COMMONWEALTH OF VIRGINIA
DEPARTMENT OF HEALTH
OFFICE OF DRINKING WATER

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To: Office of Drinking Water Staff

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Subject: **Working Memo 898**
SURVEILLANCE & REGULATIONS - Compliance Sampling and Reporting Guidance Manual

Summary:
This memo replaces Working Memo 898, dated July 7, 2017. The Compliance Sampling and Reporting Guidance Manual (*Sampling Manual)* Version 6.0 is hereby released with this memo, and the following Working Memos are revoked:

- WM 912: Transition Between Stage 1 and Stage 2 DDBP Rules and Stage 2 Extension requests;
- WM 909: Stage 2 D/DBP – Initial Distribution System Evaluation (IDSE) Final Reports; and
- WM 895: Stage 2 DBP – Initial Distribution System Evaluation – System Specific Study and Standard Monitoring Plan.

In version 6.0 of the *Sampling Manual,* Chapter 5 has been updated for the complete transition from Stage 1 to Stage 2 Disinfectant/Disinfection Byproducts Rule, and Chapter 6 has been revised to clarify Lead and Copper Sampling consumer notification requirements, and Water Quality Parameter monitoring. Related attachments for both chapters have been revised accordingly.

Disclaimer:
The *Sampling Manual* is an informational resource for Office of Drinking Water (ODW) staff and waterworks owners and operators. It provides instructions and clarifications regarding the compliance sampling and reporting requirements of the *Waterworks Regulations*. It identifies, describes, and provides information related to: sample groups; sampling locations; monitoring plans; sample scheduling; monitoring waivers; chemical/physical/radionuclide compliance determinations; approved laboratories; DCLS sample request procedures; and reporting of results.

The *Sampling Manual* is not intended to replace the requirements of the *Waterworks Regulations*. It has been and will remain the responsibility of the waterworks owner to ensure that the proper number of samples (bacteriological, physical, chemical, and radiological) are collected, submitted for analysis, analyzed and results reported to ODW. The *Sampling Manual* references a number of templates (forms and letters) which are intended to standardize office procedures, improve office efficiency, and address regulatory requirements. The templates should only be modified to address specific circumstances or where noted as optional.

This document is not a regulation; it is not legally enforceable; and it does not confer legal rights or impose legal obligations on any party, including the Commonwealth, the Virginia Department of Health (VDH), or the regulated community. While VDH has made every effort to ensure the accuracy of the discussion in this document, the obligations of the regulated community are determined by statutes, regulations, or other legally binding requirements. The recommendations discussed are not a substitute for applicable legal requirements. In the event of a conflict between the discussion in this document and any statute or regulation, this document would not be controlling.

Compliance Sampling and Reporting Guidance Manual for ODW Staff

Version 6.0
September 29, 2017

VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

COMPLIANCE SAMPLING AND REPORTING GUIDANCE MANUAL

Version 6.0

FOREWARD

The *Waterworks Regulations* require routine monitoring of all public water supplies. It is the responsibility of the waterworks owner to ensure that the proper number of samples (bacteriological, chemical, physical, and radiological) are collected, submitted for analysis, analyzed and results reported to the appropriate Field Office. However, the Health Department will assist the owner, on a regular frequency in obtaining the necessary services from State approved laboratories for the collection of bacteriological, chemical, physical, and radiological samples.

This manual provides guidance for ODW staff on the procedures required for compliance sampling and reporting. It identifies: sampling locations, monitoring plans, sample schedules, groundwater source sampling requirements and surface water influence determination, monitoring waiver procedures, chemical and radionuclides compliance decision flow charts, special procedures for ordering invoices from the Division of Consolidated Laboratories (DCLS); and reporting of results. The manual also includes copies of various standard monitoring plans, review/evaluation forms, and letters.

EXCLUSIONS

This manual does NOT cover well development sampling.

REVISIONS SUMMARY

DATE	DESCRIPTION OF CHANGES
February 6, 2007	Original issuance
Sept. 21, 2009 (Version 2.0)	**1.** Revised DCLS Table 2.1 with Sample Groups and Methods; **2.** Revised Section 4 Bacteriological Sample Site Report to include TNC (section 4.1.5) and Triggered Source Water sample criteria (Section 4.2.); **3.** Revised Section 6 Lead and Copper Monitoring Plan, to include LCR-STR changes; **4.** Revised Section 7, Groundwater Sources Raw Water Sampling and GUDI Determination; **5.** Included Section 8, Radiological Samples; **6.** Revised Section 9, Monitoring Waivers; **7.** Deleted Section V.III. New Sources; **8.** Deleted Section V.IV. Groundwater Sources and Surface Influence Determination **9.** Included note regarding TTHM / HAA5 Running Annual Average, Section 11.5; **10.** Revised Section 12, Laboratories; **11.** Revised Section 13 DCLS Sample Kit Request Procedures to include new Ad Hoc ordering procedures and Triggered Source Water Monitoring kit dispatch; **12.** Revision to Section 14, Evaluation and Distribution of Sample Results; **13.** Included Section 15, with revised Samples / Letters / Forms for Bacteriological Sample Site Report (to include Triggered Source Water Samples) and **14.** Lead and Copper Monitoring Review Forms and Approval Letters updates to include LCR-STR changes.
April 19, 2011 (Version 3.0)	1. Revised section 2.1, DCLS Sample Groups. 2. Updated Section 5 – Disinfection and Disinfection Byproducts Regulatory Requirements and Monitoring Plans, for provisions of ST2 Rule, as incorporated into the revised *Waterworks Regulations*. 3. Updated Section 6 – Lead and Copper Monitoring Plan, to include LCR Short Term Revisions and Clarifications. This section incorporates WM 907, which

	has been deleted. Includes new flowchart for Corrosion Control Treatment and Examples section. 4. Revised Section 7- Groundwater Sources Raw Water Sampling and GUDI Determination. Revised GUDI Determination Review Sheet, and Raw Water Monitoring Decision Flow Chart, and notification letter. This section incorporates WM 905, which has been deleted, and deletes the original GUDI Determination Flow Chart. 5. Added new Section 9 – Contaminants of Concern. It includes emerging non-regulated contaminants such as MTBE, Chromium-6 and Percholate. The MTBE section replaces WM 807 and WM831, which have been deleted. 6. Section 12 "Laboratories" has been deleted, and Section 16 "Sample Letters and Forms" has been deleted.
August 22, 2011 (Version 3.1)	1. Revised Chapter 5, Disinfectants and Disinfection Byproducts: changes to sections 5.1, 5.4.1 and 5.4.2. Added DBP & OEL results letter and new OEL Report Review Sheet. 2. Revised Chapter 13, section 13.3 – Bacterial Repeat and triggered source water monitoring kit dispatch with staff procedure for ordering additional repeat bottle containers and labels. 3. Deleted section 14.3, Calculation form for Running Annual Average.
Dec. 29, 2011 (Version 3.2)	1. Revise Chapter 11, section 11.8- Standard Monitoring Schedule to correct 1st, 2nd and 3rd period delimiters, clarify & correct radionuclides monitoring.
March 12, 2012 (Version 3.3)	1. Revise Chapter 5, section 5.4.2 – DBP Compliance & Operational Evaluation Level (OEL) Calculations, to include OEL forms, 2. Revise Chapter 5, section 5.4.3 - Stage 2 Reduced Monitoring, to clarify source running annual average TOC criteria. 3. Added sentence to first paragraph of section 11. Sample Scheduling noting when a thorough review of sampling requirements is needed.
October 10, 2012 (Version 3.4)	1. Chapter 2, Table 2.1 – DCLS Sample Groups, has been eliminated. Reference now made to ODW Website for information. 2. Chapter 5, Section 5.4.1. – DBP monitoring changes from ST1 to ST2 Rules have been clarified. 3. Chapter 9 – Section 9.3 Perchlorate has been updated. 4. Chapter 11, Table 11.6 – Location for TOC & Alkalinity sampling points has been corrected, footnote on alkalinity monitoring has been added, and the significant digits of the TOC removal ratio corrected. 5. Chapter 13 – Monitoring schedules posted to ODW Website and those submitted to DCLS have been clarified.
February 4, 2015 (Version 3.5)	1. Chapter 5 (5.4.2 DBP Compliance & Operational Evaluation Level (OEL) Calculations) - A compliance equation for situations where a quarterly sample is missed has been added. A reference to the OEL approval letter template has been added. 2. Chapter 5 (5.5.5. ST2: Groundwater Systems Serving <10,000) – The decision flowchart has been corrected. 3. Chapter 7 (Groundwater Source Water Monitoring and GUDI Determinations) is revised completely, including associated attachments (form letters and GUDI Determination Worksheet). 4. Chapter 9 – A section on harmful algal blooms has been added.

