# AR TARGET SHEET

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# SUPPLEMENT C1
# C-106 DATA QUALITY OBJECTIVES REPORT

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Revision 0

# TANK 241-C-106 COMPONENT CLOSURE ACTION DATA QUALITY OBJECTIVES

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## SIGNATURE PAGE

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## LIST OF TERMS

| | |
|---|---|
| CAS | Chemical Abstracts Service |
| CFR | *Code of Federal Regulations* |
| CI | confidence interval |
| CVAA | cold vapor atomic absorption |
| DOE | U.S. Department of Energy |
| DQO | Data quality objective |
| Ecology | State of Washington Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| EDTA | ethylene diamine tetra acetic acid |
| EQL | estimated quantitation limit |
| g | grams |
| GC/MS | gas chromatography/mass spectrometry |
| GEA | gamma energy analysis |
| GFAA | graphite furnace atomic absorption |
| IC | ion chromatography |
| ICP/AES | inductively coupled plasma/atomic emission spectroscopy |
| ICP/MS | inductively coupled plasma/mass spectrometry |
| ISE | ion-specific electrode |
| LCS | laboratory control sample |
| M | molarity of moles per liter |
| MDL | method detection limit |
| mg/g | milligrams per gram |
| mg/kg | milligrams per kilograms |
| mL | milliliters |
| MTCA | Model Toxics Control Act |
| N/A | not applicable |
| NIST | National Institute of Science and Technology |
| NP | not performed |
| NRC | U.S. Nuclear Regulatory Commission |
| PCB | polychlorinated biphenyls |
| PNNL | Pacific Northwest National Laboratory |
| QA | quality assurance |
| QC | quality control |
| RPD | relative percent difference |
| SST | single-shell tank |
| SVOC | semivolatile organic compound |
| TIC | tentatively identified compound |
| UCL | upper confidence limit |
| UHC | underlying hazardous constituent |
| Tri-Party Agreement | *Hanford Federal Facility Agreement and Consent Order* |
| VOA | Volatile organic analysis |
| VOC | volatile organic compound |

## LIST OF TERMS, Continued

| | |
|---|---|
| WAC | *Washington Administrative Code* |
| % | percent |
| $Ci/m^3$ | Curies per cubic meter |
| nCi/g | Nanocuries per gram |
| µCi/g | microcuries per gram |
| µg | micrograms |
| µL | microliters |

## GLOSSARY

| | |
|---|---|
| Closure action/activity | Refers to the 241-C-106 component closure actions and/or activities throughout this document. |
| Wiemers | List of constituents identified for characterization in Table 4.4 of the *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project* (Wiemers et al. 1998) |
| A | Identifies constituents from the Part A Permit. |
| U | Identifies constituents as Underlying Hazardous Constituents. |
| W | Identifies constituents in Table 4.4 of the *Regulatory Data Quality Objectives Supporting Tank Waste Remediation System Privatization Project* (Wiemers et al. 1998) |

# 1.0 INTRODUCTION

A key closure activity associated with Hanford Site cleanup is removal of the remaining single-shell tank (SST) waste and final closure of the SST farms. To accomplish closure of the SST farms, information addressing the residual waste (waste remaining in individual SSTs after completion of waste retrieval) is required. Data are required to address risk assessment as well as performance criteria. Tanks within a tank farm will undergo component closure activities in accordance with the site wide permit. Required information includes but is not limited to the volume of the residual waste left in the tanks, the concentration of certain constituents (see Section 4.0) in the residual waste, and data from risk assessment tests on residual solids. The concentration and the volume of the residual waste will provide the inventory of the constituents in the residual waste.

An important step in the closure of the SST farms will be the component closure actions of tank 241-C-106. In order to obtain the concentrations of the constituents of concern, samples of the residual waste (liquid and solids) will be required. Liquid grab samples will be obtained during the final waste retrieval activity and the solids after the final waste retrieval (see Section 8.0). The waste retrieval operations are detailed in the *Process Control Plan for Tank 241-C-106 Closure* (May 2003). Retrieval actions will be complete prior to permit issuance. Retrieval activities are included in the 241-C-106 component closure activity plan for information purposes only in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989) M-45-00 milestone issues.

This document describes the Data Quality Objective (DQO) process undertaken to ensure appropriate data are collected to support the component closure activities for tank 241-C-106 and will cover all sampling and analytical activities for that purpose. Final component closure activities will be addressed in the SST Closure Plan and determined in the site wide permit. The DQO process was implemented in accordance with *Data Quality Objectives for Sampling and Analyses,* TFC-ENG-CHEM-C-16, Rev. A (Banning 2003) and the U.S. Environmental Protection Agency (EPA) QA/G4, *Guidance for the Data Quality Objectives Process* (EPA 2000), with some modifications to accommodate project or tank specific requirements and constraints. The DQO process is an iterative process. Therefore, changes to this document will be made during the project if information is obtained that changes the requirements stated in this document.

The State of Washington Department of Ecology (Ecology) will not address information directly related to the strict application of the U.S. Department of Energy/Atomic Energy Agency (DOE/AEA) regulations in this DQO. However, Ecology will address information related to mixed waste and radionuclides as required by regulations, guidance, and the Tri-Party Agreement, as well as retrieval/closure agreements, documents, and plans.

## 2.0 PROBLEM STATEMENT

The objective of a problem statement is to clearly define the problem (the reason analytical data are required) so the focus of the project (tank 241-C-106 component closure action) will be unambiguous. With the objective of the problem statement in mind, the scope of this DQO can be outlined in the following statements:

- The DQO process will address only the component closure activities for tank 241-C-106.
- This DQO will not address soil sampling and analysis or any ancillary equipment in the tank farm. Therefore, the component closure action boundary for tank 241-C-106 will be the exterior of the tank walls. However, the closure action criteria will be consistent with and support final closure of the C Tank Farm. Because the development of this DQO did not focus on soil and ancillary equipment (pipes, pits, vaults, etc.) in the tank farm, this DQO does not adequately serve as a basis for final closure of the C Tank Farm. These issues will be addressed separately.

Considering the purpose and scope of this DQO, a concise statement of the problem can be written as follows:

> Conduct component closure activities for tank 241-C-106 in a manner that is contributive to final closure of the C Tank Farm.

The principal study question (PSQ) identifies key unknown conditions that reveal the solution to the problem. Generally, the PSQ requires data to be resolved. The PSQ that addresses the problem statement shown above is:

> Does the residual waste in tank 241-C-106 meet the Tri-Party Agreement M-45-00 milestone volume requirements and support Washington Administrative Code (WAC) 173-303-610 (2) closure performance standards for protection of human health and the environment to allow component closure activities to continue?

## 3.0 DECISION STATEMENTS

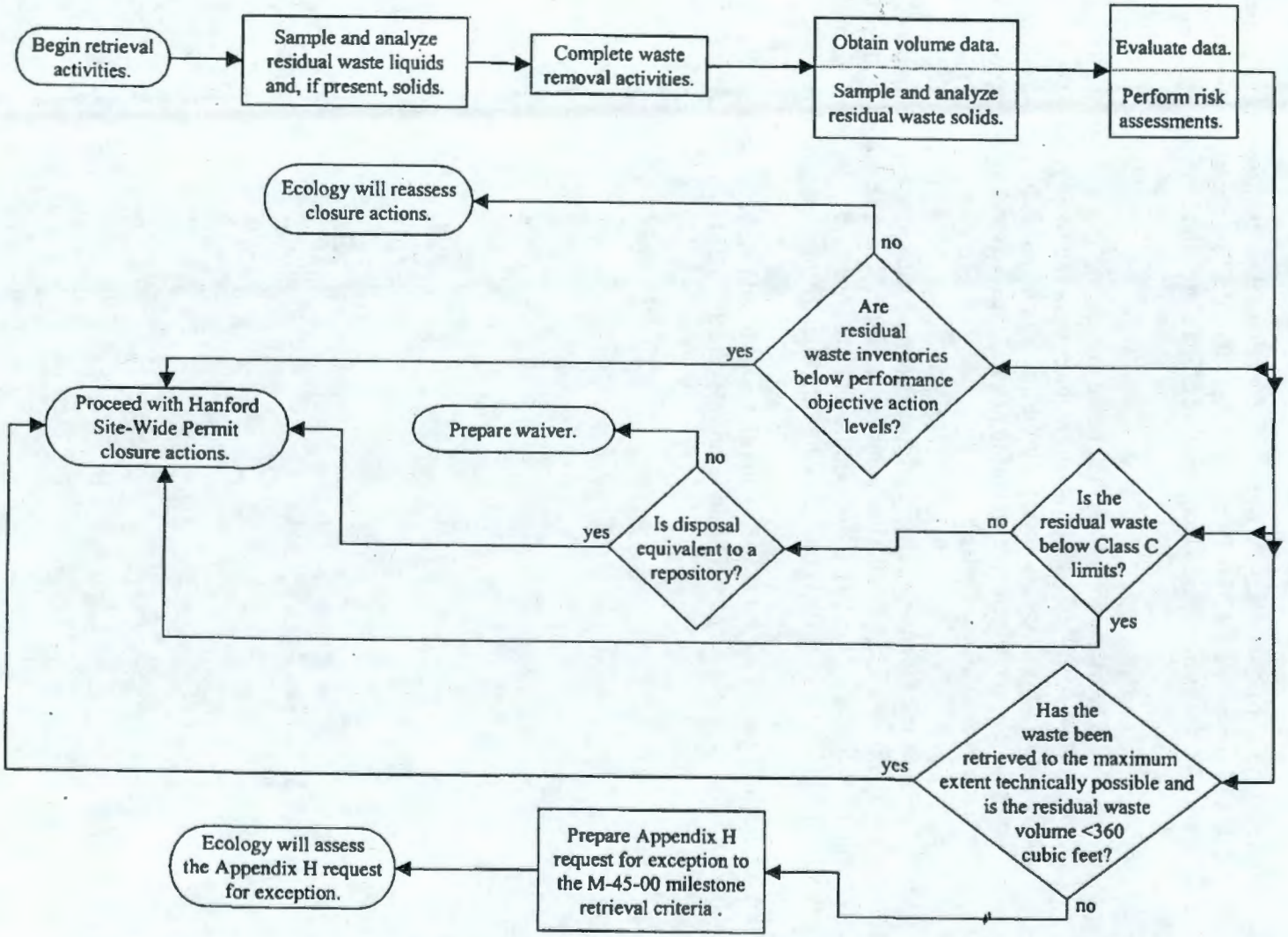
Decision statements link alternative actions with the principal study question and express a choice between alternative actions. Decision statements are created by combining the study questions with alternative actions. Using this formula, the decision statement can be expressed as:

> Determine whether or not the residual waste in tank 241-C-106 meets the Tri-Party Agreement M-45-00 milestone volume requirements and supports the WAC 173-303-610 (2) closure performance standard for protection of human health and the environment and allows the component closure actions to proceed, or reassessment of the component closure actions will be required.

Figure 3-1 shows the general logic flowchart for the component closure action of tank 241-C-106. The flowchart shows the decisions and activities that are covered by this DQO and are needed to address the tank 241-C-106 component closure action. The decisions are discussed and expanded in Section 6.0 while the sampling activities are discussed in Section 8.0.

As indicated in Figure 3-1, all three decision rules must be addressed to proceed with Hanford Site-Wide Permit closure actions. The decision rules are discussed in Section 6.0.

**Figure 3-1. Component Closure Action Logic Flowchart.**



# 4.0 DATA INPUTS

This section describes the information required to address the problem statement and the decision statement shown above. As mentioned above, three types of data are required for the component closure activities for tank 241-C-106: volume data, constituent concentrations including radionuclides, and release rates of critical constituents. The volume data are required to address one of the decision rules (see Section 6.0) and used with constituent concentrations to determine constituent inventories in the residual waste. The constituent inventories and release rates are needed to support risk assessment calculations. In addition, the concentrations of specific radionuclides are required to address the decision rule concerning Class C limits.

The determination of selected constituent release rate tests, required for risk assessment calculations, will be conducted by Pacific Northwest National Laboratory (PNNL) from samples collected through this DQO (see Section 8.0). This work will be governed by a test plan that will be submitted to Ecology for concurrence.

## 4.1 ANALYTICAL PARAMETERS

An analytical strategy for the component closure action of tank 241-C-106 was developed during the DQO process meetings. This strategy is based on analyzing for major constituent categories (volatile organic compounds [VOC], semivolatile organic compounds [SVOC], inorganics, and radionuclides) by a set of specific analytical methods. The strategy identifies specific or "primary" constituents (Single-Shell Tank Part A Permit [Part A] [CH2M HILL 2003], underlying hazardous constituents [UHC], and radionuclides from 10 CFR 61.55) that will be analyzed with the quality control (QC) specified in this DQO. The secondary constituents (those constituents that can be detected with the analytical methods being used but not a Part A, UHC, or 10 CFR 61.55 constituent) will be reported using the QC indicated in the strategy described for each analytical group.

The following sections discuss the major constituent categories: organic, inorganic, and radiochemical. The sections include flowcharts showing the analytical strategy and tables showing the SW-846 (EPA 1986) analytical methods and the Part A, UHC, and 10 CFR 61.55 (primary constituents) covered by these analytical methods. Some constituents may be measured by more than one method. In these cases, the selection of the method may depend on the action levels required for a decision or the expectation that the constituent is present.

Waste analyses will be performed utilizing the applicable methods outlined in SW-846. However, SW-846 methods may require modifications to address radiological concerns and some matrix conditions found in the Hanford Site tank waste. All attempts will be made to meet the data quality objectives.

### 4.1.1 Organics

Other than plant solvents, the amount of organic constituents that may have entered the tank waste is expected to be small in volume and highly variable compared to the inorganic and radionuclide components that make up the largest fraction of the wastes. These organic constituents are subject to hydrolytic, radiolytic, and volatile, chemical reactions that lead to changes in their composition. Because of the large amount of uncertainty in their composition, a strategy for effectively evaluating the primary constituents is needed as well as a way to effectively evaluate the tentatively identified compounds (TIC). The strategic approach for analyzing VOCs and SVOCs is shown in Figure 4-1.

Based on the strategy (see Figure 4-1) for organic components, the primary constituents would be analyzed with the specified level of QC (see Section 4.2). This means they would be included in the calibration of the gas chromatographs and method detection limits (MDL) would be determined for each constituent for the appropriate sample preparation required.

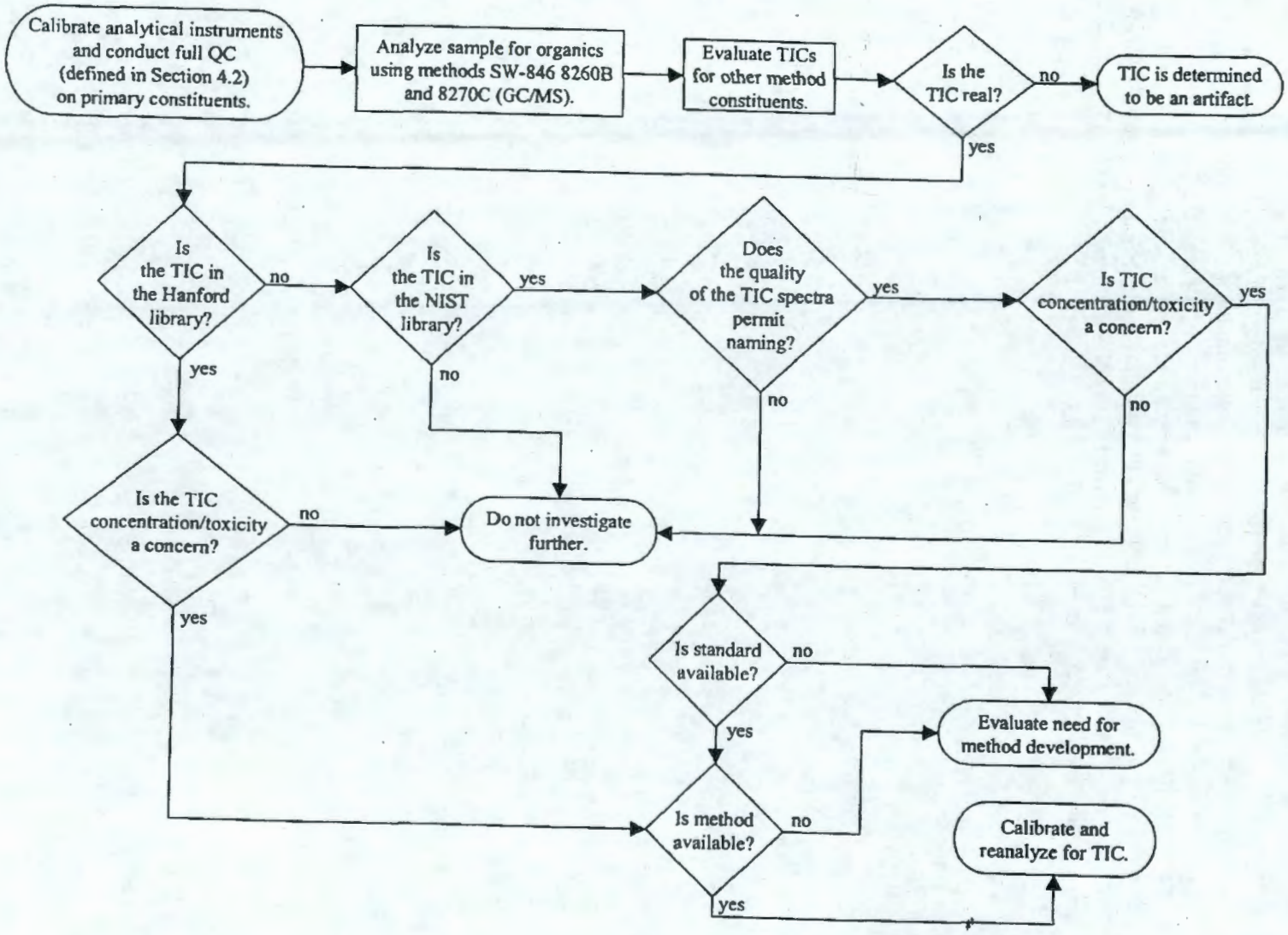
Because the volatile organic analysis (VOA) calibration standards are normally prepared in methanol, this constituent cannot be included as an analyte. Methanol is not expected to be present in tank waste, and because it is highly soluble in water, it should be removed when the liquid waste is retrieved.

Organic constituents that are detected and not part of the calibration mix (Part A and UHC constituents) are TICs. The flowchart (Figure 4-1) shows the process for evaluating these TICs to support component closure action decisions. Some TICs are the result of bleeding from the chromatographic column being used. Other TICs may be caused by reactions of the waste matrices with surrogates added to the sample. If the TIC is determined to be an artifact of the testing, no further evaluation is needed. If the TIC is determined to be real, it will be evaluated against a gas chromatographic library containing the secondary compounds of interest. This library of compounds (called the "Hanford Library") will be composed of constituents that have been identified as possibly being present in Hanford Site waste in the Regulatory DQO (Wiemers et al. 1998) except those already identified as primary constituents.

The "Hanford Library" is under development and will be completed prior to analyzing samples from tank 241-C-106. The "Hanford Library" is developed by running single standards of the constituents on the laboratory's gas chromatography/mass spectrometry (GC/MS) systems. The results of these analyses will provide accurate retention time information and mass response factors for these compounds and permit a better evaluation of the TIC. If a TIC is positively identified in the "Hanford Library" of compounds, a semi-quantitative estimate of its concentration will be made and evaluated. If the concentration of the TIC is significantly below the level of concern, then no further investigation is needed. However, if the concentration level of the TIC is considered significant, then a further evaluation of the TIC will be conducted (see Figure 4-1). This could be as simple as recalibrating and reanalyzing or as complex as developing a new method.

