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MEETING NOTES
Data Quality Objectives for the Waste Management Area A-AX

MEETING NUMBER: WMA-A-AX-DQO-2017-7
MEETING DATE: July 13, 2017
LOCATION: 3100 Port of Benton Blvd, Room 3A
ATTENDEES:

Mike Barnes (Ecology)	Bob Hiergesell (WRPS)	Julie Robertson (Freestone)
Marcel Bergeron (WRPS)	Melissa Holm (WRPS)	Kim Schuyler (Freestone)
Jan Bovier (DOE-ORP)	Scott Luke (WRPS)	Kristin Singleton (WRPS)
Phil Burke (CHPRC)	Jeff Lyon (Ecology)	Marysia Skorska (Ecology)
Joe Caggiano (Ecology)	Jeremy Lynn (CHPRC)	Harold Sydnor (WRPS)
Ryan Childress (Terra Graphics)	Dan Parker (WRPS)	Cindy Tabor (WRPS)
Jim Field (WRPS)	MD Rahman (INTERA)	Robin Varljen (WRPS)
Paul Gassman (WRPS)	Beth Rochette (Ecology)	

BACKGROUND INFORMATION: These meetings are to promote discussions among Washington State Department of Ecology (Ecology), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy Office of River Protection (DOE-ORP), and Washington River Protection Solutions (WRPS) to develop data quality objectives (DQO) for Waste Management Area (WMA) A-AX vadose zone soil. Representatives from the DOE Richland Operations Office (DOE-RL) and the Central Plateau contractor (CH2MHILL Plateau Remediation Contractor [CHPRC]), were invited to participate to promote integration. A DQO process for the same purpose was started in 2011 but was suspended prior to completion in May 2011. Agreements and progress made as part of the 2011 effort will be leveraged in support of the current DQO process.

Lists of agreements and actions (including the status of any actions) are documented in the meeting notes.

PURPOSE OF MEETING: This meeting was called to continue the WMA A-AX vadose zone characterization DQO process initiated in January 2017.

STATUS OF PRIOR MEETING NOTES: Ms. Robertson stated that meeting notes for the May 25, 2017, meeting (Meeting #5) had already been signed, that the meeting notes for the June 15, 2017, meeting (Meeting #6) were being signed at this July 13, 2017, meeting, and that both would be entered into the Administrative Record immediately after this July 13, 2017, meeting.

STEPS 5 AND 6: Ms. Schuyler provided Handout #1 to support the discussion. Ms. Tabor noted that the information provided in the handouts was based on analyzing for constituents as agreed to in the June 15, 2017 meeting with the addition of hexavalent chromium. Ms. Robertson noted that the information also used principal study questions (PSQs) that were tentatively agreed to in a small, interagency working group meeting in early July 2017. The information described proposed lab methods, detection limits, quality control acceptance criteria, and acceptable levels against which chemical and radiological analytical results will be compared. The information also described proposed decision rules and specifications of the estimator for the various PSQs. Regarding Tables 9 and 10, Mr. Barnes stated a preference for using ICP/MS for technetium and also expressed a desire to ensure a method is used that will allow confirmation of technetium exceedances just above the acceptance level.

Four actions were assigned as a result of the discussion (**ACTIONS 2017-07-13-01, 2017-07-13-02, 2017-07-13-03, 2017-07-13-04**)

DEEP VADOSE ZONE PRESENTATION: Mr. Burke gave a presentation on the status of the 200-DV-1 and 200-EA-1 Operable Unit work as it relates to investigations at WMA A-AX (**ACTION 2017-07-13-05**).

REVIEW OF DQO PROCESS DISCUSSIONS TO DATE: Ms. Robertson provided Handout #2, which summarized discussions to date. Ms. Robertson reviewed changes to the handout that had been made since the June 15, 2017, meeting to address concerns and actions discussed at that meeting. The changes were shown in purple on the handout.

- Background Information: A note was added and a paragraph moved to the top of the page to close ACTION 2017-06-15-09. Scope statements were revised for consistency with other information in the handout. The meeting attendees accepted these revisions. Mr. Lyon requested that a bullet be added to the scope statements to clarify that groundwater characterization is outside the scope of this DQO process (**ACTION 2017-07-13-06**), and he noted that this change may result in further discussion.
- Step 1 – Define the Problem: Additional CHPRC personnel were added to the team. The meeting attendees accepted these revisions as shown in Handout #2.
- Step 2 – Identify the Goals of the Study: Text as well as Table 3 were revised to reflect the outcome of a small, interagency working group meeting to close ACTION 2017-05-25-03. The last sentence on page 3 of 11 of Handout #2 was revised at the meeting to state "Data supporting the DQO effort (collected prior to and collected using this DQO process) will be used to develop and refine the conceptual site model" (**ACTION 2017-07-13-07**). The meeting attendees agreed on the contents of Step 2 as modified in this meeting (**Agreement 12 dated July 13, 2017**).
- Step 3 – Data Inputs: Mr. Barnes provided a comment related to Table 5, suggesting that a larger diameter borehole may be required to obtain sufficient information about physical properties of the vadose zone. Ms. Tabor acknowledged the comment and noted that no change was needed to Table 5, which already included methods for placing larger diameter boreholes. The meeting attendees accepted Table 5 as shown in the handout, closing Action 2017-05-25-05 (**Agreement 13 dated July 13, 2017**). Ms. Robertson noted the addition to Handout #2 of a paragraph related to Table 6. Hexavalent chromium is now included on the constituent list, closing ACTION 2017-06-15-04 (**ACTION 2017-07-13-08**).
- Step 4 – Define the Boundaries of the Study: The text was corrected to reflect that samples taken at depths <15 ft bgs support the ecological assessment, closing ACTION 2017-06-15-10. The meeting attendees agreed on the contents of Step 4 (**Agreement 14 dated July 13, 2017**).
- Step 7 – Develop the Plan for Obtaining Data: The text was clarified to state that a duplicate surface sample will be collected at one in four sample locations, closing ACTION 2017-06-15-08.

AGREEMENTS AND ACTIONS: A summary of agreements and actions are provided in the tables below. Several new actions were recorded at this meeting. Mr. Lyon requested clarification of Agreement 4; updated text was agreed upon at this meeting and is reflected in the revised Agreements table below.

NEXT MEETING: The next meeting has been scheduled for July 27, 2017, to discuss Step 7 and review open items related to Steps 2 through 6.

Jan B Bovier	Jan B Bovier	8/7/2017
DOE Project Manager (print)	DOE Project Manager (signature)	Date
Jeffery J. Lyon		8/7/2017
Ecology Project Manager (print)	Ecology Project Manager (signature)	Date

DATE	AGREEMENTS (2 pages)
01/26/2017	1. DOE-ORP acknowledged the need for a Phase 2 RFI at WMA A-AX.
01/26/2017	2. Available tank waste and concrete condition information will be considered for inclusion in the RFI/CMS report(s).
01/26/2017	3. **Problem Statement**: "Vadose zone contamination in and adjacent to the A-AX Tank Farms may pose a current and future risk to human health and the environment, including groundwater, that requires corrective action to support closure."
03/30/17; 07/13/17	4. The DQO will move forward with a modified scope. The DQO Revision 0 will evaluate the Tank 241-A-104/105 focus area. It is agreed that there is a priority to collect additional information from the release areas associated with Tanks 241-A-104 and -105 in order to assess the movement of contamination in the environment. Information from the resulting investigation will inform the development of the model being developed for the 241-A/AX performance assessment.
05/25/17	5. **Boundaries**: The parties agreed to a Tank A-104/105 focus area horizontal boundary as shown on the first page of Handout #1 attached to the 05/25/2017 DQO meeting notes, a vertical boundary extending from ground surface to the groundwater, and a temporal boundary driven by planned retrieval operations.
05/25/17	6. The parties agreed to the **scope, objectives, and DQO approach**: as described in Handout #2 attached to the 05/25/2017 DQO meeting notes.
05/25/17	7. The parties agreed to the **Goal of the study** as described in Handout #2 attached to the 05/25/2017 DQO meeting notes.
06/15/17	8. The parties agreed to use the **list of constituents** contained in Handout #1 attached to the 06/15/2017 meeting notes, except that further discussion is required regarding volatile organics, semi-volatile organics, and hexavalent chromium.
06/15/17	9. The parties agreed to the information in Handout # 2 attached to the 06/15/2017 meeting notes, describing the **basis for identification and setting of acceptable levels for decision and estimation statements**.

06/15/17	10. The parties agreed to the information in Handout # 3 attached to the 06/15/2017 meeting notes, describing the **number of samples** that will be taken. Clarification will be provided regarding duplicate sampling at 25% of surface sample locations.
06/15/17	11. The parties agreed to the Step 4 information on pages 10-12 of Handout # 5 attached to the 06/15/2017 meeting notes, describing the **sampling unit, constraints to sampling/data collection**, and **smallest decision unit**. The second bullet under **Study Boundaries** will be corrected to reflect that samples taken at depths <15 ft bgs also support the ecological assessment.
07/13/17	12. The parties agreed on the contents of **Step 2** as modified in the 07/13/17 meeting (Handout #2).
07/13/17	13. The parties accepted Table 5 (**Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization**) as shown in Handout #2 attached to the 07/13/2017 DQO meeting notes.
07/13/17	14. The parties agreed on the contents of **Step 4** as shown in Handout #2 attached to the 07/13/2017 DQO meeting notes.

ACTIONS (4 pages)			
Action Number	**Actionee**	**Description**	**Status**
2017-03-30-03	Lyon/Bovier	Ecology and DOE-ORP will identify whether there are other potential 241-A/AX focus areas of interest and their level of interest in other focus areas relative to the Tanks A-104/105 focus area.	Open. Ecology identified the areas near Tanks A-103, AX-102, and AX-104 as being of interest.
2017-03-30-04	Tabor	Report back about whether an engineering evaluation has been or could be developed to determine whether temperatures seen in 2014 at direct push boreholes can be explained by thermal heat propagating from Tanks A-104/105.	Closed 07/13/17. Meeting held 06/21/17 to discuss subsurface heat propagation. No further action required.
2017-04-13-02	Bovier/Lyon	Discuss how DQO Step 4, define the boundaries of the study, will be addressed for the whole of WMA A-AX.	Open.
2017-05-25-01	Tabor	Evaluate borehole placement/configuration after getting updated GPR results.	Open. On hold until conduct GPR study.
2017-05-25-02	Levitt	Evaluate whether microgravity is applicable next to tanks and at what distance it might be applicable.	In progress.