DATE	DESCRIPTION OF CHANGES
Dec. 9, 2015 (Version 4.0)	1. Chapter 1 - Changed "BSSR" to "BSSP" in the List of Abbreviations. 2. Chapter 4 - Replaced entire text to include requirements of both RTCR and GWR. Triggered source water monitoring is combined with BSSP for groundwater systems. 3. Chapter 6 – Corrected *Regulations* reference in section 6.15. 4. Chapter 13 - Updated to include requirements of RTCR for repeat samples. 5. Minor corrections made to flowcharts 5.5.5, 6.22, 12.1.6, 12.2.1, and 12.2.2.
June 15, 2016 (Version 4.1)	1. Created new Chapter 13 to incorporate WMs 892 and 904, and established staff guidance on monitoring of surface water sources, incorporating EPA's WSG 198 dated April 8, 2016. 2. Renumbered existing Chapters 13 and 14 to Chapters 14 and 15, respectively. 3. Updated Chapter 10 to include Source Water Assessment information in the evaluation of SOC waiver applications, and updated all attachments. Created a single waiver application form.
May 22, 2017 (Version 5.0)	1. Chapter 4 – Revised Attachment C.1 to differentiate new and revised BSSP reviews. Introduced a new Attachment C.3 letter to waterworks for required actions following a routine TC+ result. 2. Chapter 6 – Updates include: a. Referenced new LCR Monitoring Plan templates (Attachments A.1.a and A.1.b) and approval letter (Attachment A.2.) b. Clarified tap sampling procedure to exclude flushing of tap prior to 6-hr holding time (section 6.4.) c. Added classification of waterworks system size "Large", "Medium" and "Small", by population. d. Referenced results notification letter templates (Attachments B.1 and B.2.) e. Revised monitoring table headings to be consistent with the *Regulations* (section 6.5.) f. Clarified requirements for waterworks on reduced monitoring after exceeding AL (section 6.6.) g. Added new policy disallowing LCR monitoring waiver or variance (section 6.7.), except for community waterworks with ion exchange treatment units at every service connection POE. h. Added new section 6.8 - Combined Distribution System Monitoring, and renumbered subsequent sections. i. Updated section 6.10 - Monitoring for Water Quality Parameters (WQPs), including new reporting template (Attachment C.1.) and review transmittal letter (Attachment C.2.) j. Added new policy disallowing reduction in monitoring of WQPs (section 6.11.) k. Added requirements for WQPs in Operation Permit Conditions, review of monitoring results, compliance determinations and treatment technique violations (section 6.12.) l. Revised consumer notification templates with delivery certification form (Attachments D.1 and D.2.) with a specific requirement on providing contact information to the Local Health Department. m. Revised table of required treatment techniques (section 6.15.) n. Reorganized and streamlined section 6.17 Corrosion Control Treatment. Added clarification for small and medium waterworks to pursue optimum corrosion control if LCR Action Levels are exceeded in multiple sampling periods. Added a new paragraph on Operational Control Monitoring. o. Eliminated 6.22. Corrosion Control Treatment Flowchart. p. Referenced public education templates with certification forms (Attachments E.1, E.2, and E.3.)

	3. Chapter 7 - Clarified certification requirements for MPN tests in section 7.3. 4. Chapter 8 – Expand and reorganize Chapter 8. Add 5 attachments, including vulnerability designation form letters, and delete reference to WM 872. 5. Chapter 9 - Added new sections 9.5 Fluorinated Organic Compounds, 9.6. Legionella, 9.7 Endocrine Disruptors and 9.8 Pesticides and Human Health Benchmarks. 6. Chapter 12 - Corrected 12.1.2. IOC Increased Monitoring Flow Chart 7. Chapter 14 - Removed historical reference to four repeat samples under TCR in section 14.2, and added reference to Attachment C.3 in sections 14.2. 8. Chapter 15 - added reference to Attachment C.3.
July 7, 2017 (Version 5.1)	1. Chapter 8 – Corrected 8.4 Monitoring for Beta Particle and Photon Radioactivity. Separated notification letter B.1 into: B.1.a Sources Designated as Vulnerable, and B.1.b Sources Designated as Contaminated. Modified letter B.2. 2. Chapter 9 – Corrected MTBE minimum monitoring frequency to annually. 3. Chapter 12 – Corrected 12.1.1. IOC Routine Monitoring and 12.4.1. Radionuclides Rule Routine Monitoring flowcharts.
Sept. 29, 2017 (Version 6.0)	1. Chapter 5 – reworded title to appropriately describe the chapter content. a. Incorporated relevant information from WM 895 and WM 909 for the Stage 2 Rule and reorganized content. b. Re-ordered the decision flowcharts with minor revisions. c. Re-organized and labeled templates (Attachments A.1 through A.7) and letters (Attachments B.1 through B.7) with minor revisions. 2. Chapter 6 – a. Added the "Consumer Notification" box into the LCR Decision Flowchart. b. Added information on WQP testing and reporting in Section 6.10. c. Updated Attachments A.1.a, A.1.b, B.2., C.1, D.1., D.2., E.1., E.2., and E.3.

1. LIST OF ABBREVIATIONS

BSSP – Bacteriological Sample Siting Plan

CCR – Consumer Confidence Report

CCT – Corrosion Control Treatment

CP – Copper Pipe

CR – Combined Radium Ra226 + Ra228

Cu - Copper

DBCP - Dibromochloropropane

DBP – Disinfection Byproducts

DBPR – Disinfection Byproducts Rule

DCLS – Division of Consolidated Laboratory Services

EDB – Ethylene dibromide

EP – Entry Point

GA – Gross Alpha Activity

GUDI – Groundwater Under the Direct Influence of Surface Water

GW - Groundwater

HAA5 – Haloacetic Acids (five)

IOC – Inorganic Chemicals

LSLR – Lead Service Line Replacement

LSR – Lead Service Lines

LUA – Land Use Activity

MCL – Maximum Contaminant Level

MCLG – Maximum Contaminant Level Goal

MFR – Multi-Family Residence

MPN – Most Probable Number bacteriological analysis method

MRDL – Maximum Residual Disinfection Level

NTNC – Nontransient Noncommunity water system

ODW – Office of Drinking Water

OWQP – Optimum Water Quality Parameters

Pb – Lead

PWS – Public Water System

RAA – Running Annual Average

SDWA – Safe Drinking Water Act

SFR – Single Family Residence

SOC – Synthetic Organic Chemicals

SOP – Standard Operating Procedure

SUVA – Specific Ultraviolet Absorption at 254 nanometers

SW – Surface Water

TNC – Transient Noncommunity waterworks

TOC – Total Organic Carbon

TTHM – Total Trihalomethanes

U - Uranium

VOC – Volatile Organic Chemicals

WQP – Water Quality Parameters

2. SAMPLE GROUPS

The *Waterworks Regulations* include a list of the required bacteriological, chemical, physical, and radiological samples.

Required bacteriological analyses are based on whether the water sample is collected from the distribution system or directly from the water source.

Required Bacteriological Sampling Locations and Analysis Methods

Sample Location	Analysis Type
Source/Raw Water	Quantitative Analysis Methods
Approved Distribution System Sites	Presence / Absence Analysis Methods for total coliform and E. coli bacteria

Required chemical, physical, and radiological analyses are listed in Tables 2.2 through 2.13 of the *Waterworks Regulations*. A current list of the various contaminants by analysis group is included in the monitoring schedules (MS Excel workbook) posted on the ODW Website under "Information for Laboratories" tab.

3. SAMPLE LOCATIONS / MONITORING PLANS

3.1. Compliance Sample Location Types

Water samples to be analyzed for compliance purposes must be collected from sample locations within a waterworks listed below:

Source Water (Raw Water) – Source water samples are water samples collected from the source prior to any treatment.

Combined Filter Effluent – Combined Filter Effluent samples are water samples collected where the effluent from multiple filters combine to represent the treated water at a conventional surface water treatment plant.

Entry Point – Entry Point samples are water samples collected after application of any treatment as the water is entering the distribution system before the first customer.

Distribution System – Distribution System samples are water samples collected from approved locations within the distribution system of a waterworks.

Treatment Process Control - Treatment Process Control samples are water samples collected at various locations within a treatment plant and include but are not limited to source water samples, treated water samples, settled water samples, individual filter effluent water samples, combined filter effluent water samples, and entry point samples. Treatment Process Control samples are not only used for compliance purposes but also for the purpose of identifying needed process changes at a treatment plant.

3.2. Monitoring Plans

The *Waterworks Regulations* require certain monitoring plans to be submitted for review and approval. Listed below are the various monitoring plans needed by waterworks. The procedures for developing, reviewing, and approving these monitoring plans are found in the sections listed below.

- Bacteriological Sample Site Plan (Section 4)
- Disinfectants/Disinfection Byproducts Rule (Stage 1 and 2 DBPR) Regulatory Requirements and Monitoring Plans (Section 5)
- Lead and Copper Rule Materials Survey/Sampling Plan and Water Quality Monitoring (WQP) Sampling Plan (Section 6)

4. BACTERIOLOGICAL MONITORING

Bacteriological monitoring is required under two EPA Rules: the Revised Total Coliform Rule (RTCR) and the Groundwater Rule (GWR). For waterworks with groundwater sources, both rules apply. For waterworks with only surface water sources or those that have been declared to be groundwater under the direct influence (GUDI) of surface water, only the RTCR applies. All consecutive waterworks must comply with the RTCR, regardless of the source water. If the consecutive waterworks' source water is groundwater, the raw water sampling requirements of the GWR will apply to the wholesaler waterworks.

4.1. RTCR and GWR Requirements

The RTCR and the GWR require bacteriological monitoring of the distribution system and untreated groundwater source supplies, respectively. Each rule requires a monitoring plan establishing sampling sites specifically selected to ensure representative sampling. Where appropriate, ODW has elected to have these two monitoring plans combined into a single plan, referred to as a Bacteriological Sample Siting Plan (BSSP), with all of the sample site information specified. All monitoring plans shall be reviewed and approved by ODW in accordance with this guidance. For groundwater systems, use Attachment C.3 to select the appropriate combination of actions from the repeat, additional, and triggered source water monitoring requirements and notify the waterworks accordingly; see also Sections 4.3 and 4.7.

4.1.1. Bacteriological Sample Siting Plan (BSSP)

Under the RTCR, all waterworks must monitor their distribution systems according to a specific frequency established in a written, approved BSSP, as described in the *Waterworks Regulations.* The BSSP establishes the collection of routine and repeat water samples for microbial analysis, specifically total coliform and *Escherichia coli* (*E. coli*). Whenever a routine sample is tested and the result indicates the presence of total coliform, **three repeat samples**[1] must be collected for each total coliform-positive routine sample.

The number of routine samples to be collected by any waterworks is based on the population served, in accordance with the *Waterworks Regulations*. However, in cases where the population may vary during the monitoring period, particularly seasonal waterworks, the number of samples must be adjusted accordingly. The BSSP will establish all of the routine and repeat sample sites representative of water quality in the distribution system.

Under the GWR, source water monitoring for *E. coli* is required for all groundwater source waterworks that do not provide 4-log virus inactivation, whenever there is a total coliform-positive result from routine RTCR distribution system monitoring. Groundwater waterworks are required to conduct triggered source water monitoring, representative of all water sources in use at the time that resulted in the total coliform-positive sample. All triggered source water monitoring sites are to be identified in the BSSP.