If the TIC is not found in the "Hanford Library" of compounds, then the TIC will be evaluated against the standard National Institute of Standards and Technology (NIST) library of compounds. This library has over 100,000 compounds. However, because they are collected on different instruments from those used for the actual analysis, the retention times and response factors will be different. Before the analyst can name or identify the TIC, the analyst must be confident that the chromatogram and mass spectra match well enough to name the compound. If the analyst cannot confidently name the compound, it is identified as an unknown and no further action is required. When a TIC is identified in the NIST library, then the TIC will be evaluated in a similar manner as a "Hanford Library" TIC.

**Figure 4-1. Strategy for Organic Analyses.**



The standard SW-846 methods may not be the best suited for some TIC compounds. If the sensitivity or the quality of the data is not adequate for making confident decisions, then it may be necessary to develop an improved method. The best available technology and results shall be used in the tank assessments until improved methods are available. These methods shall be applied to future samples where these TICs may be identified

The 222-S Laboratory follows the Contract Laboratory Program approach to identifying and estimating TICs. The Reconstructed Ion Chromatogram is evaluated for TICs by identifying any peaks that have not already been identified as target compounds. Any TIC peaks identified that are greater than 10 percent of the nearest internal standard (IS) area free from interferences will be reported. A library search will be performed and evaluated by the responsible chemist. An estimate of the concentration will be made based on the concentration of the IS used and a response factor of 1. All TIC results will be flagged with a "J" to indicate that the result is an estimate and an "N" if the identification of the unknown is based on a library search.

Table 4-1 shows SW-846 method 8260B VOC considered primary for this DQO. In addition, the table shows the reason for inclusion as a primary constituent (found in the Part A or UHC) and which of these primary constituents are found in the Regulatory DQO (Wiemers et al. 1998). Constituents identified with asterisks may be determined by more than one method. All of the method numbers discussed in this section are SW-846 methods.

**Table 4-1. Method 8260B For VOC Analyses. (2 Sheets)**

| Constituent | CAS | Reason for Inclusion | Comments |
|---|---|---|---|
| 1,1,1-Trichloroethane | 71-55-6 | A, U, W | |
| 1,1,2,2-Tetrachloroethene | 127-18-4 | A, W | |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | A, U, W | |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | A, W | |
| 1,1,2-Trichloroethane | 79-00-5 | A, W | |
| 1,1,2-Trichloroethylene | 79-01-6 | A, U, W | |
| 1,1-Dichloroethene | 75-35-4 | A, U, W | |
| 1,2-Dichloroethane | 107-06-2 | A, W | |
| Chloroethene(vinyl chloride) | 75-01-4 | A, W | |
| 2-Butanone(MEK) | 78-93-3 | A, U, W | |
| 2-Nitropropane | 79-46-9 | A | |
| 2-Propanone (Acetone) | 67-64-1 | A, U, W | |
| 4-Methyl-2-pentanone (MIBK) | 108-10-1 | A, U, W | |
| Benzene | 71-43-2 | U, W | |
| Carbon disulfide | 75-15-0 | A, W | |
| Carbon tetrachloride | 56-23-5 | A, U, W | |
| Chlorobenzene | 108-90-7 | A, U, W | |
| Chloroform | 67-66-3 | A, W | |
| Dichloromethane (methylene chloride) | 75-09-2 | A, U W | |
| Ethyl Acetate | 141-78-6 | A, W | |
| Ethylbenzene | 100-41-4 | A, W | |
| Diethyl ether | 60-29-7 | A | |
| Isobutanol | 78-83-1 | A | |
| Methanol | 67-56-1 | A, W | Will not be analyzed. See explanation in text. |
| n-Butyl alcohol (1-butanol) | 71-36-3 | A, U, W | |

**Table 4-1. Method 8260B For VOC Analyses. (2 Sheets)**

| Constituent | CAS | Reason for Inclusion | Comments |
|---|---|---|---|
| Toluene | 108-88-3 | A, U, W | |
| trans-1,3-dichloropropene | 10061-02-6 | U, W | |
| Trichlorofluoromethane | 75-69-4 | A, W | |
| Xylenes | 1330-20-7 | A, W | |
| o-Xylene | 95-47-6 | A, W | |
| m-Xylene | 108-38-3 | A, W | |
| p-Xylene | 106-42-3 | A, W | |

Notes:

| | |
|---|---|
| CAS | Chemical Abstracts Service |
| * | Constituent may be analyzed by an alternate method. |
| A | Part A constituent. |
| U | UHC constituent. |
| W | Constituent in Wiemers et al. (1998). |

Table 4-2 shows method 8270C SVOC considered primary for this DQO. In addition, the table shows the reason for inclusion as a primary constituent (found in the Part A or UHC) and which of these primary constituents are found in the Regulatory DQO (Wiemers et al. 1998).

**Table 4-2. Method 8270C For SVOC Analyses. (2 Sheets)**

| Constituent | CAS | Reason for Inclusion | Comments |
|---|---|---|---|
| 1,2,4-Trichlorobenzene* | 120-82-1 | U, W | |
| 2,4-Dinitrotoluene | 121-14-2 | A | |
| 2,4,5-Trichlorophenol | 95-95-4 | A, U | |
| 2,4,6-Trichlorophenol | 88-06-2 | U | |
| 2,6-Bis (tert-butyl)-4-methylphenol | 128-37-0 | A, W | |
| 2-Chlorophenol | 95-57-8 | U | |
| 2-Ethoxyethanol | 110-80-5 | A | |
| 2-Methylphenol (o-cresol) | 95-48-7 | A | |
| 4-Methylphenol (p-cresol) | 106-44-5 | A | |
| Acenaphthene | 83-32-9 | U | |
| Butylbenzylphthalate | 85-68-7 | U | |
| Cresylic acid (cresol, mixed isomers) | 1319-77-3 | A | |
| Cyclohexanone | 108-94-1 | A, W | |
| Di-n-butylphthalate | 84-74-2 | U | |
| Di-n-octylphthalate | 117-84-0 | U | |
| N-nitroso-di-n-propylamine | 621-64-7 | U | |
| Fluoranthene | 206-44-0 | U | |
| Hexachlorobutadiene* | 87-68-3 | A, W | |
| Hexachloroethane | 67-72-1 | A | |
| m-Cresol (3-Methylphenol) | 108-39-4 | A | |
| Naphthalene | 91-20-3 | U | |
| Nitrobenzene* | 98-95-3 | A, W | |

**Table 4-2. Method 8270C For SVOC Analyses. (2 Sheets)**

| Constituent | CAS | Reason for Inclusion | Comments |
|---|---|---|---|
| n-Nitrosomorpholine | 59-89-2 | U | |
| o-Dichlorobenzene* | 95-50-1 | A, W | |
| o-Nitrophenol | 88-75-5 | U | |
| p-Chloro-m-cresol (4-Chloro-3-methylphenol) | 59-50-7 | U | |
| Pyrene | 129-00-0 | U | |
| Pyridine* | 110-86-1 | A, W | |

Notes:

| | |
|---|---|
| CAS | Chemical Abstracts Service |
| * | Constituent may be analyzed by an alternate method. |
| A | Part A constituent. |
| U | UHC constituent. |
| W | Constituent in Wiemers et al. (1998). |

In addition to the organic constituents shown in Table 4-1 and Table 4-2, polychlorinated biphenyls (PCBs) will be analyzed as primary constituents. In addition, percent water is required for solids so the PCB concentration can be reported on a dry weight basis. The total PCB concentration is determined using SW-846 method 8082.

Total PCB concentrations are calculated by summing the concentrations of seven Aroclors (1016, 1221, 1232, 1242, 1248, 1254, and 1260) found in a sample. The total PCBs in a sample are calculated by summing only detected Aroclors. If no Aroclors are detected, the total PCB concentration is considered the detection limit for the single most common Aroclor expected in the sample. This reflects the policy of the EPA Manchester Laboratory for determining total PCB concentrations in a sample. In addition, this method was specified by agreement in a meeting with representatives from EPA Region 10, EPA Manchester Laboratory, Ecology, DOE, PNNL, and CH2M HILL Hanford Group, Inc. (CH2M HILL).

Table 4-3 shows the "Hanford Library" constituents for VOCs (method 8260B) and SVOCs (method 8270C). All of these constituents are found in the Regulatory DQO (Wiemers et al. 1998) and analyzed according to the strategy shown in Figure 4-1.

Table 4-3 includes constituents identified under the polynuclear aromatic hydrocarbon procedure 8310 and pesticide procedure 8081A. These constituents are not expected in Hanford Site waste, and analyses by these methods will not be conducted unless detected by method 8270C and require additional delineation.

One VOC (butane) and four SVOCs (pentachloronaphthalene, hexachloronaphtahlene, tetrachloronaphthalene, and octachloronaphthalene) will not be included in the "Hanford Library." It was not possible to get butane into solution, and the four SVOCs could not be obtained as pure compounds suitable for a standard. The NIST library will be relied on for the identification of these compounds.

**Table 4-3. Secondary Organic Constituents "Hanford Library." (2 Sheets)**

| Method 8260B VOC | CAS | Method 8270C SVOC | CAS |
|---|---|---|---|
| cis-1,3-Dichloropropene | 10061-01-5 | p-Nitrochlorobenzene | 100-00-5 |
| Ethylene dibromide (1,2, Dibromoethane) | 106-93-4 | 1,4-Dinitrobenzene | 100-25-4 |
| Butane | 106-97-8 | 1,4-Dichlorobenzene | 106-46-7 |
| 1,3-Butadiene | 106-99-0 | Phenol | 108-95-2 |
| Acrolein (propenal) | 107-02-8 | Hexachlorobenzene | 118-74-1 |
| 3-Chloropropene (Allyl chloride) | 107-05-1 | N,N-Diphenylamine | 122-39-4 |
| Propionitrile (Ethyl cyanide) | 107-12-0 | Pentachloronaphthalene | 1321-64-8 |
| Acrylonitrile | 107-13-1 | Hexachloronaphtahlene* | 1335-87-1 |
| 2-Pentanone | 107-87-9 | Tetrachloronaphthalene | 1335-88-2 |
| Methylcyclohexane | 108-87-2 | Octachloronaphthalene | 2234-13-1 |
| n-Pentane | 109-66-0 | Isodrin* | 465-73-6 |
| 5-Methyl-2-hexanone | 110-12-3 | Benzo[a]pyrene* | 50-32-8 |
| 2-Heptanone | 110-43-0 | Dibenz[a,h]anthracene* | 53-70-3 |
| n-Hexane | 110-54-3 | 1,3-Dichlorobenzene | 541-73-1 |
| Cyclohexane | 110-82-7 | 3-Methyl-2-butanone | 563-80-4 |
| n-Octane | 111-65-9 | N-Nitroso-N,N-dimethylamine | 62-75-9 |
| 4-Heptanone | 123-19-3 | Hexafluoroacetone | 684-16-2 |
| Acetic acid, n-butylester | 123-86-4 | Pentachloronitrobenzene (PCNB) | 82-68-8 |
| 1,4-Dioxane | 123-91-1 | Pentachlorophenol | 87-86-5 |
| n-Heptane | 142-82-5 | 2-sec-Butyl-4,6-dinitophenol (Dinoseb) | 88-85-7 |
| Cyclopentane | 287-92-3 | 1,1'-Biphenyl | 92-52-4 |
| Ethyl alcohol | 64-17-5 | Acetophenone | 98-86-2 |
| 2-Propyl alcohol | 67-63-0 | Toxaphene* | 8001-35-2 |
| n-propyl alcohol (1-propanol) | 71-23-8 | Nitric acid, propyl ester | 627-13-4 |
| Bromomethane | 74-83-9 | Aldrin* | 309-00-2 |
| Chloroethane | 75-00-3 | alpha-BHC* | 319-84-6 |
| Acetonitrile | 75-05-8 | beta-BHC* | 319-85-7 |
| 1,1 Dichloroethane | 75-34-3 | gamma-BHC (Lindane)* | 58-89-9 |
| Dichlorofluromethane | 75-43-4 | Dieldrin* | 60-57-1 |
| Chlorodifluoromethane | 75-45-6 | Endrin* | 72-20-8 |
| 3-Methy-2-butanone* | 563-80-4 | Tributyl phosphate | 126-73-8 |
| Hexafluoroacetone* | 684-16-2 | 1,1-Dimethylhydrazine | 57-14-7 |
| 2-Butenaldehyde (2-Butenal) | 4170-30-3 | Methylhydrazine | 60-34-4 |
| Methyl isocyanate | 624-83-9 | | |
| n-Propionaldehyde | 123-38-6 | | |
| 3-Heptanone | 106-35-4 | | |
| Chloromethane | 74-87-3 | | |
| n-Nonane | 111-84-2 | | |
| Styrene | 100-42-5 | | |
| Tetrahydrofuran | 109-99-9 | | |
| Cyclohexene | 110-83-8 | | |
| 2-Methyl-2-propenenitrile | 126-98-7 | | |
| 2-Hexanone | 591-78-6 | | |
| Triethylamine | 121-44-8 | | |
| Oxirane | 75-21-8 | | |
| 2-Methyl-2-propanol | 75-65-0 | | |
| Dichlorodifluoromethane | 75-71-8 | | |
| 1,2-Dichloro-1,1,2,2-tetrafluoroethane | 76-14-2 | | |
| Heptachlor | 76-44-8 | | |

**Table 4-3. Secondary Organic Constituents "Hanford Library." (2 Sheets)**

| Method 8260B VOC | CAS | Method 8270C SVOC | CAS |
|---|---|---|---|
| 1,2-Dichloropropane | 78-87-5 | | |
| 1-Methylpropyl alcohol | 78-92-2 | | |
| 3-Pentanone | 96-22-0 | | |

Notes:

CAS Chemical Abstracts Service
• Constituent may be analyzed by an alternate method.

### 4.1.2 Inorganics

The analytical strategy for inorganics is similar to that of the organics and is shown Figure 4-2. Although the inorganic methods do not have TICs, some inorganic analytical methods are capable of analyzing multiple constituents. This allows additional data to be obtained with minimum effort and costs. When these methods are utilized, all constituents will be reported. The QC of these secondary constituents may fall outside of the criteria shown in Table 4-7. Figure 4-2 shows the strategy for the inorganic analytical methods for multiple constituents (e.g., inductively coupled plasma/atomic emission spectroscopy [ICP/AES]).

As with the organic analyses, the primary inorganic constituents are identified as Part A and UHC constituents. This means these constituents must meet the highest level of quality for data evaluation. The secondary constituents will be addressed as indicated in Figure 4-2.

The analytical strategy for primary constituents that are analyzed by a single constituent analytical method (e.g., mercury) is shown in Figure 4-3. This is the same as the Part A and UHC analytical path in Figure 4-2.

As shown in Figure 4-2, if the primary constituent does not meet the quantitation limits (see Section 4.2), then it would be reanalyzed using either a smaller dilution (larger sample size) or a more sensitive existing method, such as inductively coupled plasma/mass spectrometry (ICP/MS). If neither of these options is possible, then a new method may need to be developed.

**Figure 4-2. Strategy for Inorganic Analyses Using Methods for Multiple Constituents.**

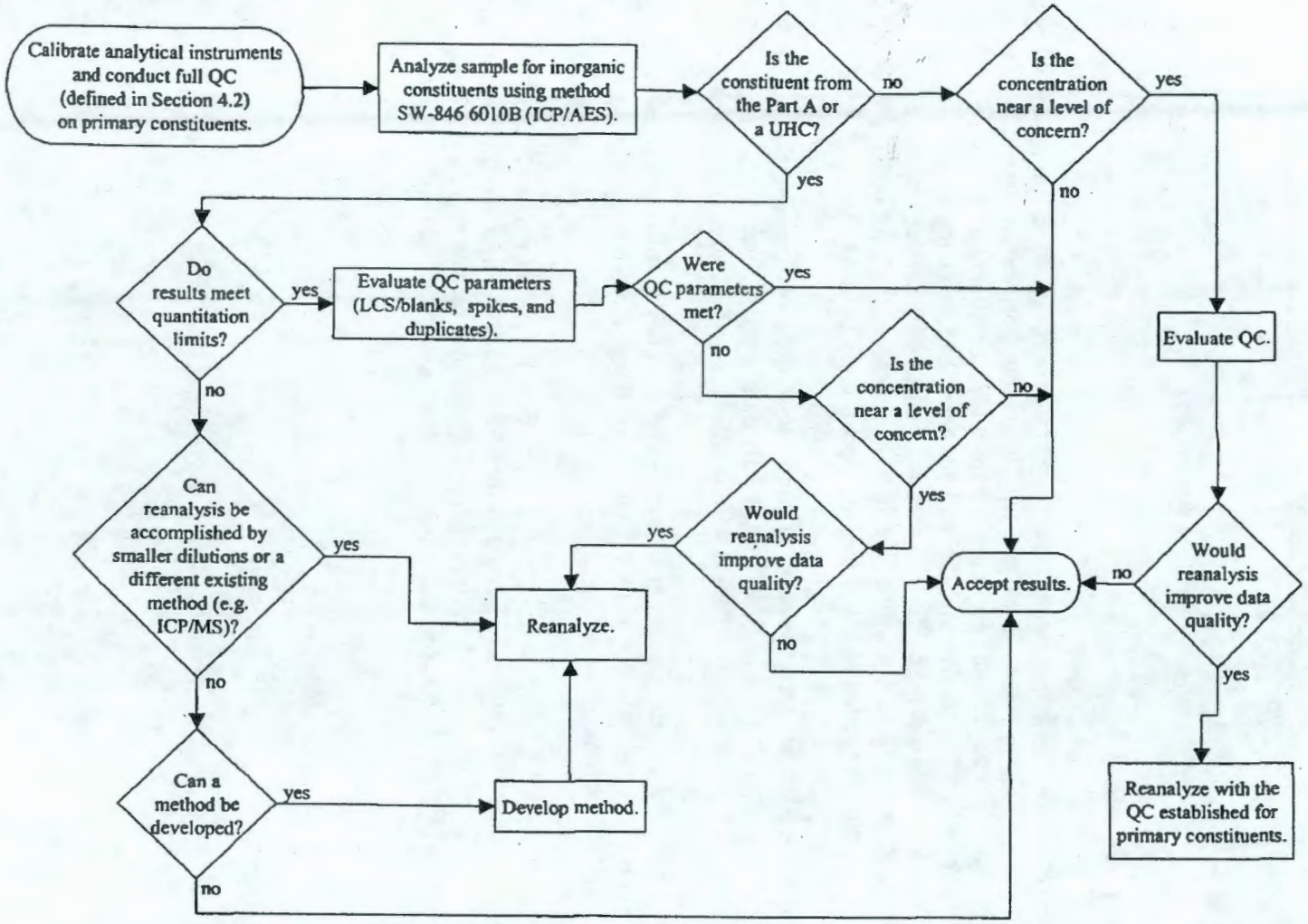
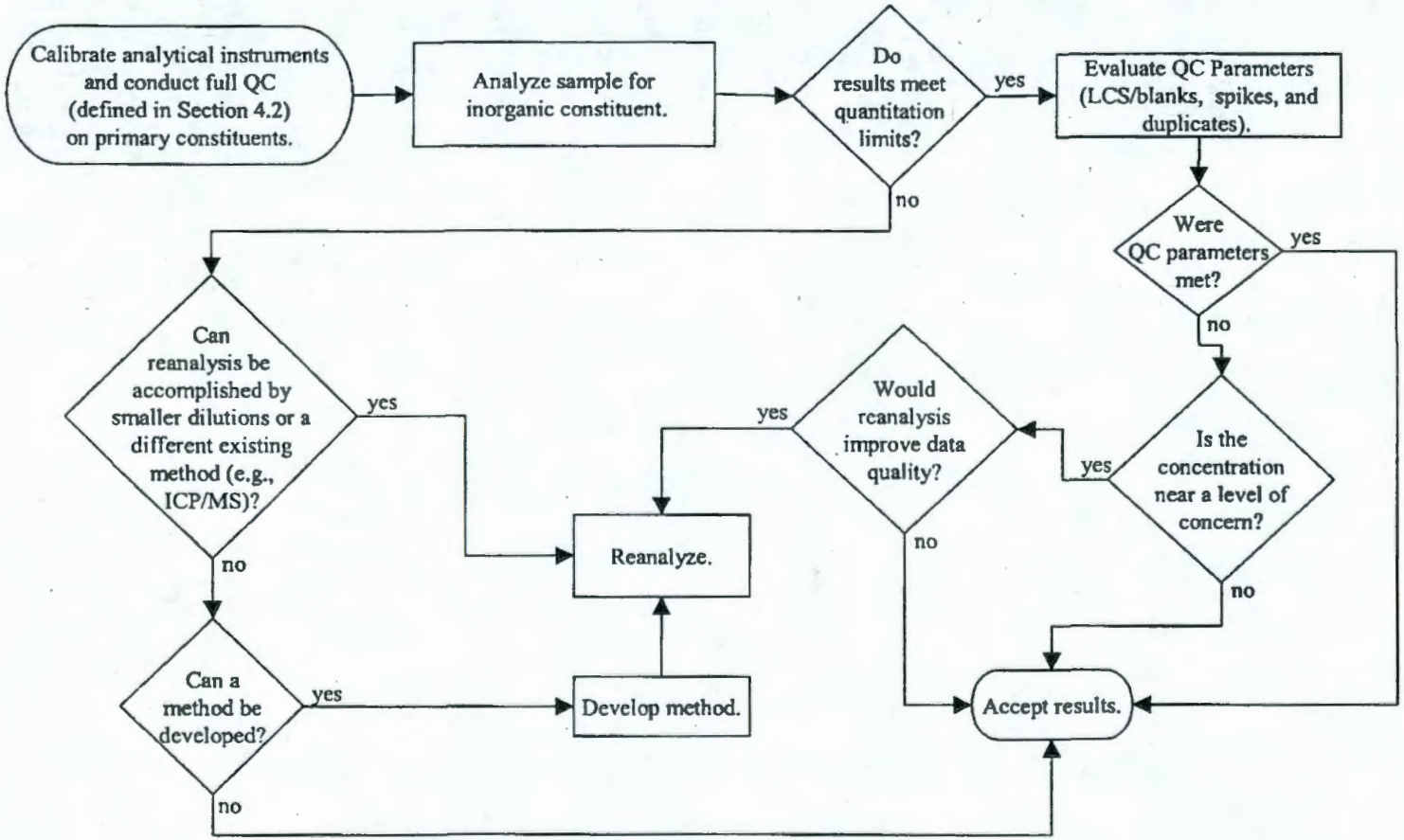