ACTIONS (4 pages)			
Action Number	**Actionee**	**Description**	**Status**
2017-05-25-03	Tabor	Review Table 3 of Handout #2, containing the PSQs, alternative actions, and decision/estimation statements, with Skorska (Ecology).	Closed 07/13/17. Meeting held 06/29/17. Agreement reached by email 07/05/17.
2017-05-25-05	Barnes	Ecology review Table 5 of Handout #2 listing potentially appropriate field and analytical methods and provide feedback.	Closed 07/13/17. Email provided 07/07/17.
2017-05-25-06	Tabor	Provide briefing on deep vadose zone project applicability to A-104/105 focus area.	Closed 07/13/17. Completed at 07/13/17 meeting.
2017-06-15-01	Tabor	Add information to the constituent list providing the basis for identification of WMA C **primary constituents**.	Closed 7/13/17. Column B (2nd column) now identifies why constituent was categorized as Primary (letters after P, defined at bottom of table).
2017-06-15-02	Tabor and Field	Revise constituent list to retain **lanthanum, silicon, Ra-226, and thorium 232**. Review and revise as necessary the constituent list "rationale for decision" for these four constituents and for lithium.	Closed 7/13/17. Lanthanum, Silicon, Ra-226, and Th-232 now are identified as "Retain" – Rationale = Retain based on BBI detections. Lithium continues to remain identified as retained. Rationale has an added statement: Not part of tank waste but added as part of tracer for hydrostatic head fluid (as lithium bromide).
2017-06-15-03	Tabor	Modify constituent list to retain **thorium metal**.	Closed 7/13/17. Thorium is now identified as "Retain" – Rationale = Retain to review isotopic thorium.
2017-06-15-04	Tabor	Report back with information to support developing an agreement regarding whether analysis for **hexavalent chromium** should be conducted in addition to total chromium.	Closed 7/13/17. Hexavalent chromium is now identified as "Retain" (Can be Analyzed rather than Estimated from Total Chromium) and Rationale = Constituent of interest due to toxicity. The holding time for soil samples is 30 days from collection to analysis.

ACTIONS (4 pages)			
Action Number	**Actionee**	**Description**	**Status**
2017-06-15-05	Tabor	Report back regarding whether **cyanide analysis** looked for free CN vs. total CN at WMA C.	Closed 7/13/17. 222-S analyzes for total cyanide not free cyanide or ferrocyanide (No change to table).
2017-06-15-06	Lyon	Ecology review basis for retaining or eliminating **volatile organics** and **semi-volatile organics** in preparation for further discussion with DOE and WRPS.	Open.
2017-06-15-07	Tabor	Review groundwater monitoring plan addressing the requirements of the Atomic Energy Act (**DOE/RL-2015-56**) and reference in the constituent table.	Closed 7/13/17. Column D (fourth) now also provides radiological constituents analyzed for groundwater monitoring.
2017-06-15-08	Tabor	In Handout # 3 attached to the 06/15/2017 meeting notes, clarify that a duplicate sample will be obtained at 25% of surface sample locations.	Closed 07/13/17 as shown on page 11 of Handout #2.
2017-06-15-09	Robertson	The existing **DQO Process text** at the bottom of page 1 of Handout #5 attached to the meeting notes from 06/15/17 will be moved to the top of the page, before the DQO scope and objectives.	Closed 07/13/17 as shown on page 1 of Handout #2.
2017-06-15-10	Tabor	On page 10 of Handout #5 attached to the meeting notes from 06/15/17, correct the second bullet under **Study Boundaries** to reflect that samples taken at depths <15 ft bgs also support the ecological assessment.	Closed 07/13/17 as shown on page 8 of Handout #2.
2017-07-13-01	Rahman	Investigate whether there is an unrestricted level for lead that should be included in Table 8.	New.
2017-07-13-02	Rochette and Barnes	Review Tables 8, 9, and 10 and provide feedback regarding "acceptable levels" by 07/24/17.	New.
2017-07-13-03	Gassman	Work with lab to identify an achievable detection limit for hexavalent chromium.	New.

ACTIONS (4 pages)			
Action Number	**Actionee**	**Description**	**Status**
2017-07-13-04	Bergeron	Review proposal to delete Decision Rule 1 (Table 11/Step 5) language regarding use of maximum concentration or use of 95% UCL.	New.
2017-07-13-05	Tabor	Provide figures from EA-1 identifying where data is being gathered near WMA A-AX.	New.
2017-07-13-06	Robertson	Add bullet on page 1 of Handout #2 (scope) to clarify that groundwater characterization is outside the scope of this DQO process	New.
2017-07-13-07	Robertson	Change last sentence on page 3 of 11 of Handout #2 to state "Data supporting the DQO effort (collected prior to and collected using this DQO process) will be used to develop and refine the conceptual site model."	New.
2017-07-13-08	Robertson	Update last sentence on page 7 of 11 of Handout #2 to delete hexavalent chromium.	New.

Handout #1
Steps 5 and 6

STEP 5 – DECISION RULES

For decision problems, this step develops a decision rule which defines the actions to be taken as a result of exceeding an action limit. For estimation problems, this step develops the 'specification of the estimator' which specifies the estimator (parameter being estimated) and the scale of estimation (population boundary).

Per EPA QA/G-4, the major outputs of this step are:

- *Specify the population* ***parameter*** *(e.g., mean, median, percentile) considered to be important to make inferences about the target population.*
- *For decision problems, choose an* ***Action Level*** *(using information identified in Step 3) that sets the boundary between one outcome of the decision process and an alternative, and verify that there exist sampling and analysis methods that have detection limits below the Action Level.*
- *Construct the theoretical "if...then..."* ***decision rule*** *by combining the true value of the selected population parameter; the Action level, the scale of decision making (Step 4), and the alternative actions or develop the* ***specification of the estimator*** *which specifies the estimator and the scale of estimation.*

Step 5 identifies the information necessary to determine if corrective measures are required, or if conceptual site model need to be revised.

- Acceptable levels are risk-based standards established to meet requirements or agreements identified in Step 3, Table 4.
- Decision rule for PSQ# 1 will use acceptable levels to decide if evaluation of corrective measures is required.
- Acceptable levels do not apply to evaluations identified in ES#2, ES#3 or ES#4. The estimator will provide key information and assumptions necessary to obtain data needed to make these evaluations.
- Data obtained as a result of each PSQ may be used to support the evaluation of other PSQs.

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Table 11. Decision Rules and Specification of the Estimator

Step 2		Step 5
Principal Study Question	**Decision/Estimation Statement (DS/ES)**	**Decision Rule/Specification of the Estimator (DR/E)**
#1— Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	**#DS 1** — Determine whether contamination exceeds acceptable levels and, therefore, whether there is a need to evaluate corrective measures.	**#DR 1** IF concentrations for individual constituents exceed acceptable levels identified in Tables 8, 9 or 10, based on maximum concentration or 95% upper confidence limit (UCL), as appropriate, THEN evaluation of corrective measures is required, otherwise corrective measures are not necessary.
#2 – Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	**#ES 2** – The chemical/physical properties of A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. It is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil.	**#E2** The best measurement of chemical and physical properties in WMA A-AX vadose zone soil (Table 4) that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated.
#3 – Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	**#ES 3** – The chemical/physical properties of A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. It is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil.	**#E3** The best available measurements of chemical and physical properties in WMA A-AX tank waste (Table 4) that can impact contaminant movement through the soil will be estimated, and their impact on contaminant movement through the soil will be evaluated.
#4 – Is information available to define whether, and where, tank waste passed through WMA A-AX vadose zone soil and, therefore, could exist elsewhere in the environment?	**#ES 4** – Chemicals and radionuclides in tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated. It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through the soil at the location and so could exist elsewhere in the environment. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through the soil at the location.	**#E4A** The concentrations of naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment will be estimated to evaluate where waste may have passed through the soil and so could exist elsewhere in the environment. **#E4B** The concentrations in vadose zone soil of chemicals and radionuclides that can act as tank waste markers will be estimated to evaluate where waste may have passed through the soil and so could exist elsewhere in the environment.

6 – SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

Step 6 examines consequences of making incorrect decisions, and places acceptable limits on the likelihood of making decision errors.

Per EPA QA/G-4, the primary output of Step 6 is:

Performance criteria (performance metric) that the decision rule or specification of the estimator will specify and that collected data should achieve to minimize decision error and to keep estimate uncertainty within acceptable levels.

- The maximum detected concentrations will initially be used for comparison to acceptable levels to identify constituents of interest. For constituents of interest, to account for data uncertainty, analytical results are compared to the acceptable level at 95% UCL (and background for comparison purposes) to determine if action is necessary.
- Performance or acceptance criteria identified in Step 6 normally help determine sampling and analysis design, but because sampling will be judgmental and not use the probabilistic approach, Step 6 criteria have minimal impact on sample design.
- Where available, the 95% UCL is also used as the basis for the data used to support other processes such as modeling.
- Where this DQO provides sample data for technical evaluations and not for direct comparison to action levels, acceptance criteria for statistical uncertainty are not necessary.

Table 12 shows the tolerable limits on decision error based on the predicted consequences of making an incorrect decision. Data used for decision making are subject to various types of errors arising from how samples were collected or how measurements were made. Therefore, there is a chance that an erroneous decision will be made based on the collected data or that uncertainty in estimate is unacceptable.

Table 12. Tolerable Limits on Decision Errors

Action	Possible Decision Error	Severity of Consequences of Decision Error				Decision Error that has More Severe Consequences
		Far Below the Acceptable Level	Below but Near the Acceptable Level	Above but Near the Acceptable Level	Far Above the Acceptable Level	
Conduct corrective action	Remediate an uncontaminated site	Severe	Moderate	None	None	Not remediating a contaminated site
No corrective measure required	Failing to remediate a contaminated site	None	None	Moderate	Severe	

