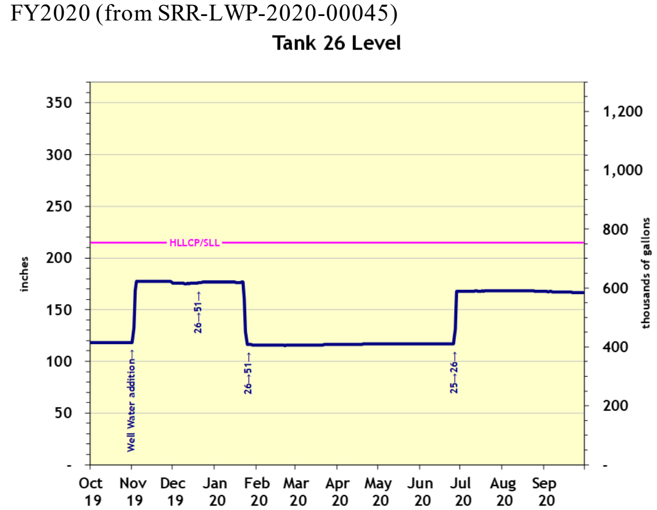
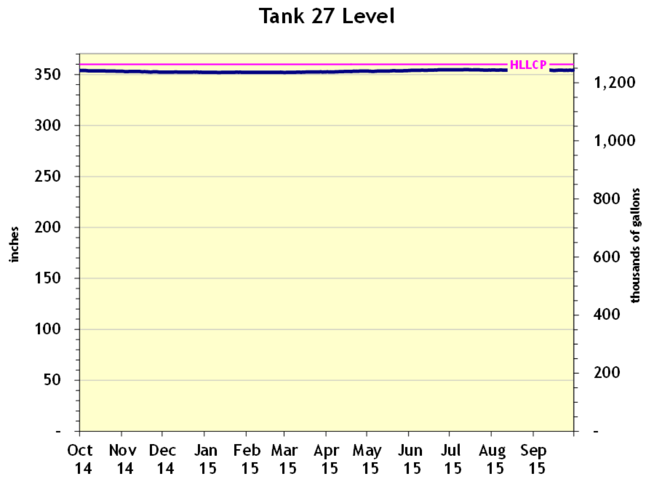
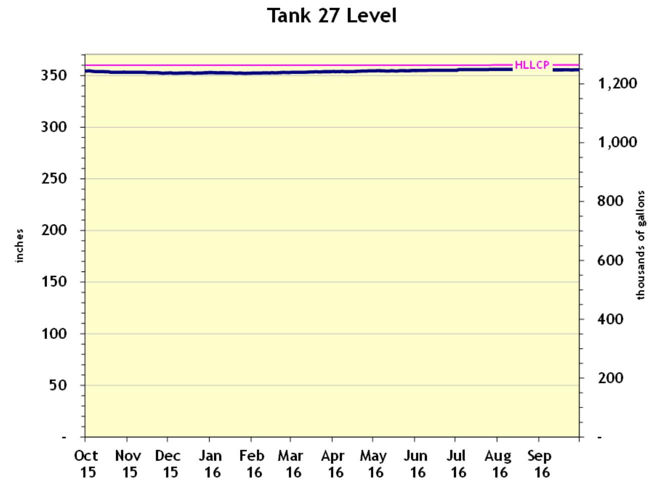


Figure INV-2.27. Tank 27 Volume History, FY2015 through FY2020

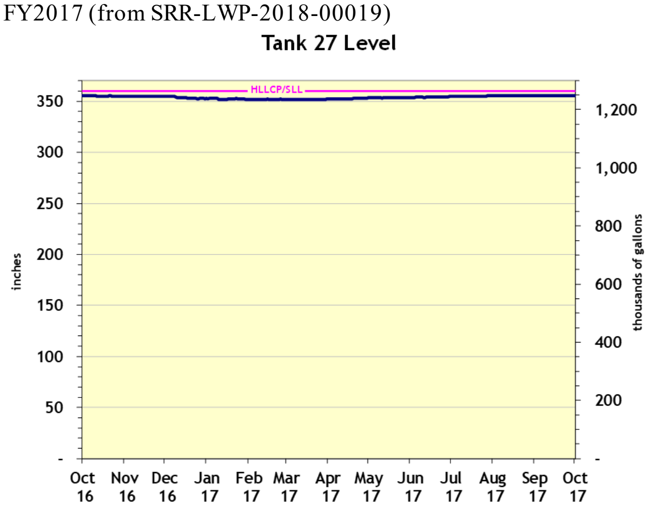
FY2015 (from SRR-LWP-2015-00049)



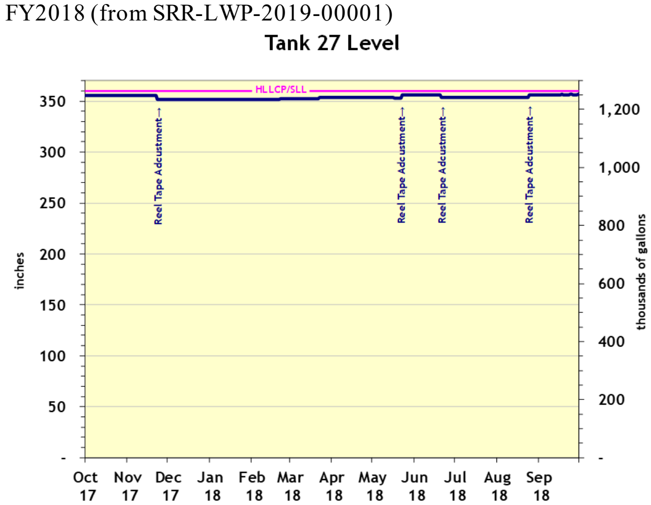
FY2016 (from SRR-LWP-2016-00049)



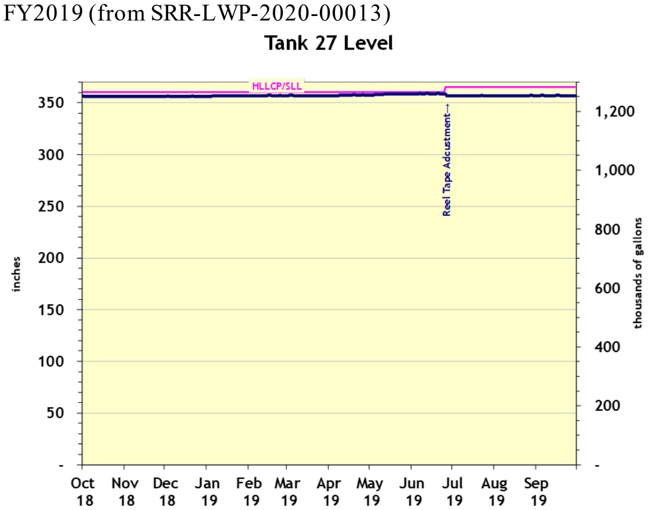
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

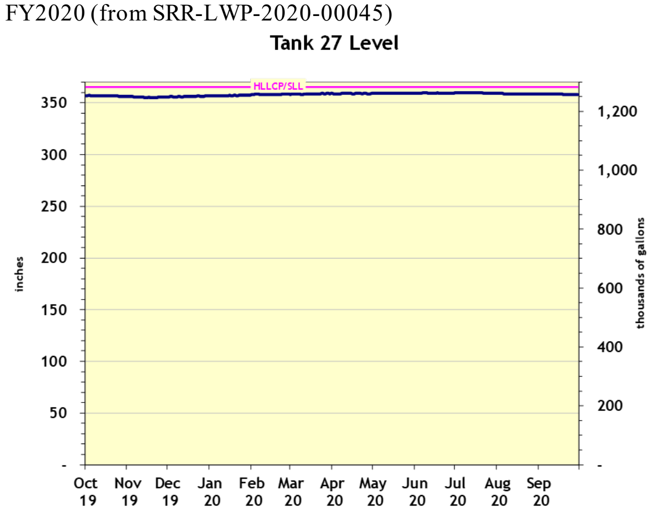


Figure INV-2.28. Tank 28 Volume History, FY2015 through FY2020

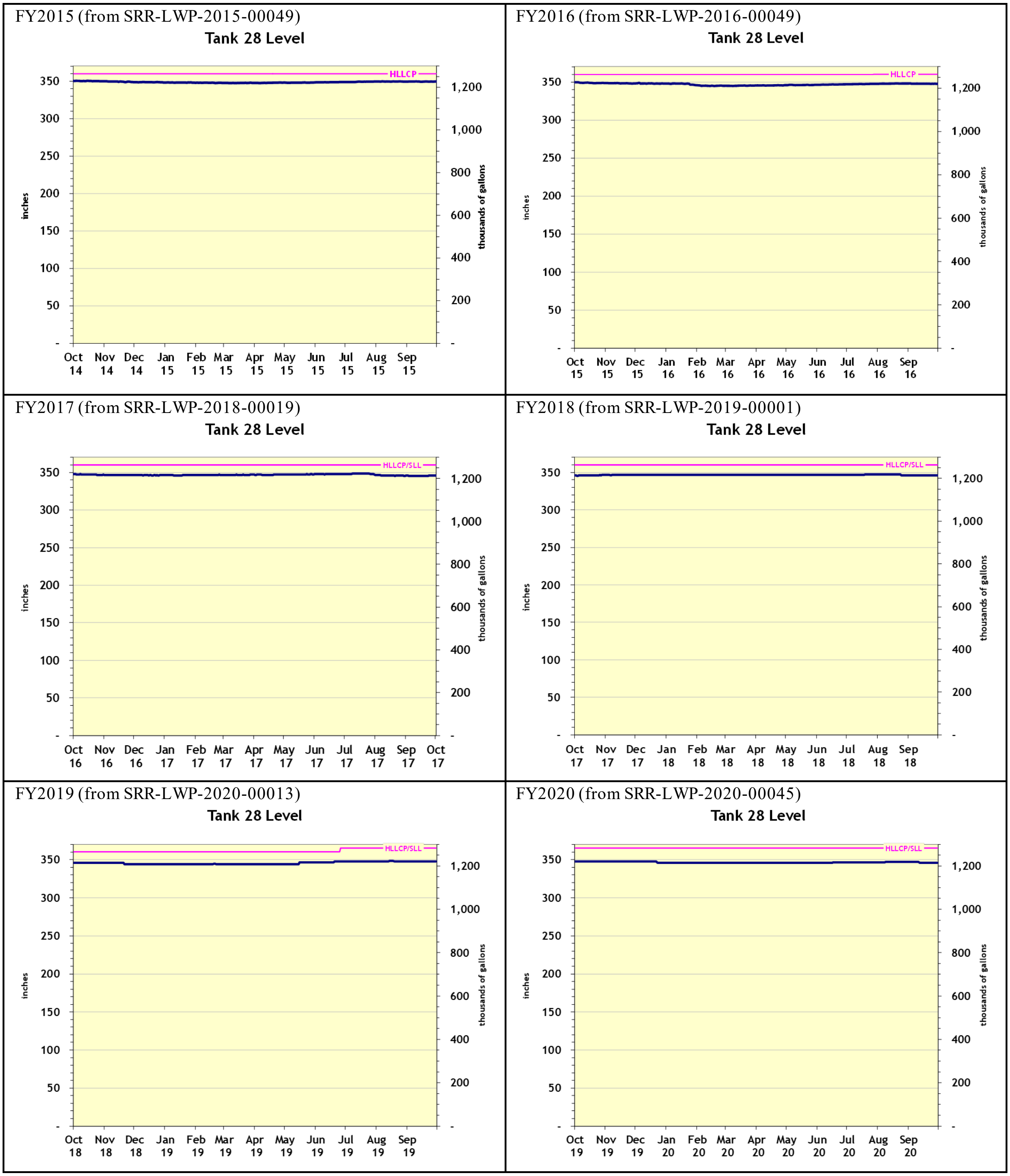


Figure INV-2.29. Tank 29 Volume History, FY2015 through FY2020

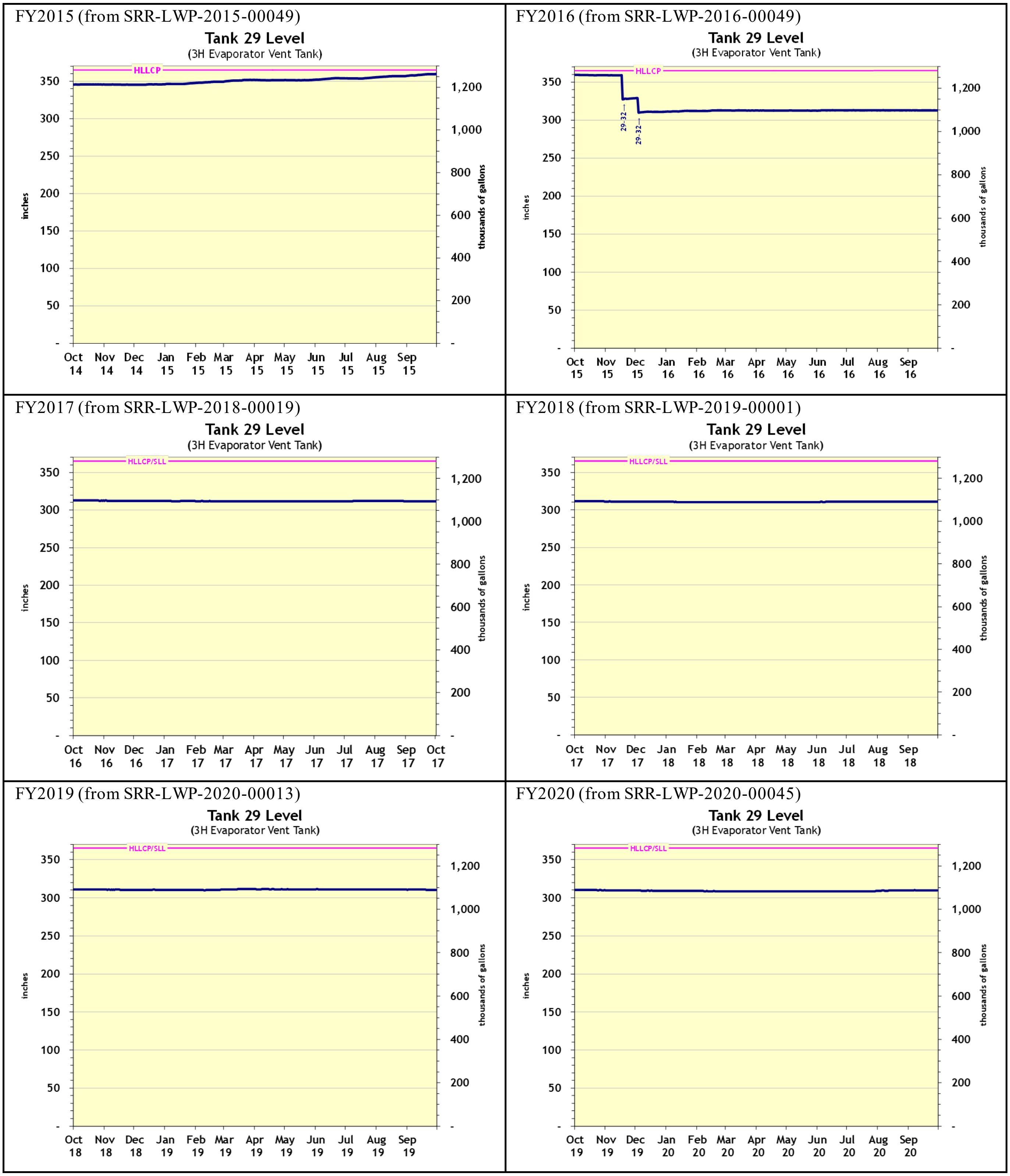


Figure INV-2.30. Tank 30 Volume History, FY2015 through FY2020

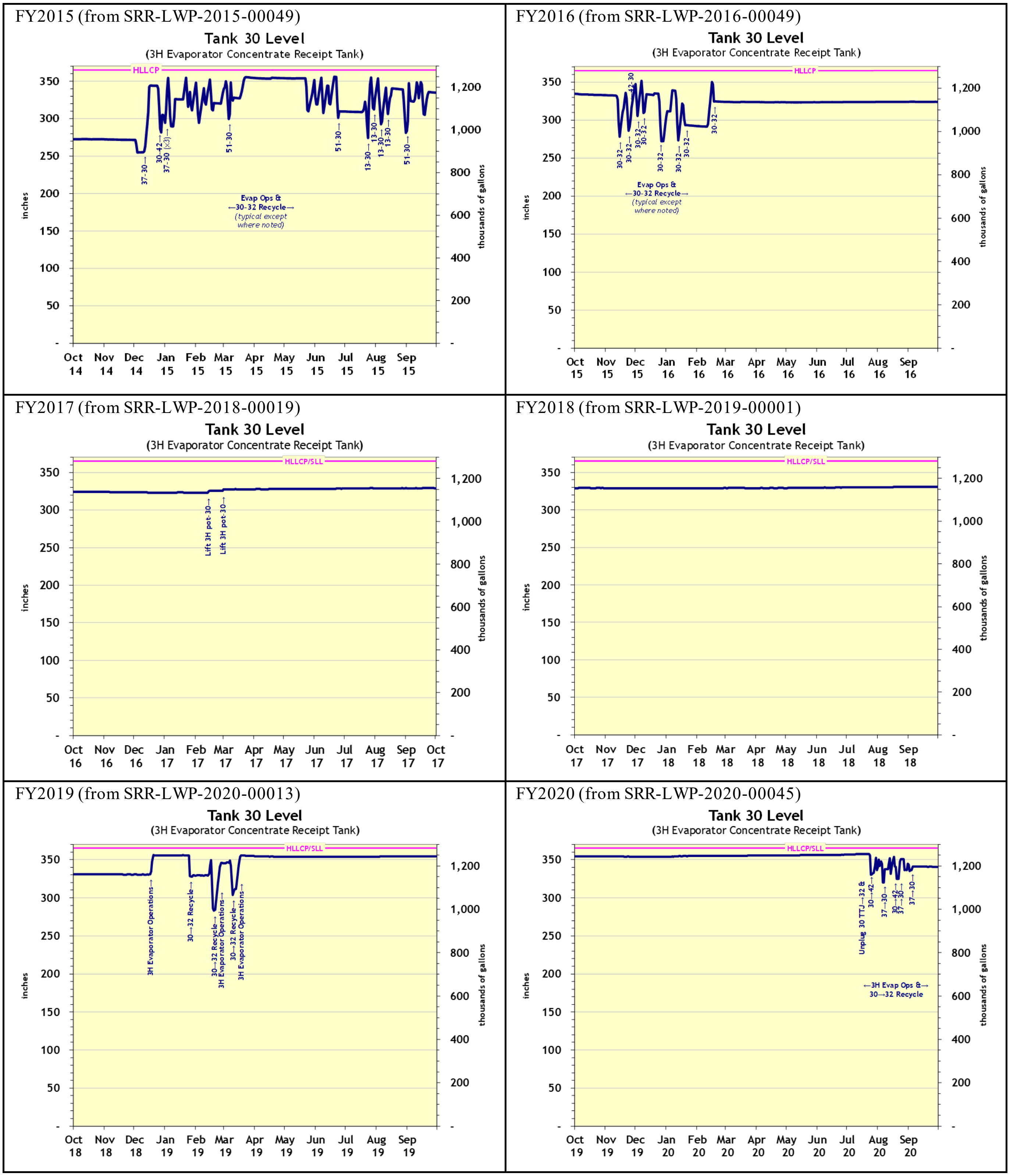
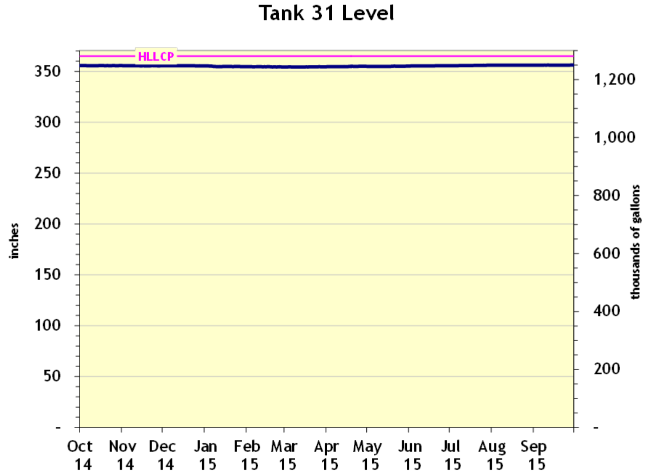
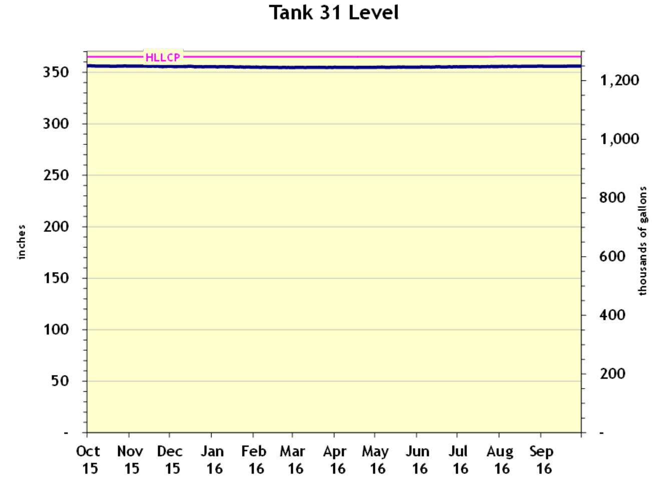


Figure INV-2.31. Tank 31 Volume History, FY2015 through FY2020

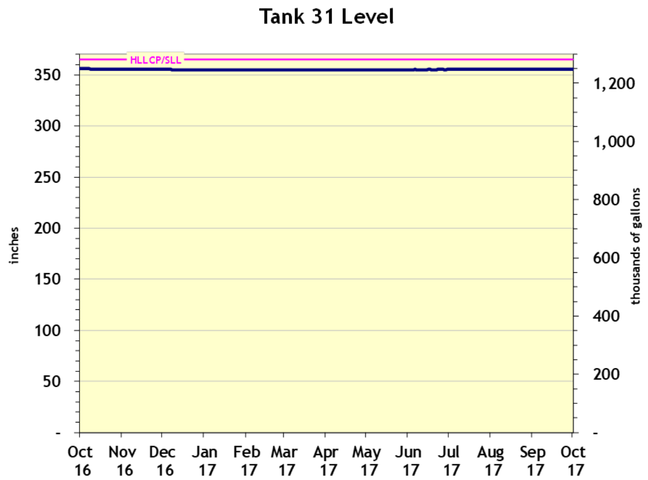
FY2015 (from SRR-LWP-2015-00049)



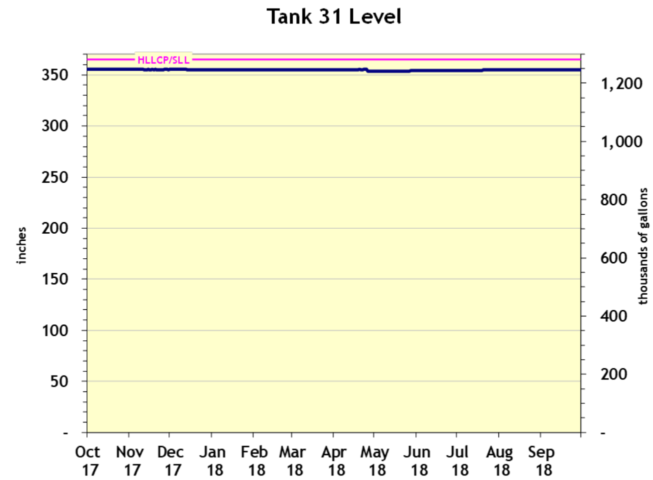
FY2016 (from SRR-LWP-2016-00049)



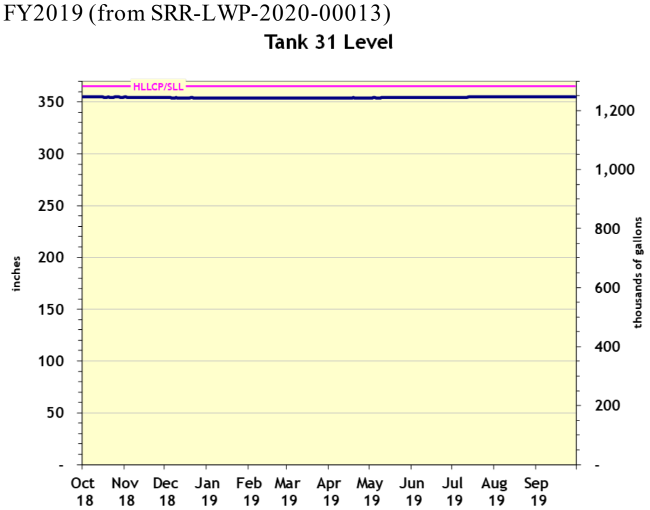
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

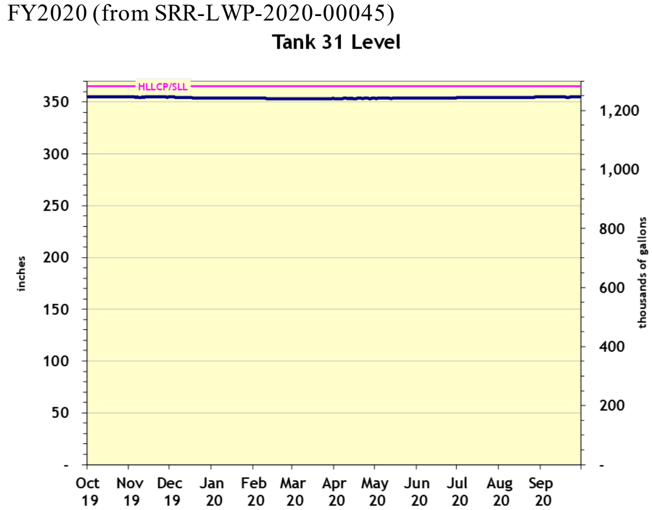


Figure INV-2.32. Tank 32 Volume History, FY2015 through FY2020

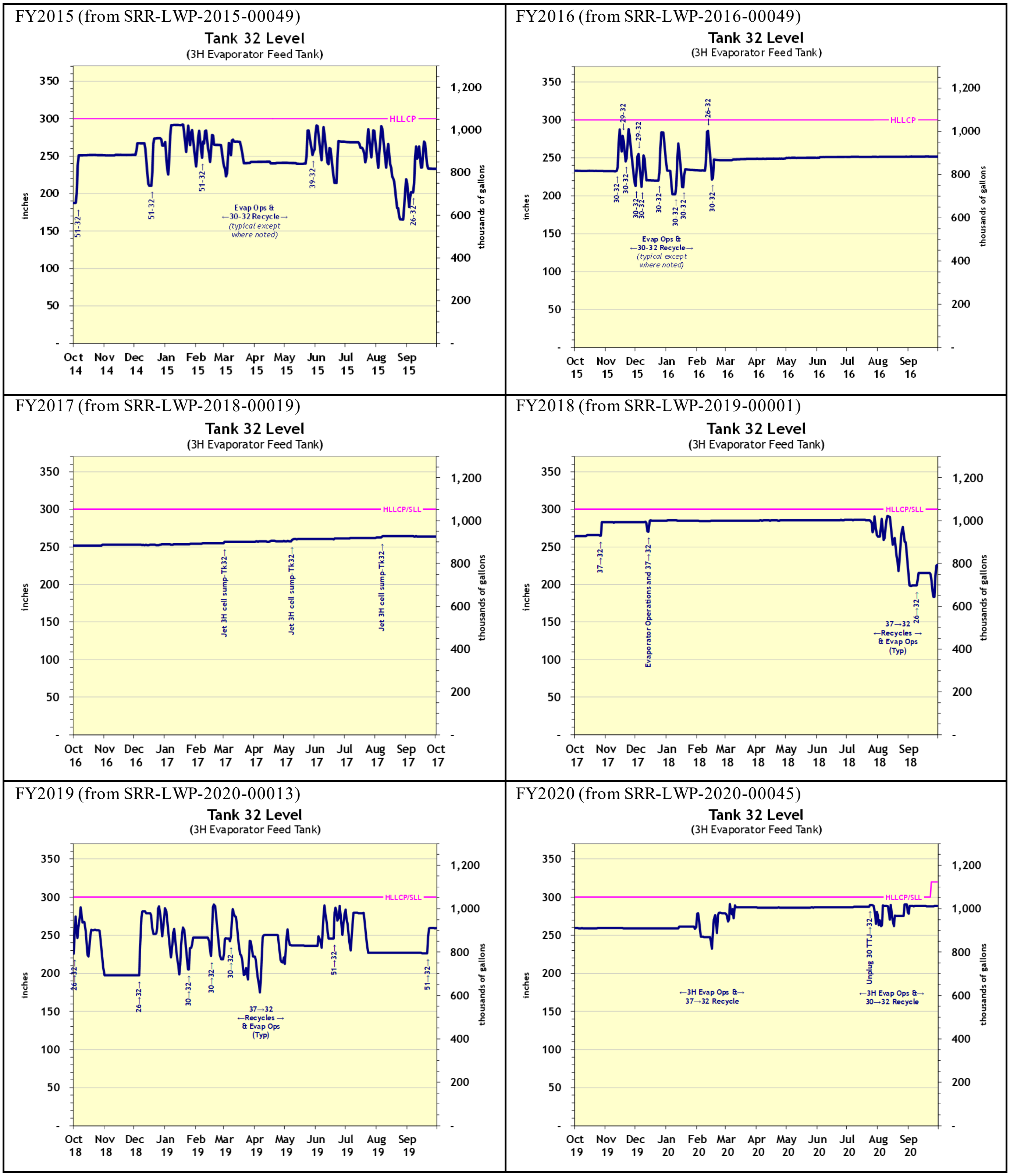
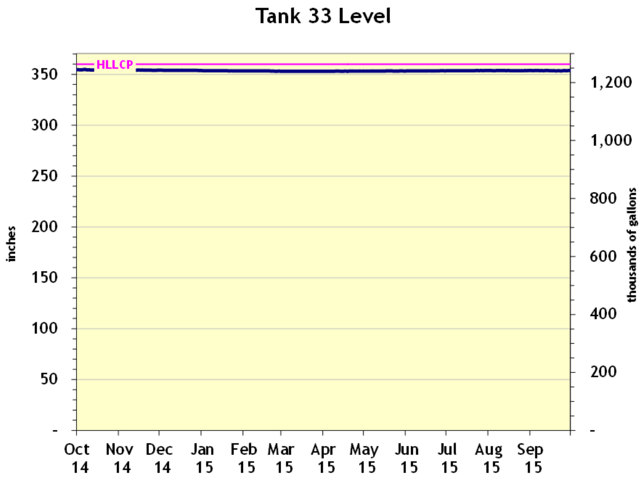
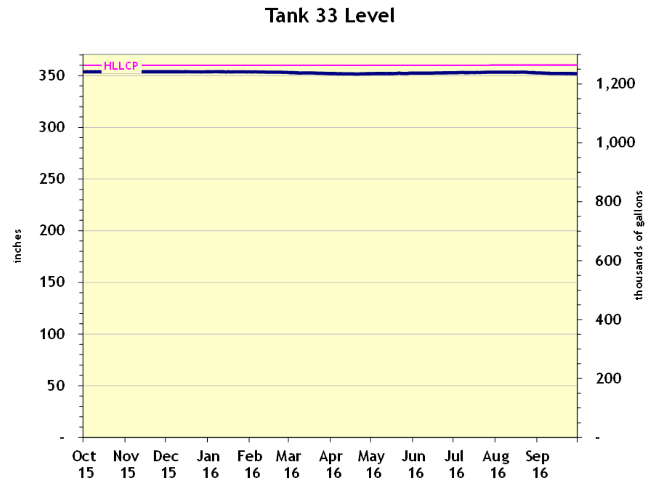