**Figure 4-3. Strategy for Inorganic Single Constituent Analytical Method.**



If a secondary constituent is detected, then the result is evaluated against the concentration levels of concern (see Section 4.3). If the concentration level is well below the levels of concern (see Section 4.3), then the data may be accepted. If the concentration of the secondary constituent is near or above the level of concern and the QC is adequate, the data are accepted. However, if the QC or uncertainty in the data does not permit a confident decision, then the sample would be reanalyzed as if it were a primary constituent.

The primary inorganic constituents and analytical methods for these constituents are shown in Table 4-4. As shown in Table 4-4, with the exception of mercury, metals are determined by ICP/AES. Mercury is determined by a cold vapor atomic absorption (CVAA) method [SW-846 7470A (for liquids) and SW-846 7471A (for solids)].

If the ICP/AES sensitivity is inadequate for some of the primary metals, they will be determined by alternative methods such as ICP/MS or graphite furnace atomic absorption (GFAA) as noted in the table. The atomic absorption methods are single constituent analytical methods and do not provide any secondary constituent information.

Three anions (fluoride, sulfide and cyanide) are identified as primary constituents. Fluoride is measured by ion chromatography (IC). This method can also provide secondary constituent information for other common anions. The IC analyses are normally performed on a water digestion of solids; however, this will not provide information on insoluble fluorides or chlorides.

The cyanide procedure uses a microdistillation and spectrophotometric measurement of the distilled cyanide. Solid samples are dissolved in ethylenediaminetetraacetic acid (EDTA) before distillation. This distillation has been demonstrated to be effective for the insoluble nickel ferrocyanides generated in some Hanford Site processes. There are no specific methods for ferrocyanide but the total cyanide measurement provides a conservative estimate.

Although not in the Part A or a UHC constituent, ammonia and hydroxide were added to the primary constituent list in the DQO process meetings.

Ammonia will be determined by the IC method. Because of the highly soluble nature of ammonia compounds, removal is expected during waste retrieval. Ammonia is normally measured on a water digestion of the waste. Because of the volatile nature of ammonia in alkaline solutions, it is important to stabilize by acidifying as soon as possible.

Free hydroxide concentration is normally determined by an approved 222-S Laboratory analytical titration method. However, titration results at low $OH^-$ concentrations (< 0.03 M) pose accuracy problems. As a general guideline, when the waste samples have a pH < 12.5, the free $OH^-$ concentration is calculated from the analytical pH measurement. For waste samples with pH > 12.5, the free hydroxide concentration is normally determined by the analytical titration method. Sodium and buffer (aluminum, phosphate, total organic carbon, and carbonate) concentrations and the shape and quality of the potentiometric titration curve are used in the evaluation of the hydroxide and pH data.

The pH of solids is determined according to SW-846 method 9045C. This method uses a 1:1 mix of solids with water and then the pH is measured. The titration method for hydroxide is not applied to solids.

**Table 4-4. Primary Inorganic Constituents and Analytical Methods.**

| Constituent | Reason For Inclusion | Analytical Method | Alternate Method |
|---|---|---|---|
| Arsenic As | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) and 7060A (GFAA) |
| Barium Ba | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Beryllium Be | U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Cadmium Cd | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Lead Pb | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Nickel Ni | U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Seleniun Se | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) and 7740 (GFAA) |
| Silver Ag | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Thallium Tl | U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Chromium Cr | A, U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Vanadium V | U, W | 6010B (ICP/AES) | |
| Zinc Zn | U, W | 6010B (ICP/AES) | 6020 (ICP/MS) |
| Mercury Hg | A, U, W | 7470A (CVAA) | |
| Fluoride $F^-$ | U, W | 9056 (IC) | |
| Cyanide $CN^-$ | A, U, W | 9014 (Spectrophotometric) | |
| Ferrocyanide $Fe(CN)^{3-}$ | A, U, W | Considered total cyanide. | |
| Sulfide $S^{2-}$ | U, W | 9215 (Ion Selective Electrode) | 9034 (Titration) |
| Ammonium $NH_4^+$ | W | 9056 (IC) | |
| Hydroxide $OH^-$ | W | Titration or pH (see text) | |

Notes:

| | |
|---|---|
| A | Part A constituent. |
| U | UHC constituent. |
| W | Constituent in Wiemers et al. (1998). |
| CVAA | Cold vapor atomic absorption |
| GFAA | Graphite furnace atomic absorption |
| IC | Ion chromatograpy. |
| ICP/AES | Inductively coupled plasma/atomic emissions spectroscopy. |
| ICP/MS | Inductively coupled plasma/mass spectrometry |

The 222-S Laboratory presently does not have a procedure for sulfide analysis. However, work was done several years ago to develop a microdistillation process to prepare samples for sulfide analyses using the ion-specific electrode (ISE) method (SW-846 method 9215). This work will have to be completed to analyze for sulfides.

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. These may be determined by microdistillation and measurement by ion selective electrode or titration methods.

The secondary inorganic constituents are identified in Table 4-5. Most of these constituents are identified in the Regulatory DQO (Wiemers et al. 1998, Table 4.7). However, constituents cerium through titanium (see Table 4-5) are determined by the ICP/AES method but not identified in the Regulatory DQO. Although many of the constituents (e.g., aluminum) in Table 4-5 are considered secondary because of their risk, they are expected to be major components of the residual sludge and important to material balance calculations.

The ICP/MS method can be used as an alternative method for most of the constituents identified for ICP/AES. However, ICP/MS will not be run for these constituents unless results are generated as part of another analysis such as uranium isotopic or it becomes required as indicated in Figure 4-2.

**Table 4-5. Secondary Inorganic Constituents. (2 Sheets)**

| Constituent | Constituent |
|---|---|
| **Method 6010B (ICP/AES)** | **Method 9056 (IC)** |
| Aluminum Al | Bromide $Br^-$ |
| Antimony Sb | Chloride $Cl^-$ |
| Boron B | Nitrate $NO_3^-$ |
| Bismuth Bi | Nitrite $NO_2^-$ |
| Calcium Ca | Phosphate $PO_4^{3-}$ |
| Cobalt Co | Sulfate $SO_4^{2-}$ |
| Copper Cu | Acetate $C_2H_3O_2^-$ |
| Iron Fe | Formate $CHO_2^-$ |
| Potassium K | Glycolate $C_2H_3O_3^-$ |
| Lithium Li | Oxalate $C_2O_4^{2-}$ |
| Molybdenum Mo | |
| Magnesium Mg | |
| Manganese Mn | |
| Sodium Na | |
| Phosphorus P | |
| Rhodium Rh | |
| Sulfur S | |
| Silicon Si | |
| Tin Sn | |
| Tantalum Ta | |
| Tungsten W | |
| Yttrium Y | |
| Zirconium Zr | |
| Uranium U | |
| Sulfur S | |
| Cerium Ce | |
| Europium Eu | |
| Lanthanum La | |
| Niobium Nb | |
| Neodymium Nd | |
| Palladium Pd | |
| Praseodymium Pr | |

**Table 4-5. Secondary Inorganic Constituents. (2 Sheets)**

| Constituent<br>Method 6010B (ICP/AES) | Constituent<br>Method 9056 (IC) |
|---|---|
| Rubidium Rb | |
| Ruthenium Ru | |
| Samarium Sm | |
| Strontium Sr | |
| Tellurium Te | |
| Thorium Th | |
| Titanium Ti | |

Notes:

IC ion chromatography
ICP/AES inductively coupled plasma/atomic emission spectroscopy

### 4.1.3 Radionuclides

The strategy for analyzing radionuclides is essentially the same as the inorganic analytical strategy but the radionuclides have more single constituent analytical methods. Therefore, the strategy for determining the radionuclides can be seen in Figures 4-2 and 4-3 by substituting radionuclides for inorganic constituents. The primary radionuclides are those identified in 10 CFR 61.55, constituents (e.g., $^{79}$Se) added for risk assessment needs, and those that could be major activity contributors. Table 4-6 shows the primary constituents required by this DQO, the reason the constituent is a primary, and the methods used for analysis.

**Table 4-6. Primary Radiochemistry Constituents. (2 Sheets)**

| Constituent | Reason for Inclusion | Analytical Method | Alternate Method |
|---|---|---|---|
| $^{137}$Cs | 10 CFR 61.55 | GEA | |
| $^{60}$Co | 10 CFR 61.55 | GEA | |
| $^{152}$Eu | Potential major activity contributor | GEA | |
| $^{154}$Eu | Potential major activity contributor | GEA | |
| $^{155}$Eu | Potential major activity contributor | GEA | |
| $^{14}$C | 10 CFR 61.55 | Liquid Scintillation Counting | |
| $^{3}$H | 10 CFR 61.55 | Liquid Scintillation Counting | |
| $^{129}$I | 10 CFR 61.55 | Low Energy Gamma Counting | ICP/MS |
| $^{63}$Ni | 10 CFR 61.55 | Liquid Scintillation Counting | |
| $^{90}$Sr | 10 CFR 61.55 | Beta Proportional Counting | |
| $^{99}$Tc | 10 CFR 61.55 | Liquid Scintillation Counting | ICP/MS |
| $^{79}$Se | Risk assessment | Liquid Scintillation Counting | ICP/MS |
| $^{233}$U | Potential major activity contributor | ICP/MS | |
| $^{234}$U | Potential major activity contributor | ICP/MS | |
| $^{235}$U | Potential major activity contributor | ICP/MS | |
| $^{236}$U | Potential major activity contributor | ICP/MS | |
| $^{238}$U | Potential major activity contributor | ICP/MS | |

**Table 4-6. Primary Radiochemistry Constituents. (2 Sheets)**

| Constituent | Reason for Inclusion | Analytical Method | Alternate Method |
|---|---|---|---|
| $^{237}Np$ | 10 CFR 61.55 | ICP/MS | Alpha Counting |
| $^{238}Pu$ | 10 CFR 61.55 | Alpha Counting | ICP/MS |
| $^{239/240}Pu$ | 10 CFR 61.55 | Alpha Counting | ICP/MS as $^{239}Pu$ and $^{240}Pu$ |
| $^{241}Pu$ | 10 CFR 61.55 | Calculate from $^{238}Pu$ & $^{239/240}Pu$ | ICP/MS |
| $^{241}Am$ | 10 CFR 61.55 | Alpha Counting | |
| $^{242}Cm$ | 10 CFR 61.55 | Alpha Counting | |
| $^{243}Cm$ | 10 CFR 61.55 | Alpha Counting | |
| $^{244}Cm$ | 10 CFR 61.55 | Alpha Counting | |
| $^{228}Th$ | Possibly significant in some tanks. | Calculation | GEA |
| $^{230}Th$ | Possibly significant in some tanks. | ICP/MS | |
| $^{232}Th$ | Possibly significant in some tanks. | ICP/MS | |

Notes:

GEA Gamma energy analysis
ICP/MS Inductively coupled plasma/mass spectrometry

The only truly multiple constituent analytical method for radiochemistry is gamma energy analysis (GEA). Therefore, the secondary constituents are those found in the GEA library. If a constituent in the GEA library is detected, the concentration will be reported.

Additional isotopes other than those requested are not normally reported for ICP/MS because measurements are made by peak hopping rather than scanning. ICP/MS may identify other isotopes but is limited to the mass range scanned.

Only two gamma emitting isotopes, $^{137}Cs$ and $^{60}Co$ are identified in 10CFR 61.55. The other gamma emitting isotopes are added for other reasons (see Table 4-6). In most Hanford Site tank waste, $^{137}Cs$ is the dominant gamma-emitting isotope. Other isotopes may not be detected or will be reported at a high less than level by GEA because of the $^{137}Cs$ background.

$^{129}I$ is measured by a chemical separation and low energy gamma counting. $^{129}I$ also may be measured by ICP/MS but sensitivity is not as good unless a collision cell is used to eliminate $^{129}Xe$ interference.

Like $^{129}I$, $^{79}Se$ may be determined by ICP/MS if collision cell technology is used to eliminate argon interferences. There are no standards or tracers for $^{79}Se$ because these isotopes are not commercially available. Nonradioactive selenium is used to correct for chemical yields in the procedures.

The $^{230}Th$ and $^{232}Th$ can be determined by alpha analysis but are normally measured by ICP/MS because of their long half-life. $^{228}Th$ must be determined by calculation from $^{232}Th$ and $^{232}U$ estimates or from alpha counting.

In addition to the constituents discussed above, a bulk density is required. Bulk density is needed to determine waste inventories.

## 4.2 QUALITY CONTROL

Laboratories performing analyses specified in this DQO shall maintain a quality assurance (QA) plan. The plan shall meet the *Hanford Analytical Services Quality Assurance Requirements Documents* (DOE-RL 1998) baseline requirements for laboratory quality systems.

All sampling events will be conducted using controlled procedures. At a minimum, two field blanks and two trip blanks will be collected for the liquid sampling event. One field blank and one trip blank are needed for the VOC analyses and the other field blank and trip blank will be used for the SVOC analyses. The grab sampling field blanks shall be lowered into the tank headspace, the stopper removed, and the blank retrieved. Field blanks and trip blanks will be analyzed using the same methods as the waste samples.

Field and trip blanks are not required for the solid sampling activity because the sampling and shipping conditions of the blanks would not be representative of the solid sample sampling and shipping conditions.

At a minimum, a duplicate analysis is required for each preparation batch. Other laboratory QC for the inorganic and radiochemistry constituents will be conducted according to the criteria outlined in Table 4-7.

**Table 4-7. Quality Control Parameters for Primary Constituents. (2 Sheets)**

| Constituents | Method | QC Acceptance Criteria | | |
|---|---|---|---|---|
| | | LCS % Recovery[a] | Spike% Recovery[b] | Duplicate RPD[c] |
| As, Ba, Be, Cd, Pb, Ni, Se, Ag, Tl, Cr, V, Zn | ICP/AES | 80 – 120% | 75 – 125% | ≤20% |
| Hg | CVAA | 80 – 120% | 75 – 125% | ≤20% |
| $F^-$, $NH_4^+$ | IC | 80 – 120% | 75 – 125% | ≤20% |
| $CN^-$ | 9014 (Spectrophotometric) | 80 – 120% | 75 – 125% | ≤20% |
| $S^{2-}$ | 9215 | 80 – 120% | 75 – 125% | ≤20% |
| $OH^-$ | Titration | 80 – 120% | N/A | ≤20% |
| | pH (see text) | ± 0.1 pH Units | N/A | N/A |
| PCB | GC/ECD | 70 – 130% | 50 – 150% | ≤30% |
| VOC | GC/MS | 70 – 130% | 50 – 150% | ≤30% |
| SVOC | GC/MS | 70 – 130% | 50 – 150% | ≤30% |
| % $H_2O$ | TGA | 80 – 120% | N/A | ≤20% |
| Bulk Density | Gravimetric | N/A | N/A | ≤20% |
| $^{233}U$ $^{234}U$, $^{235}U$ $^{236}U$, $^{238}U$, $^{237}Np$, $^{230}Th$, $^{232}Th$ | ICP/MS | 80 – 120% | 70 – 130% | ≤20% |
| $^{228}Th$ | Calculation | N/A | N/A | N/A |
| $^{60}Co$, $^{137}Cs$ | GEA | 80 – 120% | N/A[e] | ≤20% |

**Table 4-7. Quality Control Parameters for Primary Constituents. (2 Sheets)**

| Constituents | Method | QC Acceptance Criteria | | |
|---|---|---|---|---|
| | | LCS % Recovery[a] | Spike% Recovery[b] | Duplicate RPD[c] |
| $^{152}Eu$, $^{154}Eu$, $^{155}Eu$ | GEA | 80 – 120% | N/A[e] | ≤20% |
| $^{129}I$ | GEA | 75 – 125% | N/A[d] | ≤20% |
| $^{14}C$, $^{3}H$ | Liquid scintillation counting | 80 – 120% | 70 – 130% | ≤20% |
| $^{63}Ni$ | Liquid scintillation counting | 70 – 130% | N/A[d] | ≤20% |
| $^{90}Sr$ | Beta counting | 75 – 125% | N/A[d] | ≤20% |
| $^{99}Tc$ | Liquid scintillation counting | 80 – 120% | 70 – 130% | ≤20% |
| $^{79}Se$ | Liquid scintillation counting | NP | N/A[d] | ≤20% |
| $^{238}Pu$, $^{239/240}Pu$ | Alpha counting | 80 – 120% | N/A[d] | ≤20% |
| $^{241}Pu$ | Calculation from $^{238}Pu$ & $^{239/240}Pu$ | N/A | N/A | N/A |
| $^{241}Am$, $^{242}Cm$, $^{243/244}Cm$ | Alpha counting | 80 – 120% | N/A[d] | ≤20% |

Notes:

| | |
|---|---|
| CVAA | Cold Vapor Atomic Absorption |
| GEA | Gamma Energy Analysis |
| GC/ECD | Gas Chromatography/Electron Capture Detector |
| GC/MS | Gas Chromatography/Mass Spectrometry |
| IC | Ion Chromatography |
| ICP/AES | Inductively Coupled Plasma / Atomic Emission Spectroscopy |
| ICP/MS | Inductively Coupled Plasma / Mass Spectroscopy |
| TGA | Themogravimetric Analysis |
| N/A | Not applicable |
| NP | Not performed |

(a) LCS = Laboratory Control Sample. This sample is carried through the entire analytical method. The accuracy of a method is usually expressed as the percent recovery of the LCS. The LCS is a matrix with known concentration of constituents processed with each preparation and analyses batch. It is expressed as percent recovery; i.e., the amount measured, divided by the known concentration, times 100.