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i,j]		
											Accuracy		Precision
		Direct Contact, WAC 173-340-740 Method B Unrestricted RBL[b]	Direct Contact, WAC 173-340-745 Method C Industrial RBL[c]	Outdoor Worker RBL[d]	Ecological Protection[e] ≤15 ft	Groundwater Protection[f]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Metals													
Aluminum	7429-90-5	8.00E+04	3.50E+06	1.30E+06	3,988[k]	4.80E+05	1.18E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	2.75	80-120	75-125	≤30
Antimony	7440-36-0	32	1,400	519	92	5.4	130	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.13[q]	80-120	75-125	≤30
Arsenic	7440-38-2	0.67	87.5	20[l]	127	0.034	20	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.2	80-120	75-125	≤30
Barium	7440-39-3	1.60E+04	7.00E+05	2.59E+05	358	1,648	132	6010 ICP/AES (acid)	6020 ICP/MS (acid)	10.2	80-120	75-125	≤30
Beryllium	7440-41-7	160	7,000	259.5	10	63.2	1.51	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.5	80-120	75-125	≤30
Bismuth	7440-69-9	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	25.8	80-120	75-125	≤30
Boron	7440-42-8	1.60E+04	7.00E+05	2.60E+05	28.6	205	3.89	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6	80-120	75-125	≤30
Cadmium	7440-43-9	80	3,500	1,110	9.8	0.69	0.563	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.02	80-120	75-125	≤30
Calcium	7440-70-2	—	—	—	—	—	1.72E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6.25	80-120	75-125	≤30
Cerium	7440-45-1	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	10.5	80-120	75-125	≤30
Chromium	7440-47-3	1.20E+05	5.25E+06	1.95E+06	109	2,000	18.5	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.15	80-120	75-125	≤30
Hexavalent chromium	18540-29-9	240	1.05E+04	3,893	109	0.96	—	7196A	—	—[m]	80-120	75-125	≤30
Cobalt	7440-48-4	24	1,050	389	15.7	4.3	15.7	6020 ICP/MS (acid)	6010 ICP/AES (acid)	2	80-120	75-125	≤30
Copper	7440-50-8	3,200	1.40E+05	5.19E+04	58	284	22	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Iron	7439-89-6	5.60E+04	2.45E+06	9.08E+05	—	5,645	3.26E+04	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Lanthanum	7439-91-0	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	2.75	80-120	75-125	≤30
Lead	7439-92-1	—	1,000[n]	—	156	3,000	10.2	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Lithium	7439-93-2	160	7,000	2,596	2	192	13.3	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.9	80-120	75-125	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i,j]		
											Accuracy		Precision
		Direct Contact, WAC 173-340-740 Method B Unrestricted RBL[b]	Direct Contact, WAC 173-340-745 Method C Industrial RBL[c]	Outdoor Worker RBL[d]	Ecological Protection[e] ≤15 ft	Groundwater Protection[f]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Magnesium	7439-95-4	—	—	—	—	—	7,060	6010 ICP/AES (acid)	6020 ICP/MS (acid)	26	80-120	75-125	≤30
Manganese	7439-96-5	1.12E+04	4.90E+05	1.80E+05	1,260	501	512	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Mercury	7439-97-6	24	1,050	389	0.3	2.1	0	7471 Cold vapor atomic absorption (acid)	6020 ICP/MS (acid)	0	80-120	75-125	≤30
Molybdenum	7439-98-7	400	1.75E+04	6,489	2	32	0	6010 ICP/AES (acid)	6020 ICP/MS (acid)	0.47[q]	80-120	75-125	≤30
Neodymium	7440-00-8	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Nickel	7440-02-0	1,600	7.00E+04	2.59E+04	38	130	19	6020 ICP/MS (acid)	6010 ICP/AES (acid)	3	80-120	75-125	≤30
Phosphorus	7723-14-0	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	10	80-120	75-125	≤30
Potassium	7440-09-7	—	—	—	—	—	2,150	6010 ICP/AES (acid)	6020 ICP/MS (acid)	157	80-120	75-125	≤30
Rhodium	7440-16-6	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	26	80-120	75-125	≤30
Selenium	7782-49-2	400	1.75E+04	6,489	1.4	5.2	1	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.02[r]	80-120	75-125	≤30
Silicon	7440-21-3	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Silver	7440-22-4	400	1.75E+04	6,489	3	14	0.17	6020 ICP/MS (acid)	6010 ICP/AES (acid)	6.00E-04[r]	80-120	75-125	≤30
Sodium	7440-23-5	—	—	—	—	—	690	6010 ICP/AES (acid)	6020 ICP/MS (acid)	22	80-120	75-125	≤30
Strontium	7440-24-6	4.80E+04	2.10E+06	7.79E+05	4,228	6,758	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Sulfur	7704-34-9	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	11	80-120	75-125	≤30
Tantalum	7440-25-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	26	80-120	75-125	≤30
Thallium	7440-28-0	—	0	—	0.5	0.71	0.185	6020 ICP/MS (acid)	6010 ICP/AES (acid)	4.00E-04[r]	80-120	75-125	≤30
Thorium	7440-29-1	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	5	80-120	75-125	≤30
Tin	7440-31-5	4.80E+04	2.10E+06	7.79E+05	84	4.80E+04	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	6	80-120	75-125	≤30
Tungsten	7440-33-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	43	80-120	75-125	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i,j]		
											Accuracy		Precision
		Direct Contact, WAC 173-340-740 Method B Unrestricted RBL[b]	Direct Contact, WAC 173-340-745 Method C Industrial RBL[c]	Outdoor Worker RBL[d]	Ecological Protection[e] ≤15 ft	Groundwater Protection[f]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Uranium	7440-61-1	240	1.05E+04	3,892	40.3	270	3.21	6020 ICP/MS (acid)	6010 ICP/AES (acid)	0.5[h]	80-120	75-125	≤30
Vanadium	7440-62-2	400	1.75E+04	6,488	43.2	1,600	85.1	6020 ICP/MS (acid)	6010 ICP/AES (acid)	6.00E-03[r]	80-120	75-125	≤30
Yttrium	7440-65-5	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Zinc	7440-66-6	2.40E+04	1.05E+06	3.89E+05	621	5,971	67.8	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Zirconium	7440-67-7	—	—	—	—	—	—	6010 ICP/AES (acid)	6020 ICP/MS (acid)	1	80-120	75-125	≤30
Ammonium Ion													
Ammonia/ammonium	7664-41-7	—	—	—	—	—	9	300.7 IC (distillation)	—	1	80-120	75-125	≤30
Cyanides													
Cyanide (total)	57-12-5	48	2,100	180	2.07E+04	0.97	—	9014 Spectrophotometric (distillation)	9012 Colorimetric	0.5	80-120	75-125	≤30
Anions													
Chloride	16887-00-6	—	—	—	—	1,000	100	9056 IC (water)	—	0.3	80-120	75-125	≤30
Fluoride	16984-48-8	4,800	2.10E+05	7.79E+04	2,280	2,884	2.81	9056 IC (water)	—	2.81[q]	80-120	75-125	≤30
Nitrate	14797-55-8	5.68E+05	2.49E+07	9.21E+06	27°	180	52	9056 IC (water)	—	2.5	80-120	75-125	≤30
Nitrite	14797-65-0	2.40E+04	1.05E+06	4.28E+05	27°	13	—	9056 IC (water)	—	2.5	80-120	75-125	≤30
Phosphate	14265-44-2	—	—	—	—	—	0.785	9056 IC (water)	—	0.785[q]	80-120	75-125	≤30
Sulfate	14808-79-8	—	—	—	—	1,000	237	9056 IC (water)	—	2.7	80-120	75-125	≤30
Bromide	24959-67-9	—	—	—	—	—	—	9056 IC (water)	—	1	80-120	75-125	≤30
Small Organic Acids													
Acetate	71-50-1	—	—	—	—	—	—	9056 IC (water)	—	4.50	80-120	75-125	≤30
Formate	64-18-6	—	—	—	—	—	—	9056 IC (water)	—	10.0	80-120	75-125	≤30
Glycolate	666-14-8	—	—	—	—	—	—	9056 IC (water)	—	3.80	80-120	75-125	≤30
Oxalate	338-70-5	—	—	—	—	—	—	9056 IC (water)	—	2.00	80-120	75-125	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i,j]		
											Accuracy		Precision
		Direct Contact, WAC 173-340-740 Method B Unrestricted RBL[b]	Direct Contact, WAC 173-340-745 Method C Industrial RBL[c]	Outdoor Worker RBL[d]	Ecological Protection[e] ≤15 ft	Groundwater Protection[f]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Pesticides													
Aldrin	309-00-2	0.06	7.72	0.17	0.16	2.52E-03	—	8081 GC/ECD	8270 GC/MS	0.01	70-130	70-130	≤30
Benzene hexachloride (including lindane) (Alpha, beta, gamma)	58-89-9	0.91	119.32	2.83	—	2.47E-03	—	8081 GC/ECD	8270 GC/MS	0.60	70-130	70-130	≤30
Chlordane	57-74-9	2.86	375	8.02	—	0.26	—	8081 GC/ECD	8270 GC/MS	0.10	70-130	70-130	≤30
DDT/DDD/DDE (total)	50-29-3 (DDT) 72-54-8 (DDD) 72-55-9 (DDE)	—	—	—	—	—	—	8081 GC/ECD	8270 GC/MS	0.075	70-130	70-130	≤30
Dieldrin	60-57-1	0.06	8.2	273.6	0.02	2.82E-03	—	8081 GC/ECD	8270 GC/MS	0.007	70-130	70-130	≤30
Endrin	72-20-8	24.0	1050	2.83	—	4.40E-01	—	8081 GC/ECD	8270 GC/MS	0.02	70-130	70-130	≤30
Heptachlor/heptachlor epoxide (total)	1024-57-3	0.22	29.17	0.34	—	3.79E-03	—	8081 GC/ECD	8270 GC/MS	0.04	70-130	70-130	≤30
Hexachlorobenzene	118-74-1	0.63	82.03	1.42	—	8.77E-02	—	8081 GC/ECD	8270 GC/MS	1.70	70-130	70-130	≤30
Pentachlorophenol	87-86-5	2.50	328.13	4.41	—	3.47E-03	—	8081 GC/ECD	8270 GC/MS	0.30	70-130	70-130	≤30
PCBs													
Aroclor 1016	12674-11-2	5.60	245	29.7	1.80	1.07	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1221	11104-28-2	0.5	65.6	0.76	1.50	0.00	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1232	11141-16-5	0.5	65.6	0.59	1.40	0.00	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1242	53469-21-9	0.5	65.6	0.97	1.50	0.07	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1248	12672-29-6	0.5	65.6	0.98	0.33	0.07	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1254	11097-69-1	0.5	65.6	1.02	1.50	0.11	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30
Aroclor 1260	11096-82-5	0.5	65.6	1.08	1.50	0.72	—	8082 GC/ECD	—	0.02	70-130	70-130	≤30

Table 8. Analytical Performance Requirements for Chemical Constituents

Constituent	CAS Number	Acceptable Level (mg/kg)[a]					Hanford Site Background[g] (mg/kg)	Primary Method[p]	Alternative Method[p]	Detection Limit (mg/kg)	Quality Control Acceptance Criteria[i,j]		
											Accuracy		Precision
		Direct Contact, WAC 173-340-740 Method B Unrestricted RBL[b]	Direct Contact, WAC 173-340-745 Method C Industrial RBL[c]	Outdoor Worker RBL[d]	Ecological Protection[e] ≤15 ft	Groundwater Protection[f]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference

a. The preliminary screening level (from the data quality objective process) is the risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The unrestricted direct contact risk-based level is based on an excess lifetime cancer risk of 1 in 1,000,000 or hazard quotient of 1.0. ECF-HANFORD-10-0444, Revision 3, *Documentation of Standard Method B Soil Cleanup Levels for Unrestricted Land Use.*

c. The industrial direct contact risk-based level is based on an excess lifetime cancer risk of 1 in 100,000 or hazard quotient of 1.0. ECF-HANFORD-10-0453, Revision 2, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Report*.

d. The outdoor worker risk-based level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 1,000,000 or hazard quotient of 1. ECF-HANFORD-16-0134, *Calculation of Soil Nonradiological Preliminary Remediation Goals for the Outdoor Worker Scenario*.

e. CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site*.

f. ECF-HANFORD-10-0442, *Calculation of Nonradiological Soil Concentrations Protective of Groundwater Using the Fixed Parameter 3 Phase Equilibrium Partitioning Equation for the 100 Areas and 300 Area*.

g. DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*; ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

h. Uranium result will be calculated using isotopic uranium analysis results.

i. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and ATL-MP-1011, "ATL Quality Assurance Project Plan for 222-S Laboratory."

j. QC failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are QC failures associated with secondary analytes, reanalysis will not be required.

k. Aluminum ecotoxicity is only identified in soils with pH <less than 5.5 (OSWER Directive 9285.7-60, *Ecological Soil Screening Level for Aluminum Interim Final*). Most soil pH measures at the Hanford Site are >5.5 (DOE/RL-2007-21, *River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment*; DOE/RL-2007-50, *Central Plateau Ecological Risk Assessment Data Package Report*; ECF-HANFORD-11-0158). Thus, aluminum at the Hanford Site does not present an ecological risk.

l. The outdoor worker risk-based level for arsenic is equal to the site background concentration.

m. There is no detection limit identified. The sensitivity is listed as being in the part per million range, but the measured concentration is factored by the percentage of spike recovered.

n. The lead cleanup value is the Method A industrial soil cleanup level from Table 745-1 of WAC 173-340-745(3).

o. The values for nitrate and nitrite are calculated for nitrogen in nitrate plus nitrite.

p. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

q. Detection limit listed is Hanford background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

r. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

AES = atomic emission spectroscopy
CAS = Chemical abstract number
ECD = electron capture detector
GC = gas chromatography
IC = ion chromatography
ICP = inductively coupled plasma
MS = mass spectroscopy
RBL = risk-based level

Table 9. Analytical Performance Requirements for Radiological Constituents - Shallow Soil Samples (up to 15 ft below ground surface)

Constituent	CAS Number	Acceptable Level (pCi/g)[a]		Hanford Site Background[d] (pCi/g)	Primary Method[j]	Alternative Method[j]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[e,f]		
								Accuracy		Precision
		Outdoor Worker RBL[b]	Ecological Protection[c]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Americium-241	14596-10-2	613	4,840	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	80-120	—	≤30
Antimony-125	14234-35-6	—	—	—	Gamma energy analysis (direct)	—	0.3	80-120	—	≤30
Carbon-14	14762-75-5	5.70E+05	32	—	Liquid scintillation (acid)	—	1	80-120	75-125	≤30
Cesium-137	10045-97-3	10.8	924	1.05	Gamma energy analysis (direct)	—	0.1	80-120	—	≤30
Cobalt-60	10198-40-0	5.7	805	8.42E-03	Gamma energy analysis (direct)	—	0.01[g,h]	80-120	—	≤30
Curium-242	15510-73-3	—	—	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	NA	—	NA
Curium-243/244	CM-243/244	64	—	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	NA	—	NA
Europium-152	14683-23-9	6.8	1,740	—	Gamma energy analysis (direct)	—	0.1[g]	NA	—	≤30
Europium-154	15585-10-1	8.2	1,610	3.34E-02	Gamma energy analysis (direct)	—	0.03[g,h]	NA	—	≤30
Europium-155	14391-16-3	603	3.34E+04	5.39E-02	Gamma energy analysis (direct)	—	0.05[g,h]	NA	—	≤30
Iodine-129	15046-84-1	1,568	—	—	Low energy gamma counting	ICP/MS (acid)	2	80-120	—	≤30
Neptunium-237	13994-20-2	24	7,880	—	ICP/MS (acid)	Alpha energy analysis (acid)	3.80E-02	80-120	75-125	≤30
Nickel-63	13981-37-8	6.00E+05	—	—	Liquid scintillation (acid)	—	30	80-120	—	≤30
Plutonium-238	13981-16-3	3,438	5,980	3.78E-03	Alpha energy analysis (acid)	ICP/MS (acid)	1	NA	—	≤30
Plutonium-239/240	Pu-239/240	2,971	6,270	2.48E-02	Alpha energy analysis (acid)	ICP/MS (acid)	0.03[g,h]	80-120	—	≤30
Plutonium-241	14119-32-5	2.03E+04	—	—	Liquid scintillation (acid)	Est. from Pu-238 and Pu239/240	1.65E+04	80-120	75-125	≤30

Table 9. Analytical Performance Requirements for Radiological Constituents - Shallow Soil Samples (up to 15 ft below ground surface)

Constituent	CAS Number	Acceptable Level (pCi/g)[a]		Hanford Site Background[d] (pCi/g)	Primary Method[f]	Alternative Method[f]	Detection Limit[g] (pCi/g)	Quality Control Acceptance Criteria[e,f]		
								Accuracy		Precision
		Outdoor Worker RBL[b]	Ecological Protection[c]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Radium-226	13982-63-3	—	58.3	0.82	Gamma energy analysis (direct)	—	—	80-120	75-125	≤30
Selenium-79	15758-45-9	5.68E+04	—	—	Liquid scintillation (acid)	—	10	—	—	≤30
Strontium-89/90[i] (Total)	10098-97-2	1190	91	0.18	Beta GPC	—	0.18	80-120	75-125	≤30
Tin-126	15832-50-5	—	—	—	ICP/MS (acid)	—	400	80-120	75-125	≤30
Technetium-99	14133-76-7	1.17E+05	5,360	—	ICP/MS (acid)	Liquid scintillation (acid)	1	80-120	75-125	≤30
Thorium-232	7440-29-1	—	—	1.32	ICP/MS (acid)	—	4.40E-05	80-120	75-125	≤30
Tritium	10028-17-8	1.26E+04	420	—	Liquid scintillation (acid)	—	30	80-120	75-125	≤30
Uranium-233/234[k]	U-233/234	2,201	6,370	1.1	ICP/MS (acid)	—	3.75E-02	—	—	≤30
Uranium-235	15117-96-1	36	4,360	0.11	ICP/MS (acid)	—	4.32E-05	80-120	75-125	≤30
Uranium-236	13982-70-2	—	—	—	ICP/MS (acid)	—	5.18E-04	—	—	≤30
Uranium-238	7440-61-1	170	5,150	1.06	ICP/MS (acid)	—	4.37E-04	80-120	75-125	≤30

a. The preliminary screening level (from the data quality objective process) is the risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The outdoor worker risk-based level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 10,000. ECF-HANFORD-16-0133, Revision 0, *Calculation of Soil Radiological Preliminary Remedial Goals for the Outdoor Worker Scenario*.

c. CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*.

d. DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*.

e. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and ATL-MP-1011, "ATL Quality Assurance Project Plan for 222-S Laboratory."

f. Quality control failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are quality control failures associated with secondary analytes, reanalysis will not be required.

g. Detection limit listed is Hanford background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

h. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

i. Based on half-live, Strontium-89 is not present in Hanford wastes; therefore, Strontium-89/90 is equivalent to Strontium-90.

j. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

k. Value is for Uranium-234.

CAS = Chemical Abstracts Service

GPC = Gas proportional counting

GEA = Gamma energy analysis

ICP = inductively coupled plasma

MS = mass spectroscopy

RBL = risk-based level

Table 10. Analytical Performance Requirements Radiological Constituents - Deep Soil Samples (greater than 15 ft below ground surface)

Constituent	CAS Number	Acceptable Level (pCi/g)[a]		Hanford Site Background[d] (pCi/g)	Primary Method[k]	Alternative Method[k]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[a,f]		
								Accuracy		Precision
		Construction Worker RBL[b]	Ecological Protection[c]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Americium-241	14596-10-2	2.20E+04	4,840	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	80-120	NA	≤30
Antimony-125	14234-35-6	—	—	—	Gamma energy analysis (direct)	—	0.3	80-120	NA	≤30
Carbon-14	14762-75-5	4.80E+06	32	—	Liquid scintillation (acid)	—	1	80-120	75-125	≤30
Cesium-137	10045-97-3	1,550	924	1.05	Gamma energy analysis (direct)	—	0.1	80-120	NA	≤30
Cobalt-60	10198-40-0	334	805	8.42E-03	Gamma energy analysis (direct)	—	0.01[g,h]	80-120	NA	≤30
Curium-242	15510-73-3	—	—	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	NA	NA
Curium-243/244	CM-243/244	7,582	—	—	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	NA	NA
Europium-152	14683-23-9	739	1,740	—	Gamma energy analysis (direct)	—	0.1[h]	—	NA	≤30
Europium-154	15585-10-1	691	1,610	3.34E-02	Gamma energy analysis (direct)	—	0.03[g,h]	—	NA	≤30
Europium-155	14391-16-3	3.24E+04	3.34E+04	5.39E-02	Gamma energy analysis (direct)	—	0.05[g,h]	—	NA	≤30
Iodine-129	15046-84-1	1.21E+05	—	—	Low energy gamma counting	ICP/MS (acid)	2	80-120%	NA	≤30
Neptunium-237	13994-20-2	4,193	7,880	—	ICP/MS (acid)	Alpha energy analysis (acid)	3.80E-02	80-120%	75-125	≤30
Nickel-63	13981-37-8	2.86E+07	—	—	Liquid scintillation (acid)	—	30	80-120%	NA	≤30
Plutonium-238	13981-16-3	2.98E+04	5,980	3.78E-03	Alpha energy analysis (acid)	ICP/MS (acid)	1	—	NA	≤30
Plutonium-239/240	Pu-239/240	2.80E+04	6,270	2.48E-02	Alpha energy analysis (acid)	ICP/MS (acid)	0.03[g,h]	80-120%	NA	≤30
Plutonium-241	14119-32-5	1.03E+06	—	—	Liquid scintillation (acid)	Est. from Pu-238 and Pu239/240	1.65E+04	80-120%	75-125	≤30

Table 10. Analytical Performance Requirements Radiological Constituents - Deep Soil Samples (greater than 15 ft below ground surface)

Constituent	CAS Number	Acceptable Level (pCi/g)[a]		Hanford Site Background[d] (pCi/g)	Primary Method[k]	Alternative Method[k]	Detection Limit (pCi/g)	Quality Control Acceptance Criteria[e,f]		
								Accuracy		Precision
		Construction Worker RBL[b]	Ecological Protection[c]					Laboratory Control Sample Recovery (%)	Spike Recovery (%)	Relative Percent Difference
Radium-226	13982-63-3	—	58.3	0.82	GEA	—	—	80-120	75-125	≤30
Selenium-79	15758-45-9	3.20E+06	—	—	Liquid scintillation (acid)	—	10	—	NA	≤30
Strontium-89/90 (Total)[j]	10098-97-2	1.21E+05	91	0.18	Beta GPC	—	0.18	80-120	75-125	≤30
Tin-126	15832-50-5	—	—	—	ICP/MS (acid)	—	400	80-120	75-125	≤30
Technetium-99	14133-76-7	5.80E+06	5,360	—	ICP/MS (acid)	Liquid scintillation (acid)	1	80-120	75-125	≤30
Thorium-232	7440-29-1	—	—	1.32	ICP/MS (acid)	—	4.40E-05	80-120	75-125	≤30
Tritium	10028-17-8	3.26E+05	420	—	Liquid scintillation (acid)	—	30	80-120	75-125	≤30
Uranium-233/234[i]	U-233/234	5.51E+04	6,370	1.1	ICP/MS (acid)	—	3.75E-02	—	NA	≤30
Uranium-235	15117-96-1	5,984	4,360	0.11	ICP/MS (acid)	—	4.32E-05	80-120	75-125	≤30
Uranium-236	13982-70-2	—	—	—	ICP/MS (acid)	—	5.18E-04	—	—	≤30
Uranium-238	7440-61-1	2.11E+04	5,150	1.06	ICP/MS (acid)	—	4.37E-04	80-120	75-125	≤30

a. The preliminary screening level (from the data quality objective process) is the risk-based value used to determine appropriate analytical requirements (e.g., detection limits). Remedial action levels will be proposed in the corrective measure study, and will guide remediation of the sites.