Figure INV-2.33. Tank 33 Volume History, FY2015 through FY2020

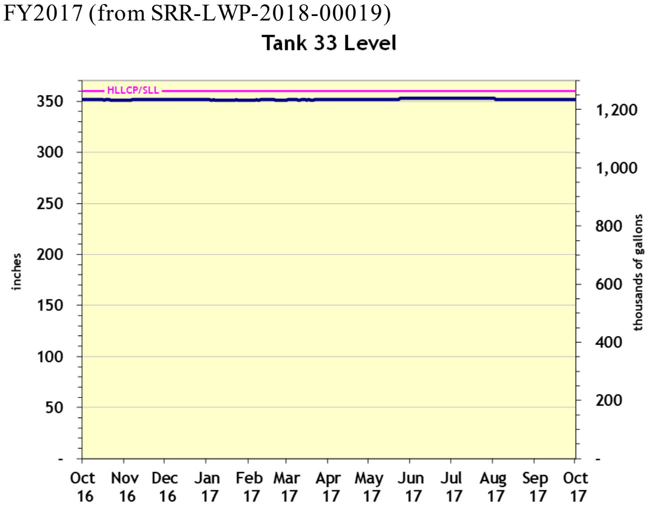
FY2015 (from SRR-LWP-2015-00049)



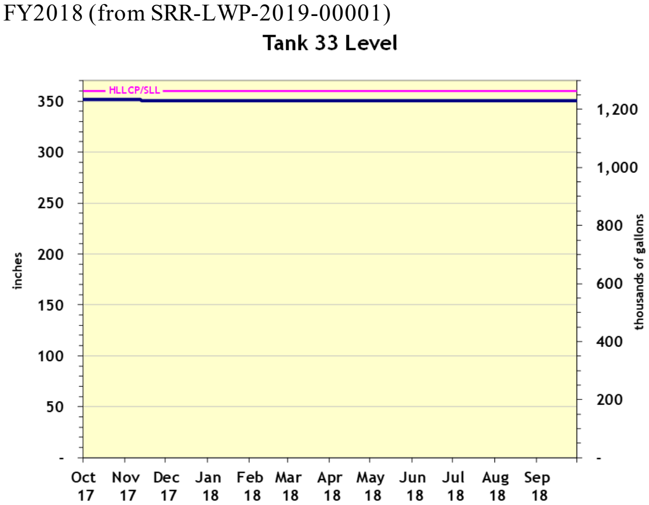
FY2016 (from SRR-LWP-2016-00049)



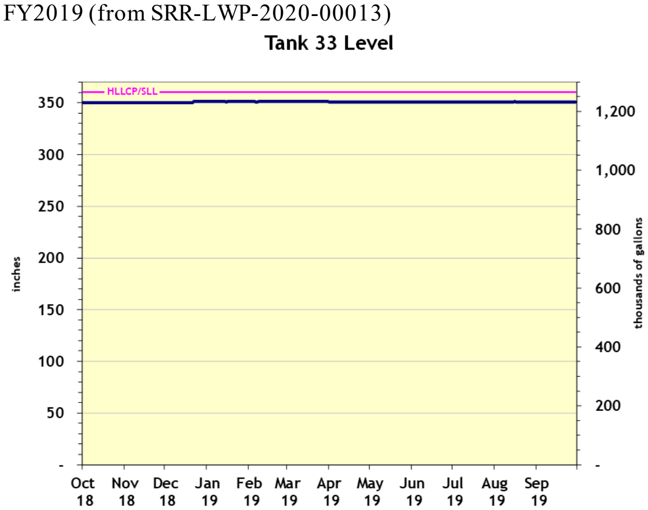
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

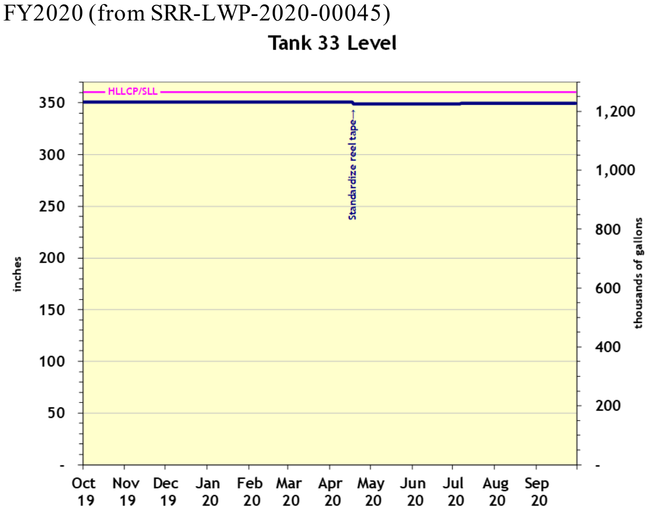
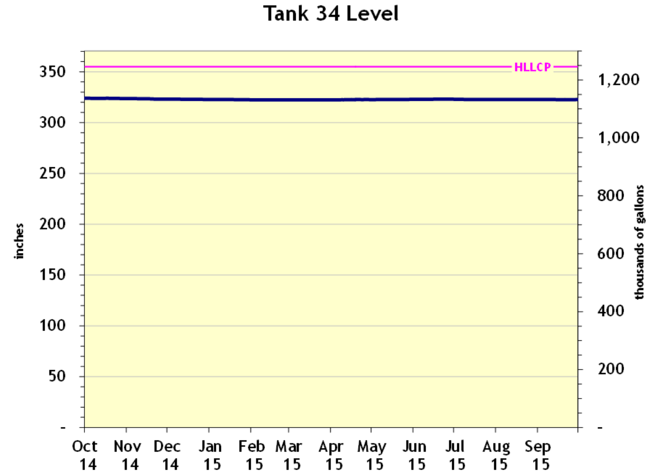
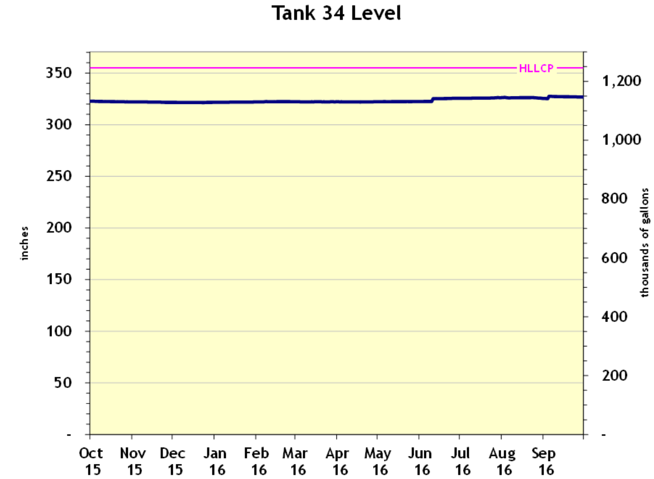


Figure INV-2.34. Tank 34 Volume History, FY2015 through FY2020

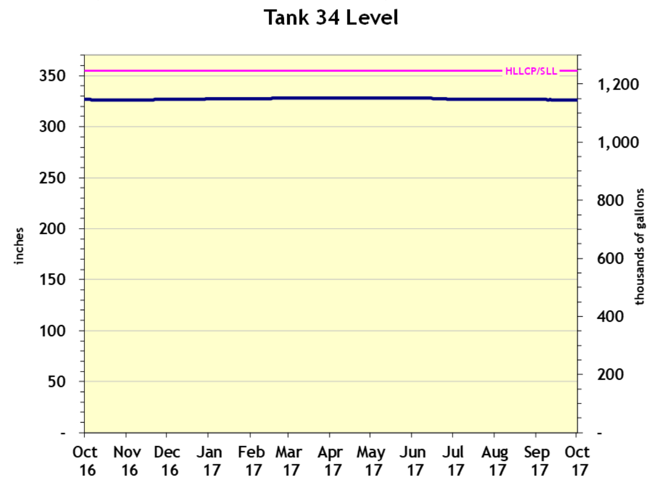
FY2015 (from SRR-LWP-2015-00049)



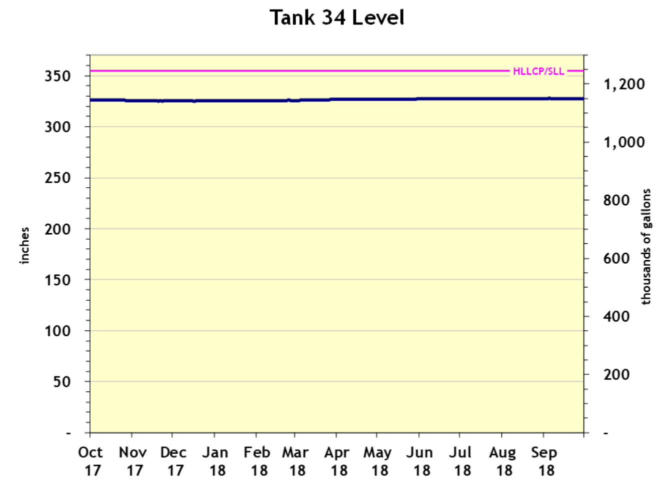
FY2016 (from SRR-LWP-2016-00049)



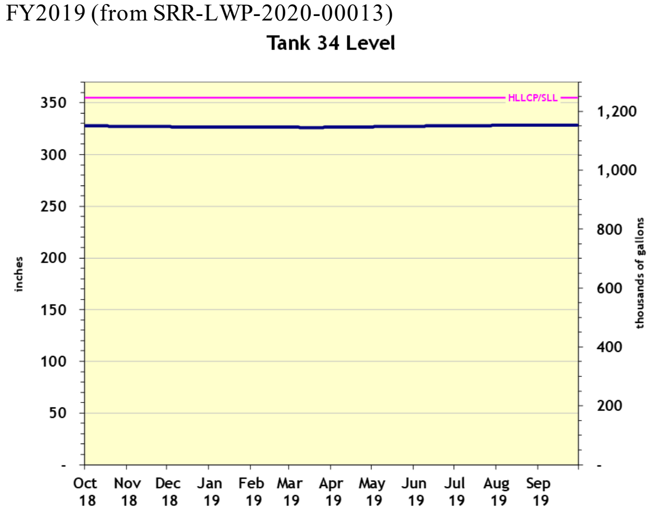
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

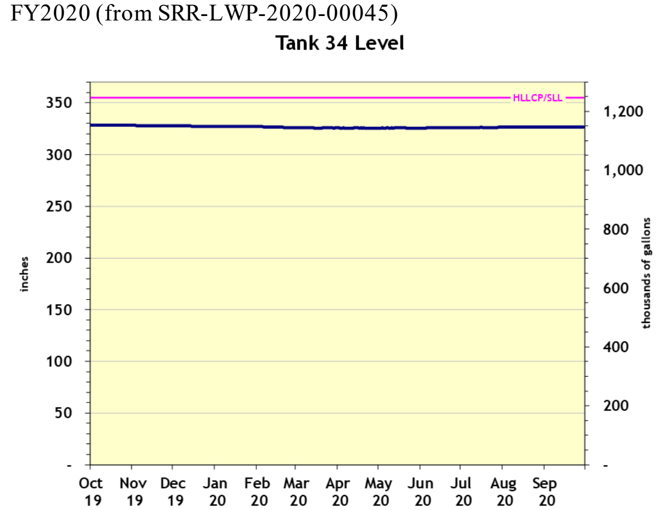
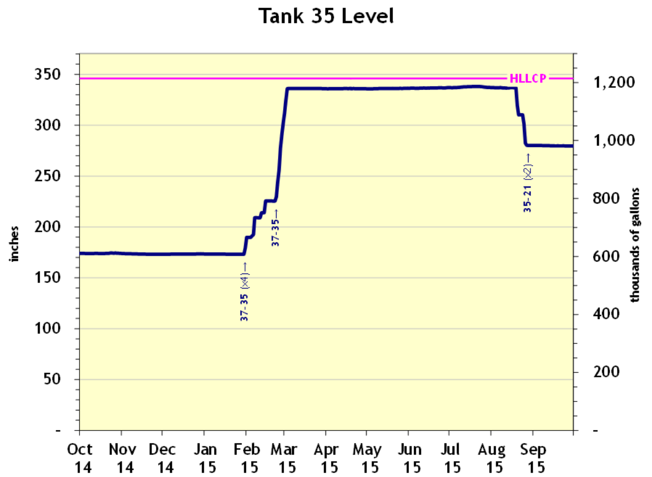
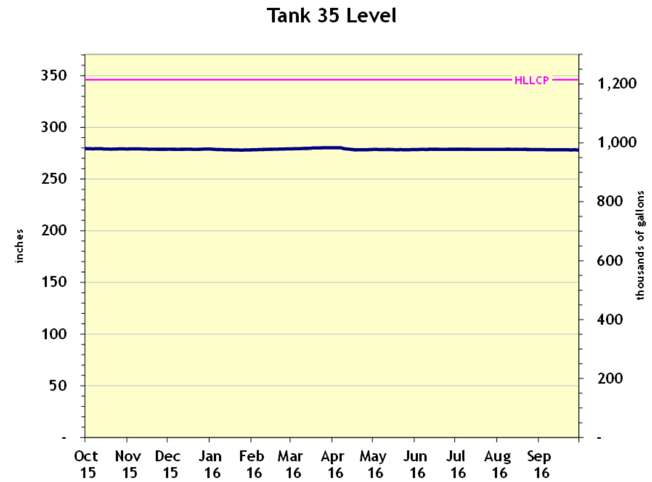


Figure INV-2.35. Tank 35 Volume History, FY2015 through FY2020

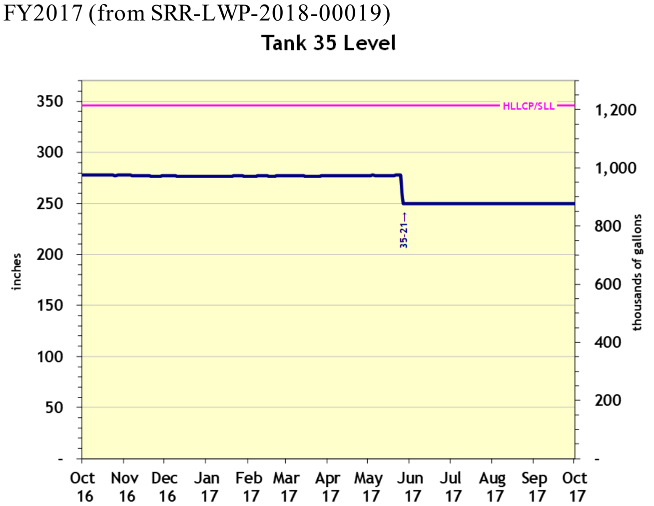
FY2015 (from SRR-LWP-2015-00049)



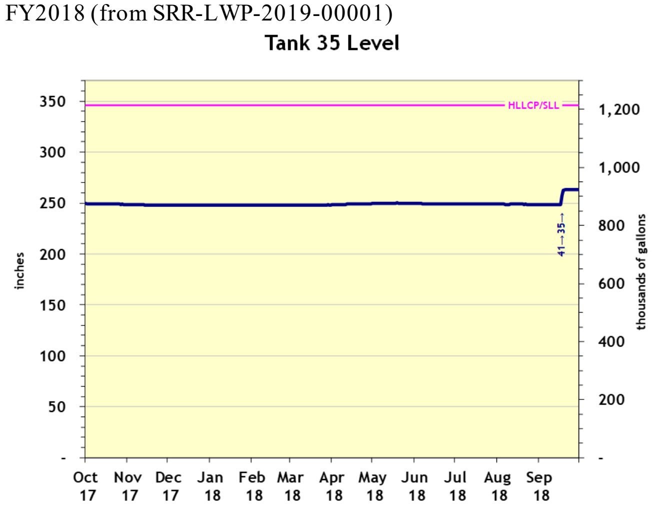
FY2016 (from SRR-LWP-2016-00049)



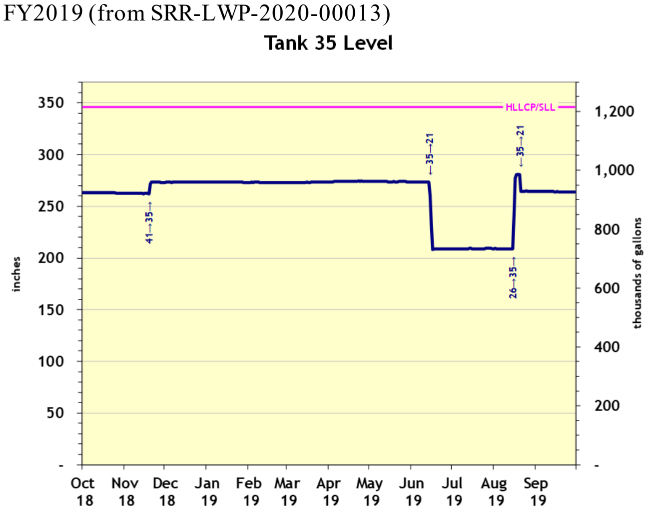
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

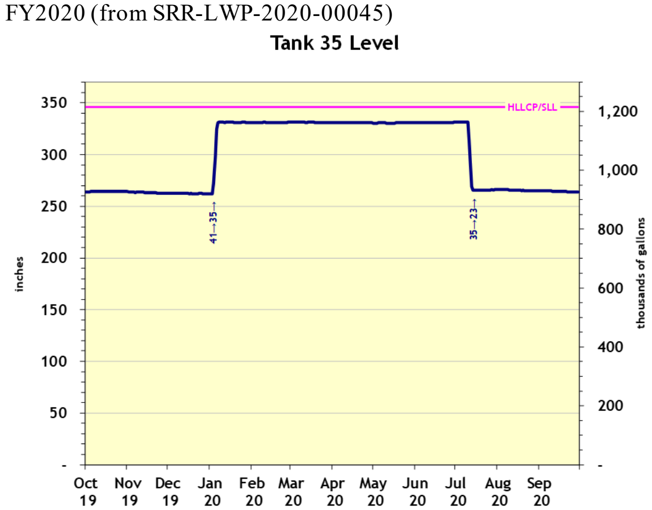


Figure INV-2.36. Tank 36 Volume History, FY2015 through FY2020

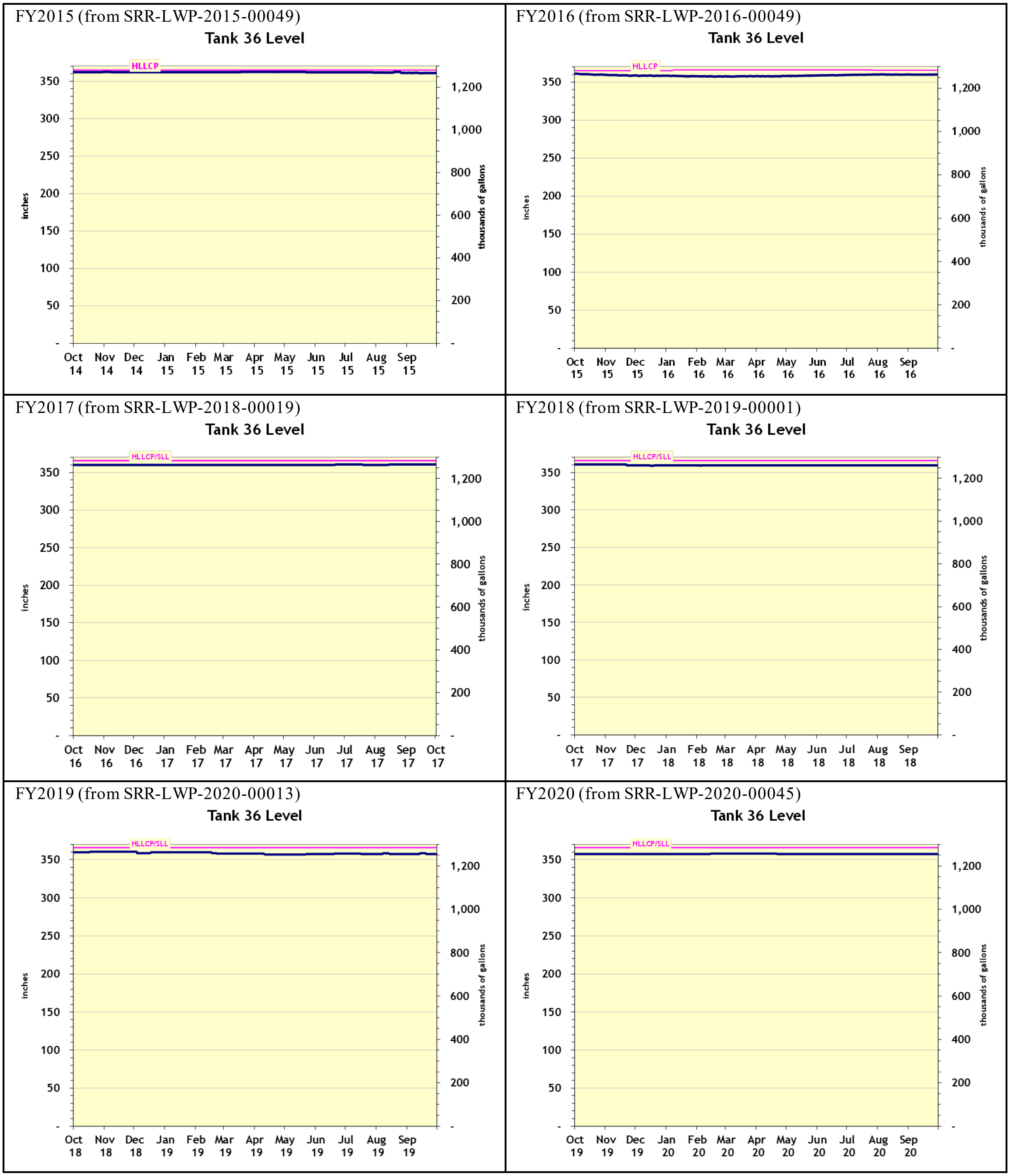


Figure INV-2.37. Tank 37 Volume History, FY2015 through FY2020

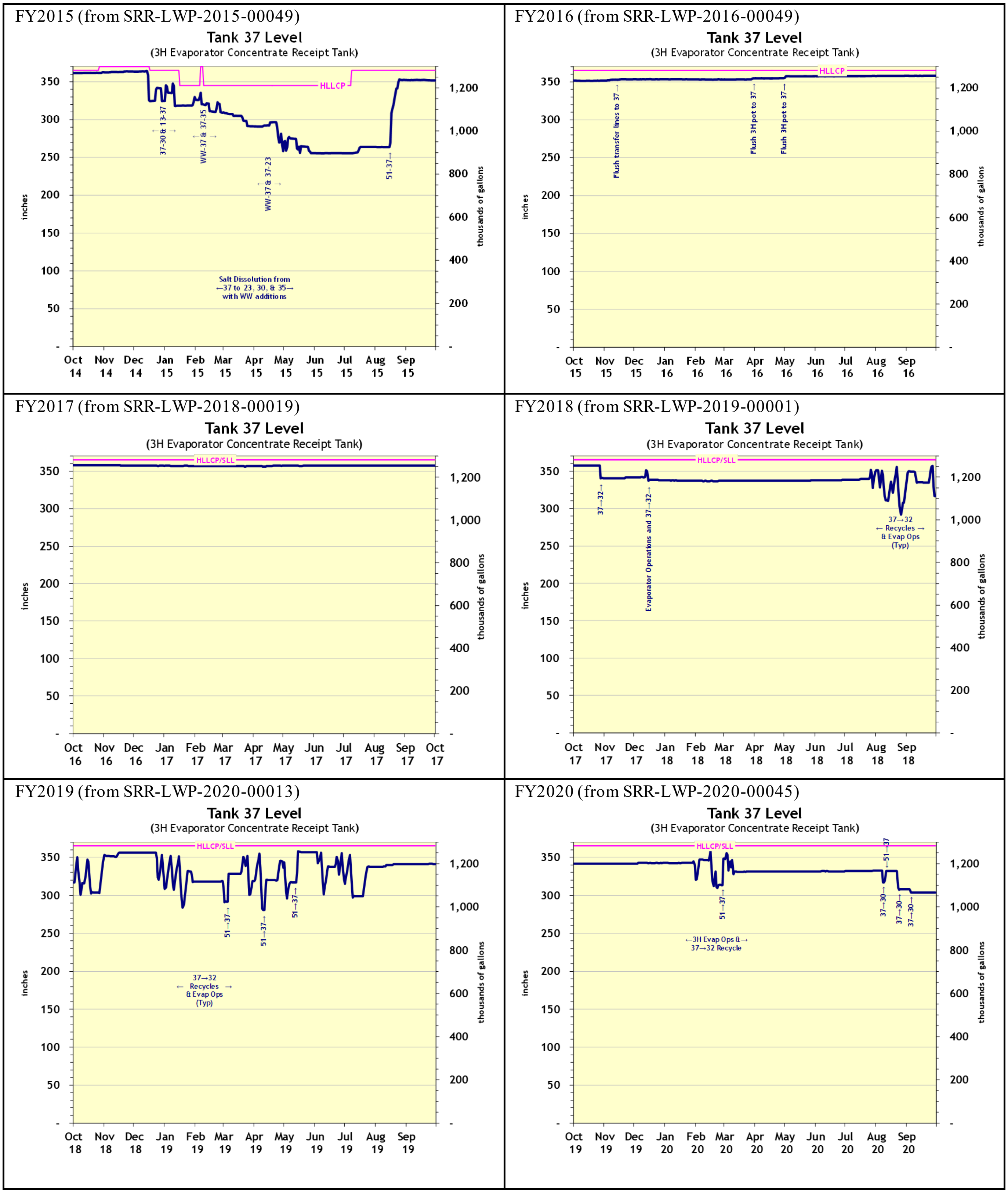


Figure INV-2.38. Tank 38 Volume History, FY2015 through FY2020

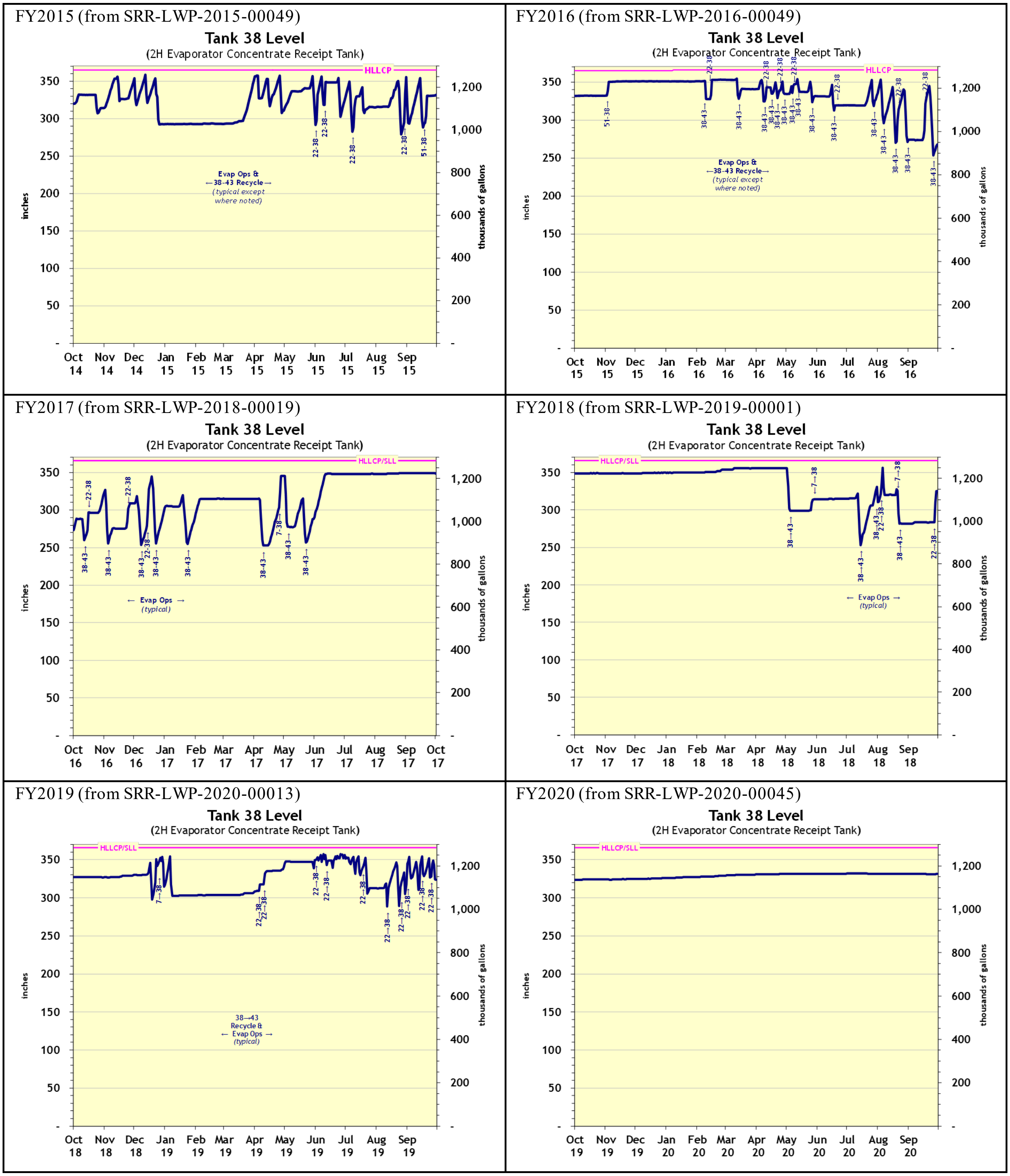
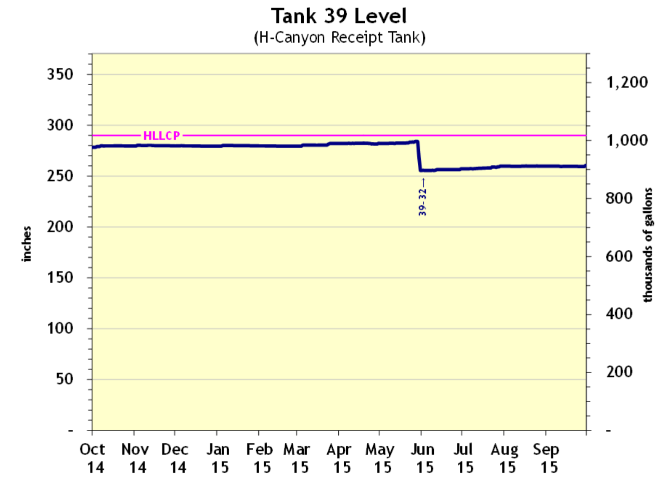
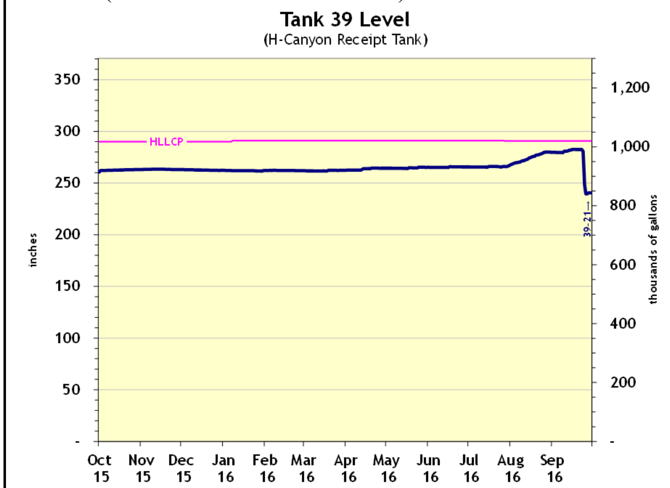