(b) For some methods, the sample accuracy is expressed as the percent recovery of a matrix spike sample. It is expressed as percent recovery; i.e., the amount measured, less the amount in the sample, divided by the spike added, times 100. One matrix spike is performed per analytical batch. Samples are batched with similar matrices. For other constituents, the accuracy is determined based on use of serial dilutions.

(c) RPD = Relative Percent Difference between the samples. Sample precision is estimated by analyzing duplicates taken separately through preparation and analysis. Acceptable sample precision is usually <20% RPD if the sample result is at least 10 times the instrument detection limit.

RPD = ((absolute difference between primary and duplicate)/mean) x 100

(d) Matrix spike analyses are not required for this method because a carrier is used to correct for constituent loss during sample preparation and analysis. The result generated using the carrier accounts for any inaccuracy of the method on the matrix. The reported results reflect this correction.

(e) The measurement is a direct reading of the energy and the analysis is not affected by the sample matrix; therefore, a matrix spike is not required.

Recommendations for ensuring sample integrity prior to analysis are provided in SW-846 (EPA 1996). The recommendations include type of sample container, holding time, preservation, and zero headspace in samples (for volatile components). These requirements are generally based on sampling of environmental samples (e.g., soil, ground or river water). The requirements are difficult to meet for Hanford Site tank waste samples. Because of their highly radioactive nature, extra precautions are used in the sample collection, shipping, and preparation for analysis to minimize radiation exposure to the workers. The SW-846 recommendations are addressed below.

- Type of sample container - In general, liquid samples will be obtained using glass bottles with Teflon[1]-lined lids or Teflon-lined septum caps as needed. The appropriate bottle size and color is determined by the specific needs of the sampling event. For example, for extremely radioactive samples, smaller sample bottles may be required to minimize the radiation source. On the other hand, if a sampling event requires a large amount of sample material for a variety of analyses and tests, larger bottles may be used to minimize the number of samples and, therefore, the exposure time to the samplers. In other words, appropriate bottle size is determined by radioactivity of the waste to be sampled and the specific needs of the sampling events.

  Solids samples are commonly obtained by core or finger-trap sampling methods. New methods are also being evaluated (e.g., clamshell device). In general, solids are much more radioactive than liquid waste. To minimize exposure to workers in the field, solids samples are shipped to the laboratory in the sampling device. That is, the solids are not transferred from the sampling device into sample bottles in the field. The samples are broken down in shielded hot-cells at the laboratory and solids are placed into bottles at that time.

- Holding time - The extra precautions required to sample Hanford Site tank waste either lengthen the time required for each sampling, shipping, and analysis step or create additional steps. For example: personnel must wear protective clothing and shielded gloves when collecting samples; samples must be stored and transported in shielded casks; samples are removed from the casks and transferred into shielded hot cells at the laboratory; samples are broken down and subsampled for analysis using remote manipulators; and samples are stored and analyzed in a manner consistent with fissile material requirements and personnel exposure control. Therefore, the recommended holding times for some analyses may not be met. However, efforts shall be made to minimize the duration between sampling and analysis of samples.

- Sample Preservation - Sample preservation could be temperature control, chemical preservation, or both. Controlling sample temperature during transport is difficult because samples are shipped in large, heavy, shielded casks. The cost of providing refrigeration capable of handling these casks would be prohibitive. Therefore, cooling of samples during transport is not required by this DQO. Efforts shall be made to maintain temperature of samples within the range of normal temperatures for the time of the year when the samples

[1] Teflon® is a registered trademark of I. E. DuPont De Nemours and Company, Inc., Wilmington, Delaware.

are collected. Hot cell space is limited and cannot accommodate large refrigeration units. However, limited (i.e., small) refrigeration capability shall be provided in the laboratory for samples for which cooling is critical (e.g., VOA).

Chemical preservations are not recommended for the Hanford Site tank waste. Hanford Site tank wastes commonly contain high levels of salt and will precipitate metals when preserved by adding acid. In addition, the waste is maintained at high pH (generally >12). Preserving the samples by adding acid may require a large amount of acid and may alter the chemical and physical characteristics of the waste. This would adversely affect the goal of assessing concentrations and physical properties of the waste, as it exists in the tank.

- Zero headspace in sample bottles - To minimize loss of volatile components, SW-846 recommends that the sample bottles contain zero headspace. This recommendation is generally not achievable because of personnel exposure concerns. Upon removing a liquid sample from a tank, the sample bottle is quickly capped and placed in a shielded cask to minimize radiation exposure to the workers. Sampling personnel are not allowed to "top off" the samples. Therefore, a zero headspace is commonly not obtained. As discussed earlier, solids samples are shipped to the laboratory in the sample device to minimize radiation exposure to the workers.

While all of the above recommendations cannot be met for every sample, efforts shall be made to minimize the potential impacts and the duration between sampling and analysis of the samples. The time between sampling the waste and the analytical time will be reported in the data package.

The data report from the 222-S Laboratory will be a format IV data package. A format IV data package, as defined in Clark (2003), is necessary because the data are expected to receive extensive review from outside individuals and organizations. The format IV data package is subject to internal laboratory QA verification and review including peer review prior to release. However, the data package will not receive a third party validation. The data package will include the data for all samples, including composites, segments, subsegments, drainable liquids, and associated blanks taken and analyzed during a single sampling activity. The data package shall be issued as a document approved for public release via an Engineering Data Transmittal form.

The data package is organized into two major parts: (1) a summary report section, and (2) a raw data compilation. Both data package sections will be organized according to the type of analyses or activity where the data were generated. The summary report section is comprised of two subsections: (1) a narrative describing the methods used and any unusual sample or QC results from each analysis or activity; and (2) summary tables of the sample and QC results. Each raw data activity is organized by analysis type and batch or by the time the activity occurred. For most analytical measurements, the batch arrangement requires the least duplication.

Examples of raw data included in the format IV data package are:

- GC chromatograms,

- GC/MS reconstructed ion chromatograms and quantitation reports,
- ICP integration data by constituent,
- Documentation of the amount of spiked material,
- Documentation of the amount of spiked surrogate,
- LABCORE completed work list reports,
- LABCORE data entry templates,
- Results of tracers and carriers,
- Results of internal standards.

Prior to issuing the format IV data package, preliminary data will be available after the data are reviewed and approved by appropriate laboratory personnel. Complete QA/QC review will not be available until the format IV data package is released.

## 4.3 REQUIRED QUANTITATION LIMITS

Detection limits are commonly set an order of magnitude below the action levels required by the DQO. The action levels for the tank 241-C-106 component closure action analytical data depend on development of the risk assessment criteria and presently are not available.

Because the action levels, needed to determine the detection limits, are under development, it was determined the initial quantitation limits for this DQO will be Washington Administrative Code Chapter 173-340 (WAC 173-340) Method B soil limits for protection of groundwater. However, as the risk assessment requirements mature, the required quantitation limits will be revised to meet the risk assessment requirements. The DQO document will be revised to reflect these changes.

Tables 4-8 through 4-12 show comparisons of the WAC 173-340 limits and the MDLs from the 222-S Laboratory. The source of the WAC 173-340 limits is shown in Appendix A. Where physical-chemical parameter values (the distribution coefficient, Kd value, and Henry's Law Constant) are not available in the CLARC 3.1 tables, parameter values were obtained from EPA Region 9 or default values of zero were used, as noted in Appendix A. The EPA Region 9 parameters are available at http://www.epa.gov/region09/waste/sfund /prg/index.htm.

## Table 4-8. Comparison of WAC 173-340 Limits to MDLs for Primary Organic Constituents (2 Sheets)

| CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8260B[a] (VOC) Estimated MDLs mg/kg | CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8270C[b] (SVOC) Estimated MDLs mg/kg |
|---|---|---|---|---|---|---|---|
| 67-64-1 | Acetone (2-Propanone) | 3.21E+00 | 0.1 | 83-32-9 | Acenaphthene | 9.79E+01 | 40 |
| 71-43-2 | Benzene | 4.48E-03 | 0.1 | 117-84-0 | Bis-2-ethylhexyl phthalate (Dioctylphthalate) | 5.32E+05 | 40 |
| 71-36-3 | Butanol; n- (n-butyl alcohol) | 6.62E+00 | 0.1 | 85-68-7 | Butylbenzylphthalate | 8.93E+02 | 40 |
| 75-15-0 | Carbon disulfide | 5.65E+00 | 0.1 | 95-57-8 | Chlorophenol; 2- | 9.43E-01 | 40 |
| 56-23-5 | Carbon tetrachloride | 3.10E-03 | 0.1 | 108-39-4 | Cresol; m- (3-Methylphenol) | 3.20E+00 | 40 |
| 108-90-7 | Chlorobenzene | 8.74E-01 | 0.1 | 95-48-7 | Cresol; o- (2-Methylphenol) | 4.66E+00 | 40 |
| 67-66-3 | Chloroform | 3.81E-02 | 0.1 | 106-44-5 | Cresol; p- (4-Methylphenol) | 3.20E-01 | 40 |
| 107-06-2 | Dichloroethane; 1,2- | 2.32E-03 | 0.1 | 1319-77-3 | Cresylic acid (cresol, mixed isomers) | Note (d) | 0.4 |
| 75-35-4 | Dichloroethylene; 1,1- (Dichloroethene) | 5.22E-04 | 0.1 | 108-94-1 | Cyclohexanone | 3.20E+02 | 0.4 |
| 75-09-2 | Dichloromethane (methylene chloride) | 2.54E-02 | 0.1 | 84-74-2 | Dibutylphthalate (Di-n-butylphthalate) | 1.14E+01 | 0.4 |
| 542-75-6 | Dichloropropene; 1,3,- (trans-) | 1.41E-03[c] | 0.1 | 95-50-1 | Dichlorobenzene; 1,2- (ortho-) | 7.03E+00 | 40 |
| 141-78-6 | Ethyl acetate | 1.61E+02 | 0.1 | 121-14-2 | Dinitrotoluene; 2,4- | 1.89E-01 | 40 |
| 60-29-7 | Ethyl ether (Diethyl ether) | 9.09E+00 | 0.1 | 110-80-5 | Ethoxyethanol; 2- | 2.56E+01 | 0.4 |
| 100-41-4 | Ethylbenzene | 6.05E+00 | 0.1 | 206-44-0 | Fluoranthene | 6.31E+02 | 40 |
| 78-83-1 | Isobutyl alcohol (Isobutanol) | 5.47E+01 | 0.1 | 87-68-3 | Hexachlorobutadiene | 6.05E+00 | 40 |
| 78-93-3 | Methyl ethyl ketone (2-Butanone) | 2.18E+01 | 0.1 | 67-72-1 | Hexachloroethane | 2.49E-01 | 40 |
| 108-10-1 | Methyl isobutyl ketone (4-methyl-2-pentanone) | 1.28E+01 | 0.1 | 128-37-0 | methylphenol; 2,6-Bis(tert-butyl)-4- | None | 0.4 |
| 79-46-9 | Nitropropane; 2- | 1.84E-05 | 0.1 | 59-50-7 | methylphenol; 4-Chloro-3- (p-Chloro-m-cresol) | None | 52 |
| 79-34-5 | Tetrachloroethane; 1,1,2,2- | 1.23E-03 | 0.1 | 91-20-3 | Naphthalene | 4.46E+00 | 0.4 |
| 127-18-4 | Tetrachloroethene; 1,1,2,2- | 9.10E-03 | 0.1 | 98-95-3 | Nitrobenzene | 5.11E-02 | 40 |
| 108-88-3 | Toluene | 7.27E+00 | 0.1 | 88-75-5 | Nitrophenol; o- | None | 40 |
| 76-13-1 | trichloro-1,2,2-trifluoroethane; 1,1,2- | 1.92E+03 | 0.1 | 621-64-7 | Nitroso-di-n-propylamine; N- | 5.60E-05 | 0.4 |
| 71-55-6 | Trichloroethane; 1,1,1- | 1.58E+00 | 0.1 | 59-89-2 | Nitrosomorpholine; N- | None | 0.4 |
| 79-00-5 | Trichloroethane; 1,1,2- | 4.27E-03 | 0.1 | 129-00-0 | Pyrene | 6.55E+02 | 40 |
| 79-01-6 | Trichloroethylene; 1,1,2- | 2.60E-02 | 0.1 | 110-86-1 | Pyridine | 3.87E-01 | 0.4 |
| 75-69-4 | Trichlorofluoromethane | 7.23E+01 | 0.1 | 120-82-1 | Trichlorobenzene; 1,2,4- | 2.98E+00 | 40 |
| 75-01-4 | Vinyl chloride (1-Chloroethene) | 1.84E-04 | 0.1 | 95-95-4 | Trichlorophenol; 2,4,5- | 5.75E+01 | 40 |
| 1330-20-7 | Xylenes | 9.14E+01 | 0.1 | 88-06-2 | Trichlorophenol; 2,4,6- | 9.24E-02 | 40 |
| 108-38-3 | Xylene; m- | 8.44E+01 | 0.1 | | | | |
| 95-47-6 | Xylene; o- | 9.19E+01 | 0.1 | | | | |
| 106-42-3 | Xylene; p- | 1.72E+02 | 0.1 | | | | |
| | | | | | | | |
| | | **Constituent Limits 0.05[e] mg/kg** | **Method 8082 PCBs MDL mg/kg** | | | | |
| 11104-26-2 | Aroclor 1221 | Note c | 0.082 | | | | |
| 11141-16-5 | Aroclor 1232 | Note c | 0.026 | | | | |
| 2674-11-2 | Aroclor 1016 | Note c | 0.46 | | | | |
| 53969-21-9 | Aroclor 1242 | Note c | 0.084 | | | | |
| 126572-29-6 | Aroclor 1248 | Note c | 0.027 | | | | |
| 11097-6999-1 | Aroclor 1254 | Note c | 0.016 | | | | |
| 11096-82-5 | Aroclor 1260 | Note c | 0.113 | | | | |

## Table 4-8. Comparison of WAC 173-340 Limits to MDLs for Primary Organic Constituents (2 Sheets)

| CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8260B[a] (VOC) Estimated MDLs mg/kg | CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8270C[b] (SVOC) Estimated MDLs mg/kg |
|---|---|---|---|---|---|---|---|

Notes:

| | |
|---|---|
| CAS | Chemical Abstracts Service |
| VOC | Volatile Organic Compound |
| SVOC | Semivolatile Organic Compound |
| MDL | Method Detection Limits |
| Shaded Limits | Constituents where the limits are close to or below MDLs. |
| None | Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating lmits. |

[a] 8260B MDL basis SW-846 5g sample, 222-S Laboratory 0.25g sample. The ratio of dilution factor is 5g/0.25g = 20. Example: SW-846 estimated quantitation limit (EQL) = 5mg/g, 222-S Laboratory EQL = 5mg/g x 20 = 100mg/g.

[b] 8270C MDL basis SW-846 30g sample, 222-S Laboratory 1g sample. The ratio of dilution factor is 30g/1g x 2mL/1mL = 60. Example: SW-846 EQL = 5mg/g, 222-S Laboratory EQL = 5mg/g x 60 = 300mg/g.

[c] 0.05 mg/kg is for total PCBs.

[d] Constituent limits are presented for the individual isomers, m-Cresol (CAS 108-39-4), p-Cresol (CAS 106-44-4), o-Cresol (CAS No. 95-48-7) instead of for the mixed isomers of cresol (also called cresylic acid (CAS 1319-77-3)

[e] Constituent limit is for 1,3-Dichloropropene (CAS 542-75-6) instead of the isomer trans-1,3-Dichloropropene.