b. The construction worker risk-based level used to determine analytical performance requirements is based on an excess lifetime cancer risk of 1 in 10,000. ECF-HANFORD-16-0132, Revision 0, *Calculation of Soil Radiological Preliminary Remedial Goals for the Construction Worker Scenario*.

c. CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*.

d. DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*.

e. Laboratory quality acceptance requirements are based on RPP-23403, RPP-RPT-38152, and ATL-MP-1011, "ATL Quality Assurance Project Plan for 222-S Laboratory."

f. Quality control failures will be brought to the immediate attention of the Primary Laboratory Contact, discussed in the report narrative, and associated result(s) qualified appropriately in the data package. Note that if there are quality control failures associated with secondary analytes, reanalysis will not be required.

g. Detection limit listed is Hanford background value. The laboratory shall attempt to achieve a detection limit less than Hanford background.

h. Detection limit may be less than can be reported by current analytical methodology. The laboratory shall report results to the lowest achievable detection limit while maintaining quality standards.

i. Value is for Uranium-234.

j. Based on half-live, Strontium-89 is not present in Hanford wastes; therefore, Strontium-89/90 is equivalent to Strontium-90.

k. Equivalent methods may be used by the laboratory with prior approval by the Primary Laboratory Contact and Project Manager.

CAS = Chemical Abstracts Service
GPC = Gas proportional counting
GEA = Gamma energy analysis
ICP = inductively coupled plasma
MS = mass spectroscopy
RBL = risk-based level

Handout #2
Data Quality Objectives Process Summary

WMA A-AX DATA QUALITY OBJECTIVES (DQO) PROCESS SUMMARY
Hand Out for July 13, 2017

BACKGROUND INFORMATION

NOTE: REVISION 0 OF THIS DQO SUMMARY REPORT IS ASSOCIATED WITH FOCUS AREA TANKS A-104 AND A-105.

DQO Process

The DQO development is a seven-step process. The DQO process for WMA A-AX will be iterative, with revisions being prepared to address focus areas, as needed. It will be setup to ensure that the data needs to support the performance assessment (PA) and risk-informed retrieval process and ultimately the Phase 2 RFI/CMS efforts are achieved. The steps and the manner in which they will be applied at WMA A-AX are identified in Table 1 (**WMA-A/AX-DQO-2017-4**).

DQO Scope and objectives

The DQO scope was outlined as follows (**WMA-A/AX-DQO-2017-1** and **WMA-A/AX-DQO-2017-6**):

- The DQO process will address vadose zone contamination in and around WMA A-AX to support the RCRA Facility Investigation (RFI).
- Data will be used to develop an assessment of risk to human health and the environment, including the future risk to groundwater to support the RFI and Appendix I Performance Assessment (IPA).
- If the risk assessment indicates a need to reduce risk to human health or the environment, the data will be used to evaluate alternatives in a CMS.
- The corrective action decisions supported by the data collected under this DQO will be consistent with and support final closure of WMA A-AX.
- This DQO will not address data requirements of SST residual waste sampling and analysis or other data required to address closure associated with ancillary equipment in the tank farm. These data requirements will be addressed in a separate DQO for the closure of the SST system.

DQO objectives (**WMA-A-AX-DQO-2017-3** for bullets 2 and 3, and **WMA-A/AX-DQO-2017-4** for bullet 1):

- Define the WMA A-AX vadose zone characterization data necessary to guide planning to make vadose zone soil remedial decisions, support an evaluation of risks by direct contact and to ecological receptors, and support integration of vadose zone and groundwater decisions.
- Optimize a data collection program that will be used to support the Phase 2 RFI/CMS characterization of WMA A-AX and to support risk-informed retrieval efforts.
- Support refining the preliminary conceptual site model (CSM).

STEP 1 – DEFINE THE PROBLEM

Step 1 of the seven-step DQO process is to clearly define the problem (the reason analytical data are needed) so that the focus of the project is clear.

DQO problem statement

Considering the DQO scope, and after review of available information, the concise statement of the problem was identified as follows (**WMA-A-AX-2017-1**):

> ***Vadose zone contamination in and adjacent to the A-AX tank farm may pose a current and future risk to human health and the environment, including groundwater, which requires corrective action to support closure.***

The DQO project team is identified as follows (**WMA-A-AX-2017-1**; modifications proposed **WMA-A-AX-2017-5**):

Table 2. DQO Planning Team Members

Organization	Name	Function/Decision Authority
U.S. Department of Energy – Office of River Protection (ORP)	Jan Bovler	ORP Project Lead
U.S. Department of Energy – Operations Office (RL)	Doug Hildebrand	RL Lead - Integration with 200-EA-1 and Groundwater OUs
Washington State Department of Ecology (Ecology)	Mike Barnes Jeff Lyon Joe Caggiano Elizabeth Rochette Marysia Skorska Jim Alzheimer	Lead WMA A-AX DQO Tank Farms Project Manager Technical Support Technical Support Technical Support Technical Support
Washington River Protection Solutions	Scott Luke Paul Rutland Cindy Tabor/Ryan Childress Julie Robertson Jim Field Robin Varljen Kristin Singleton/Marcel Bergeron Harold Sydnor Kathi Dunbar Steve McKinney/Paul Gassman Bob Hiergesell Duc Nguyen	DQO Facilitator Vadose Zone Project Director Project Lead Regulatory Support Leak Assessments and Process Knowledge Regulatory Compliance Risk Assessment Field Characterization/Sampling and Analysis QA Laboratory Interface WMA A-AX PA Integration DQO Oversight
CHPRC	Bert Day Mark Byrnes/Phil Burke Lee Brouilland/Jeremy Lynn Greg Thomas Curt Wittreich	200-EA-1 and 200-IS-1 200-DV-1 200-PO-1 200-BP-5 Groundwater OU Integration

STEP 2 – IDENTIFY THE GOALS OF THE STUDY

Step 2 identifies the decisions information that requires new environmental data to address the problem and identifies decision statements for Estimation problems identifies what needs to be estimated to solve the "problems" stated in Step 1 and associated key assumptions.

Goal of the study (WMA-A-AX-2017-1):

> ***The goal is to ensure the appropriate vadose zone soil characterization data needs are identified to support corrective measure decisions for WMA A-AX.***

The following note will be included in the DQO summary report: "It is recognized that there is a need to integrate characterization and closure actions with ongoing and nearby operations and waste site/groundwater remedial actions."

The Principal Study Questions, Alternative Actions, and Decision/Estimation Statements are described in Table 3. Data supporting the DQO effort (collected prior to and collected using this DQO process) will be reviewed for use in developing and refining the conceptual site model.

Table 3. Principal Study Questions, Alternative Actions, and Decision/Estimation Statements		
Principal Study Question (PSQ)	**Proposed Alternative Actions (AA)**	**Decision/Estimation Statement (DS/ES)**
#1— Does contamination in the WMA A-AX vadose zone soil exceed acceptable levels?	If contamination exceeds acceptable levels, evaluate the need for corrective measures; otherwise, document that corrective action is not required.	**#DS 1** — Determine whether contamination exceeds acceptable levels and, therefore, whether there is a need to evaluate corrective measures.
#2 – Is information available to define the chemical/physical properties of WMA A-AX vadose zone soil that can impact contaminant movement through the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 2** – The chemical/physical properties of A-AX vadose zone soil that can impact contaminant movement through the soil will be defined and estimated. It is expected that vadose zone soil will be shown to have chemical and physical properties that can affect contaminant movement through the soil.
#3 – Is information available to define the chemical/physical properties of tank waste that can impact contaminant movement through the WMA A-AX vadose zone soil?	Not applicable for estimation statement.	**#ES 3** – The chemical/physical properties of A-AX tank waste that can impact contaminant movement through the soil will be defined and estimated. It is expected that tank waste will be shown to have chemical and physical properties that can affect contaminant movement through the soil.
#4 – Is information available to define whether, and where, tank waste passed through WMA A-AX vadose zone soil and, therefore, could exist elsewhere in the environment?	Not applicable for estimation statement.	**#ES 4** – Chemicals and radionuclides in tank waste, as well as naturally occurring vadose zone soil constituents that are altered in the presence of tank waste in the environment, will be identified and their concentrations estimated. It is expected that tank waste contains indicator constituents that would remain in soil at detectable levels even after the bulk of the waste has passed through. Their detectable presence in the soil, even at low concentrations, could indicate that waste passed through the soil at the location and so could exist elsewhere in the environment. It is also expected that as tank waste passed through the vadose zone soil, chemical reactions may have altered the levels of naturally occurring vadose zone soil constituents, potentially indicating that waste passed through the soil at the location.
Note: Estimation Statements for Focus Area Tanks A-104/105 support the continued development of the conceptual site model, support risk informed retrieval, and evaluate leak assessment interpretation.		

STEP 3 - DATA INPUTS

This step identifies the specific data required to answer the study questions, also identified as DQO data inputs.

Per EPA QA/G4 the major outputs of Step 3 are:

- *Identification of the **types** (e.g., chemical/physical properties), **as well as sources** of information needed to resolve the decision or estimates*
- *Identification of the **basis** of information (e.g., regulations, guidance, and permits) that will gulde or support choices to be made in later steps of the DQO process; information on the number of variables (analytes) that will need to be collected; and types of information (e.g., action limits, uncertainty requirements) needed to meet performance or acceptance criteria*
- *Selection of, and information on the performance of, appropriate **sampling and analysis methods** for generating the information.*

Table 4 identifies bases for identification and setting of acceptable levels for the WMA A-AX decision and estimation statements. The contents of Table 4 were presented for discussion during DQO Meeting **WMA-A-AX-DQO-2017-6** and were accepted as presented.

Table 5 identifies a range of field and analytical methods (e.g., ground penetrating radar, geophysical logging, and direct push) that could be used for vadose zone soil characterization. The contents of Table 5 were presented for discussion during DQO Meeting **WMA-A-AX-DQO-2017-4**.