Figure INV-2.39. Tank 39 Volume History, FY2015 through FY2020

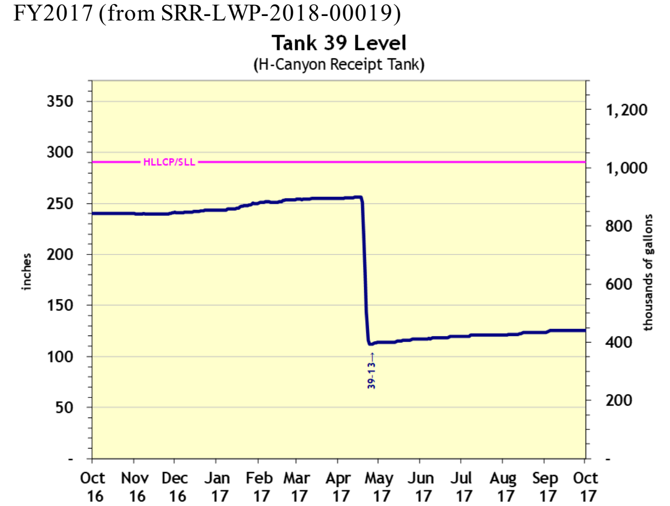
FY2015 (from SRR-LWP-2015-00049)



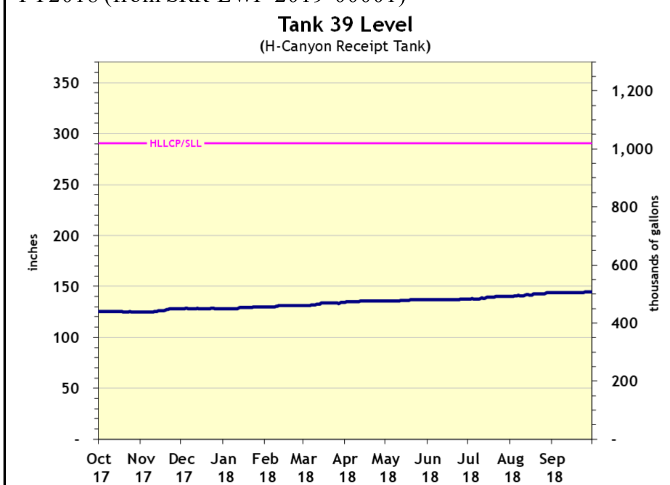
FY2016 (from SRR-LWP-2016-00049)



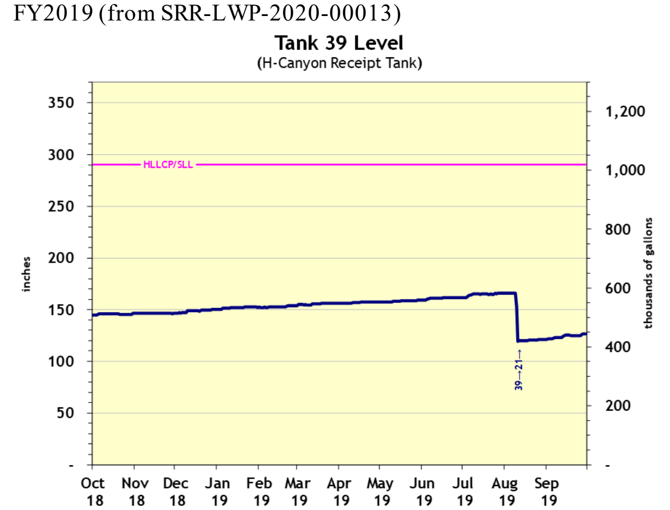
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

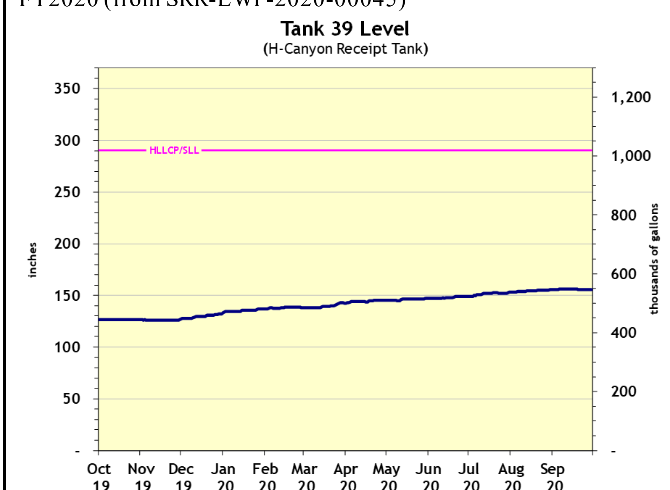


Figure INV-2.40. Tank 40 Volume History, FY2015 through FY2020

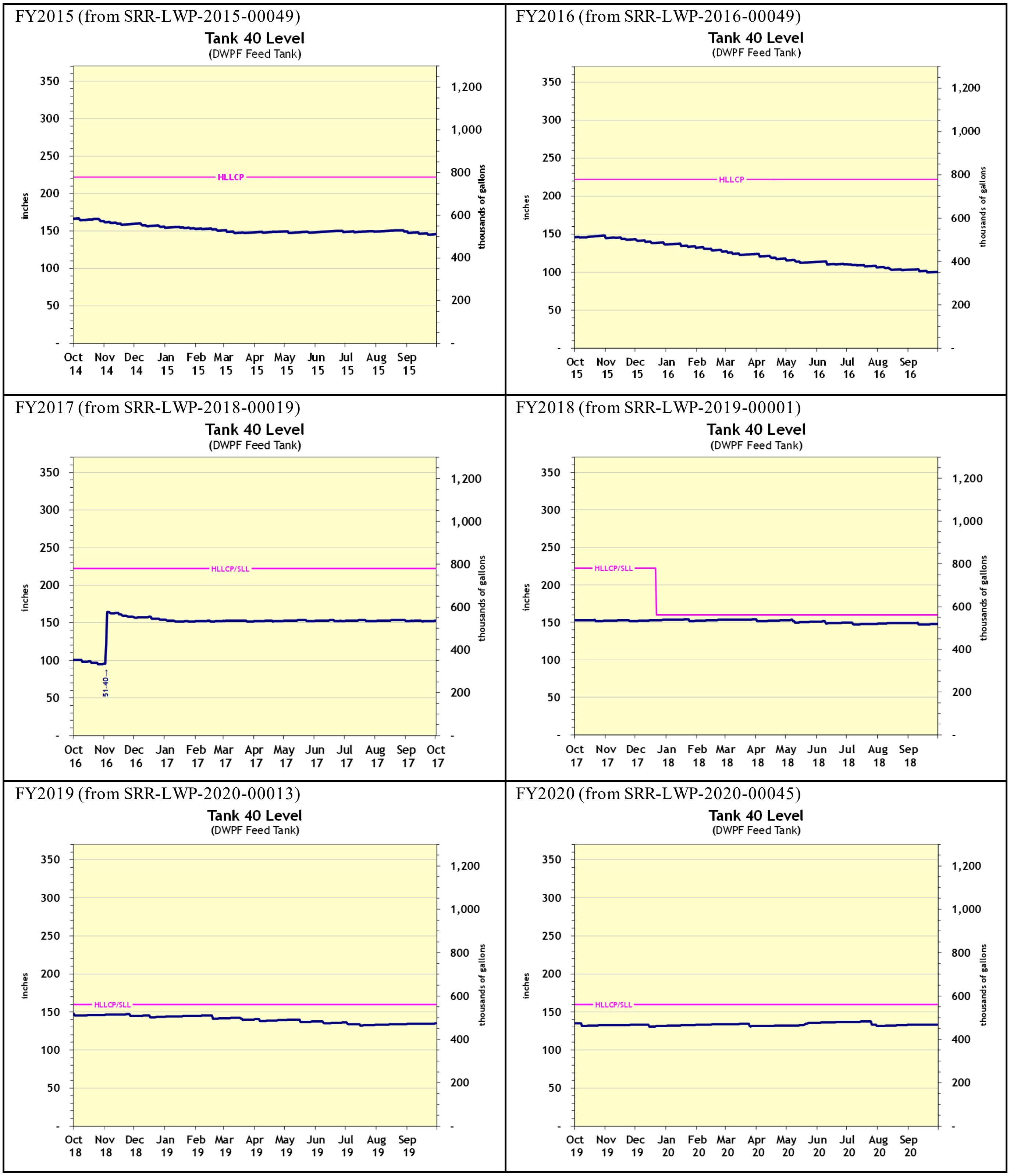


Figure INV-2.41. Tank 41 Volume History, FY2015 through FY2020

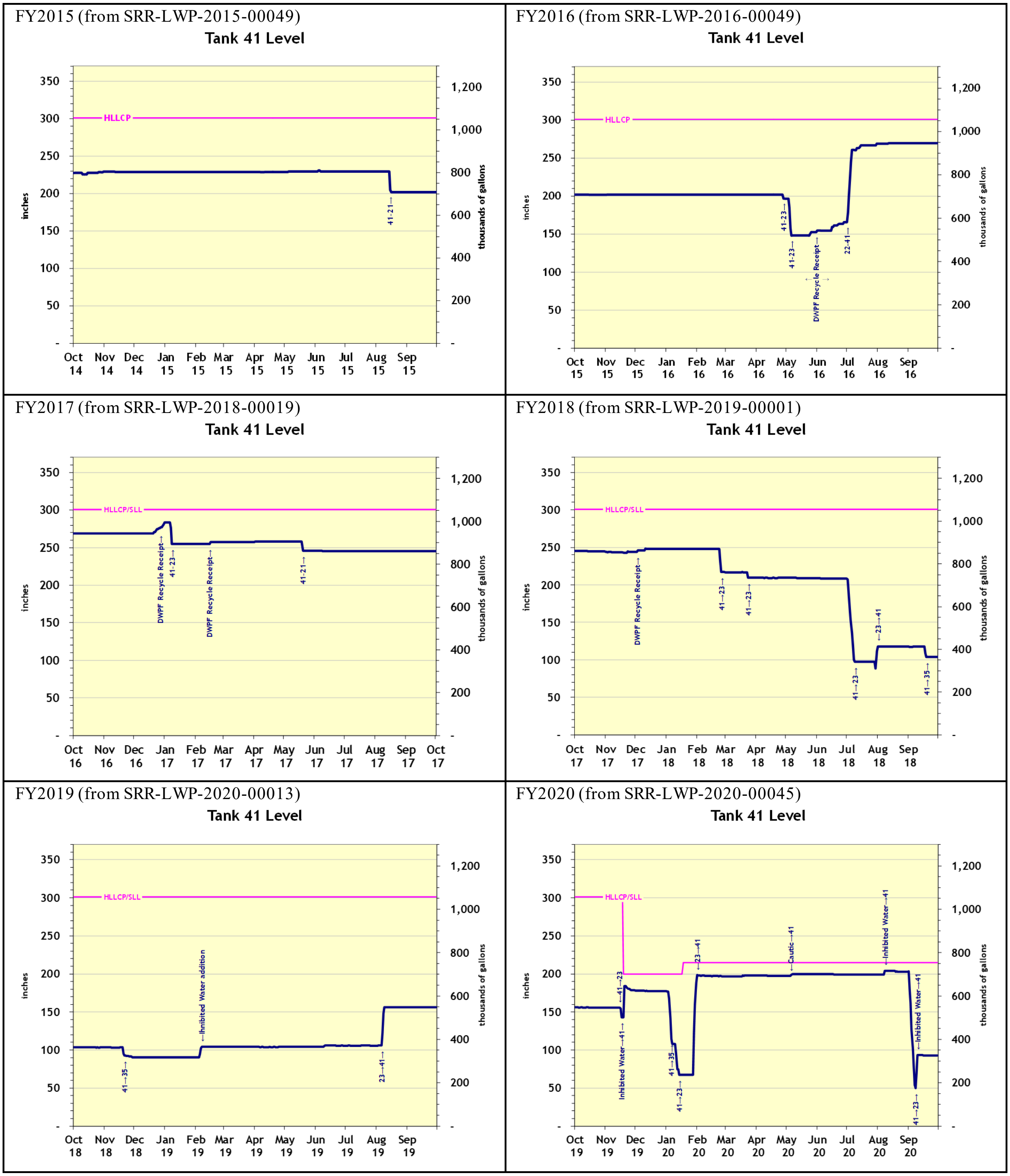
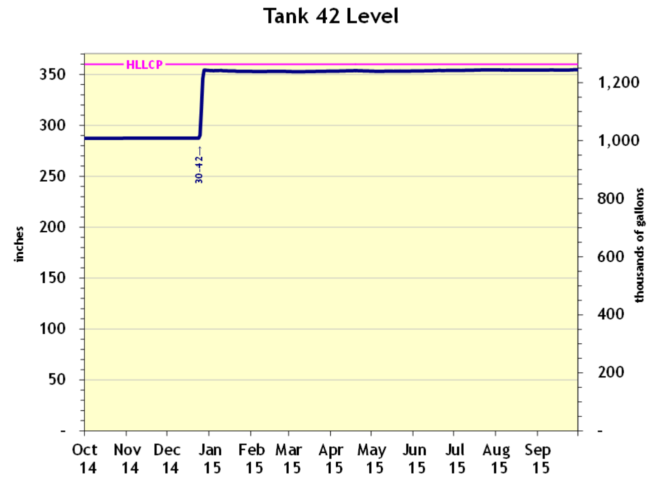
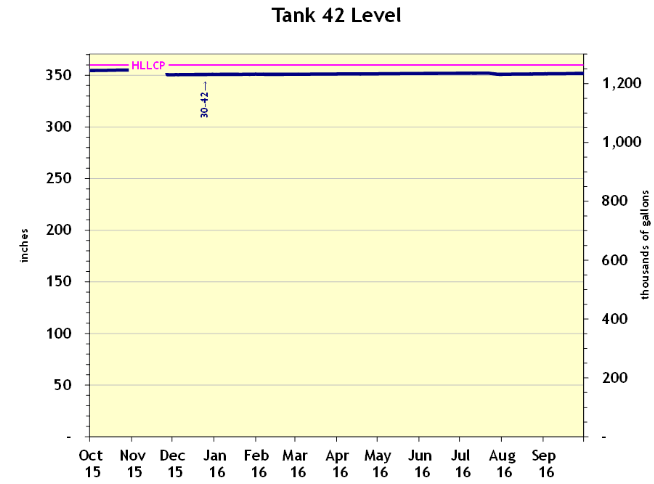


Figure INV-2.42. Tank 42 Volume History, FY2015 through FY2020

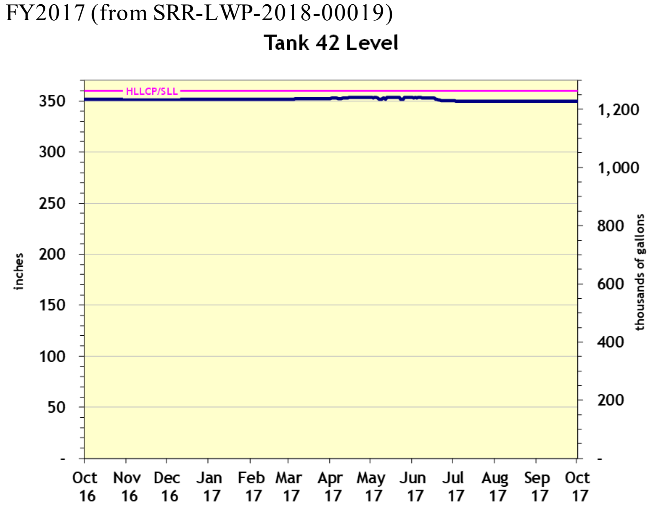
FY2015 (from SRR-LWP-2015-00049)



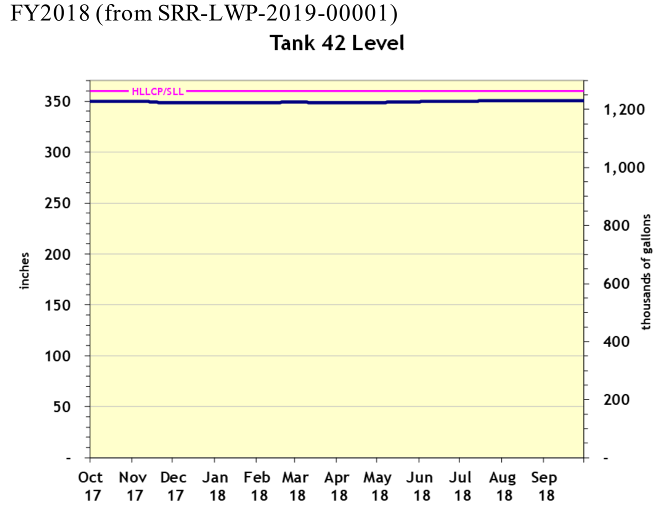
FY2016 (from SRR-LWP-2016-00049)



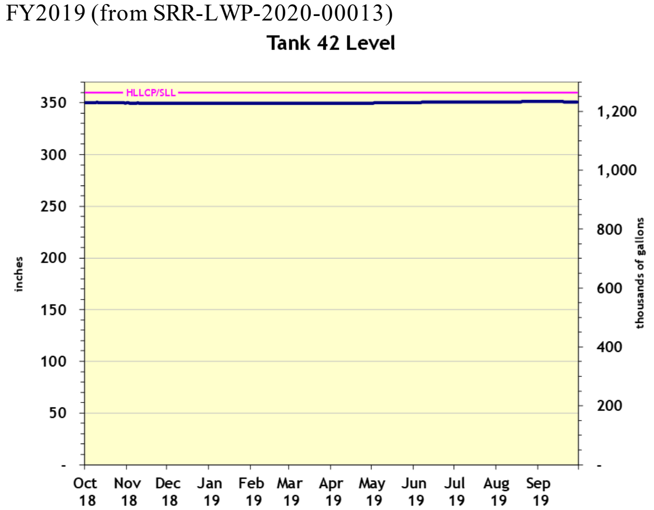
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

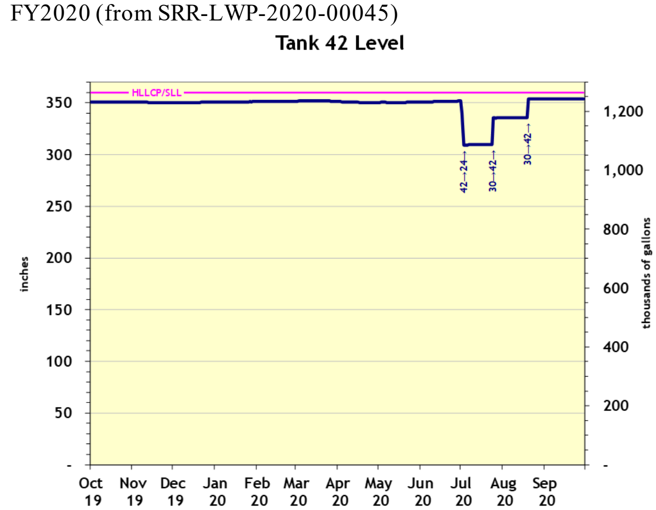


Figure INV-2.43. Tank 43 Volume History, FY2015 through FY2020

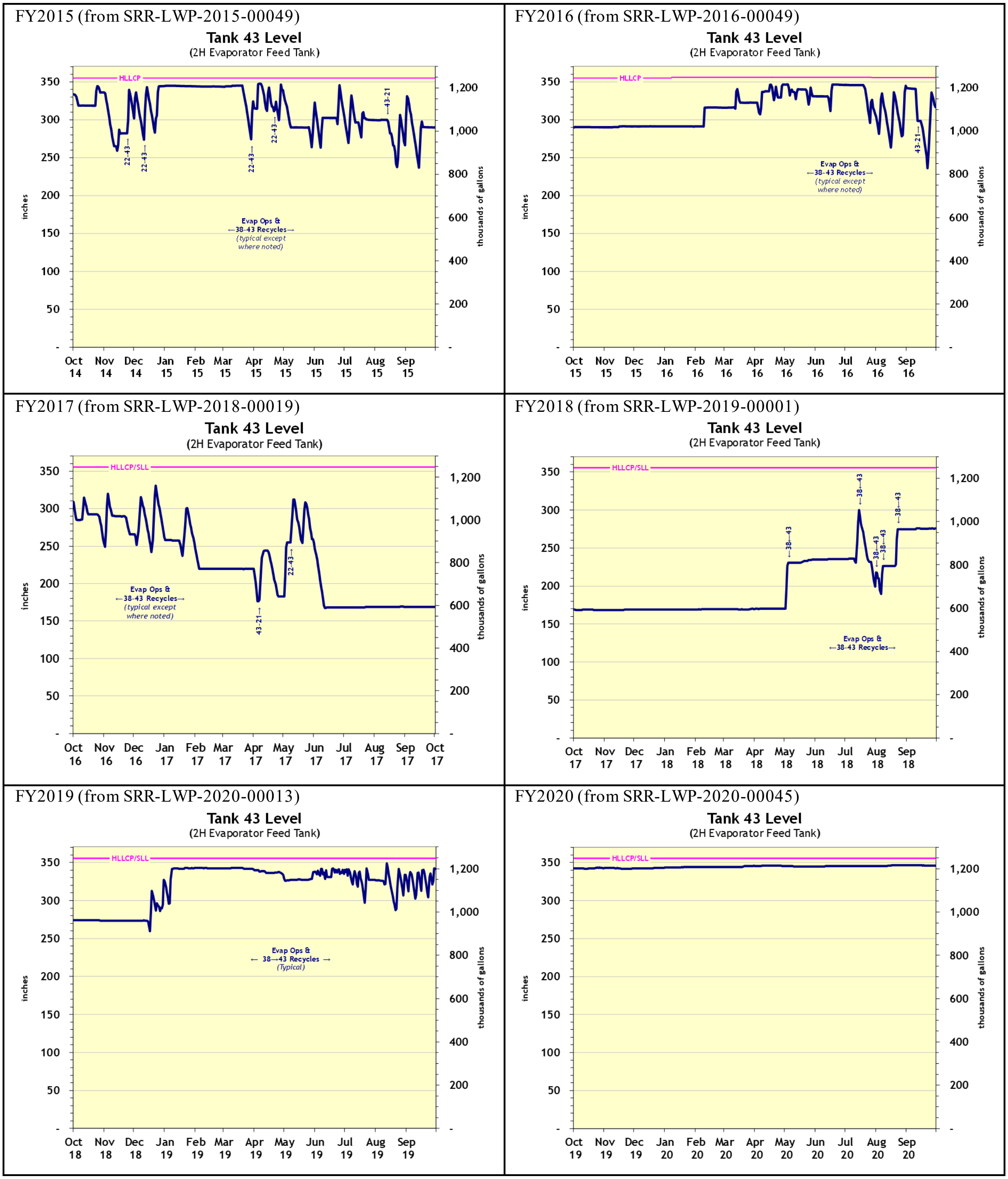
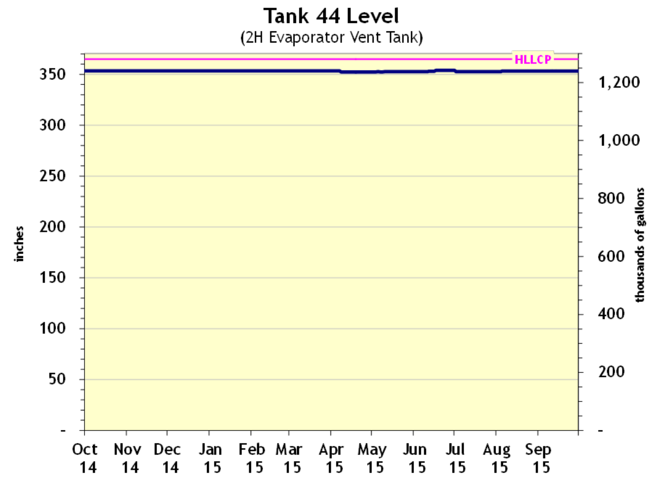
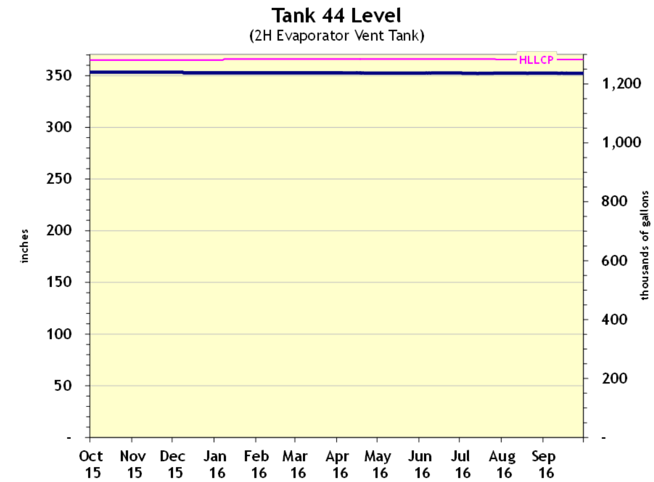