## Table 4-9. Comparison of WAC 173-340 Limits to MDLs for Secondary Organic Constituents. (2 Sheets)

| CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8260B (VOC) Estimated MDLs mg/kg | CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8270C (SVOC) Estimated MDLs mg/kg |
|---|---|---|---|---|---|---|---|
| 123-86-4 | Acetic acid, n-butylester | None | 0.1 | 98-86-2 | Acetophenone | 6.40E+00 | 0.4 |
| 75-05-8 | Acetonitrile | 2.82E-01 | 0.1 | 309-00-2 | Aldrin | 5.04E-03 | 28 |
| 107-02-8 | Acrolein (propenal) | 1.06E+00 | 0.1 | 50-32-8 | Benzo[a]pyrene | 1.37E-01 | 40 |
| 107-13-1 | Acrylonitrile | 3.33E-04 | 0.1 | 92-52-4 | Biphenyl; 1,1'- | 7.55E+02 | 0.4 |
| 107-05-1 | Allyl chloride (3-Chloropropene) | 3.20E+00 | 0.1 | 4170-30-3 | Butenaldehyde, 2- (2-Butenal) | None | 0.4 |
| 74-83-9 | Bromomethane | 5.18E-03 | 0.1 | 100-00-5 | Chloronitrobenzene (p-Nitrochlorobenzene) | 6.56E-02 | 0.4 |
| 106-99-0 | Butadiene; 1,3- | 3.55E-04 | 0.1 | 541-73-1 | Dichlorobenzene; 1,3- | None | 40 |
| 75-45-6 | Chlorodifluoromethane | None | 0.1 | 106-46-7 | Dichlorobenzene; 1,4- (para-) | 3.00E-02 | 40 |
| 74-87-3 | Chloromethane | 3.34E-02 | 0.1 | 53-70-3 | Diebenzo[a,h]anthracene | 1.37-01 | 40 |
| 110-82-7 | Cyclohexane | 1.30E+03 | 0.1 | 60-57-1 | Dieldrin | 2.82E-03 | 28 |
| 110-83-8 | Cyclohexene | None | 0.1 | 57-14-7 | Dimethylhydrazine; 1,1- | 1.35E-04 | 0.4 |
| 287-92-3 | Cyclopentane | None | 0.1 | 100-25-4 | Dinitrobenzene; 1,4- (para-) | | 0.4 |
| 76-14-2 | Dichloro-1,1,2,2-tetrafluoroethane; 1,2- | None | 0.1 | 88-85-1 | Dinoseb (2-sec-Butyl-4,6-dinitophenol) | 2.80E-02 | 0.4 |
| 75-71-8 | Dichlorodifluoromethane | 2.90E+01 | 0.1 | 122-39-4 | Diphenylamine; N,N- | 1.60E+00 | 0.4 |
| 75-34-3 | Dichloroethane; 1,1- | 4.37E+00 | 0.1 | 72-20-8 | Endrin | 4.40E-01 | 34 |
| 75-43-4 | Dichlorofluoromethane | None | 0.1 | 118-74-1 | Hexachlorobenzene | 1.50E-02 | 40 |
| 78-87-5 | Dichloropropane; 1,2- | 3.30E-03 | 0.1 | 319-84-6 | Hexachlorocyclohexane; alpha- (alpha-BHC) | 5.45E-04 | 18 |
| 10061-01-5 | Dichloropropene; 1,3- (cis-) | 1.41E-03[e] | 0.1 | 319-85-7 | Hexachlorocyclohexane; beta- (beta-BHC) | 2.27E-03 | 18 |
| 123-91-1 | Dioxane; 1,4- | 3.18E-02 | 0.1 | 1335-87-1 | Hexachloronaphtahlene | None | 0.4 |
| 64-17-5 | Ethyl alcohol | None | 0.1 | 684-16-2 | Hexafluoroacetone | None | 0.4 |
| 75-00-3 | Ethyl chloride (Chloroethane) | 3.03E-02 | 0.1 | 591-78-6 | Hexanone; 2- | None | 0.4 |
| 106-93-4 | Ethylene dibromide (1,2-Dibromoethane) | 2.83E-06 | 0.1 | 465-73-6 | Isodrin | None | 0.4 |
| 75-21-8 | Ethylene oxide (Oxirane) | 1.83E-04 | 0.1 | 58-89-9 | Lindane (gamma-BHC) | 2.09E-03 | 28 |

## Table 4-9. Comparison of WAC 173-340 Limits to MDLs for Secondary Organic Constituents. (2 Sheets)

| CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8260B (VOC) Estimated MDLs mg/kg | CAS No. | Chemical Name | WAC 173-340 Limits mg/kg | Method 8270C (SVOC) Estimated MDLs mg/kg |
|---|---|---|---|---|---|---|---|
| 76-44-8 | Heptachlor | 3.78E-03 | 26 | 563-80-4 | Methy-2-butanone; 3- | None | 0.4 |
| 142-82-5 | Heptane; n- | None | 0.1 | 126-98-7 | Methyl-2-propenenitrile; 2- | 6.57E-03 | 0.4 |
| 110-43-0 | Heptanone; 2- | None | 0.1 | 60-34-4 | Methylhydrazine | 3.18E-04 | 0.4 |
| 106-35-4 | Heptanone; 3- | None | 0.1 | 627-13-4 | Nitric acid, propyl ester | None | 0.1 |
| 123-19-3 | Heptanone; 4- | None | 0.1 | 62-75-9 | Nitrosodimethylamine; N- | 6.86E-06 | 0.4 |
| 110-54-3 | Hexane; n- | 9.62E+01 | 0.1 | 2234-13-1 | Octachloronaphthalene | None | 0.4 |
| 624-83-9 | Methyl isocyanate | None | 0.1 | 1321-64-8 | Pentachloronaphthalene | None | 0.4 |
| 110-12-3 | Methyl-2-hexanone; 5- | None | 0.1 | 82-68-8 | Pentachloronitrobenzene (PCNB) | 1.35E-03 | ? |
| 75-65-0 | Methyl-2-Propanol; 2- | None | 0.1 | 87-86-5 | Pentachlorophenol | 1.15E-02 | 132 |
| 107-87-2 | Methylcyclohexane | 1.54E+03 | 0.1 | 109-66-0 | Pentane; n- | None | 0.4 |
| 78-92-2 | Methylpropyl alcohol; 1- (2-butanol) | None | 0.1 | 108-95-2 | Phenol | 4.39E+01 | 40 |
| 111-84-2 | Nonane; n- | None | 0.1 | 123-38-6 | Propionaldehyde; n- | None | 0.4 |
| 111-65-9 | Octane; n- | None | 0.1 | 1335-88-2 | Tetrachloronaphthalene | None | 0.4 |
| 107-87-9 | Pentanone; 2- | None | 0.1 | 8001-35-2 | Toxaphene | 1.53E-01 | ? |
| 96-22-0 | Pentanone; 3- | None | 0.1 | 126-73-8 | Tributyl phosphate | None | 0.4 |
| 107-12-0 | Propionitrile (Ethyl cyanide) | None | 0.1 | 121-44-8 | Triethylamine | 5.19E-02 | 0.4 |
| 67-63-0 | Propyl alcohol; 2- | None | 0.1 | | | | |
| 71-23-8 | Propyl alcohol; n- (1-propanol) | None | 0.1 | | | | |
| 100-42-5 | Styrene | 3.28E-02 | 0.1 | | | | |
| 109-99-9 | Tetrahydrofuran | None | 0.1 | | | | |

Notes:

| | |
|---|---|
| CAS | Chemical Abstracts Service |
| VOC | Volatile Organic Compound |
| SVOC | Semivolatile Organic Compound |
| MDL | Method Detection Limits |
| Shaded Limits | Constituents where the WAC 173-340 limits are below MDLs. |
| ? | MDL estimate unknown. |
| None | Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating lmits. |

[a] Constituent limit is for 1,3-Dichloropropene (CAS 542-75-6) instead of the isomer trans-1,3-Dichloropropene.

## Table 4-10. Comparison of WAC 173-340 Limits to MDLs for Primary Inorganic Constituents (2 Sheets)

| Metals | WAC 173-340 Limits mg/kg | Primary Method 6010B (ICP/AES)[a] MDLs mg/kg | Alternate Method 6020 (ICP/MS)[b] MDLs mg/kg | Alternate Method 7060A/7740 (GFAA)[c] MDLs mg/kg |
|---|---|---|---|---|
| Arsenic As | 3.40E-02 | 34.2 | 2 | 1 |
| Barium Ba | 9.23E+02 | 27.8 | 2.00E-02 | |
| Beryllium Be | 6.32E+01 | 29.5 | 2.00E-02 | |
| Cadmium Cd | 5.00E+00 (in soil) | 30.7 | | |
| Lead Pb | 2.50E+02 | 51.2 | | |
| Nickel Ni | 1.30E+02 | 29.3 | | |
| Selenium Se | 5.20E+00 | 34.8 | 2 | 1 |
| Silver Ag | 1.36E+01 | 6.8 | 6.00E-03 | |
| Thallium Tl | 1.59E+00 can be met with alternate methods | 21.4 | 4.00E-03 | |

**Table 4-10. Comparison of WAC 173-340 Limits to MDLs for Primary Inorganic Constituents (2 Sheets)**

| Metals | WAC 173-340 Limits mg/kg | Primary Method 6010B (ICP/AES)[a] MDLs mg/kg | Alternate Method 6020 (ICP/MS)[b] MDLs mg/kg | Alternate Method 7060A/7740 (GFAA)[c] MDLs mg/kg |
|---|---|---|---|---|
| Chromium Cr | 2.00E+00 (Total Cr) | 30.7 | | |
| Vanadium V | 5.60E+02 | 32.2 | | |
| Zinc Zn | 5.97E+03 | 28.6 | 6.00E-02 | |
| | **Constituent Limits mg/kg** | **Primary Method 7470/71 (CVAA) MDLs mg/kg** | | |
| Mercury Hg[d] | 2.09E+00 | 0.016 | | |
| **Anions** | **Constituent Limits mg/kg** | **Primary Method 9056 (IC)[e] MDLs mg/kg** | | |
| Fluoride $F^-$ | 1.60E+01 | 3 | | |
| $NH_4^+$ | Not regulated | 20 | | |
| | **Constituent Limits mg/kg** | **Primary Method 9010B/9014 (Spec.) MDLs mg/kg** | | |
| Cyanide $CN^-$ [f] | 8.00E-01 | 2.5 | | |
| Ferrocyanide $FE(CN)^{3-}$ | Analyzed as cyanide | | | |
| | **Constituent Limits mg/kg** | **Primary Method 9030B/9215 (ISE) MDLs mg/kg** | | |
| Sulfide $S^{2-}$ | None | In Development | | |

Notes:

| | |
|---|---|
| Shaded Limits | Constituents where the limits are close to or below MDLs. |
| MDL | Method Detection Limits |
| CVAA | Cold Vapor Atomic Absorption. |
| GEA | Gamma Energy Analysis. |
| IC | Ion Chromatography. |
| ICP/AES | Inductively Coupled Plasma / Atomic Emission Spectroscopy. |
| ICP/MS | Inductively Coupled Plasma / Mass Spectroscopy |
| ISE | Ion Selective Electrode. |
| Spec. | Spectrophotometric |
| None | Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating lmits. |

[a] ICP/AES assumes dilution factor = 1000, 0.5g-50 mL-1mL-10. ICP MDLs based on 3050 digest.
[b] ICP/MS based on dilution factor (2000) x EQL factor 10.
[c] As and Se by GFAA assume DF = 100 from acid digest.
[d] Hg assumes a 0.0016 µg detection limit and a 0.1g sample size.
[e] IC assumes a dilution factor = 100 for water digest and a 50 µL loop and AS15 column.
[f] $CN^-$ assumes 0.1 g solid with EDTA dissolution.

**Table 4-11. Comparison of WAC 173-340 Limits to MDLs for Secondary Inorganic Analytes.**

| Metals | WAC 173-340 Limits mg/kg | Method 6010B (ICP/AES) MDLs mg/kg | Anions | WAC 173-340 Limits mg/kg | Method 9056 (IC) MDLs mg/kg |
|---|---|---|---|---|---|
| Aluminum Al | 4.52E+01 | 32.7 | Bromide $Br^-$ | None | 30 |
| Antimony Sb | 5.42E+00 | 27.6 | Chloride $Cl^-$ | 1.00E+03 | 4 |
| Boron B | 1.12E+01 | 17.9 | Nitrate $NO_3^-$ | 4.00E+01 (as nitrogen) | 30 |
| Bismuth Bi | None | 92.5 | Nitrite $NO_2^-$ | 4.00E+00 (as nitrogen) | 30 |
| Calcium Ca | None | 41.7 | Phosphate $PO_4^{3-}$ | None | 30 |
| Cobalt Co | None | 30.4 | Sulfate $SO_4^{2-}$ | 1.00E+03 | 30 |
| Iron Fe | 1.32E+03 | 33.2 | Acetate $C_2H_3O_2^-$ | None | 20 |
| Potassium K | None | 52.6 | Formate $CO^-$ | None | 20 |
| Lithium Li | None | 28 | Glycolate $C_2H_3O_3^-$ | None | 20 |
| Molybdenum Mo | 1.63E+01 | 21.5 | Oxalate $C_2O_4^{2-}$ | None | 30 |
| Magnesium Mg | None | 27.1 | | | |
| Manganese Mn | 5.02E+01 | 28.3 | | | |
| Sodium Na | None | 52.5 | | | |
| Phosphorus P | None | 25.6 | | | |
| Rhodium Rh | None | 27.4 | | | |
| Sulfur S | None | 17.3 | | | |
| Silicon Si | None | 18 | | | |
| Tin Sn | 2.50E+04 | 19.4 | | | |
| Tantalum Ta | None | 32.8 | | | |
| Tungsten W | None | 57.7 | | | |
| Yttrium Y | None | 12.9 | | | |
| Zirconium Zr | None | 18.5 | | | |
| Copper Cu | 2.63E+02 | 29 | | | |
| Uranium U | 1.32E+00 | 43.7 | | | |
| Cerium Ce | None | 23.6 | | | |
| Europium Eu | None | 12.9 | | | |
| Lanthanum La | None | 30.1 | | | |
| Niobium Nb | None | 5.0 | | | |
| Neodymium Nd | None | 15 | | | |
| Palladium Pd | None | 98.7 | | | |
| Praeseodynium Pr | None | 16.8 | | | |
| Rubidium Rb | None | 1121 | | | |
| Ruthenium Ru | None | 11.4 | | | |
| Samarium Sm | None | 11.4 | | | |
| Strontium Sr | 2.92E+03 | 28.1 | | | |
| Tellurium Te | None | 41 | | | |
| Thorium Th | None | 16.9 | | | |
| Titanium Ti | None | 19 | | | |

Notes:

| | |
|---|---|
| Shaded Limits | Constituents where the limits are close to or below MDLs. |
| ICP/AES | Inductively Coupled Plasma / Atomic Emission Spectroscopy |
| IC | Ion Chromatography |
| None | Regulatory limits for these constituents are not available in CLARC 3.1 tables. In addition, tables of toxicity information from EPA do not provide a basis for calculating lmits. |

**Table 4-12. Dose Limits and MDL Comparisons for Primary Radionuclides (2 sheets)**

| Analyte | Analytical Method | Alternate Analytical Method | Limits | | | MDLs µCi/g |
|---|---|---|---|---|---|---|
| | | | Source RESRAD-15 µCi/g | Source RESRAD-GW µCi/g | Source 10 CFR 61.55 Class C Waste µCi/g | |
| $^{137}Cs$ | GEA | | 2.34E-05 | | 3.07E+03 | 1.25E-02 |
| $^{60}Co$ | GEA | | 4.90E-06 | | | 9.00E-03 |
| $^{152}Eu$ | GEA | | 1.14E-05 | | | 1.80E-02 |
| $^{154}Eu$ | GEA | | 1.03E-05 | | | 1.25E-02 |
| $^{155}Eu$ | GEA | | 4.26E-04 | | | 2.20E-02 |
| $^{14}C$ | Liquid Scintillation Counting | | | 2.91E-04 | 5.33E+00 | 4.00E-04 |
| $^{3}H$ | Liquid Scintillation Counting | | | 4.10E-03 | | 4.60E-04 |
| $^{129}I$ | Low Energy Gamma Counting | ICP/MS | | 2.02E-06 | 5.33E-02 | 5.00E-02<br>1.06E-04 [a] |
| $^{63}Ni$ | Liquid Scintillation Counting | | 4.03E-03 | | 4.67E+02 | 5.00E-03 |
| $^{90}Sr$ | Beta Proportional Counting | | 2.41E-03 | | 4.67E+03 | 1.70E-03 |
| $^{99}Tc$ | Liquid Scintillation Counting | ICP/MS | | 1.71E-04 | 2.00E+00 | 5.00E-03<br>1.73E-04 [a] |
| $^{79}Se$ | Liquid Scintillation Counting | | 1.97E-01 | | | 1.00E-04 |
| $^{233}U$ | ICP/MS | | | | 9.00E-03 | 3.85E-06 |
| $^{234}U$ | ICP/MS | | | 3.95E-05 (as $^{233/234}U$) | 9.00E-03 | 2.50E-06 |
| $^{235}U$ | ICP/MS | | | 3.92E-06 (as $^{235/236}U$) | 9.00E-03 | 8.64E-10 |
| $^{236}U$ | ICP/MS | | | | | 2.59E-08 |
| $^{238}U$ | ICP/MS | | | 3.81E-05 | 9.00E-03 | 1.68E-09 |
| $^{237}Np$ | ICP/MS | Alpha Counting | 5.92E-05 | | 9.00E-03 | 2.82E-07<br>6.00E-02[a] |
| $^{238}Pu$ | Alpha Counting | ICP/MS | 4.70E-04 | | 9.00E-03 | 1.70E-03<br>6.84E-03[a] |
| $^{239}Pu$ | Alpha Counting | ICP/MS | 4.25E-04 | | 9.00E-03 (as $^{239/240}Pu$) | 1.70E-03 (as $^{239/240}Pu$) 2.51E-05[a] |
| $^{240}Pu$ | Alpha Counting | ICP/MS | 4.26E-04 | | 9.00E-03 (as $^{239/240}Pu$) | 1.70E-03 (as $^{239/240}Pu$) 9.08E-05[a] |
| $^{241}Pu$ | Calculate from $^{238}Pu$ & $^{239/240}Pu$ | ICP/MS | 1.11E-02 | | 3.50E+03 | 4.12E-02[a] |
| $^{241}Am$ | Alpha Counting | | 3.35E-04 | | 9.00E-03 | 5.50E-03 |
| $^{242}Cm$ | Alpha Counting | | | | 9.00E-03 | 5.50E-03 |

**Table 4-12. Dose Limits and MDL Comparisons for Primary Radionuclides (2 sheets)**

| Analyte | Analytical Method | Alternate Analytical Method | Limits | | | MDLs µCi/g |
|---|---|---|---|---|---|---|
| | | | Source RESRAD-15 µCi/g | Source RESRAD-GW µCi/g | Source 10 CFR 61.55 Class C Waste µCi/g | |
| $^{243}$Cm | Alpha Counting | | 1.10E-04 | | 9.00E-03 | 5.50E-03 (as $^{243/244}$Cm) |
| $^{244}$Cm | Alpha Counting | | 7.44E-04 | | 9.00E-03 | 5.50E-03 (as $^{243/244}$Cm) |
| $^{228}$Th | Calculation | GEA | 7.73E-06 | | | 6.00E-01 (for GEA) |
| $^{230}$Th | ICP/MS | | 2.01E-05 | | | 8.20E-06 |
| $^{232}$Th | ICP/MS | | 4.80E-06 | | | 4.76E-05 |

Notes:

| | |
|---|---|
| Shaded Limits | Constituents where the limits are close to or below MDLs. |
| GEA | Gamma Energy Analysis. |
| ICP/MS | Inductively Coupled Plasma / Mass Spectroscopy |
| RESRAD-15 | Single radionuclide concentration corresponding to a dose of 15 mrem per year above background calculated by RESRAD for 200 Area industrial soil |
| RESRAD-GW | Single radionuclide concentration calculated by RESRAD to be protective of groundwater for 200 Area industrial soil. |

[a] Method detection limits for alternate methods.

Action levels are available for some of the radiochemistry constituents (see Tables 6-1 and 6-2). These action levels are shown in Table 4-12 in the 10 CFR 61.55.

Detection limits are dependent on such things as sample size (caused by sample activity and sample availability), methods, and matrix effects. Therefore, when no action limit is established the laboratory will provide the lowest practical detection limit, which depends on the circumstances noted above.

## 5.0 STUDY BOUNDARIES

This step in the DQO process defines the spatial and temporal boundaries for the required sampling and analyses needed to make the necessary decisions. The spatial boundaries define the physical area to which the decisions will apply and where the samples should be taken. The temporal boundaries describe the timeframe that the data will represent and when the samples should be taken. In addition, this portion of the DQO addresses any sampling constraints.

### 5.1 SPATIAL AND TEMPORAL BOUNDARIES

As stated in the DQO scope statements, the spatial boundary for the sampling and analyses covered by this DQO is only tank 241-C-106. Therefore, the boundary will be the exterior of the tank walls. The soil and ancillary equipment (pipes, pits, vaults, etc.) in the tank farm will be addressed separately.

The data collected will be used to support tank 241-C-106 component closure actions. The temporal boundary for the data collected per this DQO will be the final closure of the tank farm or until the residual waste in the tank is altered. Because the data will represent the condition of the residual waste in tank 241-C-106, the timing of the sample collection must reflect these conditions. Section 8.0 describes the sampling plan including the timing of the samples. This DQO will be in effect until the sampling and analysis for the component closure activities are complete.

## 5.2 SAMPLING CONSTRAINTS

Sampling events for tank 241-C-106 will contend with the usual sampling constraints encountered in sampling Hanford Site tank waste. These constraints include operational constraints such as the type of sampling devices available, riser location and availability, and waste activity concerns (radiation exposure to the workers). Other considerations for sampling and analysis are resource limitations on the number of samples and sample handling considerations (see Section 4.2). The sampling plan is discussed in Section 8.0.