Table 5. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
Ground Penetrating Radar (GPR): Radar-reflection surface geophysical survey technique that detects contrasts in di-electric constants in the below-grade environments from the surface.	Underground structures or interferences	Requires subjective interpretation of the reflected signals. Lack of reflective below-grade surfaces or the presence of interfering matrices can complicate or invalidate the findings. The presence of nearby buildings and utilities can interfere with reflected signals. Fines (e.g., clay and heavy fly ash) can act as a reflector to the radar signal.
Electromagnetic Induction (EMI): Surface geophysical survey technique that measures electrical conductivity in below-grade soils based on detected changes in electrical fields. Generally used to support the interpretation of GPR surveys.		The presence of nearby buildings and utilities can interfere with reflected signals.
Surface Geophysical Exploration: Electrical Resistivity Imaging can be acquired to develop shallow and deep, 2-dimensional and 3-dimensional images.	Resistivity (conductivity)	Results are impacted by interference from infrastructure such as pipelines, tanks, buildings, and other large features.

Table 5. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization

Potentially Appropriate Field Method/Analytical Method	Parameter	Possible Limitations
Large Diameter Hole (LDH) Conventional Drilling (e.g., cable tool):	Geophysical Logging and Laboratory Analysis	Most drilling methods have difficulty in cobbles and boulders. Waste/tailings are brought to the surface and need to be properly contained and disposed, increasing cost and risk of exposure to workers. Not viable for new exploration in the tank farms due to waste generation and logistics (e.g., dome loading and access).
LDH Geophysical Logging	Gross and isotopic gamma emissions	Larger size instrument has lower detection limits (more sensitive) but does not fit into a small diameter hole (SDH) (<3-inch); therefore, is not a compatible technology for use with direct push methods. The count rate can effect accuracy and precision of measurements.
	Gamma emissions from fission products, Am-241, Pu-239, and Np-237 It is considered by some to be more accurate than sampling and laboratory assay because the assay is performed in situ with less disturbance of the sample, there is higher vertical spatial resolution, and the sample size is much larger. This method may also be more economical than traditional sampling and analysis.	This method does not assess radionuclides or daughter products that do not emit gamma rays. The gamma energies from these isotopes are at the low end of the spectrum, which results in high numerical minimum detectable activities and possible matrix effects from other isotopes. This technique requires the use of a single casing (installed by drilling or driving) in contact with the soil formation. The detector is too large to fit in a SDH (<3-inch); therefore, is not a compatible technology for use with direct push methods.
	Neutron emissions from plutonium	Because of the very low incidence of spontaneous plutonium fission and alpha-N reactions, the passive neutron profile is orders of magnitude lower than the gamma emission. The detector is too large to fit in a SDH (<3-inch); therefore, is not a compatible technology for use with direct push methods.
	Active neutron emissions from transuranics	Although neutron activation methods have been developed, they are not expected to be useful for this initial characterization effort. At present, these techniques are too expensive and time consuming, and logistical problems are associated with the handling of intense sources or generators. The detector is too large to fit in a SDH (<3-inch); therefore, is not a compatible technology for use with direct push methods.
	Beta emissions	Not a fully developed technology.

Table 5. Potentially Appropriate Field and Analytical Methods for Vadose Zone Soil for Characterization		
Potentially Appropriate Field Method/Analytical Method	**Parameter**	**Possible Limitations**
	Neutron moisture	Moisture zones can be very thin and can be missed based on data collection intervals (distance and time).
	Temperature	Difficult differentiating/determining source and extent of high temperatures (e.g., soil versus infrastructure).
Laboratory Analysis for LDH	Chemical and radiological constituents and physical properties	Highly contaminated samples may require use of on-site laboratories, with associated impacts (e.g., high cost, reduced analyte lists, matrix effects, degraded detection limits, and long turnaround times). Lower contamination levels may allow use of offsite laboratories, avoiding these limitations.
Small Diameter Hole (SDH) Direct Push	Geophysical Logging and Laboratory Analysis	Direct-push methods may be ineffective in cobbly or rocky soils.
SDH Geophysical Logging	Gross and isotopic gamma emissions	The smaller diameter detectors are not as sensitive as those used in LDH (Detection limits are not as low from instruments used in LDH.)
	Beta emissions	Not a fully developed technology.
	Neutron moisture	Moisture zones can be very thin and can be missed based on data collection intervals (distance and time).
	Temperature	Difficult differentiating/determining source and extent of high temperatures (e.g., soil versus infrastructure).
Laboratory Analysis for SDH	Chemical and radiological constituents and physical properties	Small sample size leads to difficulty to with large analysis list and low detection limits.
Note: Reinterpreting available data (e.g., surface geophysical exploration data) and/or determine if analysis on existing cores could be performed.		

Table 6 identifies the constituents of interest at the A-104/105 focus area and provides the rationale for inclusion or exclusion of specific constituents from the list. The contents of Table 6 were presented for discussion during DQO Meeting **WMA-A-AX-DQO-2017-6**, and several changes were incorporated as a result of the discussion. Additional discussion is needed to reach consensus regarding VOAs, SVOAs, and hexavalent chromium.

STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

Identify the target population of interest and specify the spatial and temporal features pertinent for decision making or estimation.

Per EPA QA/G-4, the major outputs of this step are as follows:

- *Definition of the target population with detailed descriptions of geographic limits (spatial boundaries)*
- *Detailed descriptions of what constitutes a sampling unit*
- *Time frame appropriate for collecting data and making the decision or estimate, together with those practical constraints that may interfere with data collection*
- *The appropriate scale for decision making or estimation.*

Focus Area:

Around Tanks A-104 and A-105

Target Population:

Vadose zone soil (surface to groundwater)

Study Boundaries (WMA-A/AX-DQO-2017-5; WMA-A/AX-DQO-2017-6)

Vertical spatial area of interest is soil depths from the following:

- <15 ft to support ecological, direct contact assessment, and groundwater assessment
- >15 ft to support groundwater assessment.

The vertical boundary is from the ground surface to the capillary fringe immediately above groundwater.
The horizontal spatial boundary for this focus area is the soil near Tanks A-104 and A-105 as shown in Figure 1.

The temporal boundary for data collection for this focus area is prior to retrieval of Tanks A-104 and A-105.
The temporal boundary for the overall data collection in the WMA A-AX area will be the final CMS for WMA A-AX. Because the data will represent the condition of the contamination in the vadose zone between now and when the final CMS is completed, the timing of the sample collection must reflect these conditions. It is anticipated that this DQO will be in effect until the sampling and analysis for the soil remedy selection for WMA A-AX is complete.

Note that sampling or other data collection can be performed any time during the DQO affectivity period and should be integrated with similar activities whenever possible to realize efficiencies.

Sampling Unit:

The smallest sampling unit is the volume of material needed to conduct analytical testing. Note that there are various constraints that can impact the amount of volume that can be collected within tank farms. Table 7 identifies the practical constraints on data collection. The contents of Table 7 were presented for discussion during DQO Meeting WMA-A-AX-DQO-2017-6 and were accepted as presented.

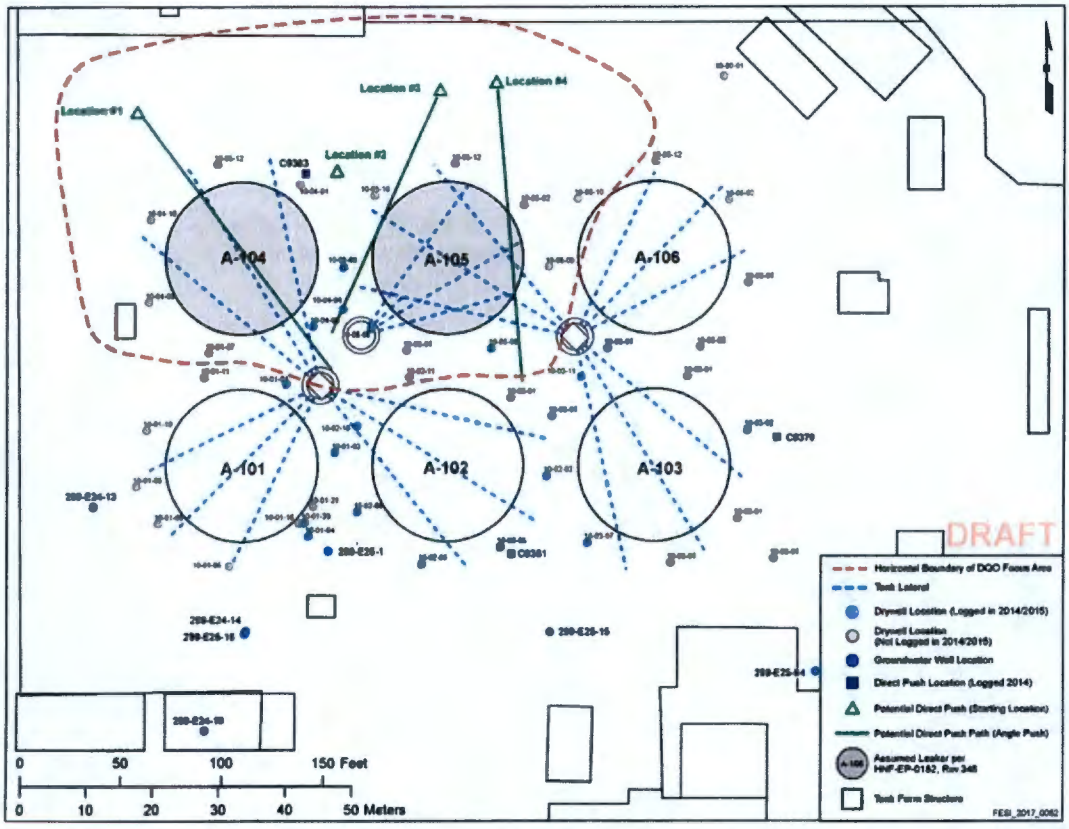
Constraints to sampling/data collection:

The practical constraints associated with data collection are shown in Table 7.

Smallest decision unit:

The smallest unit on which decisions or estimates is considered to be a release site (i.e., an area in the vadose zone where there has potentially been an impact from a known or suspected release associated WMA A-AX).

Figure 1. Depiction of Horizontal Boundary of A-104/105 DQO Focus Area



STEP 5 – DEVELOP THE ANALYTIC APPROACH

For decision problems, this step develops o decision rule which defines the octions to be token as a result of exceeding an action limit. For estimation problems, this step develops the 'specification of the estimator' which specifies the estimator (parameter being estimated) and the scole of estimotion (population boundary).