Figure INV-2.44. Tank 44 Volume History, FY2015 through FY2020

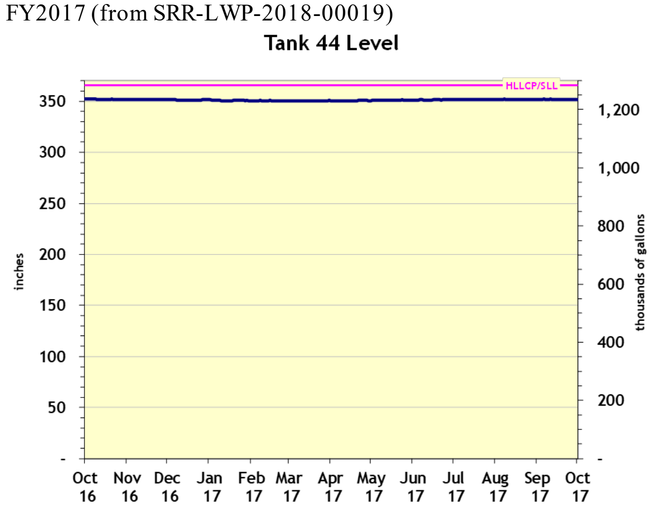
FY2015 (from SRR-LWP-2015-00049)



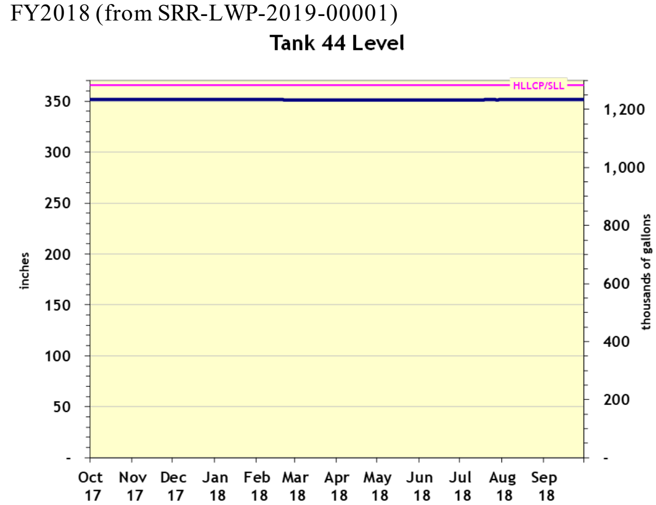
FY2016 (from SRR-LWP-2016-00049)



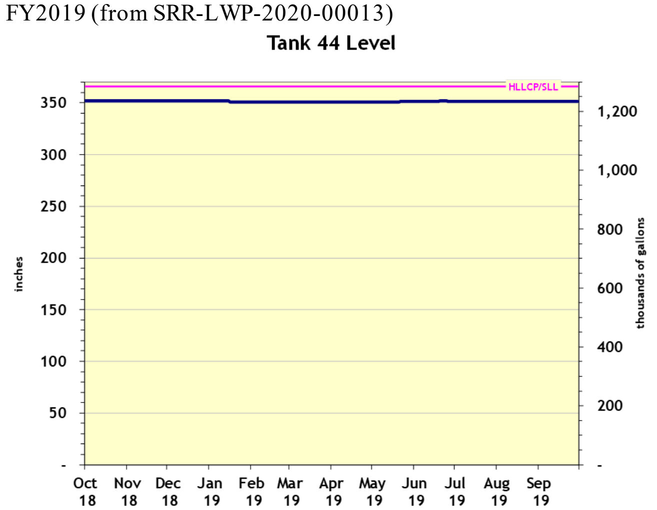
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

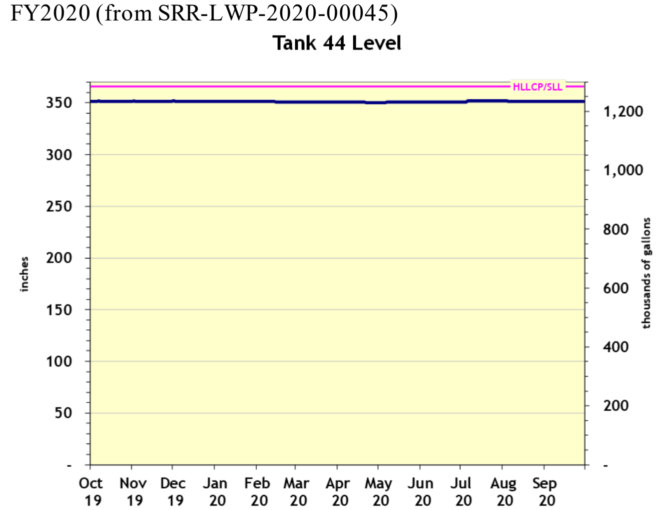
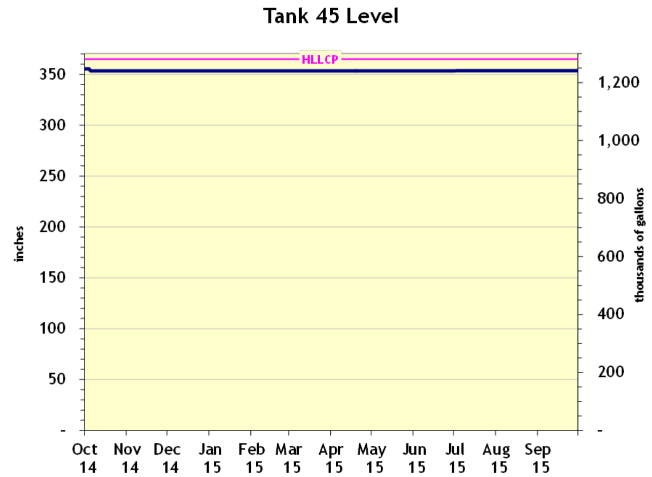
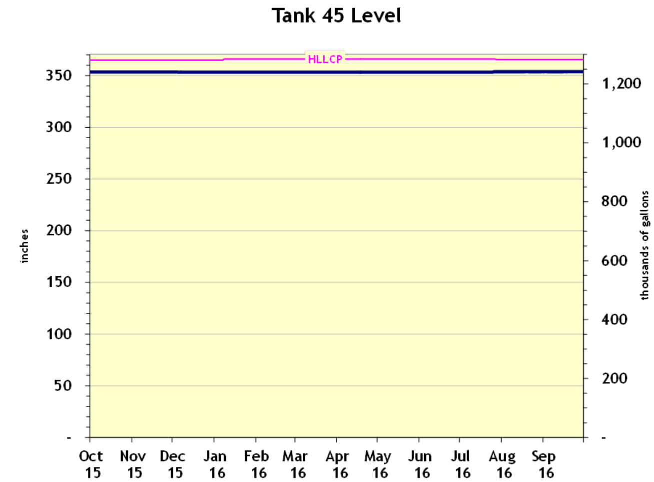


Figure INV-2.45. Tank 45 Volume History, FY2015 through FY2020

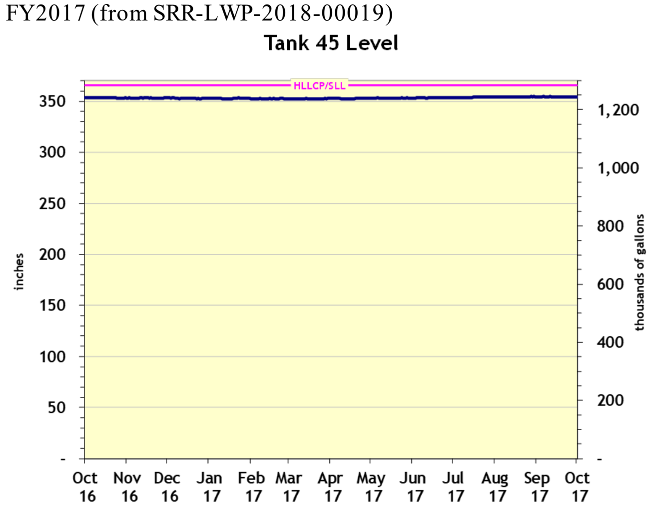
FY2015 (from SRR-LWP-2015-00049)



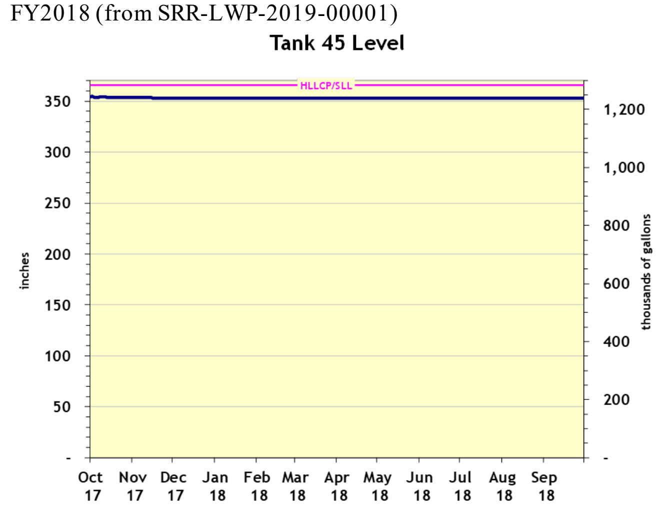
FY2016 (from SRR-LWP-2016-00049)



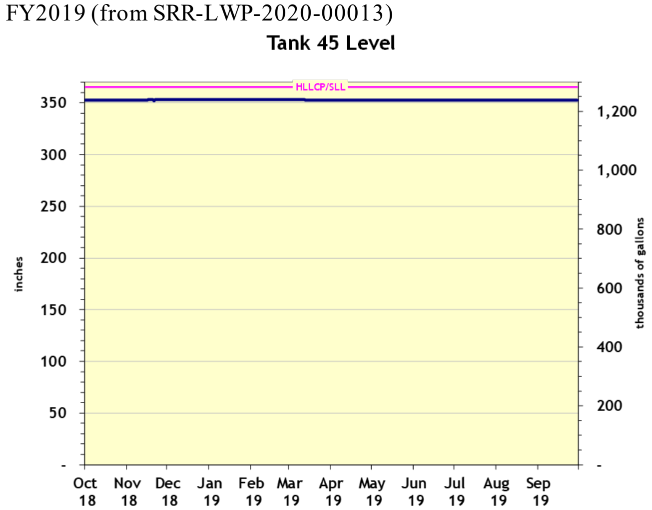
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

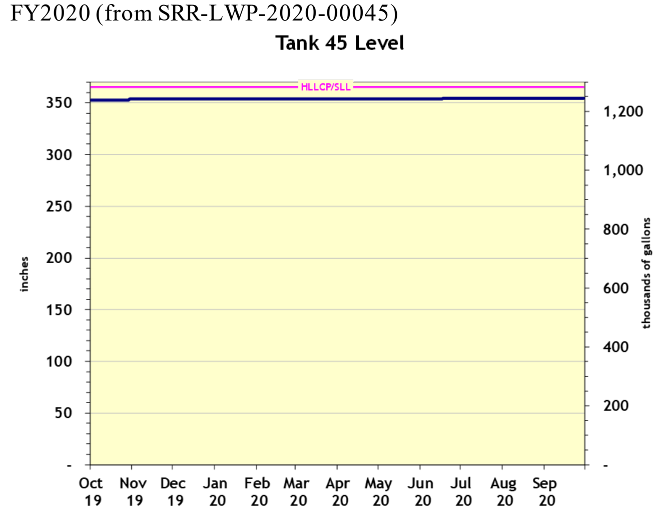


Figure INV-2.46. Tank 46 Volume History, FY2015 through FY2020

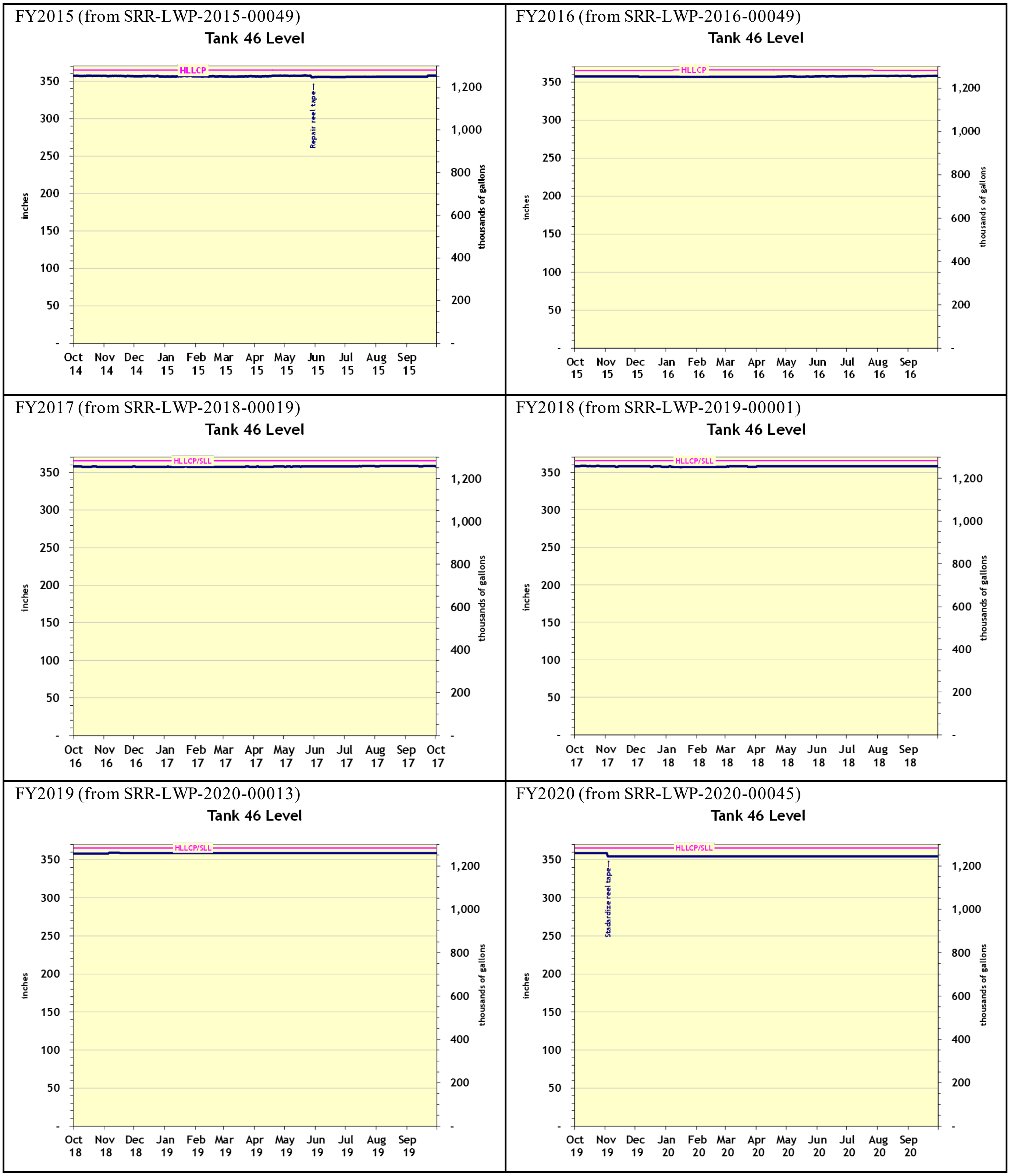
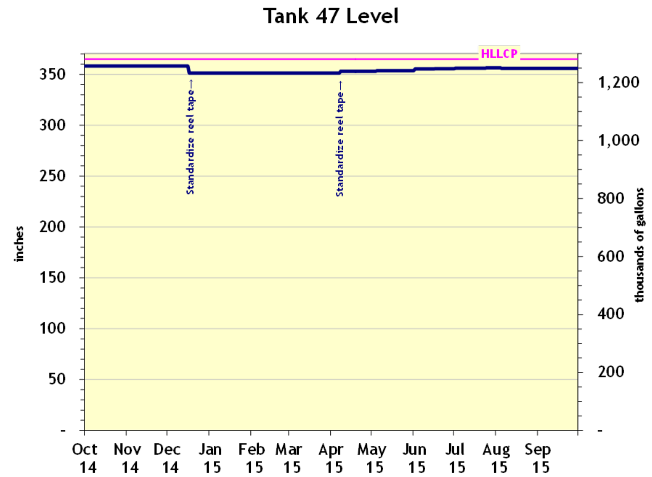
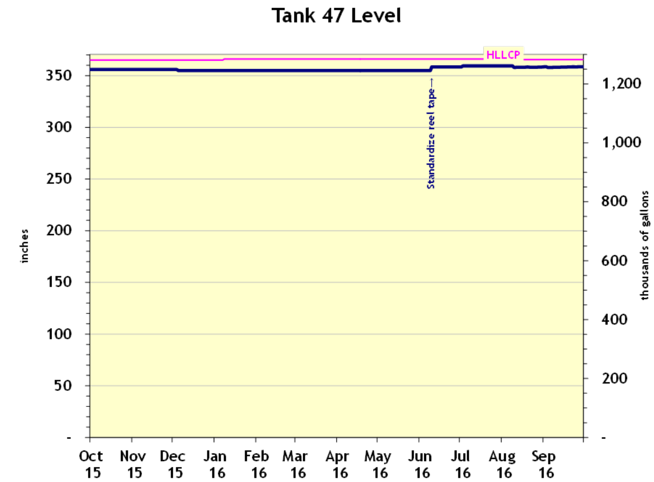


Figure INV-2.47. Tank 47 Volume History, FY2015 through FY2020

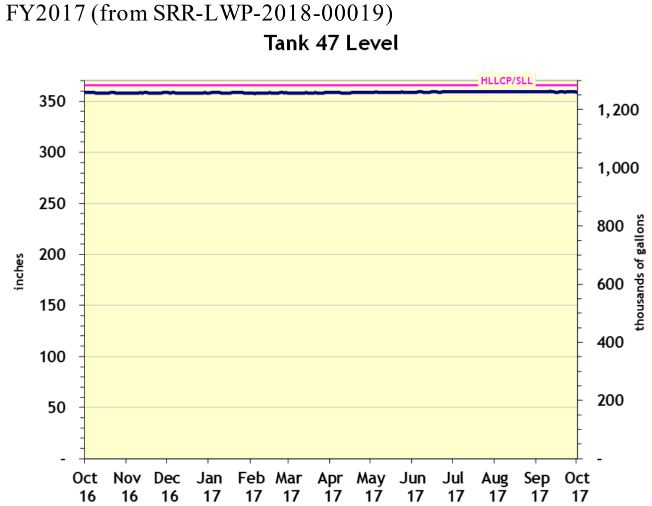
FY2015 (from SRR-LWP-2015-00049)



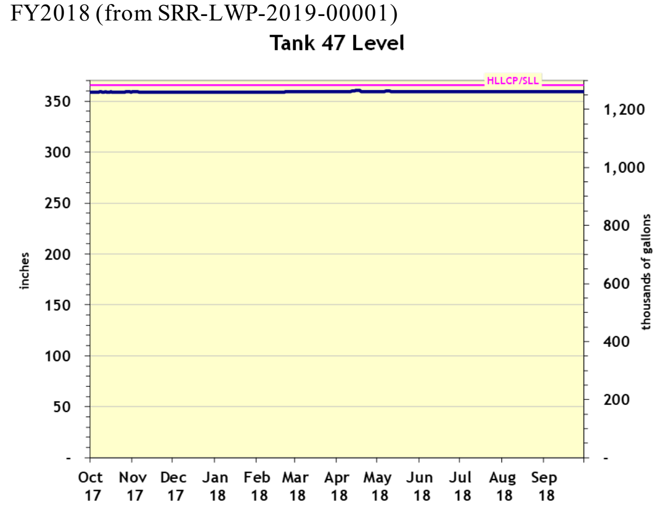
FY2016 (from SRR-LWP-2016-00049)



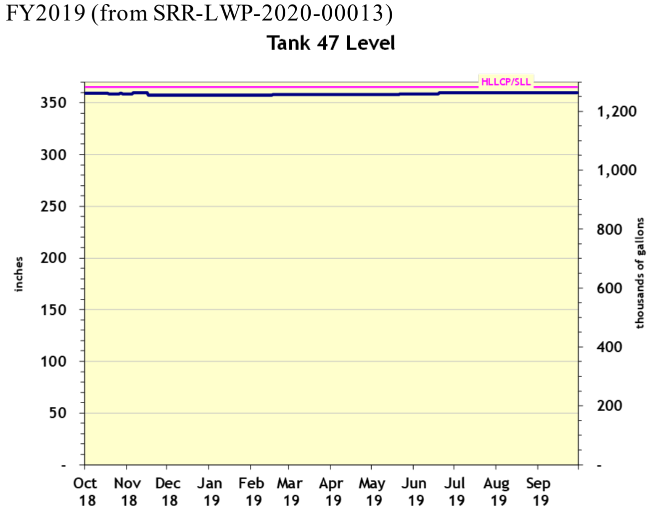
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

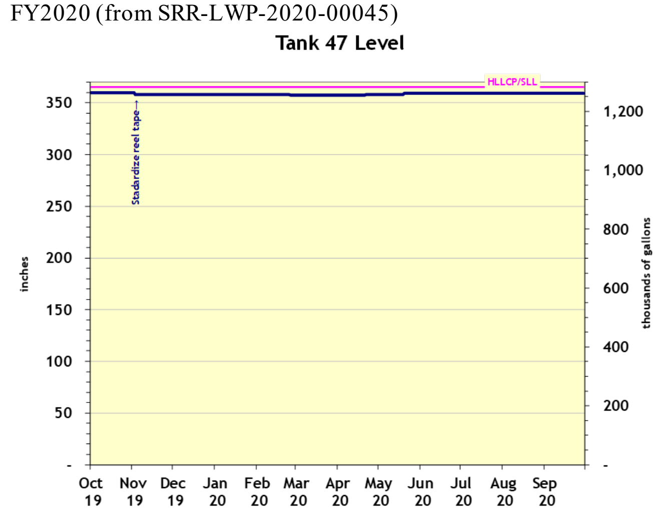
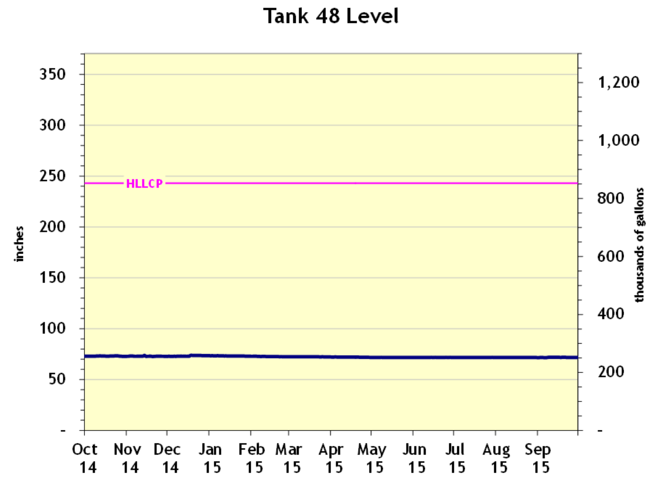
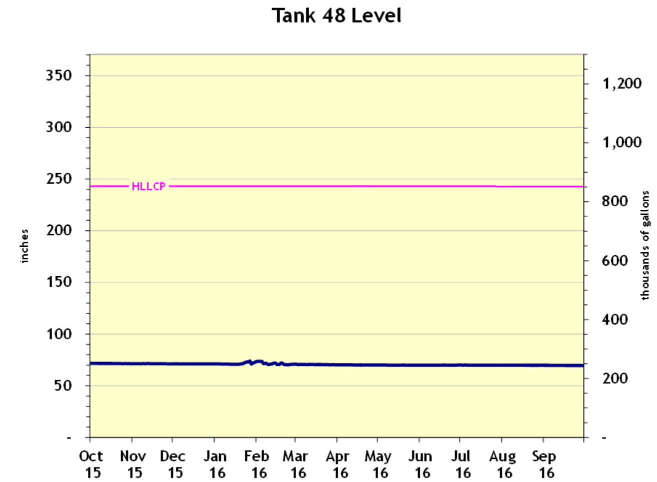


Figure INV-2.48. Tank 48 Volume History, FY2015 through FY2020

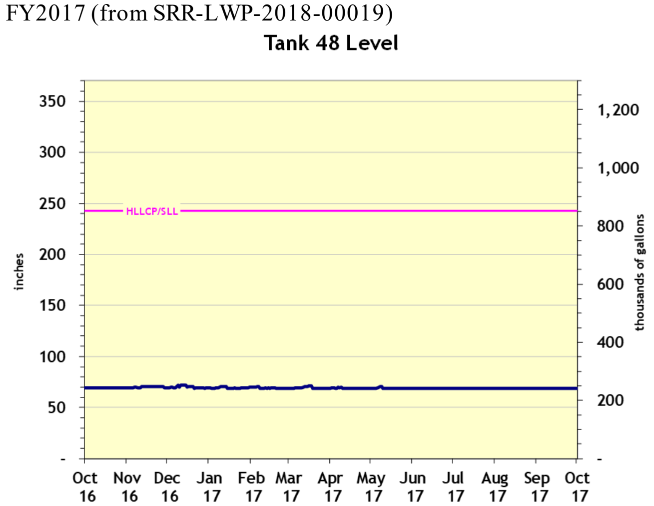
FY2015 (from SRR-LWP-2015-00049)



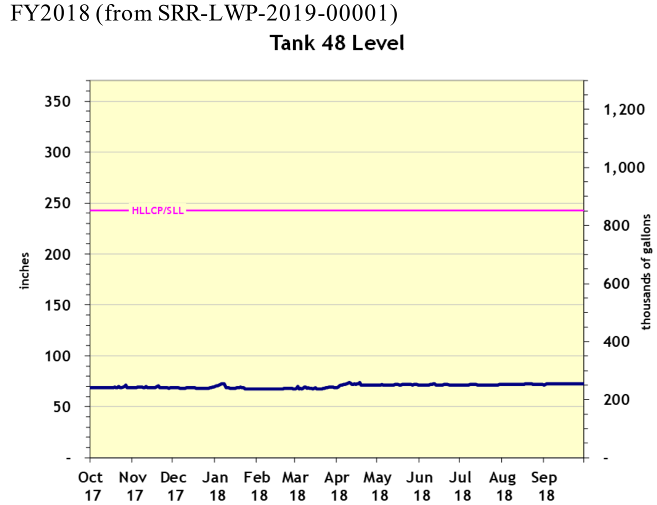
FY2016 (from SRR-LWP-2016-00049)



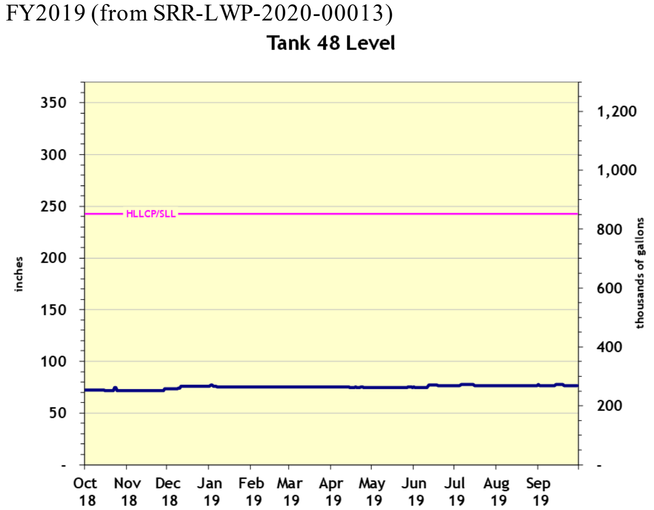
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