A waterworks map or sketch must be included and must indicate the location of every routine, repeat, and (for groundwater systems) triggered source water monitoring site. The map does not have to be to scale, but it should accurately represent the distribution system, the raw water sources, and the sample locations.

For the special case of "dual purpose sampling," a waterworks consisting of a single groundwater well, without treatment, serving 1,000 persons or fewer, and required to conduct triggered source water monitoring under the GWR, may use a groundwater raw sample to satisfy the requirements of both the triggered source water monitoring requirement of the GWR and the repeat sampling requirement of the RTCR. [This type of sample is called a "dual purpose sample"].

[1] This is a change from the TCR, which required four repeat samples.

4.1.2. Routine Source Water Monitoring

Groundwater sources that provide chlorination or UV disinfection and which may be at risk of being GUDI are required to monitor each source in accordance with Chapter 7 of this manual.

4.2. Water Distribution System Sample Sites

4.2.1. General Considerations

Sample locations shall be representative of all significant conditions that exist in a water distribution system. All sites selected should be readily accessible, regularly used, cold water taps or dedicated sampling stations. Factors to consider for site selections:

- Water distribution system configuration, including mains, laterals, loops and dead ends;
- Storage tank proximity and surrounding pressure zones;
- Pipe materials;
- Age and condition of pipe;
- Water use;
- Population density;
- Areas with 'mixed' water from different sources;
- Areas with longer hydraulic retention times; and
- Areas of the distribution system with lower system pressure.

4.2.2. Site Selection Criteria

1. A minimum of three (3) routine sample sites shall be identified for each required routine sample for waterworks serving 3,300 or fewer people. [For waterworks with extremely limited water distribution systems, exceptions are appropriate if documented following consultation with the field office staff.]
2. A minimum of 12 routine sample sites shall be identified for waterworks serving more than 3,300 people; however each large waterworks shall be evaluated on a case-by-case basis to determine the number of sample locations needed to assure representative sampling.
3. For each routine sample site, two repeat sample sites – one within five service connections upstream and one within five service connections downstream of the routine location are to be identified. When a routine sample tests positive, these three sites are to be used to collect repeat samples. Only readily identifiable repeat sample locations should be selected.
4. Each sample location must be accessible, such as a customer's water faucet, dedicated sampling station, or other designated compliance sample site, and preferably identified by a physical address (e.g., a 911 address). Each sample location must have an identifying code number; e.g., 010 for a routine site, and a 01U (upstream site) and a 01D (downstream site) as its associated repeat sites.
5. Each plan must include a statement indicating how the sample locations will rotate through each site from month to month or quarter to quarter.
6. Alternative monitoring locations for repeat samples that better characterize possible contamination routes into the distribution system can be allowed via an approved waterworks-generated Standard Operating Procedure (SOP). Waterworks can choose to specify either alternative fixed locations or criteria for selecting other repeat sampling locations on a situational basis using these SOPs. Refer to Attachment A.1 for guidance (available on \\odwshare:\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898- Sampling Manual\BSSP.) All SOPs must be included in the BSSP, and are subject to review and revisions, when significant changes are observed at the waterworks during sanitary surveys.

7. The number of samples to be taken in the monitoring period is based on population served. For waterworks with mixed populations, it is important to consider both residential and transient population together to determine an "average" population, hence the number of samples required. In addition, a seasonal waterworks may have varying populations throughout the operating period, so the number of routine samples required may vary from month-to-month.
8. The RTCR requires groundwater TNCs on a quarterly monitoring frequency to increase to monthly monitoring for 12 months if the waterworks incurs any of the following:
    - Triggers a Level 2 assessment or two Level 1 assessments in a rolling 12-month period;
    - Has an *E. coli* MCL violation;
    - Has a total coliform TT violation; or
    - Has two RTCR monitoring violations or one RTCR monitoring violation and one Level 1 assessment in a rolling 12-month period for a waterworks on quarterly monitoring.
9. Groundwater TNC waterworks may return to routine monitoring (quarterly frequency) after 12 months of monthly monitoring and the waterworks meets all of the following:
    - A sanitary survey, site visit, or a voluntary Level 2 assessment has been performed;
    - Free of sanitary defects;
    - Has a protected water source; and
    - Has a clean compliance history[2].

4.3. Repeat Monitoring

Whenever a routine sample is tested and the result indicates the presence of total coliform, ***three*** **repeat samples** must be collected for each positive routine sample in accordance with the BSSP. However, a waterworks that has a small distribution system (i.e., limited site selection options) and consists of a single well without treatment may use the GWR triggered source water monitoring sample to meet the upstream repeat sample requirement.. Use Attachment C.3 to notify waterworks of appropriate repeat and triggered sampling requirements.

If a coliform treatment technique trigger is exceeded and a Level 1 assessment is required (as described in Working Memo 917), no further repeat monitoring is performed. Note that a waterworks required to take more than one routine sample must take at least one set of repeat samples for each positive routine sample.

4.4. Representative Groundwater Source Sample Types

4.4.1. General Requirements

Waterworks with multiple groundwater sources may conduct representative untreated source water sampling in order to reduce the burden of triggered untreated source water monitoring. One of the following specific conditions must be met and listed in the approved BSSP:

1. Hydraulic conditions dictate that a source provides water to an isolated area of the distribution system. Consequently, only source(s) identified as providing water to specific RTCR monitoring locations must be used to collect the triggered source water samples based on sample results from the specified RTCR sample point. The plan must clearly identify groundwater sources linked to each RTCR monitoring site in the waterworks.

[2] A "clean compliance history" is defined as 12 consecutive months of: no *E. coli* PMCL exceedances; continuous compliance with RTCR monitoring requirements and treatment technique requirements; and no occurrence of coliform treatment technique triggers.

2. Documentation accepted by ODW exists that clearly demonstrates that the sources are chemically, physically, and hydro-geologically similar. Consequently, one source may serve as the triggered source water sample location representing two or more sources. The plan must clearly list representative triggered source water monitoring procedures, based on the documentation. References to the documentation must be included in the plan.

4.4.2. Source Water Site Selection Criteria

The selection of triggered source water monitoring sites is based on representative sampling of the sources in use at the time the total coliform-positive sample was collected. These sites are to be incorporated in the combined BSSP waterworks map (or sketch) used to indicate where every routine and repeat monitoring site is located.

4.5. Templates & ODW Review

BSSP templates were developed to assist staff in selecting and "tailoring" a BSSP for a particular waterworks in these attachments (available on \\odwshare:\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898- Sampling Manual\BSSP):

B.1. BSSP GW Serving 1,000 or Fewer People

B.2. BSSP GW Serving More than 1,000 People

B.3. BSSP SW & GUDI

B.4. BSSP TNC Seasonal Waterworks

B.5. BSSP Table for Multiple Pressure Zones – Example

Three templates (Attachments B.1, B.2, and B.4) were developed by ODW for bacteriological monitoring of groundwater waterworks, and include provisions that can be adapted to meet the sampling requirements of both the RTCR and GWR.

A wholesaler and a consecutive waterworks each need to have their own BSSP regardless of source type. However, if the wholesaler has a groundwater source, the consecutive waterworks BSSP needs to indicate that it will promptly notify the wholesaler of any positive samples collected from their distribution system (per RTCR) so that the wholesaler can collect the triggered source water monitoring sample (per GWR) in coordination with the repeat samples in the consecutive waterworks.

Attachment C.1. BSSP Review Sheet, and C.2. BSSP Approval Letter, have been developed for ODW staff to evaluate all monitoring plans and communicate with owners (available on \\odwshare:\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898- Sampling Manual\BSSP.)

4.6. TNCs

TNCs operated on a year-round basis are the only classification of waterworks that may be allowed to monitor routinely on a quarterly frequency. A monthly frequency is required for TNCs serving more than 1,000 people and for seasonal waterworks of all sizes.

The number of samples to be collected is based on the population served in accordance with Table 2.1 of the *Waterworks Regulations*. However, in cases where the population may vary during the monitoring period, as in the case of seasonal waterworks, the number of samples must be adjusted accordingly and accounted for in the BSSP.

4.7. Additional Monitoring

TNCs collecting samples on a quarterly frequency shall collect three routine samples during the month following one or more total coliform-positive samples (with or without a Level 1 treatment trigger exceedance). Use Attachment C.3 to notify waterworks of appropriate monitoring actions. This requirement may be waived if at least one of the following conditions is met:

1. ODW performs a site visit before the end of the next month to determine if additional monitoring or corrective action is needed, or
2. ODW has determined the cause of the positive sample, that the waterworks has corrected the problem or will correct the problem before the end of the next month and documented this, or
3. ODW has determined that the waterworks has corrected the contamination problem before taking the repeat samples and all of which tested total coliform negative.

4.8. Reduced Monitoring

ODW will not allow any waterworks to conduct reduced monitoring as is allowed in the federal regulations.

4.9. Seasonal Waterworks

Seasonal waterworks must perform routine monitoring on a monthly frequency. In cases where the population may vary during the monitoring period, the number of samples must be adjusted accordingly. The number of samples to be collected is based on the population served in accordance with the *Waterworks Regulations*.

Seasonal waterworks must have an approved start-up procedure, which includes the collection of two special bacteriological samples taken a minimum of 16 hours apart, from a sample site listed in its approved BSSP. These samples must test negative for the presence of total coliform before water is served to the public. WM 917 provides further guidance on seasonal waterworks start-up procedures.

5. MONITORING OF DISINFECTANT RESIDUALS, DISINFECTION BYPRODUCTS, AND DISINFECTION BYPRODUCT PRECURSORS

5.1. Monitoring Plans

All Community and NTNC waterworks using chlorine, chloramines, chlorine dioxide, and/or ozone (as a disinfectant or oxidant) must implement a Stage 2 D/DBP Rule monitoring plan for disinfectant residual and for disinfection byproduct monitoring. The monitoring plans were developed following an initial distribution system evaluation (IDSE), conducted by each applicable waterworks to determine the sampling locations with representative high TTHM and HAA5 concentrations throughout the distribution system. Compliance determinations are based on a locational running annual average (LRAA).