# 6.0 DECISION RULES

The DQO process includes development of decision rules, which define the actions to be taken as a result of exceeding an action level. Decision rules require action levels and alternative actions that will be taken if the action levels are exceeded and are expressed as "if then" statements that incorporates the parameter of interest, the scale of decision making, the action level, and the actions that would result from resolution of the decision rule. For this DQO, three decision rules were developed to address the decision statement in Section 3.0 and shown in Figure 3-1. As can be seen in Figure 3-1, the three decision rules are not sequential but are applied in parallel. All of the decision rules must be met before component closure actions can proceed.

The first decision statement addresses the residual waste volume remaining in tank 241-C-106 after completion of waste retrieval activities. This decision rule is:

> If the waste has been retrieved to the maximum extent technically possible and the maximum estimated residual waste volume within tank 241-C-106 is less than 360 cubic feet, then component closure actions for tank 241-C-106, as specified in the Hanford Site-Wide Permit, can proceed; otherwise, prepare an Appendix H request for an exception to the Tri-Party Agreement milestone M-45-00 retrieval criteria (Ecology et al. 1998).

Commonly, an action level is a concentration at which point a predetermined action is taken depending on whether the results of the analyses are above or below the specified action level. To account for uncertainty in the data, analytical results are compared to the action level at a previously agreed to confidence interval. Under ideal circumstances, confidence intervals are derived by statistical evaluation methods. However, for this decision rule, statistical confidence intervals cannot be established because of the method (see Section 8.1) of determining the

volume estimate for tank 241-C-106. The uncertainty in the measurements for this decision rule is discussed in Section 7.0.

The second decision rule addresses the concentration of constituents of concern within the residual waste in tank 241-C-106. The second decision rule is:

> If the inventories of the radiological and nonradiological constituents of concern in the residual waste within tank 241-C-106 are below the action levels, then component closure actions for tank 241-C-106, as specified in the Hanford Site-Wide Permit, can proceed; otherwise, the State of Washington Department of Ecology (Ecology) will reassess the component closure actions.

The actual action levels for the second decision rule will be developed with the risk assessment process. When the action levels are established, they will be compared to an agreed to confidence interval. Actual action levels can be incorporated as the risk assessment criteria mature and will be compared to the upper confidence limits at that time.

The third decision rule addresses Class C radiological waste concentrations in the residual waste. The residual waste will be evaluated against the U.S. Nuclear Regulatory Commission (NRC) waste classification criteria as defined in 10 CFR 61.55. The evaluation will determine if the residual waste is greater than the NRC Class C waste definition. If the waste is greater than Class C, then either a Class C waiver or an evaluation for equivalent disposal is required (see Figure 3-1).

The evaluation process and decisions to be made are shown in Figure 3-1. The process follows the requirements for determining if the waste exceeds the greater than Class C criteria for mixtures of radionuclides as defined in 10 CFR 61.55 (5) and (7).

Tables 6-1 and 6-2 show the upper limits for Class C waste. These tables are used in conjunction with Figure 6-1 to determine if the analyzed waste is greater than Class C.

**Figure 6-1. Class C Waste Evaluation.**

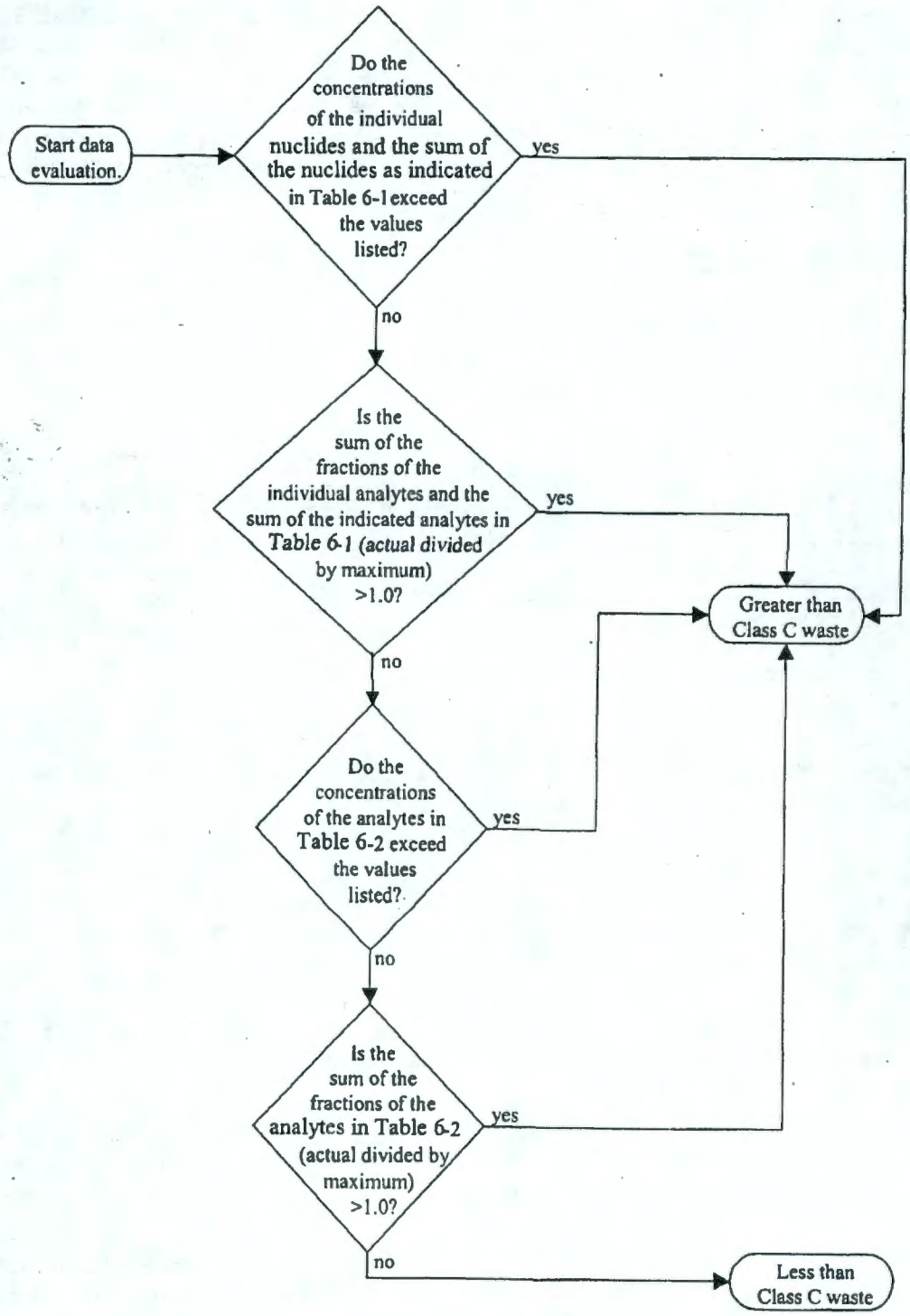


**Table 6-1. Upper Limits of Class C Waste (10 CFR 61.55 Table 1).**

| Table to be used in conjunction with Figure 3-1 and cannot be used independently. | | |
|---|---|---|
| **Constituents** | **Concentration** | **Units** |
| $^{14}C$ | 8 | $Ci/m^3$ |
| $^{99}Tc$ | 3 | $Ci/m^3$ |
| $^{129}I$ | 0.08 | $Ci/m^3$ |
| $^{241}Pu$ | 3,500 | nCi/g |
| $^{242}Cm$ | 20,000 | nCi/g |
| Sum of the concentrations of the following alpha emitting nuclides: $^{241}Am$, $^{243}Cm$, $^{244}Cm$, $^{237}Np$, $^{238}Pu$, $^{239/240}Pu$ | 100 | nCi/g |

Notes:

$Ci/m^3$ Curies per cubic meter
nCi/g Nanocuries per gram

**Table 6-2. Upper Limits of Class C Waste.(10 CFR 61.55 Table 2)**

| Table to be used in conjunction with Figure 3-1 and cannot be used independently | | |
|---|---|---|
| **Constituents** | **Concentration** | **Units** |
| $^{63}Ni$ | 700 | $Ci/m^3$ |
| $^{90}Sr$ | 7,000 | $Ci/m^3$ |
| $^{137}Cs$ | 4,600 | $Ci/m^3$ |

Notes:

$Ci/m^3$ Curies per cubic meter

The following example illustrates the process used with Figure 6-1 and Tables 6-1 and 6-2 to determine if the waste is greater than Class C.

Example:

Hypothetical waste analysis concentrations: $^{14}C = 4\ Ci/m^3$, $^{241}Am = 20$ nCi/g, $^{243}Cm = 10$ nCi/g, $^{63}Ni = 350\ Ci/m^3$, and $^{90}Sr = 5{,}250\ Ci/m^3$.

Step 1: The $^{14}C$ concentration ($4\ Ci/m^3$) is less than the maximum value for $^{14}C$ ($8\ Ci/m^3$) shown in Table 6-1. Indicates the waste is not greater than Class C.

Step 2: The sum of the alpha-emitting transuranic radionuclides ($^{241}Am$ at 20 nCi/g and $^{243}Cm$ at 10 nCi/g) is less than the maximum value (100 nCi/g) shown in Table 6-1. Indicates waste is not greater than Class C.

Step 3: The sum of the fractions (actual concentrations divided by maximum concentrations) for $^{14}C$ and the alpha-emitting transuranic radionuclides ($^{241}Am$ and $^{243}Cm$) is: $4\ Ci/m^3 / 8\ Ci/m^3 + (20\ nCi/g + 10\ nCi/g) / 100\ nCi/g = 0.5 + 0.3 = 0.8$. Indicates waste is not greater Class C.

Step 4: The $^{63}Ni$ (350 Ci/m$^3$) and $^{90}Sr$ (5,250 Ci/m$^3$) individual concentrations are less than the maximum values shown in Table 6-2. Indicates waste is not greater Class C.

Step 5: The sum of the fractions (actual concentrations divided by maximum concentrations) for $^{63}Ni$ and $^{90}Sr$ is: 350 Ci/m$^3$ / 700 Ci/m$^3$ + 5,250 Ci/m$^3$ / 7,000 Ci/m$^3$ = 0.5 + 0.75 = 1.25. Indicates waste is greater than Class C.

Conclusion: For this example, the waste would be greater than Class C because the sum of the fractions for $^{63}Ni$ and $^{90}Sr$ is greater than 1.

The third decision rule can be stated as:

> If the 95% upper confidence limit of the radiological activity in the residual tank waste does not exceed the greater than Class C waste definition, then component closure actions for tank 241-C-106, as specified in the Hanford Site-Wide Permit, can proceed; otherwise, an evaluation for equivalent disposal (disposal equivalent to a repository) is required or a Class C waiver is required.

If the data do not meet the requirements for proceeding with component closure actions, as indicated by the decision rules listed above, the component closure actions may be accomplished depending on the decisions made from the alternative requirements. However, this DQO does not address those decisions.

## 7.0 ERROR TOLERANCE

As mentioned in Section 6.0, an action level is a concentration at which point a predetermined action is taken depending on whether the results of the analyses are above or below the specified action level. To account for uncertainty in the data, analytical results are compared to the action level at an established statistical confidence interval. While an action limit exists for decision rule 1, statistical confidence intervals cannot be established because of the volume data collection method (see Section 8.1).

The uncertainty for the volume data collection has been estimated to be plus or minus 20 percent of the residual waste. The method to determine the error estimate was presented to Ecology at the Single-Shell Tank Closure Planning – C3T[2] Staff Workshop on January 23, 2003. As discussed at the workshop, the sources of error in estimating residual waste volume using a computer-aided design (CAD) created waste surface topography, based on video records, are as follows:

- As-built deviation of tank geometry from construction drawings,
- Creep or warping due to thermal effects,
- Human error in creating waste surface topography in the CAD program and
- The CAD modeling error.

[2] C3T = Cleanup Constraints and Challenges Team

Human error in creating the representation of the waste surface topography in the CAD program is considered the most significant error source. The estimate of plus or minus 20% error in the waste volume estimate using the video camera CAD modeling system is based on engineering judgment. The video camera CAD modeling system will be validated before making a final decision on the component closure action for tank 241-C-106 and will be governed by a test plan. Concurrence of the test plan will be obtained from the organizations signing the concurrence page of this document. Depending on the outcome of the validation, the estimate of a plus or minus 20% error may be revised.

Because a statistical confidence interval cannot be established, the uncertainty in the residual volume is accounted for by using the upper estimated residual waste volume value to determine if the action level is met.

The actual action levels for the decision rule 2 will be developed with the risk assessment process and are not available at this time. Therefore, the uncertainties associated with this decision rule cannot be compared to an action level. Actual action levels can be incorporated as the risk assessment criteria mature. When the action levels are established, a confidence interval can be compared to the action levels as described below for decision rule 3.

The third decision rule contains action levels and a confidence interval. Therefore, the 95% upper confidence limit can be calculated (see below) and compared to the action level for this decision rule.

It is assumed that all radionuclides will be measured on multiple samples (see Section 8.2). It is also assumed that there is at least one set of duplicate measurements (primary and duplicate) per laboratory batch. In each instance, the estimates of the means and standard deviations of the means are calculated using a one-way analysis of variance model to account for unbalanced as well as balanced data. For balanced data ($n_i = n$), the analysis of variance estimate of the mean is usually the arithmetic mean of the observations. If the observations are unbalanced, the estimate of the mean will be the restricted maximum likelihood (REML) estimates.

It is also assumed that 95% confidence is desired. Therefore, in the upper confidence limit (UCL) calculations below the t-statistic will be calculated using $\alpha = 0.05$. If it is predetermined that another level of confidence is needed, $\alpha$ may be calculated using the formula

$$\alpha = \frac{(100\% - confidence\,level)}{100\%}$$

Table 6-1 lists sixteen radionuclides with maximum concentration limits. The first five ($^{14}C$, $^{99}Tc$, $^{129}I$, $^{241}Pu$, and $^{242}Cm$) have corresponding concentration limits while the last ten ($^{241}Am$, $^{243}Cm$, $^{244}Cm$, $^{237}Np$, $^{238}Pu$, $^{239/240}Pu$) have an upper limit to compare the sum of the concentrations.

For each of the first five radionuclides, a one-way analysis of variance model is used to obtain an estimate of the mean concentration and standard deviation of the mean. That is, let

$$\overline{X}_i \; and \; S.D(\overline{X}_i), \; i = 1,2,...5$$

denote the five means and standard deviations, respectively. The upper limit to a one-sided $100(1-\alpha)\%$ UCL on the mean is

$$UCL_i = \overline{X}_i + t_{(\alpha,df)} \times S.D(\overline{X}_i), i = 1,2,...5$$

In this equation, $t_{(\alpha,df)}$ is the quantile from Student's t distribution, with $100(1-\alpha)\%$ confidence and df (generally the number of samples minus 1) degrees of freedom. For each radionuclide, the UCL is compared to the maximum concentration limit given in Table 6-1. If the UCL is greater than the corresponding concentration limit for any radionuclide, then the waste is greater than Class C.

For the second set of ten radionuclides in Table 6-1, let $A_{ij}, B_{ij}, ...F_{ij}$ denote the measured values of $^{241}$Am, $^{243}$Cm, ...$^{239/240}$Pu (each of the ten alpha emitting radionuclides with a half-life greater than five years), respectively, where i=1, 2, ...a, and j=1, 2, ...$n_i$ denote the sample number and replicate value. Also, let

$$S_{ij} = A_{ij} + B_{ij} + ... + F_{ij}$$

Again (since $S_{ij}$ are replicate observations from multiple samples), a one-way analysis of variance is used to estimate the mean and standard deviation of the mean. Let the estimate of the mean and standard deviation of the mean be denoted by $\overline{S}$ and $S.D(\overline{S})$, respectively. The UCL on the mean is

$$UCL = \overline{S} + t_{(\alpha,df)} \times S.D(\overline{S})$$

where $t_{(\alpha,df)}$ is the appropriate quantile from Student's t distribution with df, degrees of freedom, and $100(1-\alpha)\%$ confidence. If the UCL is greater than the corresponding concentration limit from Table 6-1, then the waste is greater than Class C.

For the radionuclides in Table 6-2, the methodology is the same. Let $X_{ij}$, $Y_{ij}$, and $Z_{ij}$ denote the measured values of $^{63}$N, $^{90}$Sr, and $^{137}$Cs, respectively, where i=1, 2, ...a, and j=1, 2, ...$n_i$ denote the sample number and replicate value. Each of $X_{ij}$, $Y_{ij}$, and $Z_{ij}$ are replicate observations from multiple samples. Consequently, a one-way analysis of variance is used to estimate the means and standard deviations of the means. Let the estimates of the means and standard deviations of the means be denoted by

$\overline{X}, \overline{Y}, and \; \overline{Z}$ and by

$SD(\overline{X}), SD(\overline{Y}), and \; SD(\overline{Z})$,

respectively. The one-sided $100(1-\alpha)\%$ confidence intervals (CIs) for each radionuclide are

Ni-63: $\overline{X} + t_{(\alpha,df)} \times SD(\overline{X})$
Sr-90: $\overline{Y} + t_{(\alpha,df)} \times SD(\overline{Y})$
Cs-137: $\overline{Z} + t_{(\alpha,df)} \times SD(\overline{Z})$

where $t_{(\alpha,df)}$ is the appropriate quantile from Student's t distribution with df (generally the number of samples minus 1) degrees of freedom and $100(1-\alpha)\%$ confidence.

To compare the sum of the fractions, the following methodology is used.

The sum of the fractions of each radionuclide is a linear combination of the observations. That is, for the five radionuclides and the sum of the ten radionculides from Table 6-1 denoted by $X_1$, $X_2$, $X_3$, $X_4$, $X_5$, and S, respectively,

$$R = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_6S$$

where $C_1$ through $C_6$ are $\dfrac{1}{\textit{corresponding concentration value}}$ for each radionuclide from Table 6-1.

The preferred method to compute an upper confidence limit is to combine the individual observations by sample. They are combined, using the constants $C_1$ through $C_6$, into a primary duplicate pair and/or primary values. A one-way analysis of variance model is fit to the data to provide estimates of the mean, $\overline{R}$, and the standard deviation of the mean, $SD(\overline{R})$. The upper limit to the one-sided $100(1-\alpha)\%$ CI on the mean is

$$UCL = \overline{R} + t_{(\alpha,df)} \times SD(\overline{R})$$

where $t_{(\alpha,df)}$ is the appropriate quantile from Student's t distribution with df (generally the number of samples minus 1) degrees of freedom and $100(1-\alpha)\%$ confidence. If UCL > 1.0, then the waste is greater then Class C.

The same methodology is applied to the radionuclides in Table 6-2 with $^{63}$Ni, $^{90}$Sr, and $^{137}$Cs denoted by $Y_1$, $Y_2$, and $Y_3$, respectively. The linear combination is

$$R = C_1Y_1 + C_2Y_2 + C_3Y_3$$

where $C_1$, $C_2$, and $C_3$ are $\frac{1}{\textit{corresponding concentration value}}$ for each radionuclide from Table 6-2. The upper limit to the one-sided $100(1-\alpha)\%$ CI on the mean is

$$UCL = \overline{R} + t_{(\alpha,df)} \times SD(\overline{R})$$

where $t_{(\alpha,df)}$ is the appropriate quantile from Student's t distribution with df (generally the number of samples minus 1) degrees of freedom and $100(1-\alpha)\%$ confidence. If UCL > 1.0, then the waste is greater then Class C.

## 8.0 SAMPLING DESIGN

Random sampling cannot be accomplished because of the operational constraints (e.g., sample location restrictions due to riser restrictions and the lack of off riser sampling capability, etc.) Therefore, a subjective sampling plan will be conducted as discussed in Section 8.2.