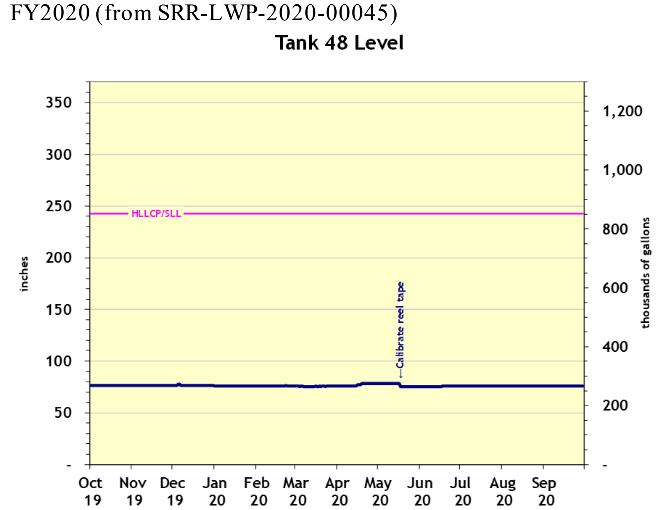


Figure INV-2.49. Tank 49 Volume History, FY2015 through FY2020

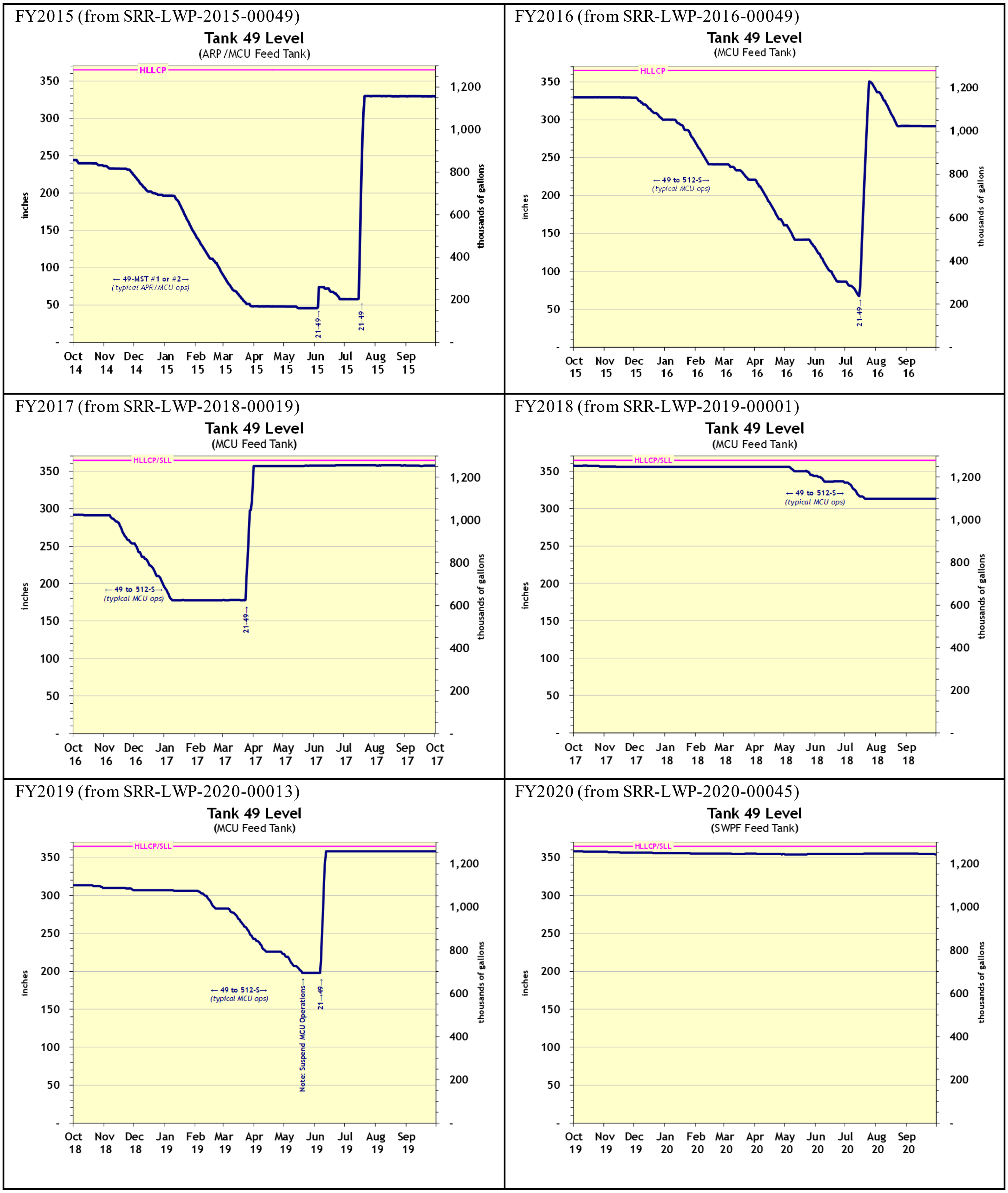


Figure INV-2.50. Tank 50 Volume History, FY2015 through FY2020

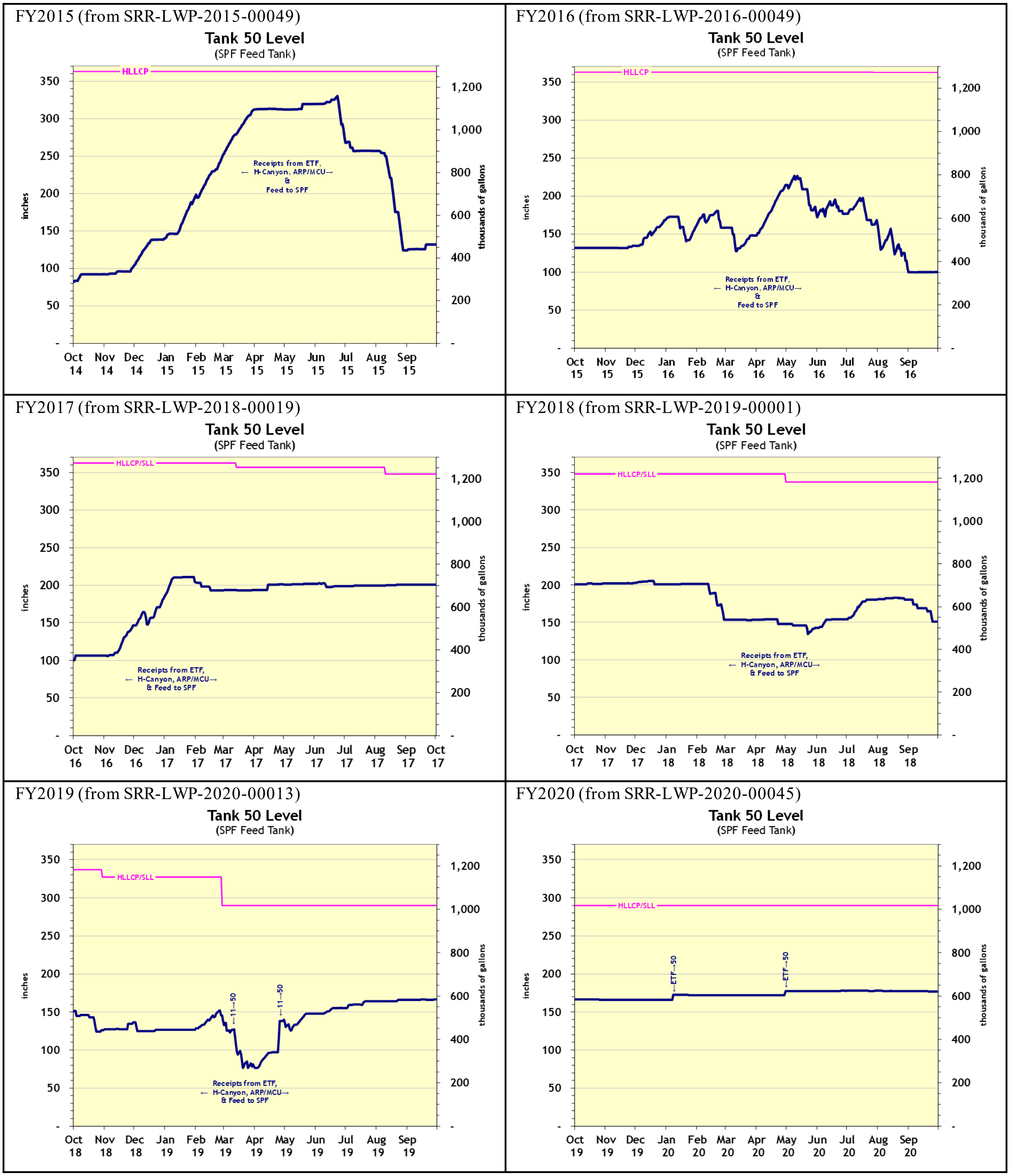
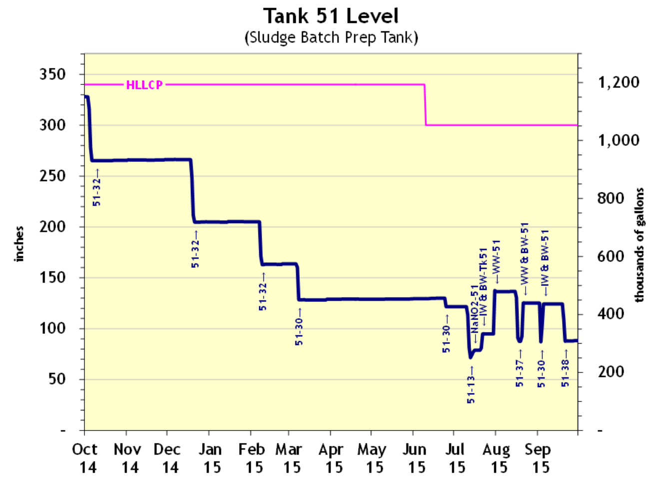
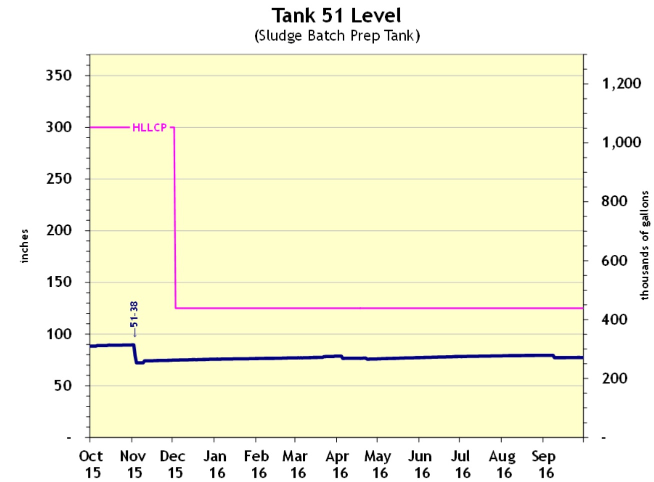


Figure INV-2.51. Tank 51 Volume History, FY2015 through FY2020

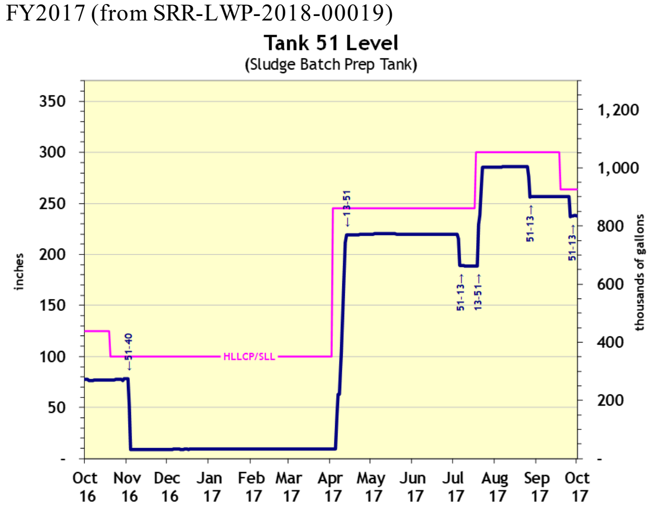
FY2015 (from SRR-LWP-2015-00049)



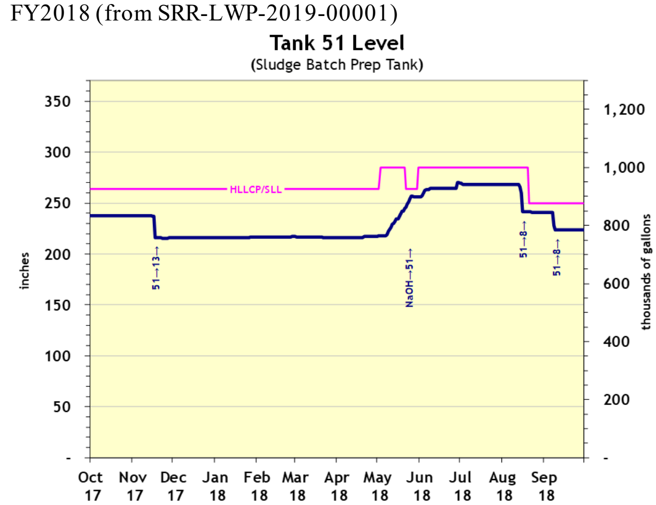
FY2016 (from SRR-LWP-2016-00049)



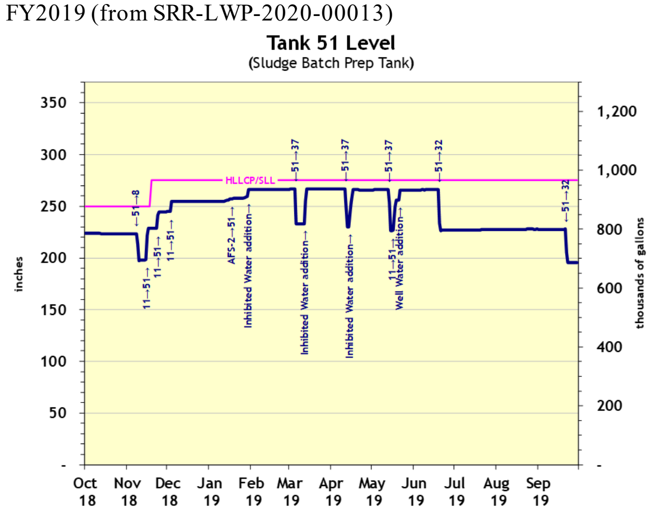
FY2017 (from SRR-LWP-2018-00019)



FY2018 (from SRR-LWP-2019-00001)



FY2019 (from SRR-LWP-2020-00013)



FY2020 (from SRR-LWP-2020-00045)

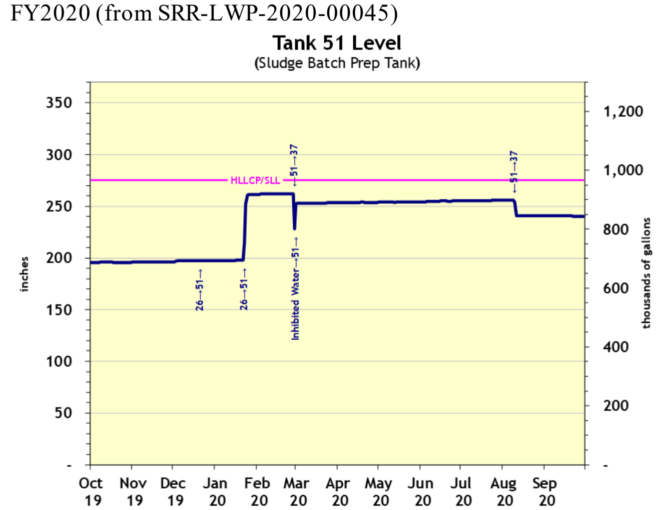


Figure INV-2.52. Cumulative Fresh Waste Receipts for SRS Liquid Waste System

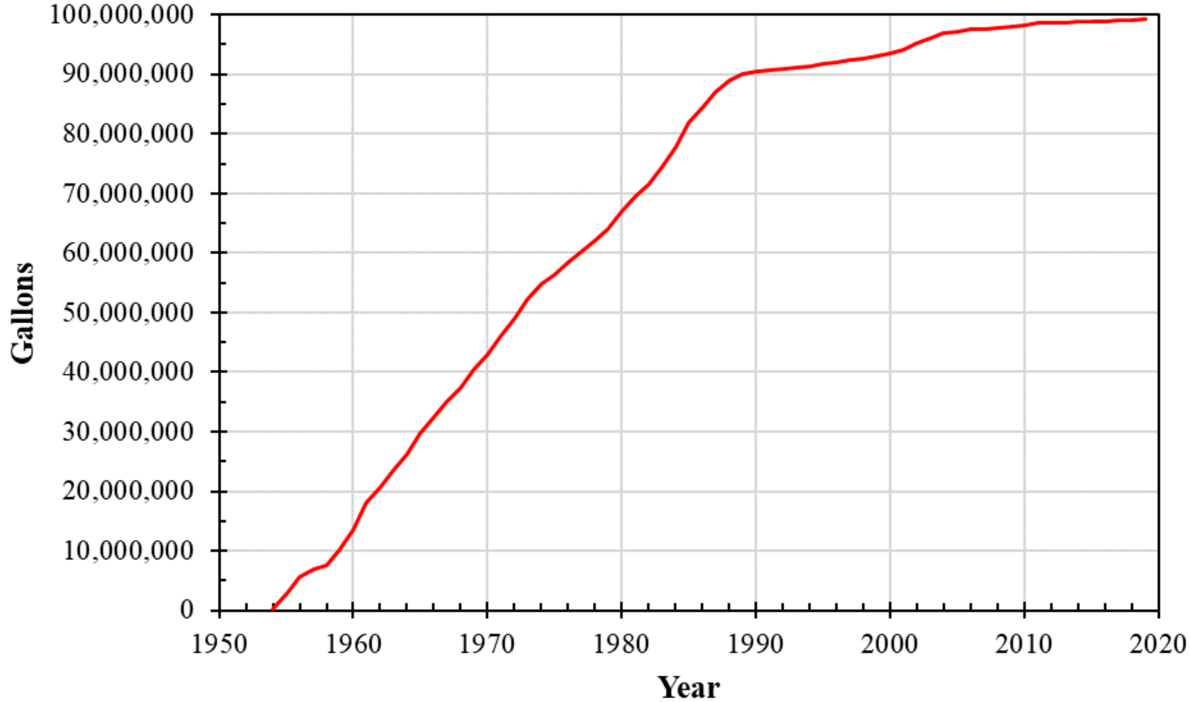


Figure INV-2.53. Annual Fresh Waste Receipts by Waste Generation Process

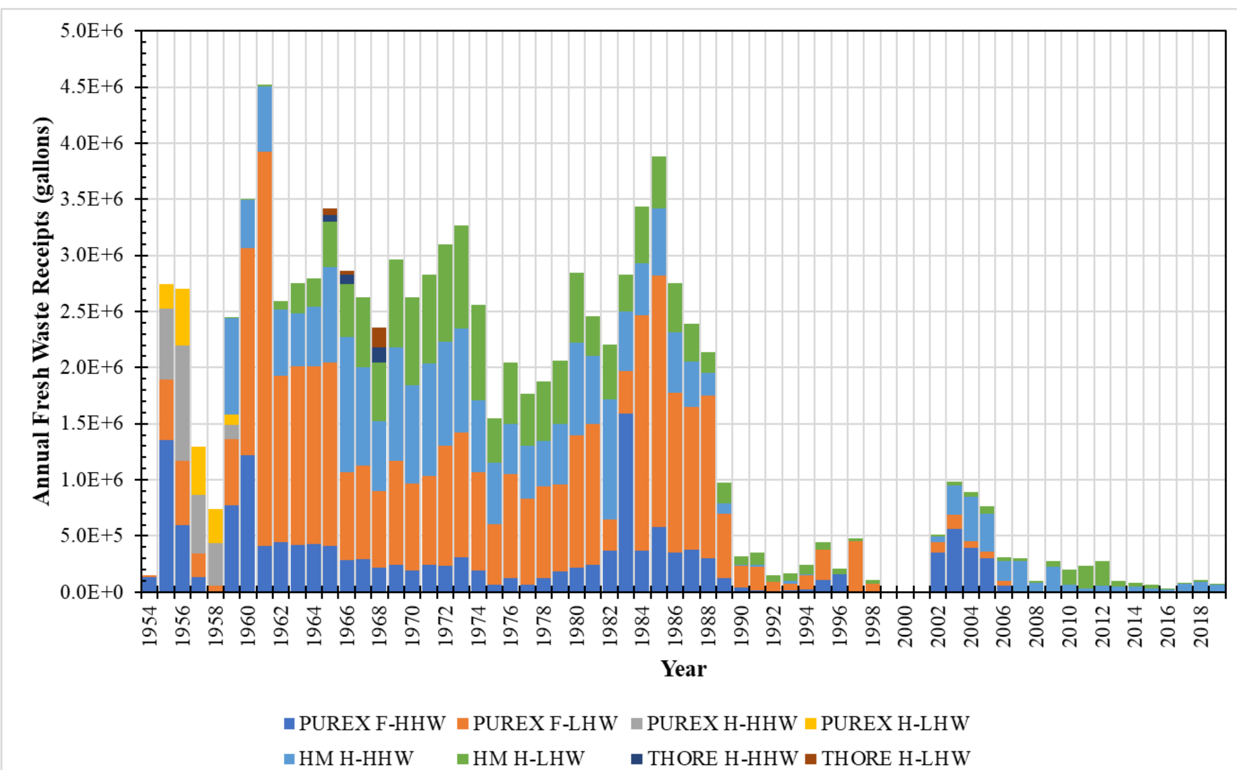
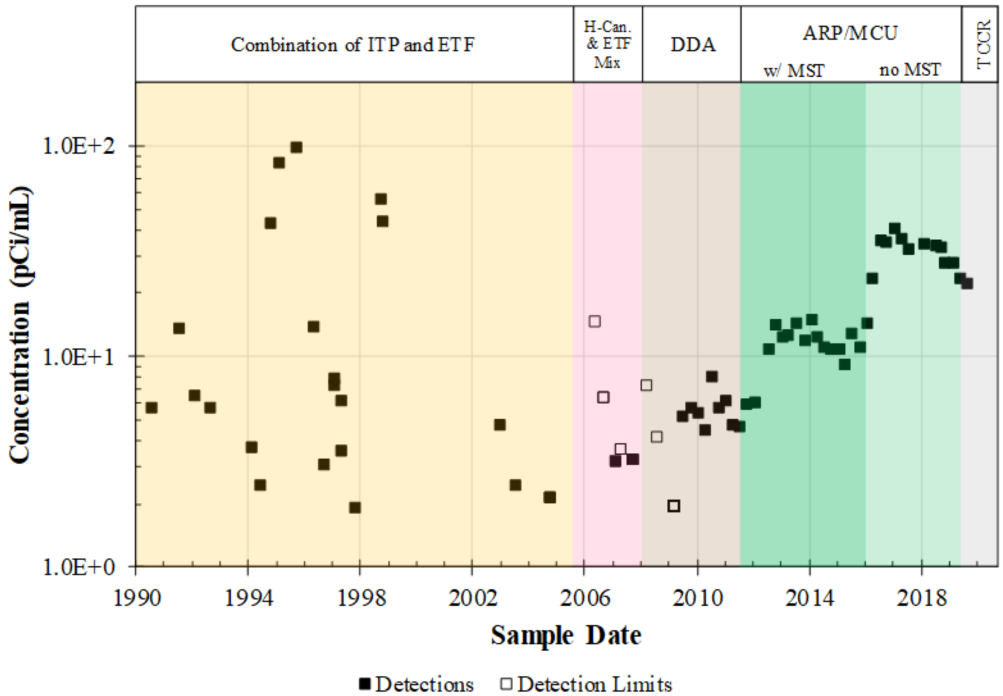


Figure INV-2.54. Tank 50 Activity Concentration for I-129 by Dominant Waste Stream



Notes: Yellow background: ITP and ETF mix, where ITP = In-Tank Precipitation (filtrate waste from the 1983 ITP demonstration project to precipitate waste from Tank 48 (DPSP-83-17-17)) and ETF = Effluent Treatment Facility (waste is comprised of evaporator bottoms from low-level radioactive wastewater).

Pink background: H-Can. and ETF mix, where H-Can. = low-level waste from H-Canyon, including evaporator bottoms from the H-Canyon General Purpose Evaporator, and unirradiated highly enriched uranium (HEU).

Tan background: DDA = Deliquification, Dissolution, and Adjustment (DDA) low-curie salt waste from Tank 41.

Green backgrounds: decontaminated salt solution from ARP/MCU, where the darker green = decontaminated salt solution (DSS) that had used monosodium titanate (MST) to absorb and remove strontium and actinides and lighter green = DSS that had not been processed using MST.

Gray background: TCCR = Tank Closure Cesium Removal DSS from Tank 11.

References for DOE Response to INV-2

SRNL-L3100-2014-00124, Pareizs, J.M., *Analytical Results of Pre-Salt Batch 8 Samples HTF-38-14-6; HTF-38-14-7; HTF-22-14-51, -52, and -53; and FTF-08-14-11*, Savannah River National Laboratory, Aiken, SC, Rev. 0, June 2014.

SRNL-L3100-2016-00221, Fowley, M.D., Bannochie, C.J., and King, W.D., *Summary of Unreported SRNL Iodine Data*, Savannah River National Laboratory, Aiken, SC, Rev. 0, December 2016.

SRNL-STI-2019-00381, Crawford, C.L., *Results for the Second Quarter Calendar Year 2019 Tank 50 Salt Solution Sample*, Savannah River National Laboratory, Aiken, SC, Rev. 0, September 2019.

SRR-CWDA-2014-00003, Olive, J., *SRR Waste Removal and Operational Closure Strategy*, Savannah River Site, Aiken, SC, Rev. 1, January 2021.

SRR-CWDA-2015-00077, *Evaluation of I-129 Concentration Data to Improve Liquid Waste Inventory Projections*, Savannah River Site, Aiken, SC, Rev. 2, February 2018.

SRR-CWDA-2015-00123, *Evaluation of Tc-99 Concentration Data to Improve Liquid Waste Inventory Projections*, Savannah River Site, Aiken, SC, Rev. 2, March 2018.

SRR-CWDA-2018-00041, Dixon, K.D., *Determination of Inventory for FY2019 Performance Assessment Modeling*, Savannah River Site, Aiken, SC, Rev. 3, July 2019.

SRR-LWP-2015-00049, Chew, D.P., *SRR Operations Performance Fiscal Year 2015 Summary*, Savannah River Site, Aiken, SC, Rev. 0, December 2015.

SRR-LWP-2016-00049, Chew, D.P., *SRR Operations Performance Fiscal Year 2016 Summary*, Savannah River Site, Aiken, SC, Rev. 0, December 2016.

SRR-LWP-2018-00019, Chew, D.P., *SRR Operations Performance Fiscal Year 2017 Summary*, Savannah River Site, Aiken, SC, Rev. 0, June 2018.

SRR-LWP-2019-00001, Chew, D.P., *SRR Operations Performance Fiscal Year 2018 Summary*, Savannah River Site, Aiken, SC, Rev. 0, July 2019.

SRR-LWP-2020-00013, Chew, D.P., *SRR Operations Performance Fiscal Year 2019 Summary*, Savannah River Site, Aiken, SC, Rev. 0, February 2020.

SRR-LWP-2020-00045, Chew, D.P., *SRR Operations Performance Fiscal Year 2020 Summary*, Savannah River Site, Aiken, SC, Rev. 1.1, December 2020.

TECHNICAL TOPIC OF INADVERTENT HUMAN INTRUDER (IHI)

IHI-1

<table>
<tr><td rowspan="3">IHI-1</td><td>Question: The NRC staff needs information about the difference between the deterministic projected doses to a chronically exposed IHI as reported in Sections 6.4.1 through 6.4.3 of the 2020 SDF PA and the corresponding deterministic doses projected by the NRC staff with the GoldSim models for the Compliance Case for SDS 9.</td></tr>
<tr><td>Basis: The NRC staff was unable to replicate the deterministic dose projections for the IHI chronic exposure scenario as reported in Sections 6.4.1 through 6.4.3 of the 2020 SDF PA. The NRC staff used the Compliance Case model for SDS 9 in the deterministic mode in the configuration provided by the DOE, except for changing the value of the element “IntruderInventorySwitch.” In that configuration, the GoldSim model is used only as a dose calculator with inputs from the SDF Aquifer Transport Model implemented with the PORFLOW code. The model results and the corresponding dose projections reported in the 2020 SDF PA are provided in Table IHI-1 below. As stated in the notes in the GoldSim model, the values for the inventory switch element are 0 (no drilling source term), 1 (soil-source term), or 2 (disposal structure-source term). The NRC staff understands that the HDPE seam welds are tested in the field during the construction phase. However, the NRC staff is not aware of longer-term tests of these seam welds after the initial testing period.

Table IHI-1: Comparison of the Deterministic Projections of the Peak Doses to an IHI in Different Chronic Exposure Scenarios Reported in the 2020 SDF PA with Doses the NRC staff Generated Using the DOE Compliance Case Model for SDS 9

<table>
<tr><th></th><th>Assumed Time of Intrusion (years after closure)</th><th>Reported in the 2020 SDF PA (mrem/yr)</th><th>Generated by the NRC Staff Using the DOE SDF GoldSim Dose Calculator with PORFLOW inputs (mrem/yr)</th></tr>
<tr><td>No Drilling Source</td><td>100</td><td>1.9</td><td>0</td></tr>
<tr><td>Soil-Source</td><td>100</td><td>2.2</td><td>86</td></tr>
<tr><td>SDS Source</td><td>1,371*</td><td>170</td><td>1,093</td></tr>
</table>

* The value for the degradation of the SDS 9 roof was taken from Table 4.4-45 of the 2020 SDF PA based on the statement in Section 6.4.3 of the 2020 SDF PA that intrusion into a disposal structure was assumed to occur at the conservative estimate of the time of the disposal structure roof degradation.</td></tr>
<tr><td>Path Forward: Provide any additional information related to the deterministic model configuration used to calculate the chronic IHI dose projections reported in Sections 6.4.1 through 6.4.3 of the 2020 SDF PA. Alternatively, provide revised deterministic projections of the peak doses to the IHI in the chronic soil drilling and disposal structure drilling exposure scenarios.</td></tr>
</table>

DOE Response to IHI-1

The NRC will not be able to replicate the IHI results from the SDF GoldSim Model files developed from version v5.051; a newer version is required. As described in Section 7.2.4 of the *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site: Quality Assurance*

Report (SRR-CWDA-2018-00068), an error in the estimated drill cuttings inventory was identified and corrected. As a result, the GoldSim model file *SRS Saltstone v5.051_PF_CaseCV.8.gsm* which was used as the base model to estimate the MOP dose results has incorrect drill-cutting inventories for the IHI modeling scenario. This was corrected in the model files that were used to support the IHI analyses.

Section 3.1 of the *QA*[8] *Addendum to FY2019 SDF PA QA Report, SRR-CWDA-2018-00068* (SRR-CWDA-2019-00046) describes the evolution of the SDF GoldSim model versions. Table 3 of SRR-CWDA-2019-00046 provides the required stipulations or limitations of each version of the SDF GoldSim Model based on the evolution of the model as issues were identified and corrected. From version 5.052 to version 5.053, the drill cutting inventories were developed to apply actual groundwater concentrations (from PORFLOW model results) as the basis for the contaminated soil drill cuttings. From version 5.055 to version 5.056, an error in the *LeachRate* model element used in the dose calculation was corrected.