TNC waterworks using chlorine dioxide as a disinfectant or oxidant must also develop a plan for disinfectant residual monitoring.

Community and NTNC waterworks with surface water (SW) or groundwater under the direct influence of surface water (GUDI) sources using conventional filtration treatment and/or ozone must also develop and implement a plan for disinfection byproduct precursor monitoring.

Monitoring decision flowcharts are provided in Section 5.6.

Existing waterworks that have added or changed disinfectants (other than UV light) will need to revise their Stage 2 monitoring plan. Waterworks that have undergone significant distribution system changes since the initial IDSE was approved may also need to revise their Stage 2 D/DBP monitoring plan sample site selection.

New waterworks are not required to conduct an IDSE; however, one may be useful in determining whether the most representative sites are chosen. This decision shall be made on a case-by-case basis by the field office director. Refer to EPA 815-B-06-002, Initial Distribution System Evaluation Guidance Manual for the Final Stage 2 Disinfectants and Disinfection Byproducts Rule, January 2006, for more information. A copy is provided in *\02-Committees\202-Rule Teams\MDBP & ESWT Rules\02-EPA Guidance Manuals\IDSE Guidance Manuals*.

Each waterworks should have one monitoring plan that includes the disinfectant residual, disinfection byproduct, and disinfection byproduct precursor monitoring, as applicable. To facilitate compliance, ODW will draft (and customize) the monitoring plan for the waterworks regardless of water source or size. The plan must include monitoring locations and dates for routine monitoring (Attachment A.1). Use the template approval letter in Attachment B.1 for plan approval.

Reduced and increased monitoring requirements for disinfection byproducts (TTHM and HAA5) are not included in the monitoring plans because the details are dependent on the results of the routine monitoring and cannot be forecasted. These will need to be handled separately.

Reduced monitoring sample sites must be selected from the approved routine sites at the time monitoring is reduced. A revised monitoring plan review sheet is provided in Attachment A.2. Notify the owner of amendments to the Stage 2 monitoring plan using the letter template provided in Attachment B.2.

ODW staff shall determine the location of any additional sample sites and contact the owner if specific addresses are needed.

5.2. Disinfectant Residual Monitoring

5.2.1. Chlorine and Chloramines

Monitoring applies to community and NTNC waterworks that use chlorine or chloramines for disinfection or oxidation. Collect monthly samples for the disinfectant residual at the same time and at the same locations as total coliforms. Heterotrophic plate count (HPC) may be measured in lieu of the residual disinfectant concentration, as described in the *Waterworks Regulations*. Reduced monitoring is not allowed.

5.2.2. Chlorine Dioxide

Monitoring applies to community, NTNC, and TNC waterworks that use chlorine dioxide (ClO_2) disinfection or oxidation. Collect daily samples at the entrance to the distribution system. When any daily sample exceeds the MRDL (0.8 mg/L as ClO_2), the owner shall collect three additional ClO_2 residual samples in the distribution system the following day as follows:

- *Waterworks with no rechlorination after entry point*: Collect samples as close to the first customer as possible, at intervals of at least six hours, in addition to the sample required at the entrance to the distribution system.
- *Waterworks with rechlorination after the entry point*: Collect one sample at each of the following locations: (i) as close to the first customer as possible, (ii) at a location representative of average residence time, and (iii) as close to the end of the distribution system as possible (reflecting maximum residence time in the distribution system).

Reduced monitoring is not allowed.

5.2.3. Ozone

Ozone residual levels shall be monitored continuously and recorded, with additional monitoring and reporting requirements to demonstrate log inactivation or removal of Giardia lamblia, virus, and Cryptosporidium.

5.2.4. Reporting and Recordkeeping Requirements

DISINFECTANT RESIDUALS (12VAC5-590-530. H.)	
Parameter	Must Report
Chlorine or Chloramines	• The number of samples collected during each month of the last quarter. • The monthly arithmetic average of all samples collected in each month for the last 12 months. • The arithmetic average of all monthly averages for the last 12 months. • Whether the MRDL was violated.
Chlorine Dioxide	• The dates, results, and locations of samples collected during the last quarter. • Whether the MRDL was violated. • Whether the MRDL was exceeded in any two consecutive daily samples and whether the resulting violation was acute or non-acute.

5.3. Disinfection Byproduct Precursors Monitoring

5.3.1. Monitoring Frequency

Total Organic Carbon (TOC) is used as a measure of disinfection byproduct precursors. Monitoring applies to community and NTNC waterworks using SW or GUDI sources and using conventional filtration treatment. One source water (prior to any treatment) TOC and alkalinity sample and one treated water (no later than the point of combined filter effluent turbidity monitoring representative of the treated water) TOC sample at each treatment plant must be collected. Source water alkalinity is also measured to facilitate the evaluation of the TOC removal levels. Waterworks that use other than conventional filtration treatment are not required to monitor for TOC. Use Attachment B.3 to notify the waterworks of the TOC results.

Routine monitoring: Collect one paired TOC sample (i.e., source water and treated water) and one source water alkalinity sample per month per water treatment plant at a time representative of normal operating conditions and influent water quality.

Reduced monitoring: If the average treated water TOC < 2.0 mg/L for two consecutive years, or < 1.0 mg/L for one year, waterworks may reduce monitoring for both TOC and alkalinity to one paired sample and one source water alkalinity sample per water treatment plant per quarter.

***Return to Routine Monitoring*:** The waterworks must return to routine monitoring in the month following the quarter when the annual average treated water TOC ≥ 2.0 mg/L.

5.3.2. Reporting and Recordkeeping Requirements

DISINFECTION BYPRODUCTS PRECURSORS (12VAC5-590-530. I.)	
Parameter	Must Report
Waterworks monitoring monthly or quarterly for TOC and required to meet the enhanced coagulation or enhanced softening requirements.	1. The number of paired (source water and treated water) samples collected during the last quarter. 2. The location, date, and results of each paired sample and associated alkalinity collected during the last quarter. 3. For each month in the reporting period that paired samples were collected, the arithmetic average of the percent reduction of TOC for each paired sample and the required TOC percent removal. 4. Calculations for determining compliance with the TOC percent removal requirements. 5. Whether the waterworks is in compliance with the enhanced coagulation or enhanced softening percent removal requirements for the last four quarters.
Waterworks monitoring monthly or quarterly for TOC and meeting one or more of the alternative compliance criteria.	1. The alternative compliance criterion that the system is using. 2. The number of paired samples collected during the last quarter. 3. The location, date, and result of each paired sample and associated alkalinity collected during the last quarter. 4. The running annual arithmetic average based on monthly averages (or quarterly samples) of source water TOC or of treated water TOC. 5. The arithmetic RAA based on monthly averages (or quarterly samples) of source water SUVA or of treated water SUVA. 6. The RAA of source water alkalinity and of treated water alkalinity. 7. The RAA for both TTHM and HAA5. 8. The RAA of the amount of magnesium hardness removal (as $CaCO_3$, in mg/L). 9. Whether the waterworks is in compliance with the particular

DISINFECTION BYPRODUCTS PRECURSORS (12VAC5-590-530. I.)	
Parameter	Must Report
	alternative compliance criterion.

5.4. Disinfection Byproducts Monitoring

Disinfection byproducts (DBPs) monitoring includes routine, increased, and reduced monitoring requirements for the applicable parameters: TTHM & HAA5, Chlorite, and Bromate.

All compliance samples must be collected at evenly spaced intervals. For waterworks required to sample quarterly, this would mean sampling in the same week in equally spaced months. <u>Example:</u> A waterworks has a peak historical month of August. The waterworks schedules sample collection for the 1st week of August. Then, to space evenly, sample collection is scheduled for the 1st weeks of November, February, and May.

Locations for reduced monitoring are not identified in the monitoring plan. They will be selected from the approved routine sites at the time monitoring is reduced. A letter to the waterworks owner identifying the recommended reduced sampling locations shall be issued (use template provided in Attachment B.2) for concurrence and signature by the waterworks owner.

Consecutive waterworks are eligible for reduced monitoring provided that both TTHM and HAA5 and source water TOC data meet the qualifying requirements; i.e., the LRAA for TTHM ≤ 0.040 mg/L and the LRAA for HAA5 ≤ 0.030 mg/L, in addition to source water annual average TOC level before any treatment ≤ 4.0 mg/L at each treatment plant treating SW or GUDI sources.

5.4.1. TTHM and HAA5

Monitoring applies to community and NTNC waterworks. Under routine monitoring, all waterworks must monitor during the month of highest DBP concentrations. Under reduced monitoring, certain systems are allowed to monitor at a location during the “quarter” with the single highest result. See Examples 1 and 2 in this section. Systems on quarterly monitoring must take dual sample sets every 90 days at each monitoring location, except waterworks using SW or GUDI sources and serving 500–3,300 that collects individual samples instead.

<u>Routine monitoring</u>: Sampling must occur at the locations listed in the waterworks approved monitoring plan. The number of sites and frequency of routine monitoring is based on population served and source type, in accordance with the following tables.

ROUTINE MONITORING – GROUNDWATER SOURCE		
Service Population	Frequency	# Sites, Sample Type[a]
<500	annual	2, individual samples
500-9,999	annual	2, dual samples
10,000-99,999	quarter	4, dual samples
100,000 – 499,999	quarter	6, dual samples
≥500,000	quarter	8, dual samples

ROUTINE MONITORING – SURFACE WATER & GUDI SOURCE		
Service Population	Frequency	# Sites, Sample Type[a]
<500	annual	2, individual samples
500-3,300	quarter	2, individual samples
3,301-9,999	quarter	2, dual samples
10,000-49,999	quarter	4, dual samples
50,000-249,999	quarter	8, dual samples
250,000-999,999	quarter	12, dual samples
1,000,000-4,999,999	quarter	16, dual samples
≥ 5,000,000	quarter	20, dual samples

[a] Individual samples mean using 1 site for TTHM only and 1 site for HAA5 only, at the locations with the highest TTHM and HAA5 concentrations, respectively. Dual samples mean using 1 site for collecting both TTHM & HAA5 samples. For waterworks serving < 500 population and monitoring annually, dual samples may be collected using 1 site for both TTHM & HAA5 only if the highest TTHM and HAA5 concentrations occur at the same location and month.