Per EPA QA/G-4, the major outputs of this step are:

- *Identification of the population* ***parameter*** *considered to be important to make inferences obout the target population.*
- *For decision problems, choose an* ***Action Level*** *(using information identified in Step 3) that sets the boundary between one outcome of the decision process and an alternative, and verify that there exist sampling and analysis methods that have detection limits below the Action Level.*
- *For decision problems, construct the theoreticol "if...then..."* ***decision rule*** *by combining the true value of the selected population parameter; the Action level, the scale of decision making (Step 4), and the alternative actions.*
- *For estimation problems, develop the '****specification of the estimator****' by combining the true value of the selected population parameter with the scale of estimation and other population boundaries (Step 4).*

STEP 6 – SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

This step specifies the decision-makers' tolerable limits on decision error and, where appropriate, some measure of uncertainty that is acceptable for the data. Step 6 examines consequences of making incorrect decisions, and places acceptable limits on the likelihood of making decision errors

Per EPA QA/G-4, the major outputs of step 6 are:

- *Performance or acceptance criteria (data quality objectives) that the decision rule or specification of the estimator will specify and that collected data should achieve to minimize decision error and to keep estimate uncertainty within acceptable levels.*
    - *For problems that require a statistical test, the outputs include specification of the range of possible true values of the parameter of interest that correspond to the baseline condition, grey area, tolerable decision error limits at selected true values of the parameter of interest (i.e., at the boundaries of the grey region)*
    - *For problems that do not require a statistical test, some acceptable measure and level of uncertainty – a performance metric that quantifies uncertainty.*

STEP 7 – DEVELOP THE PLAN FOR OBTAINING DATA

Step 7 develops a sampling design that optimizes the data collection to meet data quality requirements specified in DQO steps 1 through 6 and also takes into account the sampling boundaries and constraints identified in Step 4.

Per EPA QA/G-4, the major outputs of step 7:

- *Full documentation of the final sampling design along with key assumptions underlying the design,*
- *Details on how the design should be implemented together with contingency plan for unexpected events, and*
- *QA/QC performed to detect and correct problems and so ensure defensible results.*

Location and Number of Direct Push Boreholes (WMA-A/AX-DQO-2017-5)

See Figure 1.

Recommended Number of Samples Collected From WMA A-AX Per Direct Push Location (WMA-A/AX-DQO-2017-6)

- Each sampling location consists of one surface sample, two additional shallow (0 to 15 ft bgs) samples, and at least seven deep (>15 ft bgs) samples.
- A duplicate sample will be collected at 25% of the surface sample locations (i.e., a duplicate surface sample will be collected at one in four surface locations).
- Shallow samples taken from below the surface will be taken at ~7 to 9 ft bgs and ~12 to 14 ft bgs. The purpose of collecting samples in the first 15 ft is to provide data for the direct exposure pathway and to provide initial data for ecological risk.
- Deep samples will be taken down to a depth of ~240 to 285 ft bgs or refusal. The depths for sampling individual horizons will be selected by reviewing the gamma, temperature, and moisture logs of the first direct push and the following information: any leak loss inventory information pertinent to the site, geologic summary of the area, operational history, and historical characterization data at that site.

Summary:

- 3 Shallow Samples (0 to 15 ft bgs)
- 7 Deep Samples (>15 ft bgs to Total Depth).

Note: Proposed Vertical Total Depths for 4 boreholes are 240 (two locations), 260, and 285 ft bgs.

Handout #3
Constituent List

Table 6. WMA A-AX Analyte Rationale

Constituent	Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation Corrective Measures Study (RPP-RPT-38152, Rev 0)[a]	Single-Shell Tank Component Closure Data Quality Objectives (RPP-23403, Rev. 6)	Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX (DOE/RL-2009-70) and Hanford Atomic Energy Act Sitewide Groundwater Monitoring Plan (DOE/RL-2015-56, Rev 0)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Metals						
Aluminum – Al	P (E, R, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Antimony – Sb	P (E, R, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Arsenic – As	P (A, E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Barium – Ba	P (A, E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Beryllium – Be	P (E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Bismuth – Bi	S	X		X	Retain	Constituent listed in WMA C and SST DQO.
Boron – B	S	X			Retain	Constituent listed in WMA C and SST DQO.
Cadmium – Cd	P (A, E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Calcium - Ca	S	X		X	Retain	Constituent listed in WMA C and SST DQO.
Cerium – Ce	S	X			Retain	Retained based on tank waste and self boiling tanks. The rare earths are naturally occurring in the vadose zone.
Chromium – Cr	P (A, E, U, W)	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Chromium - hexavalent CrVI	P				**Retain (Can be Analyzed rather than Estimated from Total Chromium)**	**Constituent of interest due to toxicity. The holding time for soil samples is 30 days from collection to analysis.**
Cobalt – Co	P (E, R, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Copper – Cu	P (E, R, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Europium – Eu	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Iron – Fe	P (R, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Lanthanum – La	S	X		X	**Retain**	**Retain based on BBI detections.**
Lead – Pb	P (A, E, U, W)	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Lithium - Li	S	X			Retain	Constituent listed in WMA C and SST DQO. **Not part of tank waste but added as part of tracer for hydrostatic head fluid (as lithium bromide).**
Magnesium - Mg	S	X			Retain	Constituent listed in WMA C and SST DQO.
Manganese – Mn	P (E, R, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Mercury – Hg	P (A, E, U, W)	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Molybdenum - Mo	S	X			Retain	Constituent listed in WMA C and SST DQO.
Neodymium – Nd	S	X			Retain	Retain based on tank waste and self boiling tanks. The rare earths are naturally occurring in the vadose zone.
Nickel – Ni	P (E, U, W)	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Niobium – Nb	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Palladium – Pd	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Phosphorus - P	S	X			Retain	Constituent listed in WMA C and SST DQO.
Potassium - K	S	X		X	Retain	Constituent listed in WMA C and SST DQO.
Praseodymium – Pr	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Rhodium – Rh	S	X			Retain	Constituent listed in WMA C and SST DQO.
Rubidium – Rb	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Ruthenium – Ru	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.

Table 6. WMA A-AX Analyte Rationale

Constituent	Data Quality Objectives Report Phase 2 Characterization for Waste Management Area C RCRA Field Investigation Corrective Measures Study (RPP-RPT-38152, Rev 0)[a]	Single-Shell Tank Component Closure Data Quality Objectives (RPP-23403, Rev. 6)	Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX (DOE/RL-2009-70) and Hanford Atomic Energy Act Sitewide Groundwater Monitoring Plan (DOE/RL-2015-56, Rev 0)	Standard Best-Basis Inventory Constituents	Recommendation	Rationale for Decision
Samarium – Sm	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Selenium – Se	P (A, E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Silicon – Si	S	X		X	**Retain**	**Retain based on BBI detections.** Silicon is part of the media being analyzed (sand, gravel and silt and clay).
Silver – Ag	P (A, E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Sodium - Na	S	X		X	Retain	Constituent listed in WMA C and SST DQO.
Strontium – Sr	P (R)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Sulfur – S	S	X			Retain	Constituent listed in WMA C and SST DQO.
Tantalum – Ta	S	X			Retain	Constituent listed in WMA C and SST DQO.
Tellurium – Te	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Thallium – Tl	P (E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Thorium – Th	S	X			**Retain**	**Retain to review isotopic thorium.** The rare earths are naturally occurring in the vadose zone.
Tin – Sn	S	X			Retain	Constituent listed in WMA C and SST DQO.
Titanium – Ti	S	X			Eliminate	The rare earths are naturally occurring in the vadose zone.
Tungsten – W	S	X			Retain	Constituent listed in WMA C and SST DQO.
Uranium – U	P (E, R, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Vanadium – V	P (E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Yttrium – Y	S	X			Retain	Constituent listed in WMA C and SST DQO.
Zinc – Zn	P (E, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Zirconium – Zr	S	X		X	Retain	Constituent listed in WMA C and SST DQO.
Anions						
Bromide Br-	S	X			Retain	Constituent listed in WMA C and SST DQO.
Chloride – Cl-	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Fluoride – F-	P (U, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Nitrate – NO3-	P (R, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Nitrite – NO2-	P (R, W)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Phosphate – PO4	S	X		X	Retain	Constituent listed in WMA C and SST DQO.
Sulfate – SO42-	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Sulfide – S2-	D[b, c]		X		Eliminate	Sulfides were not routinely used in Hanford Site processes. Limited use of sulfide may have occurred during the ferrocyanide processing of ^{137}Cs in the tanks. The other possible source of sulfides would be from the reduction of sulfates. However, this is unlikely in the high nitrate tank waste matrices. Soluble sulfide is not very stable and is easily oxidized by air. Any sulfide remaining in the waste is most likely present as insoluble metal sulfide. In addition, previous analyses of tank waste have not detected sulfides in the Hanford Site tanks.
Small Organic Acids						
Acetate – C2H3O2-	P (R)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Formate – CHO2-	P (R)	X			Retain	Constituent listed in WMA C and SST DQO.
Glycolate – C2H3O3-	P (R)	X			Retain	Constituent listed in WMA C and SST DQO.
Oxalate – C2O42-	P (R)	X		X	Retain	Constituent listed in WMA C and SST DQO.
Cyanides						
Cyanide – CN-	P (A, U, W)	X	X		Retain	Constituent listed in WMA C and SST DQO.
Ferrocyanide – Fe(CN)64-	P (A, U, W)	X			Eliminate	No ferrocyanide waste in WMA A-AX tank waste.

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Ammonium Ion						
Ammonium – NH4+	P (W)	X			Retain	Constituent listed in WMA C and SST DQO.
VOCs						WMA C, containing no self-boiling tanks, received much of the organic waste (OWW). Note that sampling for organics was discontinued at the WMA C as they were only detected a few times[b, c]. At WMA A-AX, containing self-boiling tanks, received less organic waste (OWW) than WMA C (Reference: HNF-3588, RPP-21854, HNF-4240). Additionally, total organic carbon, an overall indicator of organics, is not associated with Tanks A-104 and A-105 (BBI shows 0 kg for total organic carbon).
1,1,1-Trichloroethane	D[b, c]	X	X		Eliminate	
1,1,2,2-Tetrachloroethane	D[b, c]	X	X		Eliminate	
1,1,2,2-Tetrachloroethene	D[b, c]	X	X		Eliminate	
1,1,2-Trichloro-1,2,2-trifluoroethane	D[b, c]	X			Eliminate	
1,1,2-Trichloroethane	D[b, c]	X	X		Eliminate	
1,1,2-Trichloroethylene	D[b, c]	X	X		Eliminate	
1,1-Dichloroethene	D[b, c]	X	X		Eliminate	
1,2-Dichloroethane	D[b, c]	X	X		Eliminate	
2-Butanone (MEK)	D[b, c]	X	X		Eliminate	
2-Nitropropane	D[b, c]	X			Eliminate	
2-Pentanone	D[b, c]	X			Eliminate	
2-Propanone (Acetone)	D[b, c]	X	X		Eliminate	
4-Methyl-2-pentanone (MIBK)	D[b, c]	X	X		Eliminate	
Benzene	D[b, c]	X	X		Eliminate	
Carbon disulfide	D[b, c]	X	X		Eliminate	
Carbon tetrachloride	D[b, c]	X	X		Eliminate	
Chlorobenzene	D[b, c]	X	X		Eliminate	
Chloroethene (vinyl chloride)	D[b, c]	X	X		Eliminate	
Chloroform	D[b, c]	X	X		Eliminate	
Dichloromethane (methylene chloride)	D[b, c]	X	X		Eliminate	
Diethyl ether	D[b, c]	X			Eliminate	
Ethyl Acetate	D[b, c]	X			Eliminate	
Ethylbenzene	D[b, c]	X	X		Eliminate	
Isobutanol	D[b, c]	X	X		Eliminate	
Methanol	D[b, c]	X			Eliminate	
m-Xylene	D[b, c]	X	X		Eliminate	
n-Butyl alcohol (1-butanol)	D[b, c]	X			Eliminate	
o-Xylene	D[b, c]	X	X		Eliminate	
p-Xylene	D[b, c]	X	X		Eliminate	
Tetrahydrofuran	D[b, c]	X			Eliminate	
Toluene	D[b, c]	X	X		Eliminate	
trans-1,3-dichloropropene	D[b, c]	X	X		Eliminate	