The GoldSim files[9] used to support the IHI analyses presented in Sections 6.4.1 through 6.4.3 of the SDF PA (SRR-CWDA-2019-00001) shall be provided to the NRC. These files are:

- *SRS Saltstone v5.051_PF_CaseCV.8_SL_Ratio_IHI_SoilDrill_Aa.gsm*[10]
    - Used for estimating the Chronic IHI doses assuming soil drill cuttings
- *SRS Saltstone v5.051_PF_CaseCV.8_SL_Ratioa.gsm*
    - Used for estimating the Chronic IHI doses assuming no soil drill cuttings (groundwater doses only)
- *SRS Saltstone v5.057_PF_CaseCV.9_SL_Ratio_IHI_SDU1_Drill.gsm*
    - Used for estimating the Chronic IHI doses assuming drill cuttings into SDU 1
- *SRS Saltstone v5.057_PF_CaseCV.9_SL_Ratio_IHI_SDU3B_Drill.gsm*
    - Used for estimating the Chronic IHI doses assuming drill cuttings into a 150-foot diameter SDU
- *SRS Saltstone v5.057_PF_CaseCV.9_SL_Ratio_IHI_SDU4_Drill.gsm*
    - Used for estimating the Chronic IHI doses assuming drill cuttings into SDU 4
- *SRS Saltstone v5.057_PF_CaseCV.9_SL_Ratio_IHI_SDU7_Drill.gsm*
    - Used for estimating the Chronic IHI doses assuming drill cuttings into a 375-foot diameter SDU

The associate checking forms will also be provided as these checking forms describe how the files vary from the GoldSim file (*SRS Saltstone v5.051_PF_CaseCV.8.gsm*), which was used to support the MOP Compliance Case.

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[8] QA = Quality Assurance

[9] To access files from zipped directories, the password is: 11111111.

[10] As described in Section 3.1.6 of SRR-CWDA-2019-00046, GoldSim model files that are appended with an "a" at the end of the filename have the required correction to the *LeachRate* model element.

The Excel files *SoilDrillCuttings_rev3.xlsx* and *SDUDrillCuttings_11.26.2019.xlsx* shall also be provided to the NRC as these files were used to develop the soil drill cutting inventory (as shown in Table 6.2-1 of the SDF PA (SRR-CWDA-2019-00001)) from the 1 meter soil concentrations found in the PORFLOW model results and the SDU-specific drill-cutting inventories.

References for DOE Response to IHI-1

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, March 2020.

SRR-CWDA-2018-00068, Watkins, D.R., *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site: Quality Assurance Report*, Savannah River Site, Aiken, SC, Rev. 2, January 2020.

SRR-CWDA-2019-00046, Watkins, D.R., *QA Addendum to FY2019 SDF PA QA Report, SRR-CWDA-2018-00068*, Savannah River Site, Aiken, SC, Rev. 3, March 2020.

IHI-2

IHI-2	**Question:** The NRC staff needs additional information about the radionuclide contributions to the projected chronic dose to an IHI in the deterministic soil drilling scenario.
	Basis: Section 6.4.1 of the 2020 SDF PA, which reports deterministic model results for the IHI, states that "the peak of the Chronic IHI dose from the soil-based drill cuttings is predominantly from Tc-99 and I-129." However, the NRC staff could not replicate that result for the IHI with the GoldSim models for the Compliance Case provided by the DOE run in deterministic mode. The NRC staff used the Compliance Case model for SDS 9 in the deterministic mode in the configuration provided by the DOE, except for changing the value of the element IntruderInventorySwitch" to 1 (i.e., soil drilling source). In that configuration, the GoldSim model is used only as a dose calculator with PORFLOW inputs. In the NRC staff's model runs, the "Dose_IHI_rads" element in the "IHI_1_m_Boundary" container showed the peak projected dose to occur 100 years after SDF closure. The main contributors to that peak were Strontium-90 (Sr-90) (77%), Cesium-137 (Cs-137) (14%), and Tc-99 (5.8%).
	Path Forward: Provide any additional information related to the model configuration used to calculate the deterministic chronic IHI dose projections reported in Section 6.4.1 of the 2020 SDF PA. Alternatively, provide a revised projection of the main radionuclide contributors to the deterministic peak projected dose to the IHI in the chronic soil drilling exposure scenario.

DOE Response to IHI-2

The version of the SDF GoldSim Model used for estimating the MOP dose results is not appropriate to use for estimating the IHI dose results. See the response to IHI-1. The radionuclide dose contributors presented in Section 6.4 of the SDF PA (SRR-CWDA-2019-00001) are consistent with the model results from the model files provided as part of the response to IHI-1.

IHI-3

IHI-3	**Question:** The NRC staff needs additional information about the calculation of the inventory for the IHI soil-source drilling scenario to assess the projected dose to the IHI.
	Basis: Section 6.2.1.1 of the 2020 SDF PA states that the inventory for the soil drill cuttings scenarios (both acute and chronic) is based on groundwater concentrations calculated by the Aquifer Transport model with certain adjustments applied. Section 6.2.1.1 continues, "These assumed ground water concentrations for each radionuclide were then converted into a soil drill cutting inventory based on the total volume of the drill cutting material …". However, additional information is needed to understand how the DOE performed this conversion from the aqueous concentrations to the inventory in the soil. For example, it was not stated whether the soil Kd values in Table 4.3-4 of the 2020 SDF PA were used to convert aqueous concentrations to concentrations sorbed to the soil. If they were not, the inventory of radionuclides with a Kd value greater than 0.625 milliliters per gram (mL/g) (i.e., the reciprocal of a soil density of 1.6 g/mL) could be underestimated because those radionuclides would have more activity per mL of soil than they would per mL of water. Although conservatisms were applied to the water concentrations used (e.g., using the greatest radionuclide concentrations from any location at any time) those conservatisms would not necessarily compensate for the use of aqueous rather than soil concentrations for sorptive radionuclides. For example, the radionuclide with the greatest projected dose to the chronic IHI in the soil drilling scenario as projected by the DOE GoldSim model run in deterministic mode by the NRC staff (see RAI Question IHI-2) is Sr-90. Table 4.3-4 of the 2020 SDF PA shows Sr-90 Kd values ranging from 5 mL/g for vadose zone or sandy soils to 50 mL/g in leachate-impacted clayey soils. Similarly, the greatest projected dose for the acute IHI in the soil drilling case, as projected by the GoldSim model, is from Cs-137. Table 4.3-4 of the 2020 SDF PA shows a Cs-137 Kd ranging from 10 mL/g in vadose zone or sandy soils to 50 mL/g in backfill or clayey soils. For either of those radionuclides (i.e., Sr-90 or Cs-137), the Kd values would imply that significantly more of each radionuclide would be present on the soil column than in an equal volume of water once equilibrium was reached.
	Path Forward: Describe how sorption to soils was accounted for in the soil drill cuttings scenario for the IHI or why it was not necessary to account for sorption to soils. Alternatively, provide a revised dose projection for the acute and chronic IHI in the soil drilling exposure scenario based on a revised inventory that accounts for sorption to soil.

DOE Response to IHI-3

The drill cutting inventories in the SDF PA did not account for sorption onto the soils. The inventories within the drill cutting column were estimated as the product of the IHI ground water concentration and the volume of the drill cutting column. Revised dose projections for the acute and chronic IHI, using the soil drilling exposure scenario, are presented below using a revised inventory that appropriately accounts for sorption to soils.

To update the drill cutting inventory values to account for sorption, the soil drilling inventory values in Table 6.2-1 of the SDF PA (SRR-CWDA-2019-00001) were used as the starting point. The values from this table are recreated here as Table IHI-3.1. These values were developed as the product of assumed ground water concentrations and the total volume of the drill cutting (based on an 8-inch diameter circular hole drilled to a depth of 100 feet).

Table IHI-3.1: Assumed Drill Cutting Inventory for Contaminated Soil, Not Accounting for Soil Sorption

Radionuclide	Inventory (Ci) for Soil Drill Cuttings	Radionuclide	Inventory (Ci) for Soil Drill Cuttings
Ac-227	7.30E-19	Pb-210	4.36E-31
Al-26	3.12E-43	Pt-193	9.32E-40
Am-241	5.36E-44	Pu-238	3.68E-57
Am-242m	3.29E-62	Pu-239	3.70E-38
Am-243	5.47E-44	Pu-240	9.86E-39
C-14	3.68E-24	Pu-241	7.79E-44
Cf-249	1.31E-55	Pu-242	4.45E-39
Cf-251	8.00E-51	Pu-244	1.88E-41
Cl-36	4.78E-09	Ra-226	2.92E-29
Cm-243	3.42E-72	Ra-228	3.78E-45
Cm-244	1.40E-71	Se-79	1.05E-36
Cm-245	5.01E-44	Sm-151	6.38E-62
Cm-247	3.44E-44	Sn-126	1.37E-48
Co-60	2.19E-64	Sr-90	1.40E-39
Cs-135	7.21E-11	Tc-99	4.38E-06
Cs-137	2.76E-30	Th-229	5.15E-20
Eu-152	4.19E-76	Th-230	1.16E-39
Eu-154	1.77E-77	Th-232	1.16E-46
H-3	1.97E-15	U-232	9.41E-61
I-129	3.93E-08	U-233	7.09E-19
K-40	2.17E-10	U-234	1.35E-37
Nb-93m	1.73E-42	U-235	1.48E-39
Nb-94	6.91E-40	U-236	1.41E-39
Ni-63	2.44E-34	U-238	1.25E-39
Np-237	4.78E-15	Zr-93	1.91E-42
Pa-231	2.27E-16		

[Source: SRR-CWDA-2019-00001, Table 6.2-1]

The total volume of material displaced by the IHI is estimated to be approximately 9.88E+05 mL. Assuming that the drill cutting material is comprised of backfill[11], the soils within the drill cuttings have a porosity of 0.35 and a dry bulk density of 1.71 g/cm^3 (per Table 4.3-2 of SRR-CWDA-2019-00001). By assuming that the soils in the drill cuttings are fully saturated, the volume of water in the soil is estimated to be 3.46E+05 mL (9.88E+05 mL × 0.35 = 3.46E+05 mL) and the volume of the backfill soil in the drill cutting is 6.42E+05 mL (9.88E+05 mL – 3.46E+05 mL = 6.42E+05 mL). Then, the mass of the soil in the drill cutting is estimated to be 1.10E+06 g (6.42E+05 mL ×1.71 g/cm^3 × 1 cm^3/mL).

[11] As part of this analysis, three soils were considered: backfill, upper vadose zone soil, and lower vadose zone soil, each with their own porosity and dry bulk density values. It was determined that assuming backfill results in a higher inventory estimate, so backfill was assumed for the entire soil column, even though a portion of the soil column will penetrate into the vadose zone soils.

Next, the curie values from Table IHI-3.1 were divided by the ground water volume from the drill cutting column (3.46E+05 mL). The resulting values are estimated ground water concentrations in Ci/mL. These values are shown in Table IHI-3.2.

Table IHI-3.2: Estimated Ground Water Concentrations in the Drill Cuttings for Contaminated Soil

Radionuclide	Estimated Ground Water Concentration (Ci/mL) for Soil Drill Cuttings	Radionuclide	Estimated Ground Water Concentration (Ci/mL) for Soil Drill Cuttings
Ac-227	2.11E-24	Pb-210	1.26E-36
Al-26	9.02E-49	Pt-193	2.69E-45
Am-241	1.55E-49	Pu-238	1.06E-62
Am-242m	9.50E-68	Pu-239	1.07E-43
Am-243	1.58E-49	Pu-240	2.85E-44
C-14	1.06E-29	Pu-241	2.25E-49
Cf-249	3.80E-61	Pu-242	1.29E-44
Cf-251	2.31E-56	Pu-244	5.43E-47
Cl-36	1.38E-14	Ra-226	8.45E-35
Cm-243	9.88E-78	Ra-228	1.09E-50
Cm-244	4.03E-77	Se-79	3.03E-42
Cm-245	1.45E-49	Sm-151	1.84E-67
Cm-247	9.94E-50	Sn-126	3.96E-54
Co-60	6.34E-70	Sr-90	4.03E-45
Cs-135	2.08E-16	Tc-99	1.27E-11
Cs-137	7.97E-36	Th-229	1.49E-25
Eu-152	1.21E-81	Th-230	3.35E-45
Eu-154	5.11E-83	Th-232	3.35E-52
H-3	5.71E-21	U-232	2.72E-66
I-129	1.14E-13	U-233	2.05E-24
K-40	6.27E-16	U-234	3.89E-43
Nb-93m	4.99E-48	U-235	4.27E-45
Nb-94	2.00E-45	U-236	4.08E-45
Ni-63	7.05E-40	U-238	3.60E-45
Np-237	1.38E-20	Zr-93	5.53E-48
Pa-231	6.56E-22		

Then, to determine the concentration sorbed per solid mass, these ground water concentration estimates were multiplied by the respective distribution coefficient (K_d) values. The values for the soil K_ds come from Table 4.3-4 of SRR-CWDA-2019-00001, reproduced here as Table IHI-3.3. For backfill soils, the appropriate K_ds are the clayey soil K_ds. For greater defensibility, whichever had a higher value between either the clayey soil K_d or the leachate-impacted clayey soil K_d was assumed. The resulting solid mass concentrations are provided in Table IHI-3.4.

Table IHI-3.3: Recommended K_d Values for Soils

Element or Ion	Backfill or Clayey Soils (mL/g)	Leachate-Impacted Clayey Soils (mL/g)	Vadose Zone or Sandy Soils (mL/g)	Leachate-Impacted Sandy Soils (mL/g)
Ac	9,000	10,000	1,000	2,000
Ag	30	100	10	30
Al	1,000	2,000	1,000	2,000
Am	9,000	10,000	1,000	2,000
As	200	300	100	100
B *	0	0	0	0
Ba	100	300	20	50
C	400	2,000	10	50
Cd	30	90	20	50
Cf	9,000	10,000	1,000	2,000
Cl	8	0.8	1	0.1
Cm	9,000	10,000	1,000	2,000
Co	100	300	40	100
Cr	1,000	1,000	400	600
Cs	50	50	10	10
Cu	70	200	50	200
Eu	9,000	10,000	1,000	2,000
F	8	0.8	1	0.1
Fe	400	600	200	300
H	0	0	0	0
Hg	1,000	3,000	800	3,000
I	3	0.3	1	0.1
K	30	30	5	5
Mn	200	300	20	20
Mo	1,000	1,000	1,000	1,000
N	8	0.8	1	0.1
NO_2 *	0	0	0	0
NO_3 *	0	0	0	0
Nb	1,000	1,000	1,000	1,000
Ni	30	100	7	20
Np	9	10	3	5
Pa	9	10	3	5
Pb	5,000	20,000	2,000	6,000
PO_4 *	0	0	0	0
Pt	30	100	7	20
Pu	6,000	10,000	650	1,000
Ra	200	500	30	80
Rn	0	0	0	0
Sb	3,000	4,000	3,000	4,000
Se	1,000	1,000	1,000	1,000
Sm	9,000	10,000	1,000	2,000
Sn	5,000	20,000	2,000	6,000
SO_4 *	0	0	0	0
Sr	20	50	5	20
Tc	1.8	0.2	0.6	0.06
Th	2,000	4,000	900	2,000
U	400	1,000	300	900
Zn	30	90	20	50
Zr	2,000	4,000	900	2,000

[SRR-CWDA-2019-00001, Table 4.3-4]
Note: Values with asterisks (*) assume zero values (i.e., no retardation) in PA modeling.

Table IHI-3.4: Estimated Solid Mass Concentrations in the Drill Cuttings for Contaminated Soil

Radionuclide	Estimated Solid Mass Concentration (Ci/g) for Soil Drill Cuttings
Ac-227	2.11E-20
Al-26	1.80E-45
Am-241	1.55E-45
Am-242m	9.50E-64
Am-243	1.58E-45
C-14	2.13E-26
Cf-249	3.80E-57
Cf-251	2.31E-52
Cl-36	1.11E-13
Cm-243	9.88E-74
Cm-244	4.03E-73
Cm-245	1.45E-45
Cm-247	9.94E-46
Co-60	1.90E-67
Cs-135	1.04E-14
Cs-137	3.99E-34
Eu-152	1.21E-77
Eu-154	5.11E-79
H-3	5.71E-51
I-129	3.41E-13
K-40	1.88E-14
Nb-93m	4.99E-45
Nb-94	2.00E-42
Ni-63	7.05E-38
Np-237	1.38E-19
Pa-231	6.56E-21

Radionuclide	Estimated Ground Water Concentration (Ci/g) for Soil Drill Cuttings
Pb-210	2.52E-32
Pt-193	2.69E-43
Pu-238	1.06E-58
Pu-239	1.07E-39
Pu-240	2.85E-40
Pu-241	2.25E-45
Pu-242	1.29E-40
Pu-244	5.43E-43
Ra-226	4.22E-32
Ra-228	5.47E-48
Se-79	3.03E-39
Sm-151	1.84E-63
Sn-126	7.91E-50
Sr-90	2.02E-43
Tc-99	2.28E-11
Th-229	5.95E-22
Th-230	1.34E-41
Th-232	1.34E-48
U-232	2.72E-63
U-233	2.05E-21
U-234	3.89E-40
U-235	4.27E-42
U-236	4.08E-42
U-238	3.60E-42
Zr-93	2.21E-44

Finally, the values in Table IHI-3.4 were multiplied by the total mass of the soil in the column (1.10E+06 g). The resulting values (Table IHI-3.5) represent the estimated inventory for radionuclides sorbed to the contaminated soils in the drill cuttings.

Table IHI-3.5: Estimated Inventory in the Drill Cuttings for Contaminated Soil, Accounting for Soil Sorption

Radionuclide	Estimated Solid Mass Concentration (Ci) for Soil Drill Cuttings
Ac-227	2.32E-14
Al-26	1.98E-39
Am-241	1.70E-39
Am-242m	1.04E-57
Am-243	1.74E-39
C-14	2.34E-20
Cf-249	4.18E-51
Cf-251	2.54E-46
Cl-36	1.21E-07
Cm-243	1.09E-67
Cm-244	4.43E-67
Cm-245	1.59E-39
Cm-247	1.09E-39
Co-60	2.09E-61
Cs-135	1.14E-08
Cs-137	4.38E-28
Eu-152	1.33E-71
Eu-154	5.62E-73
H-3	6.27E-45
I-129	3.74E-07
K-40	2.07E-08
Nb-93m	5.49E-39
Nb-94	2.20E-36
Ni-63	7.74E-32
Np-237	1.52E-13
Pa-231	7.21E-15

Radionuclide	Estimated Ground Water Concentration (Ci) for Soil Drill Cuttings
Pb-210	2.77E-26
Pt-193	2.96E-37
Pu-238	1.17E-52
Pu-239	1.17E-33
Pu-240	3.13E-34
Pu-241	2.47E-39
Pu-242	1.41E-34
Pu-244	5.96E-37
Ra-226	4.64E-26
Ra-228	6.01E-42
Se-79	3.33E-33
Sm-151	2.03E-57
Sn-126	8.69E-44
Sr-90	2.22E-37
Tc-99	2.51E-05
Th-229	6.54E-16
Th-230	1.47E-35
Th-232	1.47E-42
U-232	2.99E-57
U-233	2.25E-15
U-234	4.27E-34
U-235	4.69E-36
U-236	4.49E-36
U-238	3.96E-36
Zr-93	2.43E-38

This revised estimate for the drill cutting inventory was applied to the SDF GoldSim Model by replacing the values in the GoldSim element: *Drill_Cutting_Inv_Soil* (within the file: *SRS Saltstone v5.051_PF_CaseCV.8_SL_Ratio_IHI_SoilDrill_Aa.gsm*) with the values from Table IHI.3-5. The revised model file (saved with the filename: *SRS Saltstone v5.051_PF_CaseCV.8_SL_Ratio_IHI_SoilDrill_Aa_Solids.gsm*) provides IHI dose results that account for soil sorption.

Figures IHI-3.1 and IHI-3.2 present the Acute IHI dose results and the Chronic IHI at the 1-Meter Well dose results, respectively, along with the equivalent results from the SDF PA (Sections 6.3 and 6.4 of SRR-CWDA-2019-00001) for comparison. As expected, the updated dose results for the Acute IHI and the Chronic IHI at the 1-Meter Well increased due to the increased inventories from the application of soil sorption. Regardless, Figures IHI-3.1 and IHI-3.2 show that even with the increased inventory to account for soil sorption, the estimated IHI dose results are still well below the performance objectives.

Figure IHI-3.1: Comparison of the Acute IHI at the 1-Meter Well Dose Results within 10,000 Years (With and Without Accounting for Soil Sorption)

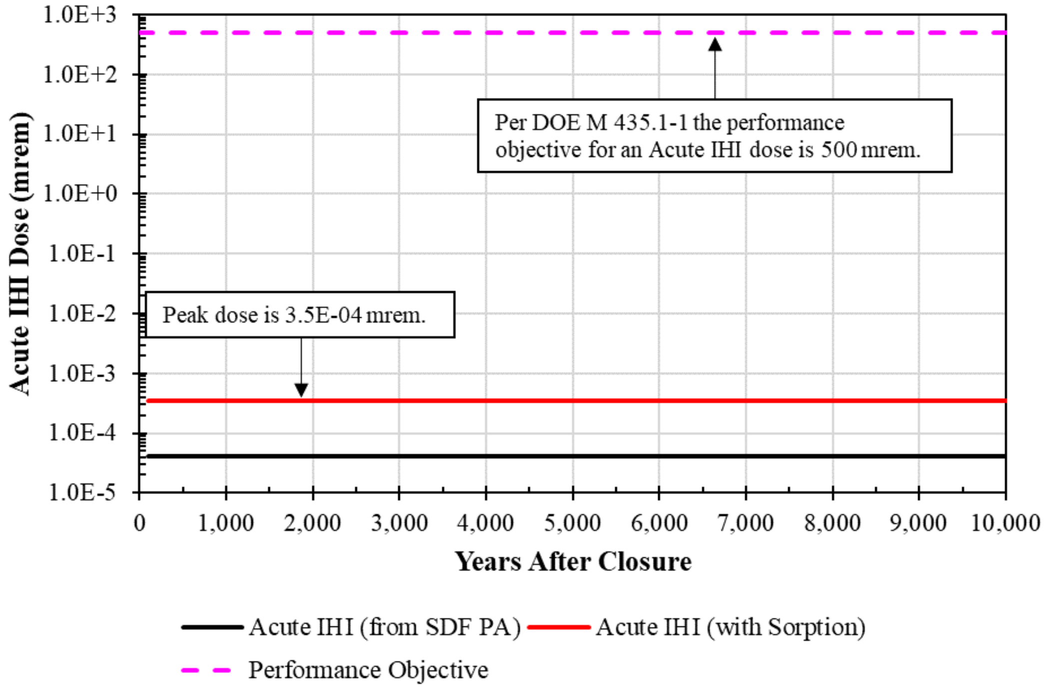
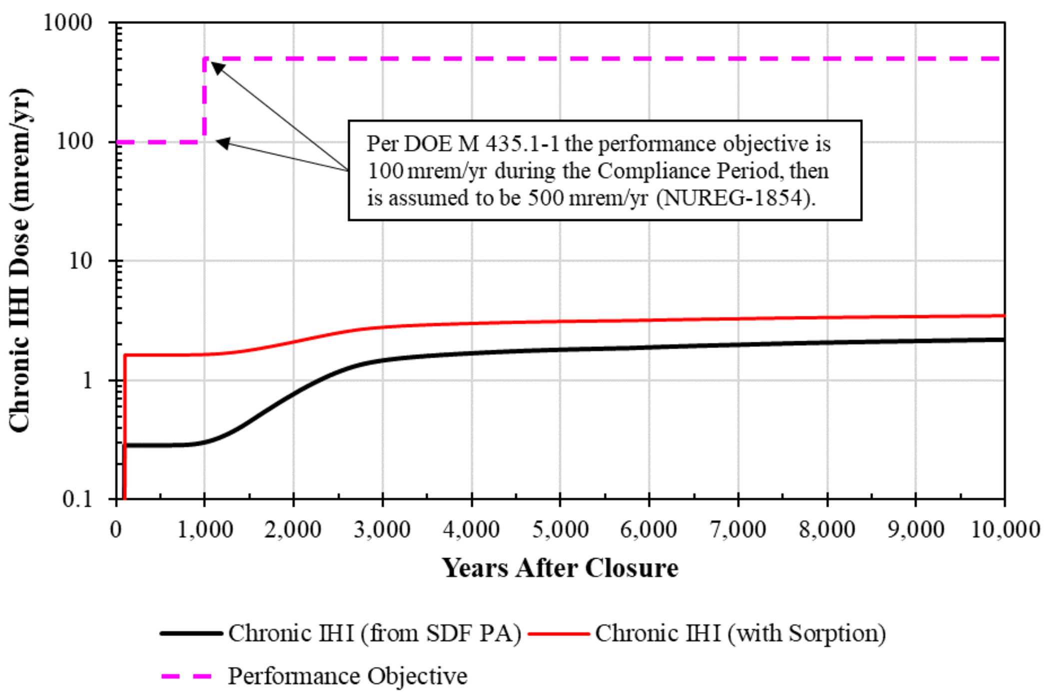


Figure IHI-3.2: Comparison of the Chronic IHI at the 1-Meter Well Dose Results within 10,000 Years (With and Without Accounting for Soil Sorption)



References for the DOE Response to IHI-3

DOE M 435.1-1, Chg. 3, *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington DC, January 2021.

ML072360184, (NUREG-1854), *NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations*, Draft Final Report for Interim Use, U.S. Nuclear Regulatory Commission, Washington, DC, August 2007.

NUREG-1854. See entry for ML072360184.

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, March 2020.

IHI-4

IHI-4	**Question:** The NRC staff needs a technical basis for the most likely garden size and the range of garden sizes used in the probabilistic analysis for the IHI in the chronic exposure scenario.
	Basis: Sections 6.4.1 and 6.4.3 of the 2020 SDF PA state that in both the soil drilling scenario and disposal structure drilling scenario, the main dose pathway to a chronic IHI is the ingestion of contaminated plants grown in a garden onsite. Garden size is reported to be a key parameter influencing the projected dose to an IHI in Section 6.6.1.3 of the 2020 SDF PA. That analysis varied garden sizes between 100 square meters (m^2) (1,080 square feet (ft^2)) and 1,000 m^2 (10,800 ft^2) with a most likely value of 100 m^2 (1,080 ft^2). However, no technical basis was provided for that range. The SDF GoldSim model calculates the fraction of produce that is locally-grown from the crop yields and garden size to ensure that the garden size is consistent with the modeled consumption of local produce. The most likely garden size in the probabilistic model, 100 m^2 (1,080 ft^2), corresponds to a fraction of local produce of 0.266, which is very similar to the mean value of the fraction of local produce consumed for "households who farm," (0.275) as seen in Table 13-68 of the U.S. Environmental Protection Agency (EPA) 2011 Exposure Factors Handbook. Given that the 100 m^2 (1,080 ft^2) garden area corresponds to a central tendency of local produce and that no other basis was presented for the range of garden sizes included in the uncertainty analysis, it is not clear to the NRC staff why the 100 m^2 (1,080 ft^2) garden size is used as the lower bound, rather than the central tendency, of the garden sizes used in the uncertainty analysis. Although the EPA 2011 Exposures Factors Handbook does not provide a distribution for the fraction of produce consumed that is locally-produced, it does provide related information. For example, Table 13-10 in the EPA 2011 Exposures Factors Handbook shows that the 25th percentile value for the mass of locally-produced vegetables for households who garden (all regions) is 41% of the median value. A similar reduction in the fraction of locally-grown produce consumed would correspond to a proportional reduction in garden size in the SDF model because the relationship between the garden size and the fraction of produce that is grown locally is modeled as linear. In an independent analysis conducted with the DOE GoldSim model for the Compliance Case for SDS 9 run in deterministic mode with a soil drilling source, the NRC staff determined that changing the garden size from 100 m^2 (1,080 ft^2) to 41 m^2 (441 ft^2) increased the projected dose to the chronic IHI by 55%.

	Path Forward: Provide a technical basis for the range of garden sizes used in the probabilistic analysis for the chronic IHI dose, including an explanation of how the range of garden sizes tested accounts for the expected variability in the fraction of produce consumed that is locally-produced. Alternatively, provide a technical basis for a revised probability distribution for garden size and a revised dose projection for the IHI in the chronic exposure scenario based on that revised garden size distribution.

DOE Response to IHI-4

Prior to providing the basis for the range of garden sizes used in the probabilistic analysis for the chronic IHI dose, it is important to provide some additional context for how this parameter is used in the SDF PA (SRR-CWDA-2019-00001).

Garden Area Applications in the SDF PA

The garden size parameter is used to define (1) the portion of the total produce consumed annually by the receptors (MOP or IHI) that has been grown locally and is therefore assumed to be contaminated and (2) the amount of dilution that will occur when contaminated drill cuttings (for the IHI) are mixed into the garden wherein the contaminated crops are grown.

The portion of the locally grown (contaminated) produce that is consumed annually is bounded by the total produce consumed annually (both contaminated and non-contaminated). In other words, the amount of contaminated produce that is consumed cannot exceed the total amount of all consumed produce. Table 4.4-110 of the SDF PA (SRR-CWDA-2019-00001) indicates a recommended value of 207 kg/yr for the total annual consumption of produce, with probabilistic multipliers of 0.01 for a minimum value and 4.0 for a maximum value to address uncertainty. Applying these multipliers, the total annual produce consumed may range from 2.07 kg/yr to 828 kg/yr. Therefore, the amount of contaminated produce consumed cannot exceed 828 kg/yr.