Reduced monitoring: The following table summarizes reduced monitoring and the criteria for selecting the locations and frequencies. Site selection must be made from the established list of routine locations. To qualify for and to maintain reduced monitoring, the following criteria must be met, otherwise, the waterworks must return to routine monitoring:

- For all waterworks based on quarterly monitoring at any location, each LRAA must have a TTHM ≤ 0.040 mg/L and a HAA5 ≤ 0.030 mg/L.
- The source water annual average TOC level, before any treatment, must be ≤ 4.0 mg/L at each treatment plant treating SW or GUDI sources.
- Waterworks on annual or triennial monitoring at any location must have a TTHM ≤ 0.060 mg/L and a HAA5 ≤ 0.045 mg/L.
- For consecutive waterworks serving > 500 people, where the primary waterworks uses SW or GUDI sources, each source must have a RAA raw water TOC ≤ 4.0.[3]

REDUCED MONITORING – GROUNDWATER SOURCE			
Service Population	Frequency	# Sites	Comments
<500	Triennial	2[a]	1 individual TTHM at site during quarter with single highest TTHM, and 1 individual HAA5 at site during quarter with single highest HAA5.
500-9,999	Annual	2[a]	1 individual TTHM at site during quarter with single highest TTHM, and 1 individual HAA5 at site during quarter with single highest HAA5.
10,000-99,999	Annual	2	1 dual sample (TTHM & HAA5) at site during quarter with single highest TTHM, and 1 dual sample (TTHM & HAA5) at site during quarter with

[3] Memorandum dated Feb 2, 2012 from Mindy Eisenberg, Acting Chief Protection Branch, Drinking Water Protection Division, EPA, Washington, D.C.

[a] Individual sampling is 1 site for TTHM (only) and 1 site for HAA5 (only), at the locations with the highest TTHM and HAA5 concentrations, respectively. Alternatively, for waterworks serving 500-3,300 population monitoring annually, dual sampling may be conducted using 1 site for both TTHM & HAA5 only if the highest TTHM and HAA5 concentrations occur at the same location and month.

			single highest HAA5.
100,000-499,999	Quarter		2 dual sample sets at the locations with the highest TTHM and highest HAA5 LRAAs
≥ 500,000	Quarter		4 dual sample sets at the locations with the 2 highest TTHM and 2 highest HAA5 LRAAs

REDUCED MONITORING – SURFACE WATER & GUDI SOURCES			
Service Population	Frequency	# Sites	Comments
<500			No reduced monitoring.
500-3,300	Annual	2[a]	1 individual TTHM at site during quarter with single highest TTHM, and 1 individual HAA5 at site during quarter with single highest HAA5.
3,301-9,999	Annual	2	1 dual sample (TTHM & HAA5) at site during quarter with single highest TTHM, and 1 dual sample (TTHM & HAA5) at site during quarter with single highest HAA5.
10,000-49,999	Quarter	2[b]	Dual samples, with one site chosen using highest TTHM LRAA and another site using the highest HAA5 LRAA.
50,000-249,999	Quarter	4[b]	Dual samples, with 2 sites chosen using the 2 highest TTHM LRAAs and another 2 sites using the 2 highest HAA5 LRAAs.
250,000-999,999	Quarter	6[b]	Dual samples, with 3 sites chosen using the 3 highest TTHM LRAAs and another 3 sites using the 3 highest HAA5 LRAAs.
1,000,000-4,999,999	Quarter	8[b]	Dual samples, with 4 sites chosen using the 4 highest TTHM LRAAs and another 4 sites using the 4 highest HAA5 LRAAs.
≥ 5,000,000	Quarter	10[c]	Dual samples, with 5 sites chosen using the 5 highest TTHM LRAAs and another 5 sites using the 5 highest HAA5 LRAAs.

[a] Individual sampling is 1 site for TTHM (only) and 1 site for HAA5 (only), at the locations with the highest TTHM and HAA5 concentrations, respectively. Alternatively, for waterworks serving 500-3,300 population monitoring annually, dual sampling may be conducted using 1 site for both TTHM & HAA5 <u>only if</u> the highest TTHM and HAA5 concentrations occur at the same location and month.

[b] Generally, sites will be selected between alternating highest TTHM and HAA5. This may be modified slightly to optimize health protection, such as using historic problem sites or seeking geographic diversity.

Some odd sampling schedules can occur at small SW/GUDI systems. Consider the following:

<u>Example 1- SW & GUDI, population: 500-3300</u>

Routine Results (individual quarterly)						Reduced Schedule (individual, annually)
	Jan	Apr	Jul	Oct		
TTHM	10	20	***30***	20		TTHM, one individual sample in July
HAA5	10	***30***	20	10		HAA5, one individual sample in April

Note that the sample site may be the same or different for TTHM and HAA5.

Example 2- SW & GUDI, population: 3301-9,999

Routine Results (2 dual, quarterly)						Reduced Schedule (2 dual, annually)
	Jan	Apr	Jul	Oct		
TTHM – Site 1	10	20	***50***	20		Site-1, one dual sample set in July (based on highest TTHM)
TTHM – Site 2	10	10	***40***	10		
HAA5 – Site 1	10	20	***40***	10		
HAA5 – Site 2	10	***30***	20	10		Site-2, one dual sample set in April (based on highest HAA5 at the remaining sites)

***Increased monitoring*:** For a waterworks monitoring annually or triennially and if a TTHM sample is > 0.080 mg/L or a HAA5 sample is > 0.060 mg/L at any location, monitoring is increased to dual sample sets once per quarter (collected every 90 days) at all locations. A waterworks must remain on increased monitoring until it qualifies for a return to routine monitoring. It may return to routine monitoring once it has conducted increased monitoring for at least four consecutive quarters and the LRAA for every monitoring location is ≤ 0.060 mg/L for TTHM and ≤ 0.045 mg/L for HAA5. Otherwise, the waterworks must remain on increased monitoring.

A TTHM and HAA5 sample must be collected once a quarter at all locations under increased monitoring; i.e., increased monitoring changes the frequency and not the number of sites to be used. The following criteria apply:

- Waterworks monitoring annually or triennially must increase monitoring to dual sample sets once per quarter (taken every 90 days) at all locations if a TTHM sample is > 0.080 mg/L or a HAA5 sample is > 0.060 mg/L at any location.
- A waterworks is in violation of the PMCL when the calculated LRAA based on four consecutive quarters of monitoring exceed the PMCLs (or the LRAA calculated based on fewer than four quarters of data if the PMCL would be exceeded regardless of the monitoring results of subsequent quarters).
- The waterworks is in violation of the monitoring requirements for each quarter that a monitoring result would be used in calculating an LRAA if it fails to monitor.

Waterworks that use only groundwater and serve fewer than 10,000 people and waterworks that use SW or GUDI sources and serve <500 people must proceed to increased monitoring if either the TTHM annual average is > 0.080 mg/L or the HAA5 annual average is > 0.060 mg/L. Increased monitoring must begin in the quarter immediately following the monitoring period where either of the above values was exceeded.

5.4.2. Chlorite

Chlorite monitoring applies to owners of community and NTNC waterworks using chlorine dioxide for disinfection or oxidation.

Routine monitoring: Collect daily samples at the entry point to the distribution system. For any daily sample that exceeds the chlorite PMCL (1.0 mg/L), the waterworks must collect three additional samples in the distribution system the following day as follows: (i) as close to the first customer as possible, (ii) in a location representative of average residence time, and (iii) as close to the end of the distribution system as possible (reflecting maximum residence time in the distribution system), in addition to the sample required at the entrance to the distribution system.

Collect a three-sample set each month in the distribution system as follows: (i) near the first customer, (ii) at a location representative of average residence time, and (iii) at a location reflecting maximum residence time in the distribution system. Any additional routine sampling shall be conducted as three-sample sets at specified locations.

***Reduced monitoring*:** Not allowed for entry point sampling**.** For the distribution system, chlorite monitoring may be reduced to one three-sample set per quarter after one year of monitoring where no individual chlorite sample collected in the distribution system has exceeded the chlorite PMCL (1.0 mg/L). The waterworks may remain on the reduced monitoring schedule as long as any of the three individual chlorite samples collected quarterly in the distribution system do not exceed the chlorite PMCL.

Return to Routine Monitoring: When any of the three individual chlorite samples under reduced monitoring collected quarterly in the distribution system exceeds the chlorite PMCL, the waterworks must return to routine monitoring.

5.4.3. Bromate

Bromate monitoring applies to owners of community and NTNC water treatment plants using ozone for disinfection or oxidation.

Routine monitoring: Collect one sample per month for analysis of bromate at the entrance to the distribution system while the ozonation system is operating under normal conditions.

Reduced monitoring: Collect quarterly samples if the waterworks RAA bromate concentration is ≤ 0.0025 mg/L based on monthly bromate measurements for the most recent four quarters. The waterworks may remain on reduced monitoring as long as the RAA of quarterly bromate samples is ≤ 0.0025 mg/L.

Return to Routine Monitoring: If the RAA bromate concentration is > 0.0025 mg/L, the owner must resume routine monitoring.

5.4.4. Reporting and Recordkeeping Requirements

DISINFECTION BYPRODUCTS (12VAC5-590-530.G.)	
Parameter	Must Report
TTHM & HAA5	1. Number of samples collected during the last quarter. 2. Location, date, and result of each sample collected during the last quarter. 3. Arithmetic average of all samples collected in the last quarter for each monitoring location. 4. LRAA of the quarterly arithmetic averages for the last four quarters for each monitoring location. 5. Whether the PMCL was exceeded at any monitoring location. 6. Whether any OEL was exceeded. If yes, the location, date, and the calculated TTHM and HAA5 OELs. Waterworks that use SW or GUDI sources (Subpart H systems) qualifying for reduced monitoring must also report whether the raw water TOC RAA exceeded 4.0 mg/L.
Chlorite (Systems using Chlorine Dioxide)	1. Number of entry point samples collected each month for the last 3 months. 2. Location, date, and result of each sample (both entry point and distribution system) collected during the last quarter. 3. For each month in the reporting period, the arithmetic average of all samples collected in each three-sample set collected in the distribution system. 4. Whether the PMCL was violated, in which month, and how many times it was violated each month.