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Trichlorofluoromethane	D[b,c]	X	X		Eliminate	
Xylenes	D[b,c]	X	X		Eliminate	
SVOCs						WMA C, containing no self-boiling tanks, received much of the organic waste (OWW). Note that sampling for organics was discontinued at the WMA C as they were only detected a few times. At WMA A-AX, containing self-boiling tanks, received less organic waste (OWW) than WMA C (Reference: HNF-3588, RPP-21854, HNF-4240). Additionally, total organic carbon, an overall indicator of organics, is not associated with Tanks A-104 and A-105 (BBI shows 0 kg for total organic carbon).
1,1-Biphenyl	S				Eliminate	
1,1-Dimethylhydrazine	S	X			Eliminate	
1,2,4-Trichlorobenzene	P (E, U, W)	X	X		Eliminate	
1,3-Dichlorobenzene	S	X			Eliminate	
1,4-Dichlorobenzene	S	X			Eliminate	
1,4-Dinitrobenzene	S	X			Eliminate	
2,4,5-Trichlorophenol	P (A, E, U)	X	X		Eliminate	
2,4,6-Trichlorophenol	P (E, U)	X	X		Eliminate	
2,4-Dinitrotoluene	P (A)	X	X		Eliminate	
2,6-Bis (tert-butyl)-4-methylphenol	P (A, W)	X			Eliminate	
2-Chlorophenol	P (U)	X	X		Eliminate	
2-Ethoxyethanol	P (A)	X			Eliminate	
2-Methylphenol (o-cresol)	P(A)	X	X		Eliminate	
2-sec-Butyl-4,6-dinitrophenol (Dinoseb)	S	X			Eliminate	
3-Methyl-2-butanone	S	X			Eliminate	
4-Methylphenol (p-cresol)	P (A)	X	X		Eliminate	
Acenaphthene	P (E, U)	X	X		Eliminate	
Acetophenone	S	X			Eliminate	
Benzo(a) anthracene	P (in D&D-30262)				Eliminate	
Benzo(a)pyrene	P (E, in D&D-30262)	X			Eliminate	
Benzo(b)fluoranthene	P (in D&D-30262)				Eliminate	
Benzo(k)fluoranthene	P (in D&D-30262)				Eliminate	
Bis(2-ethylhexyl)phthalate	P (in WMP-28945)				Eliminate	
Butylbenzylphthalate	P (U)	X	X		Eliminate	
Chrysene	P (in D&D-30262)				Eliminate	
Cresylic acid (cresol, mixed isomers) (Total Cresols)	P (A)	X			Eliminate	
Cyclohexanone	P (A, W)	X			Eliminate	
Dibenz(a,h)anthracene	P (in D&D-30262)	X			Eliminate	
Dibutyl phosphate	D[b,c]				Eliminate	
Di-n-butylphthalate	P (E, U)	X	X		Eliminate	
Di-n-octylphthalate	P (U)	X	X		Eliminate	
Ethylene glycol	D[b,c]				Eliminate	
Fluoranthene	P (U)	X	X		Eliminate	
Hexachlorobutadiene	P (A, W)	X	X		Eliminate	
Hexachloroethane	P (A)	X	X		Eliminate	

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Hexachloronaphtahlene	S	X			Eliminate	
Hexafluoroacetone	S	X			Eliminate	
Indeno (1,2,3-cd) pyrene	P (in D&D-30262)				Eliminate	
Isodrin	S	X			Eliminate	
m-Cresol (3-Methylphenol)	P (A)	X	X		Eliminate	
Methylhydrazine	S	X			Eliminate	
Monobutyl phosphate	D[b,c]				Eliminate	
N,N-Diphenylamine	S	X			Eliminate	
Naphthalene	P (U)	X	X		Eliminate	
Nitric acid, propyl ester	S	X			Eliminate	
Nitrobenzene	P (A, E, W)	X	X		Eliminate	
N-Nitrosodi-n-butylamine	S	X			Eliminate	
N-Nitroso-di-n-propylamine	P (U)	X	X		Eliminate	
N-Nitrosomethylethylamine	S	X			Eliminate	
N-Nitrosomorpholine	P (U)	X	X		Eliminate	
N-Nitroso-N, N-dimethylamine	S	X			Eliminate	
Octachloronaphthalene	S	X			Eliminate	
1,2-Dichlorobenzene (o-Dichlorobenzene)	P (A, W)	X	X		Eliminate	
o-Nitrophenol	P (U)	X	X		Eliminate	
p-Chloro-m-cresol (4-Chloro-3-methylphenol)	P (U)	X	X		Eliminate	
Pentachloronaphthalene	S	X			Eliminate	
Pentachloronitrobenzene (PCNB)	S	X			Eliminate	
Phenol	S	X			Eliminate	
p-Nitrochlorobenzene	S	X			Eliminate	
Pyrene	P (U)	X	X		Eliminate	
Pyridine	P (A, W)	X	X		Eliminate	
Tetrachloronaphthalene	S	X			Eliminate	
Toxaphene	S	X			Eliminate	
Tributyl phosphate	P (R, W)	X			Eliminate	Selected indicator organic for the occurrence of any organic contamination associated with tank waste[b].
Pesticides						
Aldrin	P	X			Retain	Constituent listed in WMA C and SST DQO.
Benzene hexachloride (including lindane) (Alpha, beta, gamma)	P	X			Retain	Constituent listed in WMA C and SST DQO.
Chlordane	P				Retain	Constituent listed in WMA C DQO.
DDT/DDD/DDE (total)	P				Retain	Constituent listed in WMA C DQO.
Dieldrin	P	X			Retain	Constituent listed in WMA C and SST DQO.
Endrin	P	X			Retain	Constituent listed in WMA C and SST DQO.
Heptachlor/heptachlor epoxide (total)	P				Retain	Constituent listed in WMA C DQO.
Hexachlorobenzene	P	X			Retain	Constituent listed in WMA C and SST DQO.
Pentachlorophenol	P	X			Retain	Constituent listed in WMA C and SST DQO.
GRO/DRO						

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Gasoline-Range Organics	D[b, c]				Eliminate	
Diesel-Range Organics	D[b, c]				Eliminate	
PCBs						
Aroclors (1016, 1221, 1232, 1242, 1248, 1254, 1260)	P	X	X		Retain	Constituent listed in WMA C and SST DQO.
Congeners	D[b, c]				Eliminate	
Other						
TOC (total organic carbon)				X	Add	
Radionuclides						
Americium-241	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Antimony-125	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Carbon-14	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cesium-137	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Cobalt-60	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Curium-242	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Curium-243	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Curium-244	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Europium-152	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Europium-154	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Europium-155	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Iodine-129	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Neptunium-237	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Nickel-63	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-238	P			X	Retain	Constituent listed in WMA C DQO.
Plutonium-239	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-240	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Plutonium-241	P		X	X	Retain Estimated from Pu 238 and Pu 239/240	Constituent listed in WMA C DQO.
Radium-226	S		X	X	**Retain**	**Retain based on BBI detections.** TPA-CN-668 removed Radium-226 and 228 from DV-1 SAP. --- Potassium 40, radium 226, radium 228, thorium 228, thorium 230, and thorium 232 are naturally occurring background radionuclides identified by consensus of Tri Party managers as not directly related to Hanford Operations or processes in the Central Plateau.
Selenium-79	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Strontium-90	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Technetium-99	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.

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Thorium-228	P	X			Eliminate	TPA-CN-668 removed Radium-226 and 228 from DV-1 SAP. —Potassium 40, radium 226, radium 228, thorium 228, thorium 230, and thorium 232 are naturally occurring background radionuclides identified by consensus of Tri Party managers as not directly related to Hanford Operations or processes in the Central Plateau.---
Thorium-230	P	X			Eliminate	TPA-CN-668 removed Radium-226 and 228 from DV-1 SAP. —Potassium 40, radium 226, radium 228, thorium 228, thorium 230, and thorium 232 are naturally occurring background radionuclides identified by consensus of Tri Party managers as not directly related to Hanford Operations or processes in the Central Plateau.---
Thorium-232	P	X		X	Retain	**Retain based on BBI detections.** TPA-CN-668 removed Radium-226 and 228 from DV-1 SAP. --- Potassium 40, radium 226, radium 228, thorium 228, thorium 230, and thorium 232 are naturally occurring background radionuclides identified by consensus of Tri Party managers as not directly related to Hanford Operations or processes in the Central Plateau.---
Tin-126	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Tritium	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-233	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-234	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-235	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-236	P	X		X	Retain	Constituent listed in WMA C and SST DQO.
Uranium-238	P	X	X	X	Retain	Constituent listed in WMA C and SST DQO.

Detected both Shallow and Deep at WMA C (RPP-RPT-58339, Rev. 0, Phase 2 RCRA Facility Investigation Report for Waste Management Area C)
Detected Shallow at WMA C (RPP-RPT-58339, Rev. 0, Phase 2 RCRA Facility Investigation Report for Waste Management Area C)
Detected Deep at WMA C (RPP-RPT-58339, Rev. 0, Phase 2 RCRA Facility Investigation Report for Waste Management Area C)

Note:

a. P=Primary and S=Secondary as defined in RPP-PLAN-38777, Rev.3, Sampling and Analyis Plan for Phase 2 Characterization of Vadose Zone Soil in Waste Management Area C.
Discontinued (D) constituents were documented in RPP-PLAN-38777, Rev.3. Letters inside the parenthetical identify that reason why a constituent was categorized as primary per RPP-RPT-38152, Rev 0: A = Part A constituent, E= Ecological risk assessment, R = Risk assessment constituent, U = UHC (underlying hazardous constituent), and W = constituent in PNNL-12040, Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privitization Project, WMP-28945, Data Quality Objective Summary Report in Support of the 200-BP-5 Groundwater Operable Unit Remedial Investigation/Feasibility Study Process, and D&D-30262, Data Quality Objectives Summary Report for the 200-IS-1 Operable Unit Pipelines and Appurtenances.
b. 11-TPD-020, 2011, "Organic Analyses Optimization for Waste Management Area (WMA) C," Office of River Protection, U.S. Department of Energy, Richland, Washington, March 23.
c. 11-NWP-053, 2011, "Re: Organic Analyses Optimization for Waste Management Area (WMA) C," State of Washington Department of Ecology, Richland, Washington, June 1.