However, it is unreasonable to assume that 100% of a person's produce intake is from contaminated sources; some fraction of their produce will be sourced from non-contaminated crops and gardens, such that a local fraction must be determined. For the SDF PA (SRR-CWDA-2019-00001), this fraction was estimated via Eq. 4.4-247 (shown here), which shows that the local fraction is a function of both (1) the garden area and (2) the uptake (consumption or ingestion) of produce:

$$F_{local,PLANT} = \frac{\left(Y_g \times A_{garden}\right)}{U_{PLANT}} \times \frac{1}{\left(N_{fam} \times 1yr\right)}$$

where

$F_{local,PLANT}$ = fraction of consumed produce grown locally (unitless),

Y_g = crop and garden production yield (kg/m^2),

A_{garden} = garden or crop area (m^2),

U_{plant} = human ingestion rate of plants or produce (kg/yr), and

N_{fam} = assumed number of family members = 4.

As indicated, larger garden areas will result in larger local fractions. This is because a larger garden is expected to yield more output, resulting in greater availability of contaminated produce. Alternatively, larger ingestion rates will result in smaller local fractions because the more that is consumed, the more likely it becomes that outside (uncontaminated) sources of produce will be needed to sustain the receptor's appetite for produce.

However, Eq. 4.4-247 does not account for potential correlations between the area of the garden and the uptake of produce. If the receptor does not consume large amounts of produce, they are more likely to grow a smaller garden, or potentially no garden at all. But if the receptor does consume a large amount of produce, they are more likely to grow a larger garden. Accordingly, the two parameters A_{garden} and U_{plant} should be correlated to some degree. Because this relationship has not been quantified, there is no basis for applying such a correlation. Therefore, the probabilistic distributions applied in the SDF GoldSim Model described in the SDF PA (SRR-CWDA-2019-00001) sample these two parameters independently from one another. As a result, when larger garden areas are sampled with smaller ingestion rates, Eq. 4.4-247 can sometimes exceed a value of 1, indicating that the amount of contaminated produce consumed exceeds the total amount of all produce consumed. Section 5.7.3.3 of the SDF PA (SRR-CWDA-2019-00001) justifies this unrealistic result as "a conservatism within the model that may be conceptualized by the MOP choosing to consume additional produce when it is more abundant."

The Environmental Protection Agency's *Exposure Factors Handbook*, Table 13-68, indicates that for households who farm, the fraction of total fruits that are home-produced is 0.161 and the fraction of total vegetables that are home produced is 0.308 (EPA-600-R-090-052F). Weighting these values based on assumed crop yield percentages, the total fraction of produce that is home produced was estimated to be 0.275 (per Section 10.3 of SRR-CWDA-2013-00058). As such, anytime the local fraction estimated via Equation 4.4-247 exceeds 0.275, the value is potentially overestimating the local fraction.

The second application of the garden size parameter is to determine the amount of dilution that will occur as contamination from drill cuttings (for the IHI) are mixed into the garden wherein the contaminated crops are grown. Within the SDF PA (SRR-CWDA-2019-00001), this is applied via Eq. 4.4-212:

$$C_{IHIC,g} = \frac{Act_{max}}{A_{garden} \times d_{till}}$$

where

$C_{IHIC,g}$ = radionuclide concentration in the garden or crop soil from contaminated drill cuttings (pCi/m^3),

Act_{max} = maximum drilled core activity or mass (pCi) defined prior to dose calculation based on the inventory from the source of the contaminated drill cuttings,

A_{garden} = garden or crop area (m^2), and

d_{till} = depth of tilling for agriculture or gardening (m).

With this equation, larger garden sizes result in lower radionuclide concentrations in the garden or crop soil from contaminated drill cuttings. Alternatively, a smaller garden would increase the concentrations. This is because the drill cuttings are assumed to be well mixed so a larger garden would result in the drill cuttings being distributed over a larger area. This application is the source for the concern raised by IHI-4.

Garden Size versus Pasture Size

As a modeling simplification, the SDF PA (SRR-CWDA-2019-00001) assumes that concentrations of contaminants in pastures for raising livestock (fodder) are the same as the concentrations in the garden used for raising produce. However, the area required to support livestock is much larger than 1,000 m^2. For example, the *User's Manual for RESRAD Version 6* (ANL/EAD-4), recommends that an area of 1 hectare (10,000 m^2) is required to graze a single milk cow.

Changes to a pasture area would not affect the local fraction of produce consumed, so increasing the garden size to account for the area of a pasture would void the application of Eq. 4.4-247 and would require an alternative approach for estimating the local fraction. Alternatively, with respect to Eq. 4.4-212, increasing the area to account for the area of a pasture needed for livestock would indicate that the drill cuttings would be distributed over a much larger area, thus reducing the concentrations of the contaminants in the soil. Doing this would reduce the contaminant concentrations by one to two orders of magnitude. As such, the current approach for estimating doses to the IHI is likely conservative.

Basis for the Most Likely Garden Area of 100 m^2

For the SDF PA (SRR-CWDA-2019-00001), 100 m^2 was assumed as the most likely value to be consistent with other SRS performance assessments. Specifically:

- *Performance Assessment for the H-Area Tank Farm at the Savannah River Site* (SRR-CWDA-2010-00128), Table 4.6-8, and
- *Performance Assessment for F-Tank Farm at the Savannah River Site* (SRS-REG-2007-00002), Table 4.6-6, as well as
- The previous 2009 SDF PA (SRR-CWDA-2009-00017), Table 4.6-6.

The basis for this 100 m^2 value in these previous PAs was initially developed in *Baseline Parameter Update for Human Health Input and Transfer Factors for Radiological Performance Assessments at the Savannah River Site* (WSRC-STI-2007-00004), Section 3.4, which states:

The garden size of 100 m^2 for a family of four is assumed in SRS PAs and is based on a site-specific evaluation of consumption needs and annual productivity. It is assumed that a well would not be drilled for a single individual but rather for a household that includes at least two adults… Hamby (1991) estimated that a person within a 50-mile radius of SRS consumes 184 kg of vegetables annually. Section 3.1 discusses the average garden vegetable yield of 0.2 kg/m^2 but recommends the use of the agricultural 0.7 kg/m^2 ... A garden size of 260 m^2 would be required to support the annual consumption of 184 kg of vegetables for a household with two adults assuming all vegetables consumed by the adults are from their garden. Assuming that only 17% of a person's vegetables are from their home garden (EPA 1997) [12], roughly 100 m^2 would be required to feed a family of four. This report recommends use of the 100 m^2 garden size for vegetables only. However, this area is not large enough to graze livestock. Yu et al. (2001)[13] states that an area of 1 ha (10,000 m^2) is required to graze a single milk cow.

As indicated in WSRC-STI-2007-00004, the 100 m^2 value was developed based on interpretation of recommended data from Hamby (1991). Hamby conducted a regional survey of land and water use for the areas surrounding SRS (WSRC-RP-91-17). The survey was distributed to 21 county extension agents in Georgia and South Carolina. From the survey results, the "[a]verage agricultural productivity for farms in the 50-mile region is estimated to be 0.7 kg/m^2. The estimate is the average response from the survey of county extension agents when asked to approximate 'vegetable productivity'. Average garden productivity… [was] approximately 0.2 kg/m^2. The NRC default[14] for garden productivity, however, is an order of magnitude larger. For this reason, garden productivity [was assumed] … to be equal to agricultural productivity." Accordingly, both garden and agricultural yields were assumed to be 0.7 kg/m^2, as shown in Table 2 of Hamby (1991) (WSRC-RP-91-17).

The recommended 0.7 kg/m^2 for agricultural and garden productivity in Hamby (1991) is approximately three times smaller than the 2.2 kg/m^2 for agricultural and garden productivity from the SDF PA (SRR-CWDA-2019-00001, Table 4.4-116). As such, it is appropriate to re-assess the derivation of the garden size, using more current parameter values.

From Table 4.4-110 of the SDF PA (SRR-CWDA-2019-00001), a value of 207 kg/yr was recommended for produce uptake, with an uncertainty multiplier that applies a log-normal distribution that was developed as described in Section 8.1.3 of SRR-CWDA-2013-00058. This log-normal distribution multiplier has minimum and maximum value of 0.01 and 4.0, respectively, such that the corresponding minimum and maximum produce ingestion rates are 2.07 kg/yr and 828 kg/yr.

Assuming a family of four, the recommended 207 kg/yr for produce uptake would require a production rate of 828 kg/yr (207 kg/yr × 4 = 828 kg/yr). With a production yield (or agricultural productivity) of 2.2 kg/m^2, this would require a garden with an area of 376 m^2 (828 kg/yr ÷ 2.2 kg/m^2 = 376 m^2). Using this same approach, the minimum and maximum areas required would be 3.76 m^2 and 1,505 m^2, respectively.

This approach assumes that 100% of ingested produce is locally sourced from the contaminated garden (see Eq. 4.4-247 of the SDF PA [SRR-CWDA-2019-00001, Section 4.4.8.3.7]). As previously mentioned, the total fraction of produce that is home produced was estimated to be 0.275 (per Section 10.3 of SRR-CWDA-2013-00058). Applying this local fraction to the 376 m^2

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[12] EPA 1997, as cited in WSRC-STI-2007-00004 is a reference to EPA/600/P-95/002Fa, which is an earlier version of the Environmental Protection Agency's *Exposure Factors Handbook*.

[13] Yu et al. 2001, as cited in WSRC-STI-2007-00004 is a reference to ANL/EAD-4, which is the *Users Manual for RESRAD Version 6*.

[14] For NRC default parameters, Hamby 1991 (WSRC-RP-91-17) cites: "Regulatory Guide 1.109: Calculation of Annual Dose to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", U.S. Nuclear Regulatory Commission, Revision 1, October 1977. This reference recommends an agricultural productivity yield of 2 kg/m^2.

garden size needed to support a family of 4 at the recommended uptake rate of 207 kg/yr gives a garden size of 103.4 m^2 (376 $m^2 \times 0.275 = 103.4$ m^2), which is very close to the assumed 100 m^2. Given the uncertainties associated with each of the parameters that were used for this estimate, assuming 100 m^2 as the most likely value is still appropriate.

Basis for the Garden Area Range of 100 m^2 to 1,000 m^2

With respect to the aforementioned minimum and maximum area of 3.76 m^2 and 1,505 m^2, if the same total fraction of produce that is locally sourced (0.275) is applied to these extreme values, the ranges for the areas may be estimated as varying from approximately 1 m^2 and 414 m^2, which is a smaller range of values than applied in the SDF PA (per Table 4.4-116). Of course, using the fraction of 0.275 is an oversimplification because the fraction of produce that is locally sourced can, hypothetically, vary from 0 to 1.

Another important factor to consider for this problem is how the garden soil becomes contaminated via drill cuttings for the IHI scenarios. As described in Section 6.2.1.1 of the SDF PA (SRR-CWDA-2019-00001), an IHI well is assumed to be drilled into a 100-foot (30.5 m) deep column of soil that is 8 inches (0.203 m) in diameter. The contaminant concentrations are assumed to be uniform throughout the entire mass of the drill cutting material. These dimensions represent a total drill cutting volume of approximately 0.99 m^3:

$$30.5 \text{ m} \times \pi \times \left(\frac{0.203 \text{ m}}{2}\right)^2 = 0.99 \text{ m}^3$$

Because the contaminated soil is assumed to be mixed into the garden to a depth of 0.15 m (per SRR-CWDA-2019-00001, Table 4.4-116), the bounding minimum area of the contaminated soil is approximately 6.6 m^2 (0.99 $m^3 \div 0.15$ m = 6.6 m^2). This area estimate of 6.6 m^2 assumes that the produce is cultivated from soil that is entirely made up of the drill cutting material (i.e., no mixing with uncontaminated soil). However, it is more reasonable to assume that some degree of dilution will occur as contaminants from the drill cuttings are mixed with the native garden soils (e.g., Equation 2-18 from the *Description of Methodology for Biosphere Dose Model BDOSE* [ML072010081]). For example, Section 2.1.3 of *Intruder Dose Pathway Analysis for Onsite Disposal for Radioactive Waste: The ONSITE/MAXI1 Computer Program* (NUREG/CR-3620) recommends a dilution factor of 0.2 for an agricultural scenario. Applying this recommendation would increase the bounding minimum area from 6.6 m^2 to 33 m^2 (6.6 $m^2 \div 0.2 = 33$ m^2).

The following discusses additional considerations that would increase the minimum area (or decrease the contaminant concentrations of the drill cuttings within the garden area):

- It is reasonable to assume that receptors (MOP or IHI) who consume less overall produce are less likely to grow it at home, such that the fraction of the consumed produce that is locally sourced would likely reach zero before reaching the minimum consumption rate (i.e., 2.07 kg/yr per person). As such, the actual minimum area required would be based on a consumption rate greater than 2.07 kg/yr per person, so the minimum garden area is expected to be some value greater than 33 m^2.
- With smaller areas for cultivation, it also becomes less likely that the plot of land used for cultivation is the same plot of land where the drill cuttings have been distributed. While

this doesn't directly affect the garden area, it affects the probability that the local garden is contaminated.

- Section 6.2.1.1 of the SDF PA states that "As a bounding assumption, the concentrations are assumed to be uniform throughout the entire 100-foot depth and throughout the entire mass of the drill cutting material" (SRR-CWDA-2019-00001). In most cases, the SDF closure cap above the SDUs provides 10 to 20 feet of additional material which would not be contaminated (per Table 7.1-1 of SRR-CWDA-2018-00068).

Given these various considerations and given that the entire mass of the drill cuttings is assumed to be contaminated (which already skews the concentration estimates towards bounding values), the assumption of 100 m^2 for the lower bound for the garden size is reasonable.

Alternatively, for the maximum garden size, some examples of garden areas used in other PA models suggest that much larger areas for gardens may be appropriate to consider:

- The Yucca Mountain PA assumes a garden area of 2,000 m^2 per Section 4.1.2.3 of MDL-MGR-MD-000001;
- A PA for Idaho National Laboratory assumes a garden area of 2,200 m^2 area per Section 5.4.2 of DOE/NE-ID-11243; and
- A Hanford PA assumed 100 m^2 for a garden, 5,000 m^2 for a pasture, and 647,000 m^2 for a commercial farm per Table 5-1 of DOE/ORP-2005-01.

However, applying a distribution with much larger garden sizes for the upper bound of the garden area would significantly reduce the dose contributions from drill cuttings due to the increased dilution as the contaminated drill cuttings are mixed into the garden soil via Eq. 4.4-212 and it would increase the probability of estimating an unrealistic local fraction (i.e., a value greater than 1) when the large garden area is applied to Eq. 4.4-247.

Alternatively, given that assuming a local fraction of 1 yields a garden area of 1,505 m^2 (as discussed above), assuming an upper bound of 1,000 m^2 for the garden area in the SDF PA is reasonably conservative. This means that the range of garden areas applied in the SDF PA may be underestimating the amount of dilution that may occur as the contaminant concentrations in the drill cuttings are mixed into the garden and overestimating the resulting dose contribution to the IHI.

References for the DOE Response to IHI-4

ANL/EAD-4, Yu, C., Zielen, A.J., Cheng, J.J., LePoire, D.J., Gnanapragasam, E., Kamboj, S., Arnish, J.,Wallo, A., Williams, W.A., and Peterson, H., *User's Manual for RESRAD Version 6*, Argonne National Laboratory, Argonne, IL, July, 2001.

DOE/NE-ID-11243, *Performance Assessment for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site*, Idaho National Laboratory, September 2007.

DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Richland, WA, Rev. 0, April 2006.

EPA 1997. See entry for EPA/600/P-95/002Fa.

EPA/600/P-95/002A, *Exposure Factors Handbook Volume I-III*, U.S. Environmental Protection Agency (EPA), Office of Research and Development, Washington, DC, August 1997.

EPA-600-R-090-052F, *Exposure Factors Handbook: 2011 Edition*, U.S. Environmental Protection Agency, Washington DC, September 2011.

Hamby 1991. See entry for WSRC-RP-91-17.

MDL-MGR-MD-000001, Wasiolek, M.A., *Biosphere Model Report*, Sandia National Laboratory, Las Vegas, NV, Rev. 02, August 2007.

ML072010081, Simpkins, A.A., Howard, L.D., LaPlante, P.A., James W. Mancillas, J.W., and Pensado, O., *Description of Methodology for Biosphere Dose Model BDOSE*, Center for Nuclear Waste Regulatory Analyses, San Antonio, TX, July 2007.

NUREG/CR-3620, Napier, B.A., Peloquin, R.A., Kennedy, W.E., and Neuder, S.M., *Intruder Dose Pathway Analysis for Onsite Disposal for Radioactive Waste: The ONSITE/MAXII Computer Program*, PNL-4054, Pacific Northwest Laboratory, Richland Washington, October 1984.

SRR-CWDA-2009-00017, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 0, October 2009.

SRR-CWDA-2010-00128, *Performance Assessment for the H-Area Tank Farm at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 1, November 2012.

SRR-CWDA-2013-00058, Hommel, S.P., *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 2, January 2019.

SRR-CWDA-2018-00068, Watkins, D.R., *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site: Quality Assurance Report*, Savannah River Site, Aiken, SC, Rev. 2, January 2020.

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, March 2020.

SRS-REG-2007-00002, *Performance Assessment for the F-Tank Farm at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 1, March 2010.

WSRC-RP-91-17, Hamby, D.M., *Land and Water Use Characteristics in the Vicinity of the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 0, March 1991.

WSRC-STI-2007-00004, Lee, P.L., et.al., *Baseline Parameter Update for Human Health Input and Transfer Factors for Radiological Performance Assessments at the Savannah River Site*, Savannah River Site, Aiken, SC, Rev. 4, June 2008.

Yu et al. 2001. See entry for ANL/EAD-4.

IHI-5

IHI-5	**Question:** The NRC staff needs information about the impact of an IHI well on infiltration and radionuclide release.
	Basis: Section 4.6.9 of the 2020 SDF PA states that the impact of an IHI well drilled near or into a disposal structure was not considered because the "soil-only closure cap" sensitivity analysis would show the effect. However, the soil-only closure cap sensitivity analysis is not a good indicator of the effect of an IHI well on infiltration and radionuclide release because the soil-only closure cap sensitivity analysis includes performance from an undisturbed lower lateral drainage layer (LLDL) and high-density polyethylene (HDPE)/geosynthetic clay liner (GCL), which would be punctured by an IHI well. Furthermore, a well that intersected a disposal structure would also create a pathway through the disposal structure and puncture the HDPE between the mudmats. Although the NRC staff expects that material deposited in the drainage layer would be clay, the parameter values used by the DOE were that of a backfill, which is considerably sandier than clay. The uncertainty analysis in Section 6.6.3.1 of the 2020 SDF PA identifies infiltration as a key parameter affecting the projected dose for an IHI. Therefore, processes that are expected to affect infiltration, such as penetrating the closure cap, LLDL, and HDPE/GCL layer under the LLDL are expected to affect the projected dose significantly. Disruption of the HDPE between 9 the mudmats also could increase flow from the disposal structures, increasing radionuclide release and thereby increasing the projected dose.
	Path Forward: Provide revised analyses for the projected IHI dose in the chronic soil-source term and disposal structure-source term drilling cases (i.e., Sections 6.4.1 and 6.4.3 of the 2020 SDF PA) that consider the effects of the IHI well on infiltration and radionuclide release.

DOE Response to IHI-5

To be determined. Preparation of this response has been deferred to a future revision of this RAI response document.

TECHNICAL TOPIC OF SITE STABILITY (SS)

SS-1

SS-1	**Question:** The NRC staff needs additional information about how the surface settlement from the 1.5 m (5 ft)-wide soft zones was superimposed to represent a 46 m (150 ft)-wide soft zone.
	Basis: In the DOE document K-CLC-Z-00026, Rev. 0, the DOE discussed that the surface settlement due to soft zones was computed by superimposing the settlement troughs from multiple 1.5 m (5 ft)-wide soft zones to represent soft zones ranging from 7.6 m (25 ft) to 46 m (150 ft). Figure 4 of that document showed that the superimposition of additional segments increases the total surface settlement up to a width of 38 m (125 ft). However, each additional 1.5 m (5 ft)-wide segment appears to result in progressively less surface settlement. This result is counterintuitive to the NRC staff. As the width of the soft zone increases, there is expected to be a decrease in the relative amount of overlying material to fill in the underlying consolidated zone. For example, an infinitely long soft zone would not have any adjacent material in the direction of the soft zone to collapse into the underlying consolidated zone. If the superimposition of soft zone segments results in progressively more settlement, then there could be more surface settlement than assumed in the 2020 SDF PA. This additional settlement could impact the performance of key barriers (e.g., HDPE/GCL, drainage layers) and result in increased infiltration and contaminant release.
	Path Forward: Provide additional information regarding the details of the calculation of settlement using the superimposition of the individual 1.5 m (5 ft)-wide soft zones.

DOE Response to SS-1

To be determined. Preparation of this response has been deferred to a future revision of this RAI response document.

SS-2

SS-2	**Question:** The NRC staff needs additional information about the risk significance of settlement due to compression of the waste bags in SDS 4.
	Basis: In Section 5.8.7.3 of the 2020 SDF PA, the DOE discussed surface settlement due to compression of waste bags in Cells C and I of SDS 4. As documented in the DOE document K-CLC-Z-00028, Rev. 0, the maximum surface settlement of the closure cap could reasonably vary - from 7.6 cm (3 inches) to 38 cm (15 inches), based on the range of assumed compressibility for the waste bags. The DOE then evaluated the impact of potential settlement by considering an alternative conceptual model with an infiltration rate of 26.9 cm/yr (10.6 inches/year) for Cells C and I. This infiltration rate was based on a fully degraded closure cap from the DOE document WSRC-STI-2008-00244, Rev. 0. The modeled dose results from this sensitivity case are shown in Figure 5.8-75 of the 2020 SDF PA. However, the dose results with the increased infiltration for Cells C and I are not intuitive to the NRC staff. Table 4 of SRR-CWDA-2018-00062 shows the assumed inventories for Tc-99 and I-129 for SDS 4. Relative to the other cells in SDS 4, Cells C and I have a reduced inventory of Tc-99; but, an increased inventory of I-129. The NRC staff would expect to see a more significant dose impact due to settlement and increased infiltration into Cells C and I. This result is unexpected because of the importance of infiltration on contaminant release and the magnitude of increase in infiltration in this sensitivity case, which was more than four orders of magnitude more infiltration through the cover. It is not clear if the assumed increase in infiltration through the cover is still being diverted by underlying layers (e.g., HDPE/GCL, LLDL, SDS 4 roof, clean cap grout). If this sensitivity case contains significant diversion of the infiltration, then that would also be unexpected for NRC staff. A conceptual model of surface settlement due to consolidation of underlying plastic bags would appear to be capable of disrupting the overlying hydraulic barriers such as the HDPE/GCL, LLDL, SDS 4 roof, clean cap grout. Accordingly, the reasons for the projected dose impacts due to increased infiltration of water into Cells C and I and the interaction of that water with the radionuclide inventory in those cells is not clear to the NRC staff.
	Path Forward: Provide the PORFLOW Vadose Zone Flow Model files and the Vadose Zone Transport Model files for Sr-90, Tc-99, I-129 and Cs-137 for the sensitivity case described in Section 5.8.7.3. of the 2020 SDF PA. If the model results from this sensitivity case indicate that the majority of the water that is assumed to infiltrate through the closure cap is being diverted by other layers (e.g., HDPE/GCL, LLDL, SDS 4 roof, clean cap grout), then provide a technical basis for why the DOE expects these layers to divert water in light of the assumed settlement. Alternatively, provide an analysis for this sensitivity case with the conceptual model where all the overlying layers are impacted by the settlement due to consolidation of the waste bags.

DOE Response to SS-2

To be determined. Preparation of this response has been deferred to a future revision of this RAI response document.

CLARIFYING COMMENTS (CC)

CC-1

CC-1	**Comment:** Paladium-107 (Pd-107) is included in the inventories in Tables 3.3-5 through 3.3-7 of the 2020 SDF PA; however, it was not included in the SDF GoldSim model. Please explain why Pd-107 was not included in the GoldSim model so that the NRC staff can document the DOE screening process.
	Basis: Not provided.
	Path Forward: Not provided.

DOE Response to CC-1

As identified in the *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site: Quality Assurance Report*, SRR-CWDA-2018-00068, Rev. 2, the SDF PA has two known irregularities that were left uncorrected as they were identified after completion of the major PORFLOW modeling activities and determined to have a minimal impact on the modeled results. One of the irregularities was omission of Pd-107 from SDF PA Modeling due to removal during the screening process. Irregularities identified during the preparation of the SDF PA that resulted in little to no impact to the PA results were not corrected. However, they are captured and described in SRR-CWDA-2018-00068 for quality assurance purposes.

Section 7.1.1 of SRR-CWDA-2018-00068 addresses the omission of Pd-107 from the PORFLOW modeling. In the 2009 SDF PA, Pd-107 was included as a modeled Constituent of Concern. However, for the SDF PA, the screening document inadvertently screened Pd-107 out. The screening for PORFLOW modeling was presented in *Inventory Screening Methodology and Application to the FY2019 Saltstone Disposal Facility (SDF) Performance Assessment (PA) Inventory*, SRR-CWDA-2018-00044, issued in August 2018. Pd-107 was mistakenly screened out in this initial Revision 0 and in the subsequent Revision 1, issued in September 2018. By the time the omission was identified, the majority of the PORFLOW modeling had been started. In October 2018, a Revision 2 to the screening document was issued to capture the Pd-107 omission and a final Revision 3 to the screening document was released in February 2019. Because the PORFLOW modeling had already been initialized prior to discovering the omission, Pd-107 was not included in any of the PORFLOW modeling or the associated GoldSim benchmarking efforts.

Per Table 4.5-3 of SRR-CWDA-2018-00041, the Pd-107 inventory is approximately an order of magnitude lower than that of I-129. Per Table 7.1-1 of SRR-CWDA-2013-00058, the Pd-107 Ingestion Dose Conversion Factor (DCF) (1.4E-07 mrem/pCi) is more than 3 orders of magnitude lower than I-129 (4.0E-04 mrem/pCi). Similarly, the Pd-107 Inhalation DCF (2.3E-06 mrem/pCi) is approximately two orders of magnitude lower than I-129 (1.36E-04 mrem/pCi). For external exposure, there are no DCFs for Pd-107, so there is no external exposure dose contribution. (SRR-CWDA-2018-00068)

Given the lower inventory and lower DCFs, if we conservatively assume that Pd-107 has the same transport properties as I-129, it would be reasonable to expect that the maximum dose contributions from Pd-107 would be at least three to four orders of magnitude lower than that of I-129. Since the peak dose contribution from I-129 (for the Compliance Case) was 2.5E-03 mrem/yr within the Compliance Period and 0.56 mrem/yr within the Performance Period (see Table 5.5-2 of the SDF PA), then the peak dose from Pd-107 would be on the order of 3E-07 mrem/yr and 6E-05 mrem/yr, respectively (assuming equivalent transport properties). However, Pd-107 and I-129 do not have equivalent transport properties; Table 15 of SRNL-STI-2009-00473 shows that the K_ds for Pd-107 in cementitious materials range from 400 mL/g to 5,000 mL/g (depending on the chemical conditions) versus the K_ds for I-129 which never exceed 10 mL/g (see Tables 4.3-5 and 4.3-6 of the SDF PA). This means that the release and transport of Pd-107 would be significantly slower than I-129. Therefore, omitting Pd-107 from the SDF PA has no impact on the results, as any dose contributions from Pd-107 would be negligible. (SRR-CWDA-2018-00068)

References for DOE Response to CC-1

SRNL-STI-2009-00473, Kaplan, D.I., *Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site*, Savannah River National Laboratory, Aiken, SC, Rev. 1, July 2016.

SRR-CWDA-2013-00058, Hommel, S. P., *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 2, January 2019.

SRR-CWDA-2018-00041, Dixon, K.D., *Determination of Inventory for FY2019 Performance Assessment Modeling*, Savannah River Site, Aiken, SC, Rev. 3, July 2019.

SRR-CWDA-2018-00044, *Inventory Screening Methodology and Application to the FY2019 Saltstone Disposal Facility (SDF) Performance Assessment (PA) Inventory*, Savannah River Site, Aiken, SC, Rev. 0, August 2018.

SRR-CWDA-2018-00044, *Inventory Screening Methodology and Application to the FY2019 Saltstone Disposal Facility (SDF) Performance Assessment (PA) Inventory*, Savannah River Site, Aiken, SC, Rev. 1, September 2018.

SRR-CWDA-2018-00044, *Inventory Screening Methodology and Application to the FY2019 Saltstone Disposal Facility (SDF) Performance Assessment (PA) Inventory*, Savannah River Site, Aiken, SC, Rev. 2, October 2018.

SRR-CWDA-2018-00044, *Inventory Screening Methodology and Application to the FY2019 Saltstone Disposal Facility (SDF) Performance Assessment (PA) Inventory*, Savannah River Site, Aiken, SC, Rev. 3, February 2019.

SRR-CWDA-2018-00068, Watkins, D.R., *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site: Quality Assurance Report*, Savannah River Site, Aiken, SC, Rev. 2, January 2020.