Bromate (Systems using Ozone)	1. Number of samples collected during the last quarter. 2. Location, date, and result of each sample collected during the last quarter. 3. The arithmetic average of the monthly arithmetic averages of all samples collected in the last year. 4. Whether the PMCL was violated.

5.5. Disinfection Byproduct (DBP) Compliance & Operational Evaluation Level (OEL) Calculations

Disinfection byproduct compliance is based on the LRAA from the results of four consecutive quarters. The LRAA for TTHM and HAA5 is calculated using the monitoring results to determine whether each LRAA exceeds the PMCL. If the waterworks fails to complete four consecutive quarters of monitoring, it must calculate compliance with the PMCL based on the average of the available data from the most recent four quarters. If the waterworks collects more than one sample per quarter at a monitoring location, it must average all samples taken in the quarter at that location to determine a quarterly average to be used in the LRAA calculation.

The OEL is an "early warning indicator" of the potential for future PMCL exceedance. It is calculated along with the compliance level at each location in accordance with established data management procedures. The compliance and OEL levels for each location are based on the following formulae:

Compliance = (A + B + C + D) / 4;
[If a quarterly sample is missed, then = A+B+C / 3];

OEL = [B + C + (2 * D)]/4

Where:

A = TTHM or HAA5 result for the 3rd previous quarter (mg/L)
B = TTHM or HAA5 result for the 2nd previous quarter (mg/L)
C = TTHM or HAA5 result for the previous quarter (mg/L)
D = TTHM or HAA5 result for the current quarter (mg/L)

The OEL weights more recent quarters and provides an indication of unusual things in the distribution system, or of rising DBP levels, either of which may require special attention. The OEL is exceeded if TTHM is > 0.080 mg/L or if HAA5 is > 0.060 mg/L. If a waterworks exceeds the OEL level, then it must conduct an operational evaluation and submit a written report of the evaluation to the State no later than 90 days after being notified of the analytical result that caused it to exceed the OEL. Use the report form provided in Attachment A.3, and notify the waterworks owner using the letter template in Attachment B.4. The written report must be made available to the public upon request. The report must cover:

- A review of the results (calculations and history of the site).
- An examination of possible causes of the exceedance(s) in system treatment and distribution operational practices: storage tank operations, excess storage capacity, distribution system flushing, changes in sources of supply and/or source water quality, finished water quality, and treatment changes or problems that may contribute to TTHM and HAA5 formation including what steps could be considered to minimize future exceedances. Further information is provided in EPA 815-R-08-018, Stage 2 Operational Evaluation Guidance Manual. ODW field staff shall provide Attachments A.3 - Operational Evaluation Reporting Form, A.4 - Distribution System Evaluation Checklist, A.5 – Treatment Process Evaluation Checklist, and A.6 - Source Water Evaluation Checklist, to the waterworks owner to facilitate the evaluation and completion of the report.
- The waterworks may request and the State may allow it to limit the scope of the OEL if it were able to identify the cause of the OEL exceedance. The State must approve this limited scope of evaluation in writing; use letter template provided in Attachment B.5. The waterworks must keep that approval

with the completed report. If the owner can clearly show the reason for the exceedance in writing, then a detailed examination of possible causes is not warranted.

The OEL exceedance is not a violation, and does not need to be included in the CCR. However, failure to submit the report is a violation, and must be included in the CCR. ODW is *required* to review the OEL evaluation (use review sheet provided in Attachment A.7) and approve the report in writing (use letter template provided in Attachment B.6), and must keep a copy on file. If the review shows the report to be incomplete (either a minor problem missing basic items or a significant problem missing additional details), then ODW shall require the owner to complete the report in writing (use comment letter template provided in Attachment B.7.)

5.6. Stage 2 DBPR Monitoring & Compliance Decision Flowcharts

Charts for Surface Water Systems

5.6.1. Surface Water Systems Monitoring Annually & Serving < 500 People

5.6.2. Surface Water Systems Monitoring Quarterly & Serving 500 – 9,999 People

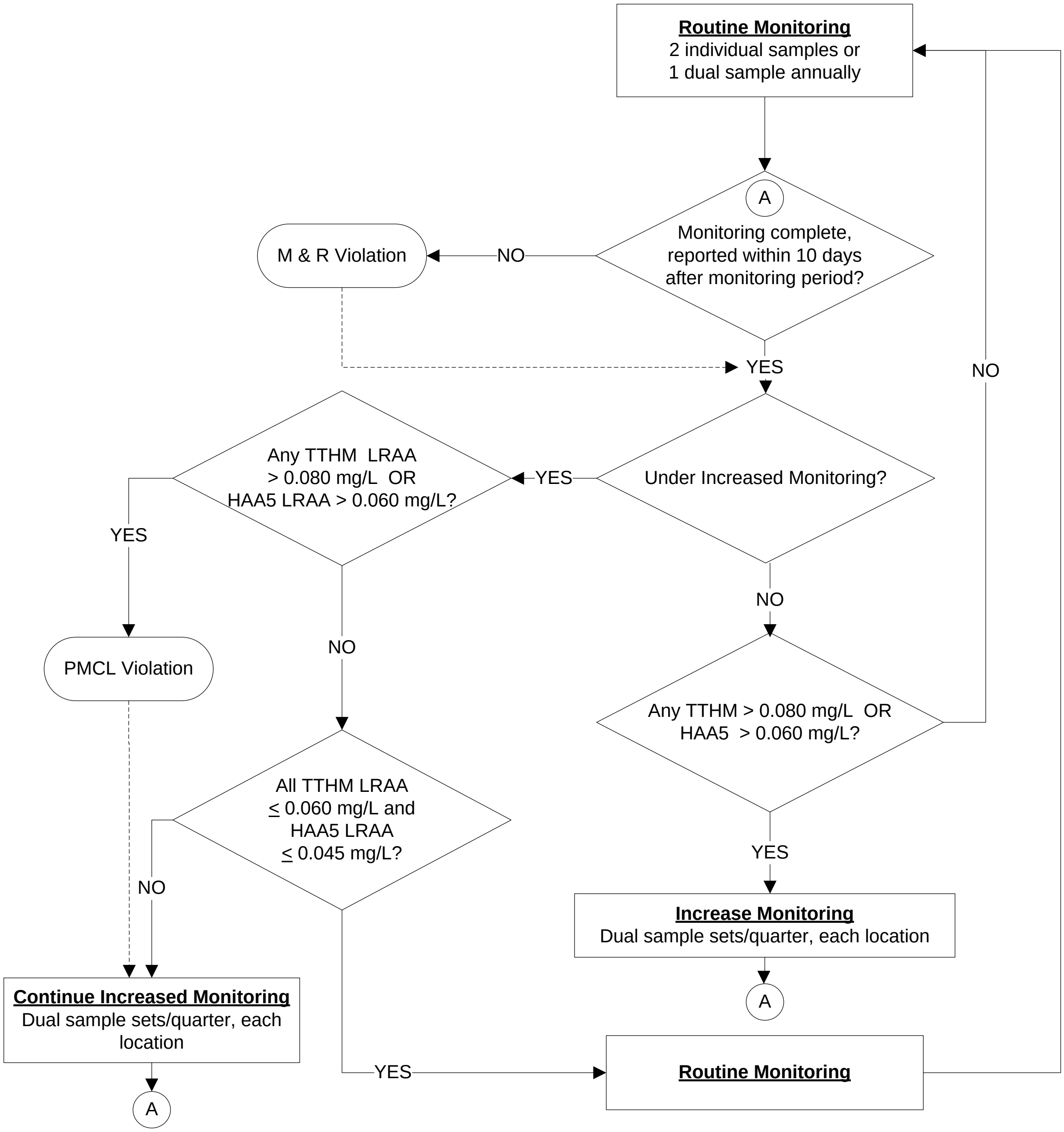
5.6.3 Surface Water Systems Monitoring Quarterly & Serving ≥ 10,000 People