In addition to supplying waste samples to address this DQO, tank waste will be obtained to conduct risk assessment tests. As stated in Section 4.0, the waste sample material collected for constituent release rate tests (used for risk assessment calculations) will be shipped to PNNL. The testing will be governed by an approved test plan. Minimum sample quantities of 120 g of solids and 150 mL of liquid were established for these tests. The optimum quantity of sample needed for the specified analyses governed by this DQO is approximately 188 g of solids and 500 mL of liquid. Therefore, the total amount of sample material needed to perform the testing and analyses are approximately 308 g of solids and 650 mL of liquid.

The only requirement for the sample sent to PNNL is the quantity of material. Requirements in Section 8.2 only pertain to the sample material sent to the 222-S Laboratory.

### 8.1 VOLUME MEASUREMENTS

The current method for determining the residual waste volume in a tank is the video camera and modeling system. This system, used for the initial baseline measurements of tank 241-C-106 (RPP-12547, Riess 2002), can be deployed without additional development. Residual waste volume measurements are obtained by inserting a video camera into a tank riser and obtaining a videotape of the tank interior. The videotape is used to identify the physical shapes of the waste and to develop a three-dimensional model of the waste surface. The model is developed using a CAD program. The residual waste volume is then estimated using the dimensions and configuration of the tank. The modeling methodology is being refined to include information on accuracy of the volume estimate.

A second method, the tank volume measurement system (TVMS), consists of a television camera and a laser range finder. The TVMS is inserted into a tank riser and the camera and laser range finder are used to map the surface of the residual waste in the tank. The TVMS will be used in

tank 241-C-106 if developed in time and determined to be a more effective and accurate method for waste volume measurements. However, the specific volume estimate methodology and accuracy have not been developed. It is expected that the TVMS map in conjunction with a CAD program will be used to calculate an estimated volume.

## 8.2 WASTE SAMPLING

Both liquid and solid samples of any residual waste are required for the component closure actions of tank 241-C-106. The flowchart for sampling liquids and solids is shown in Figure 8-1.

A sampling strategy was developed in the DQO process meetings to obtain the most representative samples of the residual liquid waste. The current plan is to obtain the liquid samples after completion of the final washing activity and prior to pumping the remaining liquid out of the tank. These samples should be representative of any liquid remaining in the tank (after final pumping) because no additional liquid will be added and the retrieval process will leave the liquid well mixed. In addition, the timing of the sampling activity (before rather then after final pumping) will increase the likelihood of obtaining sufficient liquid samples with current grab sampling techniques.

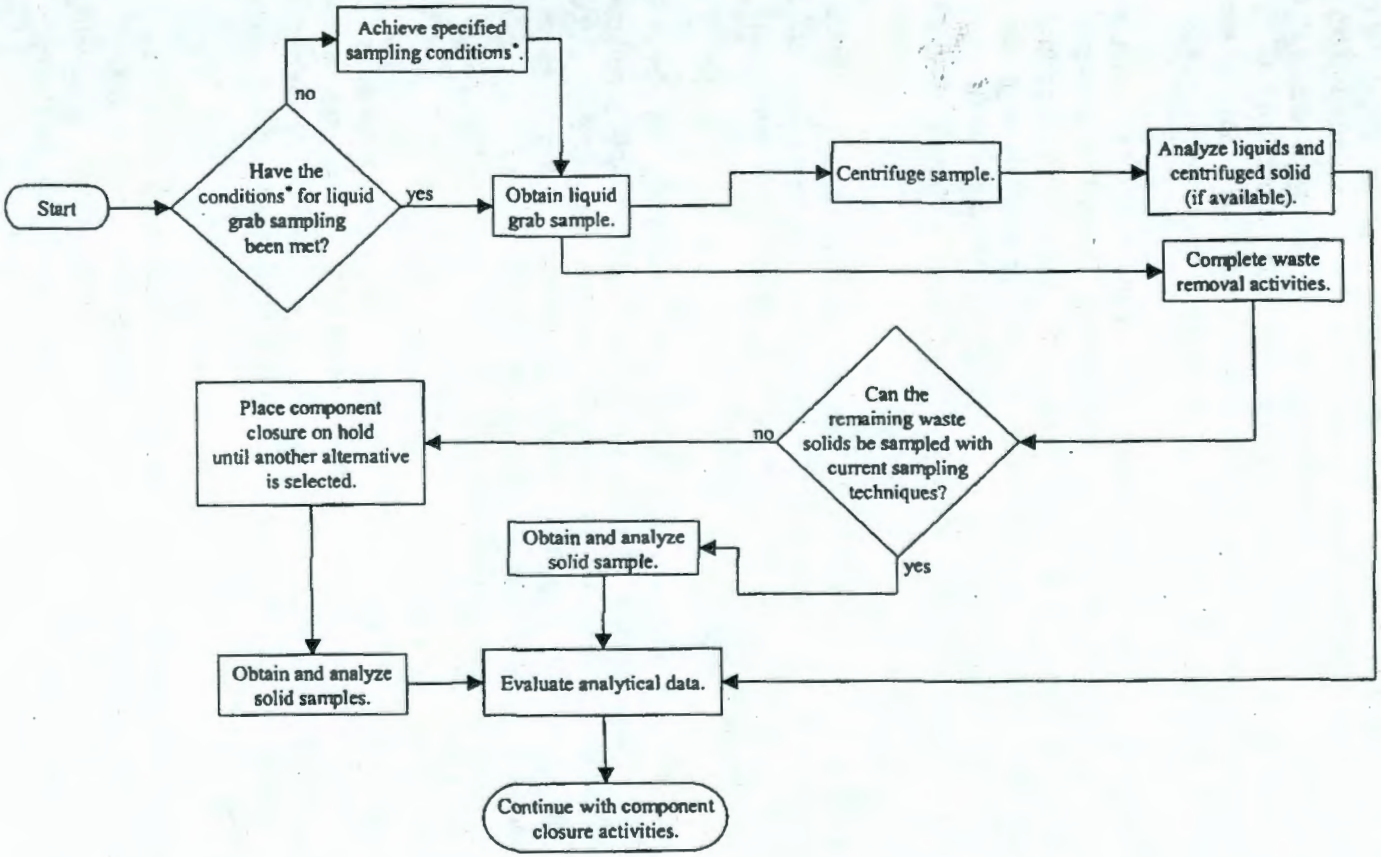
A minimum of two liquid samples (a sample and a duplicate sample) is required by this DQO. The quantity of liquid in one of the samples must be sufficient to obtain a duplicate analysis. Therefore, one sample should contain approximately 350 mL and the other sample approximately 150 mL. In addition, the liquid samples must be obtained in four separate bottles. Two bottles are required to conduct the VOC analyses (sample and duplicate sample) and the other two are required to conduct the SVOC analyses (sample and duplicate sample). The contents from each pair of bottles can be combined (if insufficient sample material is available) for the rest of the required analyses.

Inline sampling during retrieval is not available and is currently not an option.

As shown in Figure 8-1, samples of any residual solids will be obtained after retrieval is completed. The current available sampling device for solids is the finger trap and is not capable of off-riser sampling. The number of samples and the ability of the finger trap sampler to obtain waste samples will be determined by the waste configuration and the depth of waste remaining after retrieval. From the mouth of the sampler to where the fingers begin to open is 1.25 inches on the initial sampler. Therefore, to obtain any sample, the waste depth must be greater than 1.25 inches. However, a modification of the sampler reduced the minimum height of the finger trap sampler to 0.6 inches. Both samplers are presently available.

Another solid waste sampler underdevelopment is the "clamshell" sampler. This sampler will be able to sample a small waste depth but will not have off-riser sampling capability at this time. Sampling devices capable of off-riser sampling are being developed but may not be available before tank 241-C-106 waste sampling is required.

**Figure 8-1. Sampling Strategy for the 241-C-106 Component Closure**




*Conditions for Liquid Sampling

1. No additional liquid will be added to the tank
2. Remaining waste is well mixed
3. Sample just prior to final waste removal

After retrieval activities are completed, a possibility exists that insufficient residual solids or the location of the residual solids may prevent the collection of a sample. For this reason, pre-retrieval samples of the solids in tank 241-C-106 were obtained. These samples were collected using the existing finger trap sampler and archived. After all retrieval activities have been concluded and agreement is reached (by the organizations on the signature page) that a sample of the remaining solids cannot be obtained, analyses of the archived sample will be conducted if that is the alternative action (see Figure 8-1) agreed to by the organizations on the signature page. Before analyses, the archived samples will undergo laboratory simulated retrieval activities. For example, if oxalic acid is added to the tank to facilitate retrieval, the samples will be subjected to oxalic acid of the same concentration prior to analyses.

At the end of the final waste washing activity, an attempt will be made to move any solid waste, which cannot be retrieved, under a tank riser available for sampling. This will be attempted to facilitate sampling and increase the probability of collecting sufficient waste for the planned analyses. In the current retrieval plans, only one riser (riser 14) will be available for waste sampling because the other risers will contain equipment. Sampling from one riser (i.e., one location) may be adequate because the retrieval activities will mobilize and mix the solid waste within the tank.

A minimum of two solid samples (a sample and a duplicate sample) will be collected for the analyses specified in this DQO. A sample may be composed of more than one grab. A grab in this instance is defined as the deployment of one sampling device. Multiple grabs may be required to obtain enough material for the complete analysis.

The optimum amount of solid sample material to accomplish the analytical requirements in this DQO is approximately 188 g. This would allow enough material to optimize detection limits. While approximately 188 g is the optimum amount of sample, the analyses required by this DQO could be accomplished with a minimum of approximately 80 g. However, an 80 g sample could reduce detection limits and may be insufficient if sample material is lost during analytical operations. The amount of material listed in other places in this DQO is for the optimum amount.

The optimum amount of material needed for the VOC and SVOC analyses is approximately 24 g for the sample with the duplicate analysis and 18 g for the other sample. The optimum amount of material for the remaining analyses is 88 g for the sample with the duplicate analysis and 58 g for the other sample. In addition, sufficient sample quantities (see Section 8.0) will be required for PNNL to conduct risk assessment tests.

The solids sampling strategy, described above, is dependent on the ability of the retrieval equipment to mobilize the solids and move the residual solids under riser 14. If the final configuration of the residual solids is different from the anticipated, alternatives (e.g., use the pre-retrieval sample material, samples from a different riser, wait until off-riser sampling is available, etc.) will be evaluated.

In addition to the analyses mentioned above, the liquid samples will be centrifuged and any solids obtained will be analyzed (see Figure 8-1). It is unlikely sufficient centrifuged solids will

be obtained to analyze a complete set of solid analyses. Therefore, the types of solid analyses may require prioritization. The analytical priorities in order of preference are: radiochemistry (particularly for long half-life radionuclides), inorganic metals, inorganic anions, SVOCs, PCBs, and VOCs.

## 9.0 REFERENCES

10 CFR 61.55, 1982, "Waste Designation," *Code of Federal Regulations*, as amended.

40 CFR 141, 2002, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

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# APPENDIX A

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

| | | Soil Direct Contact | | Groundwater Cleanup Levels | | Drinking Water MCL[b] mg/L | Overall GW Cleanup Level | | 3-Phase Partitioning Model Equation for Soil Protection of GW | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAS No. | Chemical Name | Carcinogen mg/kg | Non-carcinogen mg/kg | Carcinogen mg/L | Non-carcinogen mg/L | | mg/L | Source | Kd uL/g | Source | Henry's Law Constant | Source | Soil Conc. for GW Protection mg/kg |
| 50-32-8 | benzo[a]pyrene | 1.37E-01 | | 1.20E-02 | | 2.00E-01 | 1.20E-02 | MTCA B | 9.69E+02 | CLARC 3.1 | 4.63E-05 | CLARC 3.1 | 2.33E-01 |
| 53-70-3 | dibenzo[a,h]anthracene | 1.37E-01 | | 1.20E-02 | | | 1.20E-02 | MTCA B | 1.79E+03 | CLARC 3.1 | 6.03E-07 | CLARC 3.1 | 4.29E-01 |
| 56-23-5 | carbon tetrachloride | 7.69E+00 | 5.60E+01 | 3.37E-01 | 5.60E+00 | 5.00E+00 | 3.37E-01 | MTCA B | 1.52E-01 | CLARC 3.1 | 1.25E+00 | CLARC 3.1 | 3.10E-03 |
| 57-12-5 | cyanide | | 1.60E+03 | | 3.20E+02 | 2.00E+02 | 2.00E+02 | MCL | 0.00E+00 | Default | 0.00E+00 | Default | 8.00E-01 |
| 57-14-7 | dimethylhydrazine;1,1- | 3.85E-01 | | 3.37E-02 | | | 3.37E-02 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 1.35E-04 |
| 58-89-9 | lindane [gamma-BHC] | 7.69E-01 | 2.40E+01 | 6.73E-02 | 4.80E+00 | 2.00E-01 | 6.73E-02 | MTCA B | 1.35E+00 | CLARC 3.1 | 5.74E-04 | CLARC 3.1 | 2.09E-03 |
| 60-29-7 | ethyl ether (diethyl ether) | | 1.60E+04 | | 1.60E+03 | | 1.60E+03 | MTCA B | 8.40E-02 | Region 9 | 5.30E-04 | Region 9 | 9.09E+00 |
| 60-34-4 | methylhydrazine | 9.09E-01 | | 7.95E-02 | | | 7.95E-02 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 3.18E-04 |
| 60-57-1 | dieldrin | 6.25E-02 | 4.00E+00 | 5.47E-03 | 8.00E-01 | | 5.47E-03 | MTCA B | 2.56E+01 | CLARC 3.1 | 6.19E-04 | CLARC 3.1 | 2.82E-03 |
| 62-75-9 | nitrosodimethylamine;N- | 1.96E-02 | | 1.72E-03 | | | 1.72E-03 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 6.86E-06 |
| 67-64-1 | acetone (2-Propanone) | | 8.00E+03 | | 8.00E+02 | | 8.00E+02 | MTCA B | 5.75E-04 | CLARC 3.1 | 1.59E-03 | CLARC 3.1 | 3.21E+00 |
| 67-66-3 | chloroform (trichloromethane) | 1.64E+02 | 8.00E+02 | 7.17E+00 | 8.00E+01 | | 7.17E+00 | MTCA B | 5.30E-02 | CLARC 3.1 | 1.50E-01 | CLARC 3.1 | 3.81E-02 |
| 67-72-1 | hexachloroethane | 7.14E+01 | 8.00E+01 | 6.25E+00 | 1.60E+01 | | 6.25E+00 | MTCA B | 1.78E+00 | CLARC 3.1 | 1.59E-01 | CLARC 3.1 | 2.49E-01 |
| 71-36-3 | butanol;n- (n-butyl alcohol) | | 8.00E+03 | | 1.60E+03 | | 1.60E+03 | MTCA B | 6.92E-03 | CLARC 3.1 | 3.61E-04 | CLARC 3.1 | 6.62E+00 |
| 71-43-2 | benzene | 1.82E+02 | 2.40E+02 | 7.95E-01 | 2.40E+01 | 5.00E+00 | 7.95E-01 | MTCA B | 6.20E-02 | CLARC 3.1 | 2.28E-01 | CLARC 3.1 | 4.48E-03 |
| 71-55-6 | trichloroethane;1,1,1- | | 7.20E+04 | | 7.20E+03 | 2.00E+02 | 2.00E+02 | MCL | 1.35E-01 | CLARC 3.1 | 7.05E-01 | CLARC 3.1 | 1.58E+00 |
| 72-20-8 | endrin | | 2.40E+01 | | 4.80E+00 | 2.00E+00 | 2.00E+00 | MCL | 1.08E+01 | CLARC 3.1 | 3.08E-04 | CLARC 3.1 | 4.40E-01 |
| 74-83-9 | bromomethane [methyl bromide] | | 1.12E+02 | | 1.12E+01 | | 1.12E+01 | MTCA B | 9.00E-03 | CLARC 3.1 | 2.56E-01 | CLARC 3.1 | 5.18E-03 |
| 74-87-3 | chloromethane | 7.69E+01 | | 3.37E+00 | | | 3.37E+00 | MTCA B | 2.10E-01 | Region 9 | 9.80E-01 | Region 9 | 3.34E-02 |
| 75-00-3 | ethyl chloride [chloroethane] | | | | | 4.64E+00 | 4.64E+00 | Region 9 | 8.80E-02 | Region 9 | 4.50E-01 | Region 9 | 3.03E-02 |
| 75-01-4 | vinyl chloride [chloroethene; 1-] | 6.67E-01 | 2.40E+02 | 2.92E-02 | 2.40E+01 | 2.00E+00 | 2.92E-02 | MTCA B | 1.86E-02 | CLARC 3.1 | 1.11E+00 | CLARC 3.1 | 1.84E-04 |
| 75-05-8 | acetonitrile | | 4.80E+02 | | 4.80E+01 | | 4.80E+01 | MTCA B | 9.40E-02 | Region 9 | 8.20E-04 | Region 9 | 2.82E-01 |
| 75-09-2 | dichloromethane (methylene chloride) | 1.33E+02 | 4.80E+03 | 5.83E+00 | 4.80E+02 | 5.00E+00 | 5.00E+00 | MCL | 1.00E-02 | CLARC 3.1 | 8.98E-02 | CLARC 3.1 | 2.54E-02 |
| 75-15-0 | carbon disulfide | | 8.00E+03 | | 8.00E+02 | | 8.00E+02 | MTCA B | 4.57E-02 | CLARC 3.1 | 1.24E+00 | CLARC 3.1 | 5.65E+00 |
| 75-21-8 | ethylene oxide | 9.80E-01 | | 4.29E-02 | | | 4.29E-02 | MTCA B | 1.30E-02 | Region 9 | 3.10E-03 | Region 9 | 1.83E-04 |
| 75-35-4 | dichloroethylene;1,1- | 1.67E+00 | 7.20E+02 | 7.29E-02 | 7.20E+01 | 7.00E+00 | 7.29E-02 | MTCA B | 6.50E-02 | CLARC 3.1 | 1.07E+00 | CLARC 3.1 | 5.22E-04 |
| 75-69-4 | trichlorofluoromethane | | 2.40E+04 | | 2.40E+03 | | 2.40E+03 | MTCA B | 9.60E-01 | Region 9 | 4.00E+00 | Region 9 | 7.23E+01 |
| 75-71-8 | dichlorodifluoromethane | | 1.60E+04 | | 1.60E+03 | | 1.60E+03 | MTCA B | 3.50E-01 | Region 9 | 4.10E+00 | Region 9 | 2.90E+01 |
| 76-13-1 | trichloro-1,2,2- | | 2.40E+06 | | 4.80E+05 | | 4.80E+05 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 1.92E+03 |