CC-2

CC-2	**Comment:** Table 10.3-1 of the 2020 SDF PA provides a value for the parameter *Flocal,FISH* and labels the parameter the "Fraction of households that fish." However, the recommended value of *Flocal,FISH* in Table 10.3-1 (i.e., 0.325) corresponds to the 2011 Exposure Factors Handbook fraction of locally-caught fish consumed for households that fish, which is consistent with how the value is used in the GoldSim model. Please verify the DOE description of the Flocal,FISH parameter.
	Basis: Not provided.
	Path Forward: Not provided.

DOE Response to CC-2

The SDF PA (SRR-CWDA-2019-00001) does not have a Table 10.3-1. However, Table 4.4-118 of the SDF PA does include a parameter for "The fraction of households that fish" ($F_{local,FISH}$) with a value of 0.325. This table comes from Table 10.3-1 of *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site* (SRR-CWDA-2013-00058).

As indicated in CC-2, the value of 0.325 corresponds to the 2011 Exposure Factors Handbook fraction of locally-caught fish consumed for households that fish (EPA-600-R-090-052F, Table 13-68); therefore, the description for this parameter would have been more accurately described as "The fraction of locally-caught fish consumed for households that fish." The application of this parameter (see Eq. 4.4-162 of the SDF PA) is consistent with this revised description.

References for DOE Response to CC-2

EPA-600-R-090-052F, *Exposure Factors Handbook: 2011 Edition*, U.S. Environmental Protection Agency, Washington DC, September 2011.

SRR-CWDA-2013-00058, Hommel, S. P., *Dose Calculation Methodology for Liquid Waste Performance Assessments at the Savannah River Site,* Savannah River Site, Aiken, SC, Rev. 2, January 2019.

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site, Savannah River Site*, Aiken, SC, Rev. 0, March 2020.

CC-3

CC-3	**Comment:** Section 6.2.1.1 of the 2020 SDF PA states that groundwater concentrations used in the soil drilling scenario for the IHI were multiplied by a factor of eight to "ensure greater defensibility" if a well were slightly closer than 1 m from a disposal structure. Please provide the reasoning used in the development of that factor so that the NRC staff can assess the degree of conservatism it introduced.
	Basis: Not provided.
	Path Forward: Not provided.

DOE Response to CC-3

For clarification, the ground water concentrations used for developing the soil drill cutting concentration were multiplied by a factor of 7.79 (in Section 6.2.1.1 of the SDF PA it says a factor of "approximately 8"). The development of this factor is described below.

The location with the highest ground water concentrations between the 1-meter well and each of the IHI wells occurs at the 1-meter well, as indicated by the concentration values presented in Section 6.1 and illustrated by the IHI dose results shown in Figure 6.5-1 of the SDF PA (SRR-CWDA-2019-00001). Based on this, the concentrations from the 1-meter well were selected as the starting points for developing the assumed drill cutting inventories.

Ideally, to ensure the greatest amount of defensibility in the assumed drill cutting concentrations, the peak 1-meter well concentrations from the Pessimistic Case would have been used. However, for the Pessimistic Case, the 1-meter well concentrations were only available for Cl-36, I-129, and Tc-99; whereas, the Compliance Case concentrations at the 1-meter well were available for the full suite of contaminants. Therefore, it was decided to compare the available Pessimistic Case concentrations against the respective Compliance Case concentrations to develop a defensible (and potentially bounding) scaling factor.

Table CC-3.1 shows the peak 1-meter well concentrations for Cl-36, I-129, and Tc-99 from both the Compliance Case results and the Pessimistic Case results. Note that these are the peak values over the entire 20,000-year time period that was simulated and the timings for these peaks vary depending on the radionuclide and the modeling case.

Table CC-3.1. 20,000-Year Peak Ground Water Concentrations for Cl-36, I-129, and Tc-99 at the 1-Meter Well from the Compliance Case and the Pessimistic Case

Radionuclide	Compliance Case Concentration (pCi/L)	Pessimistic Case Concentration (pCi/L)	Ratio (Pessimistic Case / Compliance Case)
Cl-36	0.621	2.89	4.65
I-129	5.11	39.8	7.79
Tc-99	570	1,544	2.71

Based on the comparisons in Table CC-3.1, the largest ratio for the concentrations was estimated to be 7.79 (from I-129). Therefore, this value was selected as a defensible scaling factor. This value was applied as a multiplier on the 1-meter well concentrations for the full suite of contaminants determined from the Compliance Case. Specifically, the peak concentration (from the entire 20,000-year time period) for each radionuclide was multiplied by 7.79 and those values were converted to the Ci based on the 0.988 m^3 volume of the assumed drill cuttings. The calculations and resulting values are provided in the Excel file: *SoilDrillCuttings_rev3.xlsx*, provided as part of the response to IHI-1.

CC-4

CC-4	**Comment:** Section 7.1.7 of the 2020 SDF PA states "The only modeling case that showed IHI doses that exceeded performance objectives relied on unrealistic assumptions and were presented for informational purposes only." The NRC staff could not locate IHI dose projections that exceeded the performance objectives in the 2020 SDF PA. Please direct the NRC staff to the modeling cases being referred to by the DOE.
	Basis: Not provided.
	Path Forward: Not provided.

DOE Response to CC-4

The text in Section 7.1.7 of the SDF PA (SRR-CWDA-2019-00001) states "The only modeling case that showed IHI doses that exceeded performance objectives relied on unrealistic assumptions and were presented for informational purposes only" should have been deleted from the report. It was written as part of an earlier draft of the document and does not reflect the final results of the SDF PA.

For informational purposes, the current revision of the SDF PA (i.e., Revision 0) assumes that the timing at which an IHI may drill through an SDU is limited by the condition of the SDU roof, such that the earliest an intrusion will occur corresponds to the earliest time at which the concrete of the SDU roof could become fully degraded:

- SDU 1 at 683 years,
- SDU 4 at 518 years,
- 150-foot diameter SDUs at 914 years, and
- 375-foot diameter SDUs at 1,371 years.

As a result, these are the years the correspond to the peak doses from each SDU-to-IHI drill cutting scenarios shown in Figure 6.4-4 of the SDF PA (and reproduced here as Figure CC-4.1).

Alternatively, in an earlier draft of the report, it was assumed that the IHI would intrude into the SDU at 500 years after SDF closure, regardless of any other conditions. As a result of this superseded assumption, the earlier draft showed dose results that exceeded the 100 mrem/yr performance objective within 1,000 years, shown here as Figure CC-4.2. However, since this assumption for the timing of intrusion was revised for the final version of the report, the statement in Section 7.1.7 no longer applies.

Figure CC-4.1: Chronic IHI Dose Results within 10,000 Years Based on Assuming Drill Cuttings from Drilling All the Way through an SDU from the SDF PA

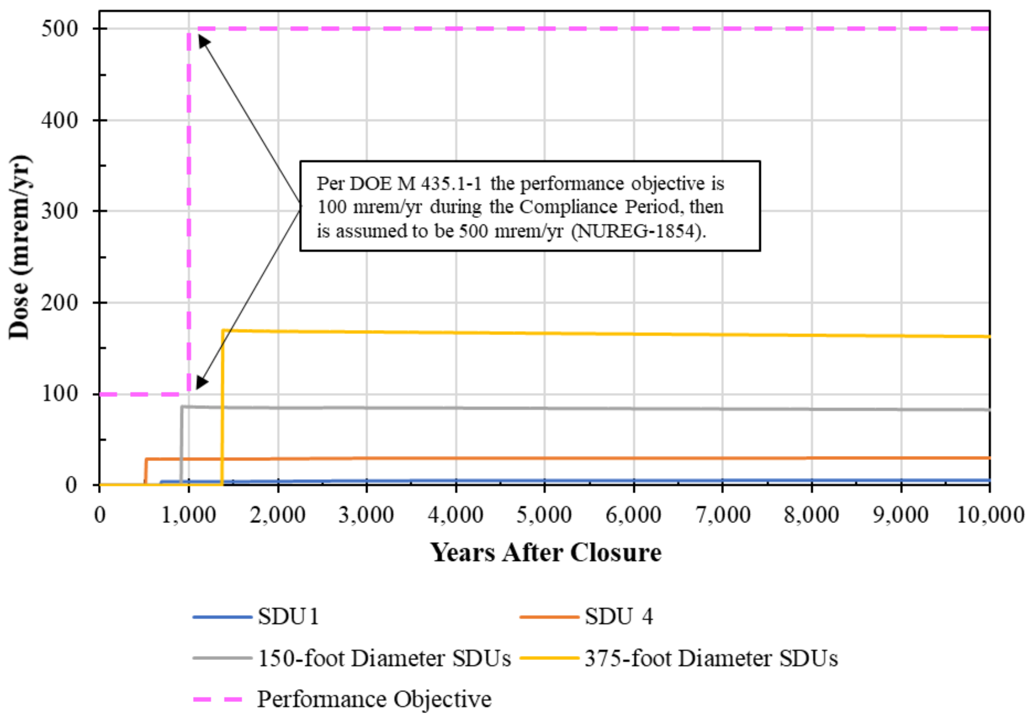
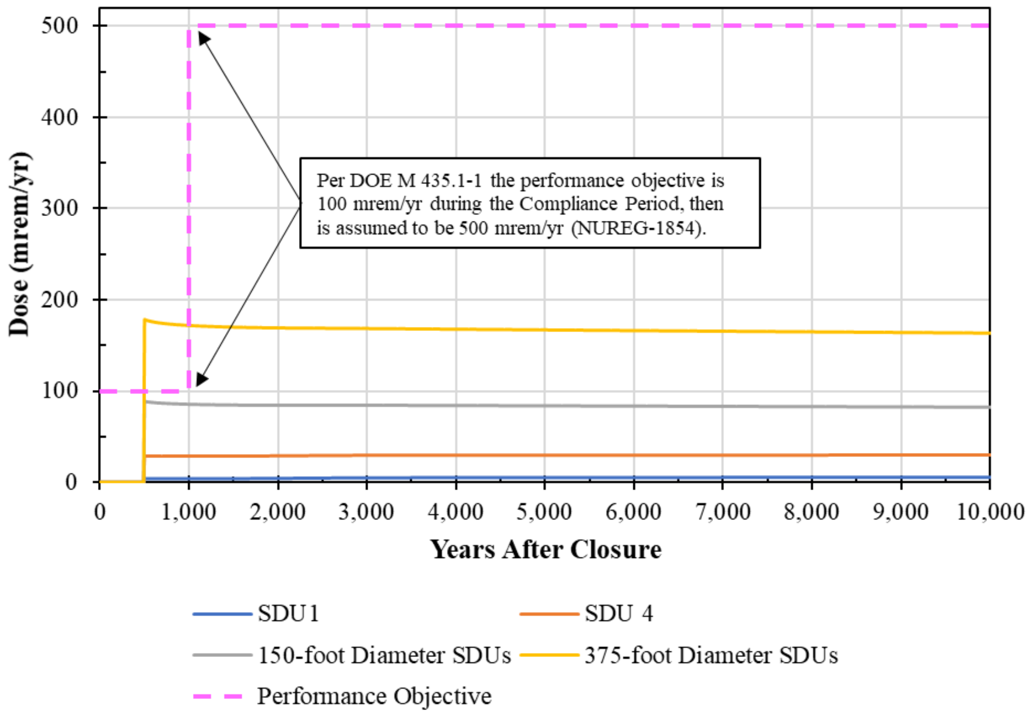


Figure CC-4.2: Chronic IHI Dose Results within 10,000 Years Based on Assuming Drill Cuttings from Drilling All the Way through an SDU at 500 Years



CC-5

CC-5	**Comment:** Settlement data from grouted disposal structures provides information about the stability of SRS Z-Area. Please provide the most recent reports on settlement data for the 46 m (150 ft) diameter disposal structures that have been grouted.
	Basis: Not provided.
	Path Forward: Not provided.

DOE Response to CC-5

To be determined. Preparation of this response has been deferred to a future revision of this RAI response document.

CC-6

CC-6	**Comment:** In the DOE document SRNL-TR-2012-00160, Rev. 0 the DOE discussed that a multi-year soft zone investigation by the Georgia Institute of Technology was underway. Please provide any additional information related to soft zones that was developed since 2012, including any additional insights on the subsurface conditions that can lead to the formation and collapse of soft zones.
	Basis: Not provided.
	Path Forward: Not provided.

DOE Response to CC-6

The Georgia Institute of Technology (GIT) was contracted by the Department of Energy (DOE) from 2009 to 2014 to better understand the formation and geologic evolution of the Santee Formation and to assess the impacts of the resulting physical and mechanical properties for engineering applications and to provide an independent evaluation of the soft zones and their implications at the SRS. The greater portion of this work occurred after the discovery of several, large soft zones and voids during excavation for the power block foundations for two, new-build nuclear reactors at the Vogtle Electric Generation Plant (Plant Vogtle) in the Summer of 2010. The Plant Vogtle site is located directly across the Savannah River from the Savannah River Site and the soft zones and voids occurred within geologic strata that is common to both sites.

The following are five documents dealing with the GIT studies.

K-ESR-G-00023 – S-Area Soft Zone Mapping and Geophysical and Geotechnical Characterization

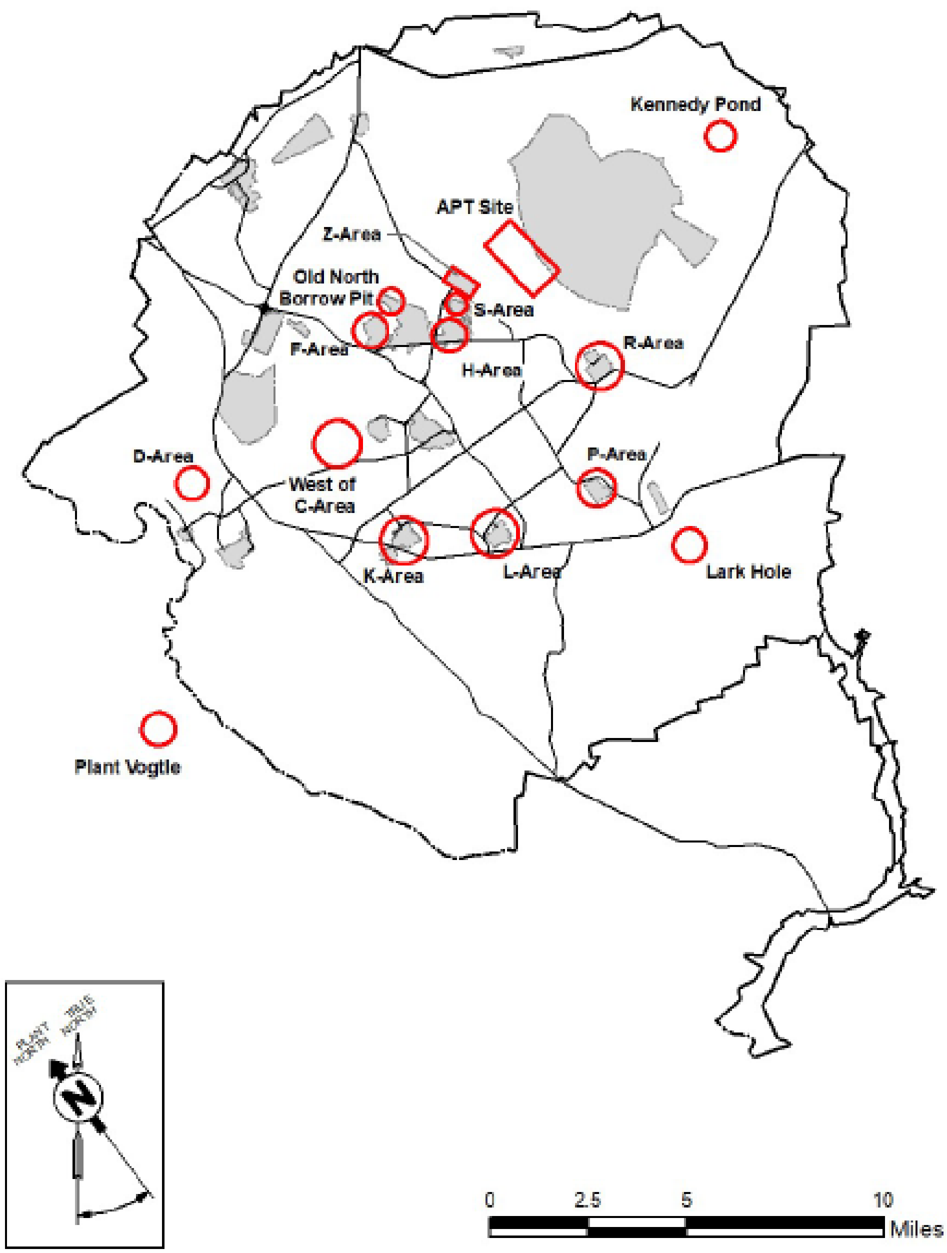
The purpose of this report was to collate and synthesize the results of efforts made during the period from 2010 through 2014 to improve soft zone identification and characterization and to further develop the techniques for mapping the soft zones and characterizing the soft zone infill soil. Extensive field exploration and testing was performed at the SRS with emphasis in the northern section of S-Area at the site of the previously proposed Glass Waste Storage Building #3. Recommendations from a research group at GIT were incorporated into the field study and focused primarily on methods for determining the state of stress within and around the soft zones.

The GIT efforts included analysis of soil samples from the Plant Vogtle site and the SRS, field testing at the SRS, and numerical modeling. Field tests included piezocone penetrometer tests (CPTu) and spectral analysis of surface wave tests (SASW). The results of the effort by GIT are summarized in a separate report (K-TRT-G-00008).

Cone Penetrometer Tests (CPTs) were performed in the F-Area Old North Borrow Pit and in D-Area due to the shallow depth to the Santee Formation and SASW tests were performed by Georgia Tech at the F-Area Old North Borrow Pit, Kennedy Pond, and the former Accelerator Production of Tritium (APT). SASW tests were supported with CPTs. CPTs and boreholes were performed in K-Area to support the siting and design for the Pit Disassembly and Conversion Sand Filter and are summarized in *K-Area PDC Sand Filter Soft Zone Geotechnical Investigation Report*, K-ESR-K-00008, from November 2011.

CPTs and mud rotary wireline coreholes with geophysical logs were performed around the perimeter of Lark Hole, which is a karst sinkhole near the former town of Dunbarton in the southeastern section of the SRS. No exploration or testing was performed within the interior of the sinkhole zone. The locations of the additional investigations are shown in Figure CC-6.1. CPTu data from the additional investigations at the Old North Borrow Pit, D-Area, Kennedy Pond, APT, and Lark Hole are given in Appendix H of K-ESR-G-00023.

Figure CC-6.1: Locations of Soft Zone Investigations Used in K-ESR-G-00023



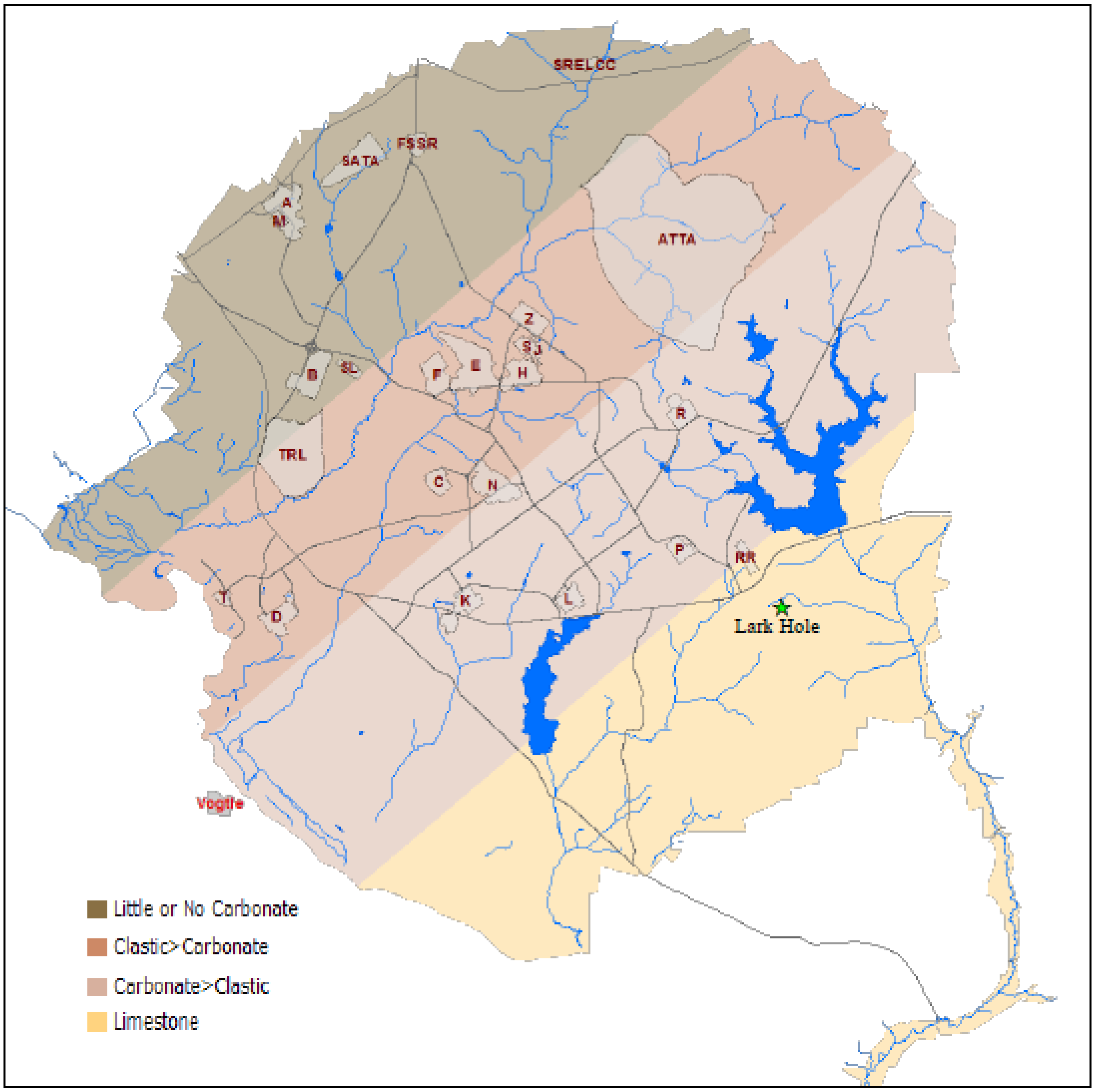
Source: K-ESR-G-00023, Figure 2-3.

K-TRT-G-00008 - Comprehensive Geocharacterization of the Santee Formation and Its Implications for Engineering Behavior

In this work, a series of geotechnical studies were undertaken to better quantify how and why the soil and rock formations within the Santee formed and dissolutioned, to detail the properties and behavior of the Santee formation materials, and to assess how those geologic processes affected and/or altered the conditions of the overlying soil column of interbedded sands and clays above it. The research program involved an integrated approach of experimental, analytical, and numerical components in order to consider a comprehensive understanding of the situation. The investigation: (1) performed a comprehensive assessment of the historical literature and data collected to date from the site, (2) identified unknowns, uncertainties, and/or gaps in the basic laboratory and field data, (3) performed additional lab and field investigations to quantify unknown properties and to give insight into the behavior of the formation materials, and (4) performed numerical and analytical modeling of the proposed design solutions.

According to summaries provided by Dr. Frank Syms of Savannah River Nuclear Solutions (SRNS), carbonates are much less prevalent in the northwestern parts of SRS and increase in the southeasternmost portions of SRS. The General Separations Area, which includes the Saltstone Disposal Facility (Z Area) and the Tank Farms (F and H Areas), is closer hydrostratigraphically to the northwestern portion of the SRS, while Plant Vogtle is hydrostratigraphically in line with the more southerly portions of the SRS (See Figure CC-6.2). The hydrostratigraphic horizon of the Santee Formation is presented in Figure CC-6.2. The figure presents a transitional lithofacies changing from little or no carbonate in the horizon to the northwest and progressing to a limestone-dominated horizon to the southeast. It should be noted that the GSA is located in the zone where clastics dominate over carbonates. However, Plant Vogtle is located hydrostratigraphically down dip from the GSA, in a portion of the Santee where carbonate dominates the horizon over clastics.

Figure CC-6.2: Lithofacies Map of the Upper Santee Formation Deposits Showing Carbonate Dominant Zones Throughout the SRS



Source: K-ESR-G-00023, Figure 2-1

Chong 2014 - The Effect of Subsurface Mass Loss on the Response of Shallow Foundations

In December 2014, Song-Hun Chong of the GIT prepared a thesis on *The Effect of Subsurface Mass Loss on the Response of Shallow Foundations* (Chong 2014). This thesis does not produce additional soft zone field data but instead utilizes existing data from SRS, specifically from the Defense Waste Processing Facility (DWPF), to calibrate his model.

In the report, the finite element numerical simulation environment is used to explore the effect of localized subsurface mass loss on free-surface deformation and shallow foundations settlement and bearing capacity. A stress relaxation module is developed to reproduce the change in stress associated to dissolution features and soft zone formation. The comprehensive parametric study is summarized in terms of dimensionless ratios that can be readily used for engineering applications.

Field settlement data gathered at the SRS are back-analyzed to compare measured values with predictions based on in-situ shear wave velocity and strain-dependent stiffness degradation. The calibrated model is used to estimate additional settlements due to the pre-existing cavities, new cavities, and potential seismic events during the design life of the facility.

The report proposed the following conclusions related to predictions specific to the SRS:

- The SRS subsurface model is calibrated through back analysis of settlement data gathered during the construction of the DWPF at SRS. The initial stiffness adopted for each layer is based on small strain geophysical field measurements.

- Results for the DWPF at SRS show that load-induced settlements overwhelm settlements induced by soft zone formation (before or after) any seismic events.

- The formation of cavities or soft zones either before or after the application of the building load may cause an increase in settlement of less than 10-20% (for the simulated conditions, which disregard cementation and dilation). Thus, the differences in formation history can be disregarded for all practical purposes within the limitations of the hypothetical cases analyzed in this study.

- Seismic loading of the structure sitting on top of the sediment with cavities will cause negligible additional settlement (<5% of settlement caused by the static load). Furthermore, anticipated seismic induced strains are low and no major reduction of stiffness or strength properties would be expected. On the bases of these results, more complex seismic models that take into consideration inertial effects are not necessary at this point and for the purposes of this analysis.

- No cohesion is considered in any of the layers throughout this study. Stable open cavities and tensile fractures observed at the Vogtle site excavation suggest cementation. Adding cohesion to overlying layers would dramatically diminish the impact of soft zones on shallow foundations.

K-ESR-G-00029 – Soft Zone Numerical Modeling Approach

In February 2020, a series of numerical modeling analyses were initiated by SRNS, aimed at quantifying and resolving issues related to the soft zones that underlie portions of the SRS. Based on the results of the characterization efforts presented in K-TRT-G-00008, numerical modeling analyses are being performed to characterize the behavior of the soil mass containing soft zones and voids. The numerical models progress from simple to complex for both the subsurface features and the model (constitutive and failure models). For the simplest case, soft zones and open voids are analyzed with the linear elastic-perfectly plastic constitutive model and the Mohr-Coulomb failure criterion in the effective stress state with static loading. The most complex cases incorporate overlying hard layers with the soft zones and voids. These apply the hyperbolic hardening constitutive model with small-strain stiffness and the Mohr-Coulomb failure criterion with static and dynamic loading. Other analyses use the Modified Cam Clay model and consolidation properties.

Three software packages have been used to numerically model the soil mass behavior with the inclusion of voids and soft zones in the subsurface. ABAQUS software was used by the GIT for two-dimensional analyses included in K-TRT-G-00008. The modeling efforts by SRNS include the use of Sigma/W and Plaxis. Sigma/W is available in a two-dimensional formulation and Plaxis is available in two-dimensional and three-dimensional formulations.

This effort involves three phases of modeling:

- Basic Numerical Modeling
- Intermediate Numerical Modeling
- Advanced Numerical Modeling

Descriptions of the modeling phases are presented in Table 1 of K-ESR-G-00029. As of March 2021, the results of these modeling efforts are not yet complete, but will be forwarded on, as available. Per SRNS personnel, modeling is tentatively scheduled to be completed in mid-2022, with a subsequent report to be issued.

K-ESR-K-00008, K-Area PDC Sand Filter Soft Zone Geotechnical Investigation Report

The purpose of the field investigation was to delineate soft zones beneath the footprints of the proposed sand filter building and associated structures and to determine how well the subsurface stratigraphy compares to that recently discovered at Plant Vogtle, across the Savannah River from the Site. After the delineation of the soft zones, soft zone samples were taken to determine the compressibility parameters in order to estimate settlement resulting from the potential collapse of a soft zone. Results of this testing were inconclusive as viable soft zone samples were unable to be obtained to characterize K-Area soft zones. A copy of this report is included for completeness.

References for DOE Response to CC-6

K-TRT-G-00008, *Comprehensive Geocharacterization of the Santee Formation and Its Implications for Engineering Behavior*, Savannah River Site, Aiken, SC, Rev. 0, June 2015.

K-ESR-G-00023, *S-Area Soft Zone Mapping and Geophysical and Geotechnical Characterization*, Savannah River Site, Aiken, SC, Rev. 0, July 2019.

K-ESR-G-00029, *Soft Zone Numerical Modeling Approach, Savannah River Site*, Aiken, SC, Rev. 0, February 2020.

Chong, S., *The Effect of Subsurface Mass Loss on the Response of Shallow Foundations*, Georgia Institute of Technology, December 2014.

K-ESR-K-00008, *K-Area PDC Sand Filter Soft Zone Geotechnical Investigation Report,* Savannah River Site, Aiken, SC, Rev. A, November 2011.