Charts for Groundwater Systems

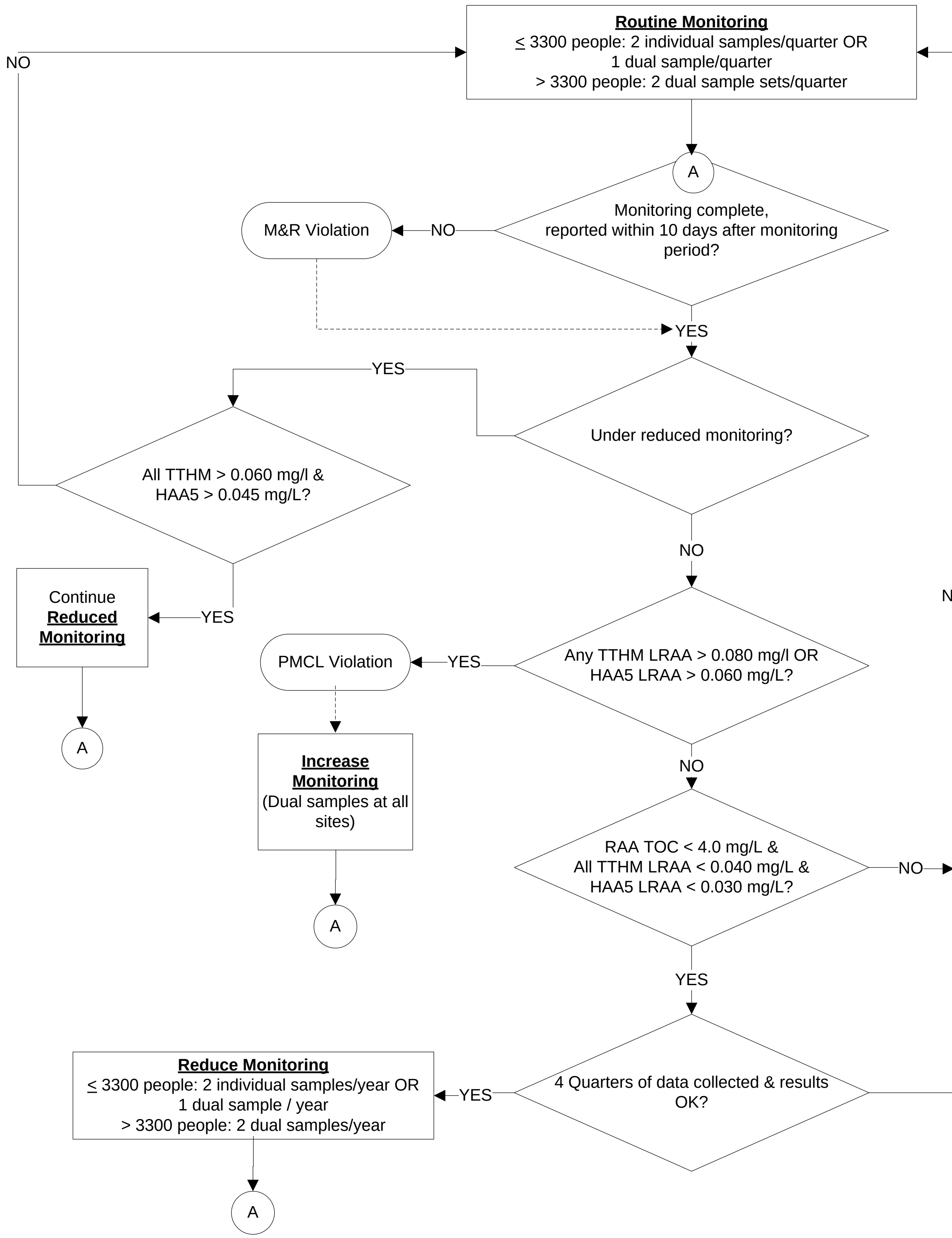
5.6.4. Groundwater Systems Monitoring Annually & Serving < 10,000 People

5.6.5. Groundwater Systems Monitoring Quarterly & Serving 10,000 – 99,999 People

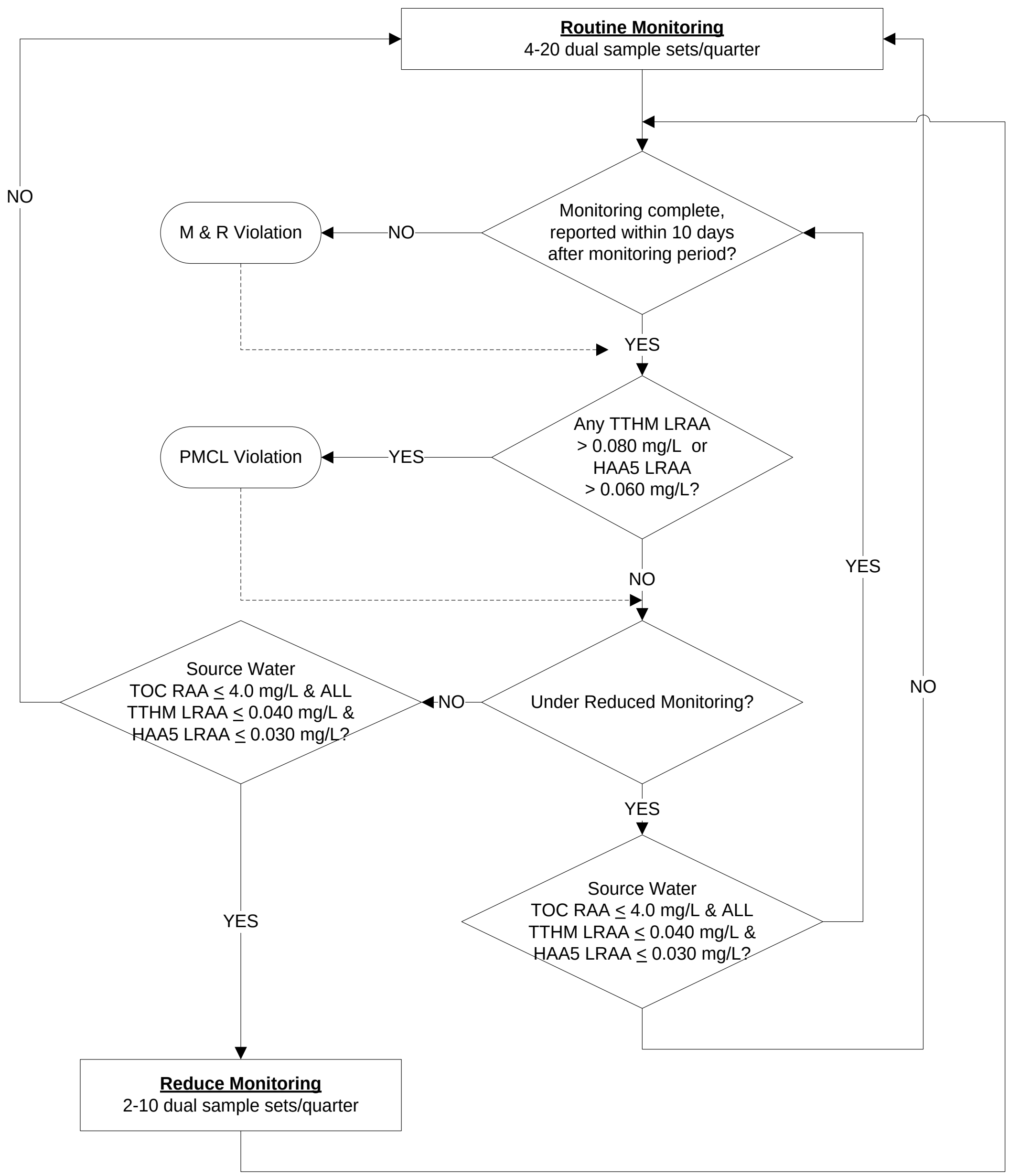
5.6.1. Surface Water Systems Monitoring Annually & Serving < 500 People



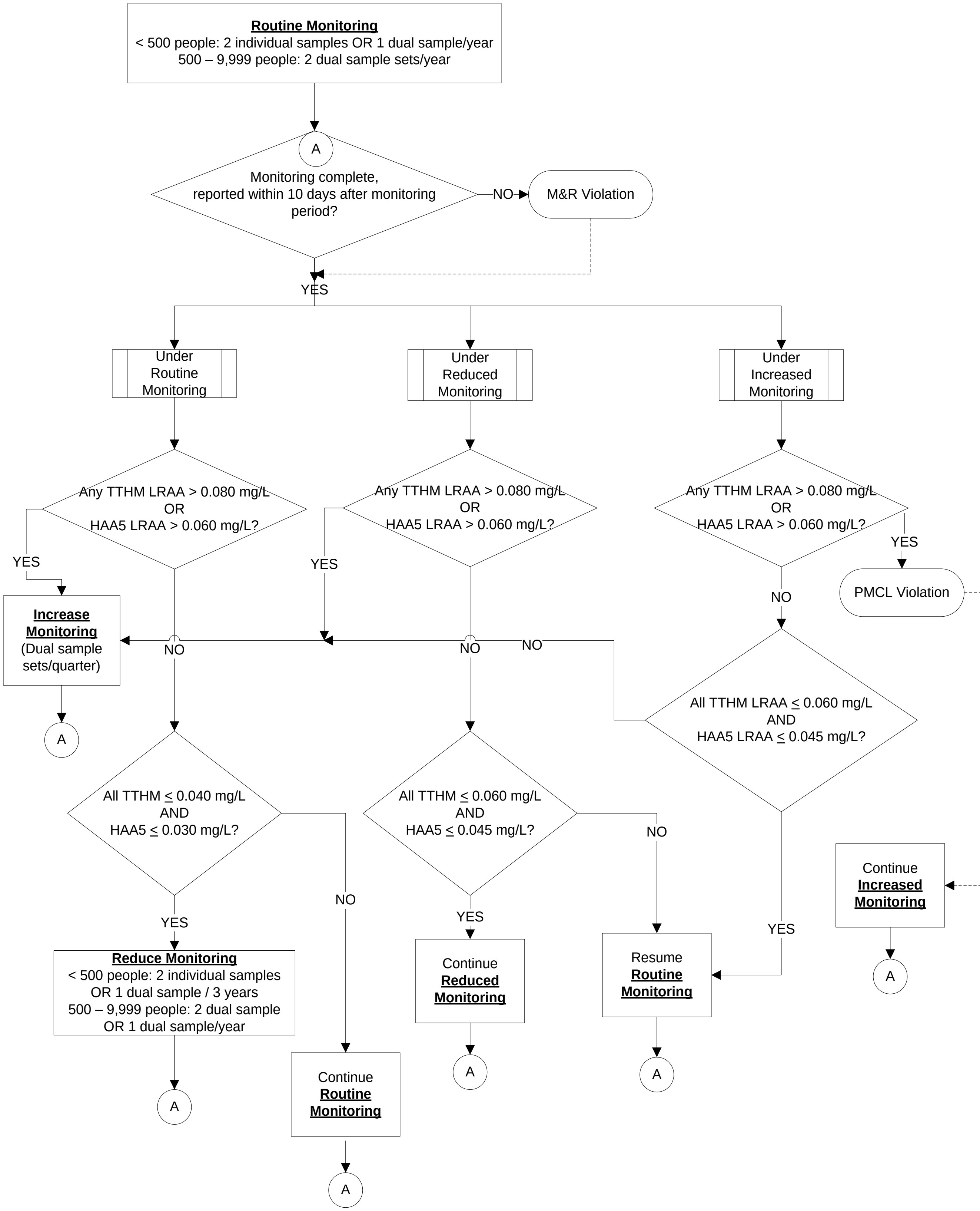
5.6.2. Surface Water Systems Monitoring Quarterly & Serving 500 – 9,999 People