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

| | | Soil Direct Contact | | Groundwater Cleanup Levels | | Drinking Water MCL[b] mg/L | Overall GW Cleanup Level | | 3-Phase Partitioning Model Equation for Soil Protection of GW | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAS No. | Chemical Name | Carcinogen mg/kg | Non-carcinogen mg/kg | Carcinogen mg/L | Non-carcinogen mgL | | mg/L | Source | Kd uL/g | Source | Henry's Law Constant | Source | Soil Conc. for GW Protection mg/kg |
| | trifluoroethane;1,1,2- | | | | | | | | | | | | |
| 76-44-8 | heptachlor | 2.22E-01 | 4.00E+01 | 1.94E-02 | 8.00E+00 | 4.00E-01 | 1.94E-02 | MTCA B | 9.53E+00 | CLARC 3.1 | 4.47E-02 | CLARC 3.1 | 3.78E-03 |
| 78-87-5 | dichloropropane;1,2- | 1.47E+01 | | 6.43E-01 | | 5.00E+00 | 6.43E-01 | MTCA B | 4.70E-02 | CLARC 3.1 | 1.15E-01 | CLARC 3.1 | 3.30E-03 |
| 79-00-5 | trichloroethane;1,1,2- | 1.75E+01 | 3.20E+02 | 7.68E-01 | 3.20E+01 | 5.00E+00 | 7.68E-01 | MTCA B | 7.50E-02 | CLARC 3.1 | 3.74E-02 | CLARC 3.1 | 4.27E-03 |
| 79-01-6 | trichloroethylene (TCE; trichloroethene) | 9.09E+01 | | 3.98E+00 | | 5.00E+00 | 3.98E+00 | MTCA B | 9.40E-02 | CLARC 3.1 | 4.22E-01 | CLARC 3.1 | 2.63E-02 |
| 79-34-5 | tetrachloroethane;1,1,2,2- | 5.00E+00 | | 2.19E-01 | | | 2.19E-01 | MTCA B | 7.90E-02 | CLARC 3.1 | 1.41E-02 | CLARC 3.1 | 1.23E-03 |
| 79-46-9 | nitropropane; 2- | 1.05E-01 | | 4.61E-03 | | | 4.61E-03 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 1.84E-05 |
| 82-68-8 | pentachloronitrobenzene | 3.85E+00 | 2.40E+02 | 3.37E-01 | 4.80E+01 | | 3.37E-01 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 1.35E-03 |
| 83-32-9 | acenaphthene | | 4.80E+03 | | 9.60E+02 | | 9.60E+02 | MTCA B | 4.90E+00 | CLARC 3.1 | 6.36E-03 | CLARC 3.1 | 9.79E+01 |
| 84-74-2 | di-butyl phthalate | | 8.00E+03 | | 1.60E+03 | | 1.60E+03 | MTCA B | 1.57E-01 | CLARC 3.1 | 3.85E-08 | CLARC 3.1 | 1.14E+01 |
| 85-68-7 | butyl benzyl phthalate | | 1.60E+04 | | 3.20E+03 | | 3.20E+03 | MTCA B | 1.38E+01 | CLARC 3.1 | 5.17E-05 | CLARC 3.1 | 8.93E+02 |
| 87-68-3 | hexachlorobutadiene | 1.28E+01 | 1.60E+01 | 5.61E-01 | 1.60E+00 | | 5.61E-01 | MTCA B | 5.37E+01 | CLARC 3.1 | 3.34E-01 | CLARC 3.1 | 6.05E-01 |
| 87-86-5 | pentachlorophenol | 8.33E+00 | 2.40E+03 | 7.29E-01 | 4.80E+02 | 1.00E+00 | 7.29E-01 | MTCA B | 5.92E-01 | CLARC 3.1 | 1.00E-06 | CLARC 3.1 | 1.15E-02 |
| 88-06-2 | trichlorophenol;2,4,6- | 9.09E+01 | | 7.95E+00 | | | 7.95E+00 | MTCA B | 3.81E-01 | CLARC 3.1 | 3.19E-04 | CLARC 3.1 | 9.24E-02 |
| 88-85-1 | dinoseb (2-sec-butyl-4,6-dinitophenol) | | 8.00E+01 | | 1.60E+01 | 7.00E+00 | 7.00E+00 | MCL | 0.00E+00 | Default | 0.00E+00 | Default | 2.80E-02 |
| 91-20-3 | naphthalene | | 1.60E+03 | | 1.60E+02 | | 1.60E+02 | MTCA B | 1.19E+00 | CLARC 3.1 | 1.98E-02 | CLARC 3.1 | 4.46E+00 |
| 92-52-4 | biphenyl;1,1- | | 4.00E+03 | | 8.00E+02 | | 8.00E+02 | MTCA B | 4.70E+01 | Region 9 | 2.10E-02 | Region 9 | 7.55E+02 |
| 95-47-6 | xylene;o- | | 1.60E+05 | | 1.60E+04 | 1.00E+04 | 1.00E+04 | MCL | 2.41E-01 | CLARC 3.1 | 2.13E-01 | CLARC 3.1 | 9.19E+01 |
| 95-48-7 | cresol; o- (2-methylphenol) | | 4.00E+03 | | 8.00E+02 | | 8.00E+02 | MTCA B | 9.12E-02 | CLARC 3.1 | 4.92E-05 | CLARC 3.1 | 4.66E+00 |
| 95-50-1 | dichlorobenzene;1,2- [ortho] | | 7.20E+03 | | 7.20E+02 | 6.00E+02 | 6.00E+02 | MCL | 3.79E-01 | CLARC 3.1 | 7.79E-02 | CLARC 3.1 | 7.03E+00 |
| 95-57-8 | chlorophenol;2- | | 4.00E+02 | | 8.00E+01 | | 8.00E+01 | MTCA B | 3.88E-01 | CLARC 3.1 | 1.60E-02 | CLARC 3.1 | 9.43E-01 |
| 95-95-4 | trichlorophenol;2,4,5- | | 8.00E+03 | | 1.60E+03 | | 1.60E+03 | MTCA B | 1.60E+00 | CLARC 3.1 | 1.78E-04 | CLARC 3.1 | 5.75E+01 |
| 98-86-2 | acetophenone | | 8.00E+03 | | 1.60E+03 | | 1.60E+03 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 6.40E+00 |
| 98-95-3 | nitrobenzene | | 4.00E+01 | | 8.00E+00 | | 8.00E+00 | MTCA B | 1.19E-01 | CLARC 3.1 | 9.84E-04 | CLARC 3.1 | 5.11E-02 |
| 100-00-5 | chloronitrobenzene;p- | 5.56E+01 | | 4.86E+00 | | | 4.86E+00 | MTCA B | 3.90E-01 | Region 9 | 9.80E-01 | Region 9 | 6.56E-02 |
| 100-25-4 | Dinitrobenzene; 1,4- (para-) | | 3.20E+01 | | 6.40E+00 | | 6.40E+00 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | |
| 100-41-4 | ethylbenzene | | 8.00E+03 | | 8.00E+02 | 7.00E+02 | 7.00E+02 | MCL | 2.04E-01 | CLARC 3.1 | 3.23E-01 | CLARC 3.1 | 6.05E+00 |
| 100-42-5 | styrene | 3.33E+01 | 1.60E+04 | 1.46E+00 | 1.60E+03 | 1.00E+02 | 1.46E+00 | MTCA B | 9.12E-01 | CLARC 3.1 | 1.13E-01 | CLARC 3.1 | 3.28E-02 |
| 106-42-3 | xylene;p- | | | | | | 1.60E+04 | MTCA B | 3.11E-01 | CLARC 3.1 | 3.14E-01 | CLARC 3.1 | 1.72E+02 |

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

| | | Soil Direct Contact | | Groundwater Cleanup Levels | | Drinking Water MCL[b] mg/L | Overall GW Cleanup Level | | 3-Phase Partitioning Model Equation for Soil Protection of GW | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAS No. | Chemical Name | Carcinogen mg/kg | Non-carcinogen mg/kg | Carcinogen mg/L | Non-carcinogen mgL | | mg/L | Source | Kd uL/g | Source | Henry's Law Constant | Source | Soil Conc. for GW Protection mg/kg |
| 106-44-5 | cresol; p- (4-methylphenol) | | 4.00E+02 | | 8.00E+01 | | 8.00E+01 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 3.20E-01 |
| 106-46-7 | dichlorobenzene;1,4-[para] | 4.17E+01 | | 1.82E+00 | | 7.50E+01 | 1.82E+00 | MTCA B | 6.16E-01 | CLARC 3.1 | 9.96E-02 | CLARC 3.1 | 3.00E-02 |
| 106-93-4 | ethylene dibromide (1,2-dibromoethane) | 1.18E-02 | | 5.15E-04 | | 5.00E-02 | 5.15E-04 | MTCA B | 6.60E-02 | CLARC 3.1 | 1.00E-01 | Region 9 | 2.83E-06 |
| 106-99-0 | butadiene;1,3- | | | | | | 1.14E-02 | Region 9 | 7.20E-01 | Region 9 | 7.30E+00 | Region 9 | 3.55E-04 |
| 107-02-8 | acrolein | | 1.60E+03 | | 1.60E+02 | | 1.60E+02 | MTCA B | 1.30E-01 | Region 9 | 4.90E-03 | Region 9 | 1.06E+00 |
| 107-05-1 | allyl chloride [chloropropene; 3-] | | 4.00E+03 | | 8.00E+02 | | 8.00E+02 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 3.20E+00 |
| 107-13-1 | acrylonitrile | 1.85E+00 | 8.00E+01 | 8.10E-02 | 8.00E+00 | | 8.10E-02 | MTCA B | 5.10E-03 | Region 9 | 3.60E-03 | Region 9 | 3.33E-04 |
| 107-87-2 | methylcyclohexane | | | | | | 5.22E+03 | Region 9 | 1.30E+01 | Region 9 | 1.80E+01 | Region 9 | 1.54E+03 |
| 108-38-3 | xylene;m- | | 1.60E+05 | | 1.60E+04 | 1.00E+04 | 1.00E+04 | MCL | 1.96E-01 | CLARC 3.1 | 3.01E-01 | CLARC 3.1 | 8.44E+01 |
| 108-39-4 | cresol; m- (m-cresylic acid) | | 4.00E+03 | | 8.00E+02 | | 8.00E+02 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 3.20E+00 |
| 108-88-3 | toluene | | 1.60E+04 | | 1.60E+03 | 1.00E+03 | 1.00E+03 | MCL | 1.40E-01 | CLARC 3.1 | 2.72E-01 | CLARC 3.1 | 7.27E+00 |
| 108-90-7 | chlorobenzene | | 1.60E+03 | | 1.60E+02 | 1.00E+02 | 1.00E+02 | MCL | 2.24E-01 | CLARC 3.1 | 1.52E-01 | CLARC 3.1 | 8.74E-01 |
| 108-94-1 | cyclohexanone | | 4.00E+05 | | 8.00E+04 | | 8.00E+04 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 3.20E+02 |
| 108-95-2 | phenol | | 4.80E+04 | | 9.60E+03 | | 9.60E+03 | MTCA B | 2.88E-02 | CLARC 3.1 | 1.63E-05 | CLARC 3.1 | 4.39E+01 |
| 110-54-3 | hexane;n- | | 4.80E+03 | | 4.80E+02 | | 4.80E+02 | MTCA B | 3.41E+00 | CLARC 3.1 | 7.40E+01 | CLARC 3.1 | 9.62E+01 |
| 110-80-5 | ethoxyethanol; 2- | | 3.20E+04 | | 6.40E+03 | | 6.40E+03 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 2.56E+01 |
| 110-82-7 | cyclohexane | | | | | | 3.47E+04 | Region 9 | 9.60E-01 | Region 9 | 8.20E+00 | Region 9 | 1.30E+03 |
| 110-86-1 | pyridine . | | 8.00E+01 | | 1.60E+01 | | 1.60E+01 | MTCA B | 1.00E+00 | Region 9 | 1.00E-01 | Region 9 | 3.87E-01 |
| 118-74-1 | hexachlorobenzene | 6.25E-01 | 6.40E+01 | 5.47E-02 | 1.28E+01 | 1.00E+00 | 5.47E-02 | MTCA B | 8.00E+01 | CLARC 3.1 | 5.41E-02 | CLARC 3.1 | 1.50E-02 |
| 120-82-1 | trichlorobenzene;1,2,4- | | 8.00E+02 | | 8.00E+01 | 7.00E+01 | 7.00E+01 | MCL | 1.66E+00 | CLARC 3.1 | 5.82E-02 | CLARC 3.1 | 2.98E+00 |
| 121-14-2 | dinitrotoluene;2,4- | | 1.60E+02 | | 3.20E+01 | | 3.20E+01 | MTCA B | 9.55E-02 | CLARC 3.1 | 3.80E-06 | CLARC 3.1 | 1.89E-01 |
| 121-44-8 | triethylamine | | | | | | 1.22E+01 | Region 9 | 1.30E-02 | Region 9 | 3.70E-03 | Region 9 | 5.19E-02 |
| 122-39-4 | diphenylamine | | 2.00E+03 | | 4.00E+02 | | 4.00E+02 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 1.60E+00 |
| 123-91-1 | dioxane;1,4- | 9.09E+01 | | 7.95E+00 | | | 7.95E+00 | MTCA B | 0.00E+00 | Default | 0.00E+00 | Default | 3.18E-02 |
| 126-98-7 | methacrylonitrile | | 8.00E+00 | | 1.60E+00 | | 1.60E+00 | MTCA B | 5.10E-03 | Region 9 | 3.60E-03 | Region 9 | 6.57E-03 |
| 127-18-4 | tetrachloroethylene (PCE; tetrachlorethene) | 1.96E+01 | 8.00E+02 | 8.58E-01 | 8.00E+01 | 5.00E+00 | 8.58E-01 | MTCA B | 2.65E-01 | CLARC 3.1 | 7.54E-01 | CLARC 3.1 | 9.10E-03 |
| 129-00-0 | pyrene | | 2.40E+03 | | 4.80E+02 | | 4.80E+02 | MTCA B | 6.80E+01 | CLARC 3.1 | 4.51E-04 | CLARC 3.1 | 6.55E+02 |
| 141-78-6 | ethyl acetate | | 7.20E+04 | | 1.44E+04 | | 1.44E+04 | MTCA B | 3.60E-01 | Region 9 | 5.70E-03 | Region 9 | 1.61E+02 |
| 206-44-0 | fluoranthene | | 3.20E+03 | | 6.40E+02 | | 6.40E+02 | MTCA B | 4.91E+01 | CLARC 3.1 | 6.60E-04 | CLARC 3.1 | 6.31E+02 |

Table A-1. WAC 173-340 Method B Cleanup Levels for Chemicals in Order by Chemical Abstract Number[a].

| | | Soil Direct Contact | | Groundwater Cleanup Levels | | Drinking Water MCL[b] mg/L | Overall GW Cleanup Level | | 3-Phase Partitioning Model Equation for Soil Protection of GW | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAS No. | Chemical Name | Carcinogen mg/kg | Non-carcinogen mg/kg | Carcinogen mg/L | Non-carcinogen mgL | | mg/L | Source | Kd uL/g | Source | Henry's Law Constant | Source | Soil Conc. for GW Protection mg/kg |
| 309-00-2 | aldrin | 5.88E-02 | 2.40E+00 | 5.15E-03 | 4.80E-01 | | 5.15E-03 | MTCA B | 4.87E+01 | CLARC 3.1 | 6.97E-03 | CLARC 3.1 | 5.04E-03 |
| 319-84-6 | hexachlorocyclohexane;alpha (alpha-BHC) | 1.59E-01 | | 1.39E-02 | | | 1.39E-02 | MTCA B | 1.76E+00 | CLARC 3.1 | 4.35E-04 | CLARC 3.1 | 5.45E-04 |
| 319-85-7 | hexachlorocyclohexane;beta- (beta-BHC) | 5.56E-01 | | 4.86E-02 | | | 4.86E-02 | MTCA B | 2.14E+00 | CLARC 3.1 | 3.05E-05 | CLARC 3.1 | 2.27E-03 |
| 319-86-8 | hexachlorocyclohexane;delta- (delta-BHC) | | | | | | | MTCA B | | | | | |
| 542-75-6 | dichloropropene;1,3- | 5.56E+00 | 2.40E+03 | 2.43E-01 | 2.40E+02 | | 2.43E-01 | MTCA B | 2.70E-02 | CLARC 3.1 | 7.26E-01 | CLARC 3.1 | 1.41E-03 |
| 621-64-7 | nitroso-di-n-propylamine;N- | 1.43E-01 | | 1.25E-02 | | | 1.25E-02 | MTCA B | 2.40E-02 | CLARC 3.1 | 9.23E-05 | CLARC 3.1 | 5.60E-05 |
| 1330-20-7 | xylene | | 1.60E+05 | | 1.60E+04 | 1.00E+04 | 1.00E+04 | MCL | 2.33E-01 | CLARC 3.1 | 2.79E-01 | CLARC 3.1 | 9.14E+01 |
| 7439-92-1 | lead | | 2.50E+02 | | | 1.50E+01 | 1.50E+01 | MCL | 1.00E+04 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 3.00E+03 |
| 7439-97-6 | mercury | | 2.40E+01 | | 4.80E+00 | 2.00E+00 | 2.00E+00 | MCL | 5.20E+01 | CLARC 3.1 | 4.70E-01 | CLARC 3.1 | 2.09E+00 |
| 7440-02-0 | nickel, soluble salts[c] | | 1.60E+03 | | 3.20E+02 | 1.00E+02 | 1.00E+02 | MCL (WAC) | 6.50E+01 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 1.30E+02 |
| 7440-22-4 | silver[c] | | 4.00E+02 | | 8.00E+01 | 1.00E+02 | 8.00E+01 | MTCA B | 8.30E+00 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 1.36E+01 |
| 7440-28-0 | thallium, soluble salts | | 5.60E+00 | | 1.12E+00 | 2.00E+00 | 1.12E+00 | MTCA B | 7.10E+01 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 1.59E+00 |
| 7440-38-2 | arsenic, inorganic | 6.67E-01 | 2.40E+01 | 5.83E-02 | 4.80E+00 | 5.00E+00 | 5.83E-02 | MTCA B | 2.90E+01 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 3.40E-02 |
| 7440-39-3 | barium | | 5.60E+03 | | 1.12E+03 | 2.00E+03 | 1.12E+03 | MTCA B | 4.10E+01 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 9.23E+02 |
| 7440-41-7 | beryllium | | 1.60E+02 | | 3.20E+01 | 4.00E+00 | 4.00E+00 | MCL | 7.90E+02 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 6.32E+01 |
| 7440-47-3 | chromium (total) | | | | | 1.00E+02 | 1.00E+02 | MCL | 1.00E+03 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 2.00E+03 |
| 7440-62-2 | vanadium | | 5.60E+02 | | 1.12E+02 | | 1.12E+02 | MTCA B | 1.00E+03 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 2.24E+03 |
| 7782-49-2 | selenium and compounds | | 4.00E+02 | | 8.00E+01 | 5.00E+01 | 5.00E+01 | MCL | 5.00E+00 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 5.20E+00 |
| 8001-35-2 | toxaphene | 9.09E-01 | | 7.95E-02 | | 5.00E+00 | 7.95E-02 | MTCA B | 9.58E+01 | CLARC 3.1 | 2.46E-04 | CLARC 3.1 | 1.53E-01 |
| 16065-83-1 | chromium(III) | | 1.20E+05 | | 2.40E+04 | | 2.40E+04 | MTCA B | 1.00E+03 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 2.00E+03 |
| 16984-48-8 | fluoride | | | | | 4.00E+03 | 4.00E+03 | MCL | 0.00E+00 | Default | 0.00E+00 | Default | 1.60E+01 |
| 18540-29-9 | chromium(VI) | | 2.40E+02 | | 4.80E+01 | | 4.80E+01 | MTCA B | 1.90E+01 | CLARC 3.1 | 0.00E+00 | CLARC 3.1 | 1.84E+01 |

Notes:

GW – Ground Water

CAS – Chemical Abstract Service

(a) The lowest value of columns 3 and 4 (Soil Direct Contact) and column 14 (Soil Conc. for GW Protection mg/kg) is used in Tables 4-8 through 4-11.

(b) MCL is the drinking water maximum contaminant level from 40 CFR 141

(c) MCL for nickel, soluble salts, from WAC-173-201A "Water Quality Standards for Surface Waters of the State of Washington