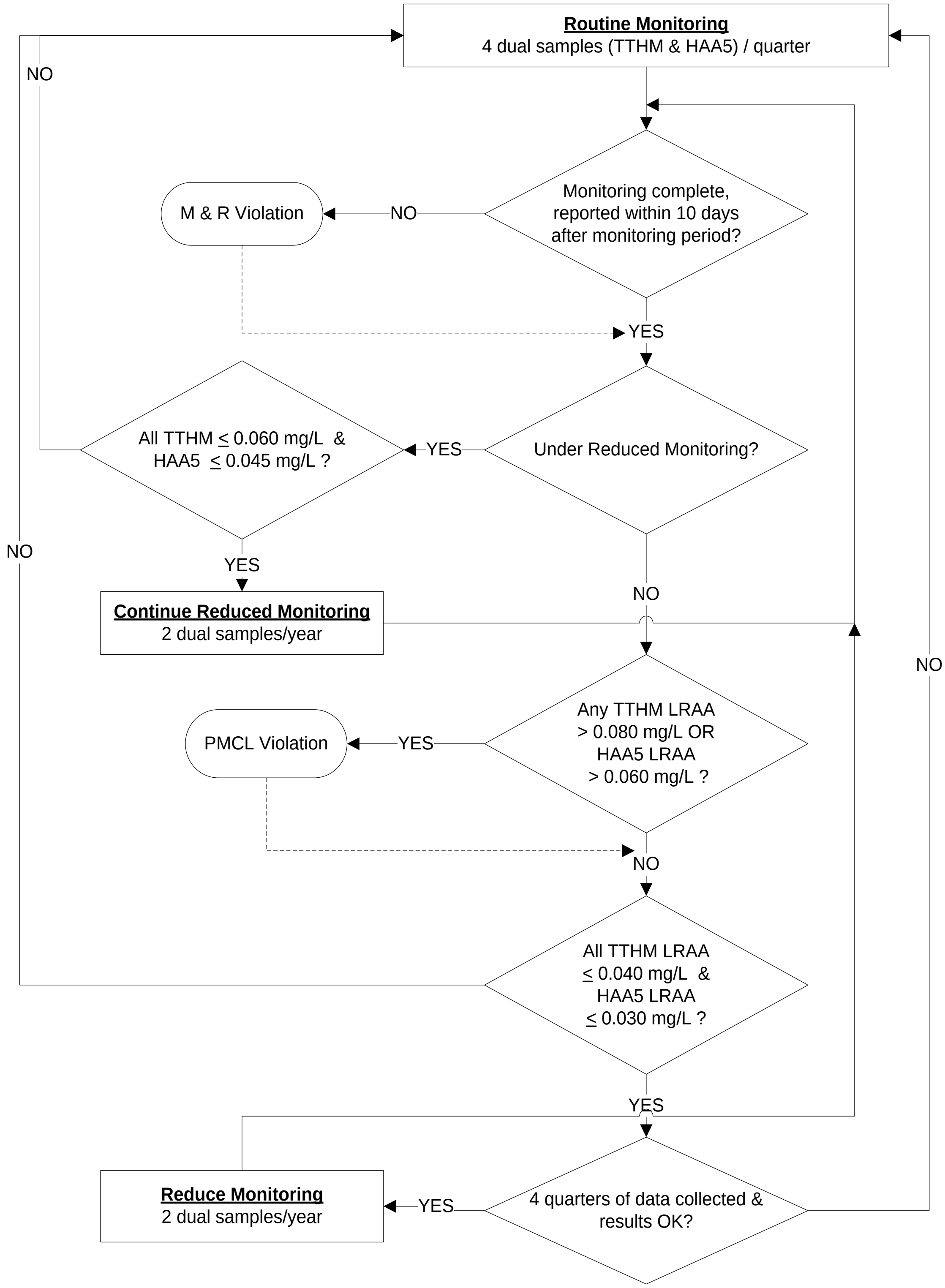
5.6.3. Surface Water Systems Monitoring Quarterly & Serving ≥ 10,000 People



5.6.4. Groundwater Systems Monitoring Annually & Serving < 10,000 People



5.6.5. Groundwater Systems Monitoring Quarterly & Serving 10,000 – 99,999 People

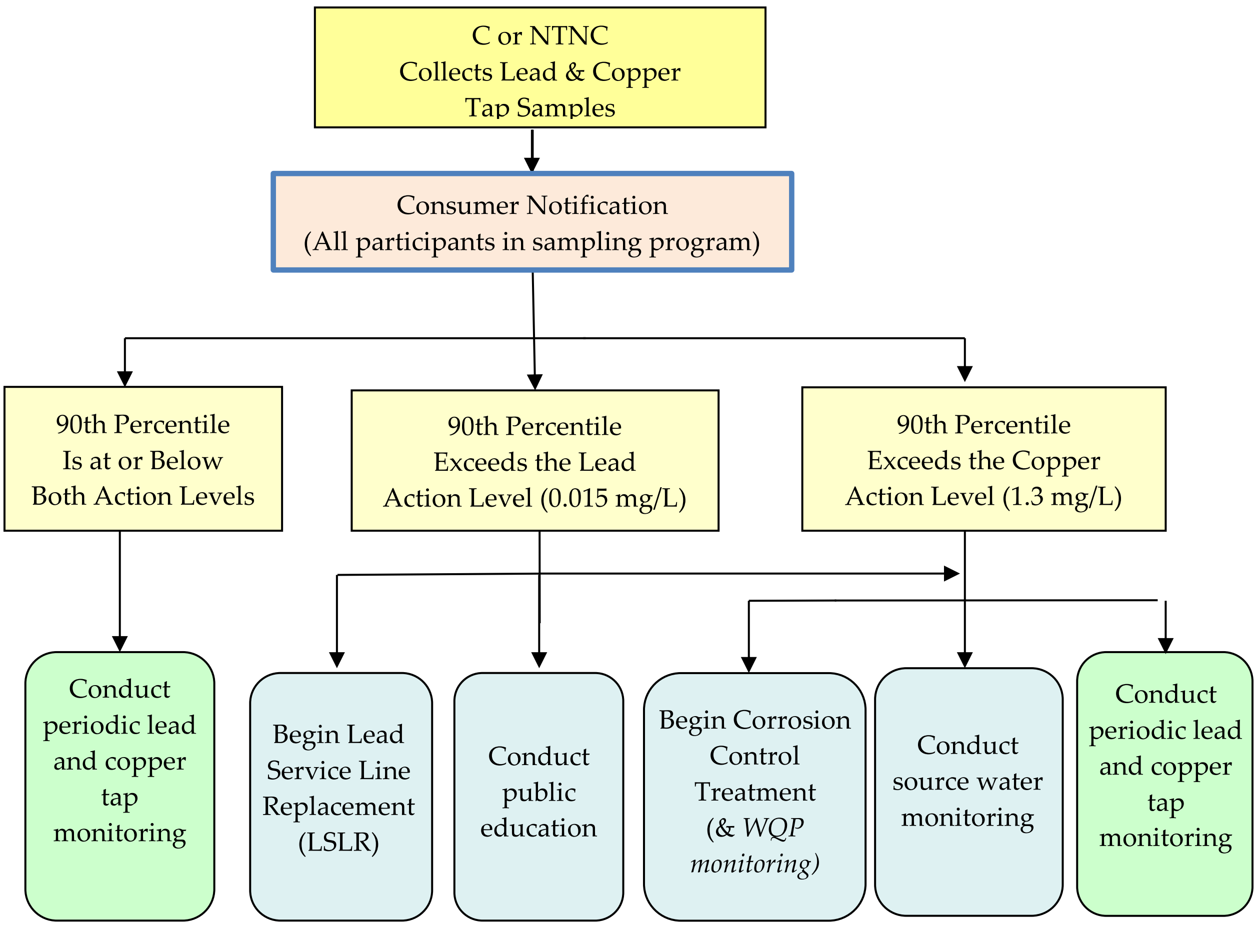


6. LEAD AND COPPER SAMPLING AND TREATMENT TECHNIQUES

The Lead and Copper Rule (LCR) originally published on June 7, 1991, followed by subsequent amendments, stipulates lead and copper monitoring requirements and treatment techniques for all community (CWS) and non-transient non-community (NTNC) waterworks.

The LCR monitoring requirements are contained in the *Waterworks Regulations* 12VAC5-590-375 and the LCR treatment technique requirements are contained in the *Waterworks Regulations* 12VAC5-590-405.

LCR Decision Flow Chart



6.1. Lead and Copper Monitoring at Consumers Taps

Lead and copper tap monitoring must be conducted at sample sites deemed to be the highest risk locations within the distribution system for leaching lead. This priority "Tier and Category" of sample sites is based on a survey of the plumbing materials found at residences and other buildings located within the distribution system. An acceptable sampling location should be a tap that is normally used for human consumption. This is typically a cold water kitchen or bathroom tap, or drinking water fountains and water coolers located in schools or other buildings. <u>Outside hose bibs or utility sinks are not acceptable sampling locations.</u>

6.2. Materials Survey

Prior to collecting any lead and copper tap samples, the waterworks must perform a survey of their water distribution system piping materials and the plumbing materials of all service connections, including interior plumbing materials, to develop a list of priority sample sites. Local plumbing codes, building officials, contractors, and door-to-door visits with residents are sources and methods that can be used to complete the survey.

Upon completion of this survey, the waterworks owner should use Attachment A.1.a (community waterworks) or Attachment A.1.b (NTNC waterworks) to submit a sampling plan that incorporates the results of the survey and the list of chosen sample sites. Note that all monitoring for lead and copper (initial monitoring and all future monitoring) must come from sites that are identified in the materials survey/sampling plan. Waterworks owners are encouraged to identify more sites than the minimum number required. This will allow for a pool of replacement locations when a site may become unavailable in the future. Any request by the waterworks owner for a new replacement site must be in writing to the field office for review and approval. Use Attachment A.2 for approvals of sampling locations.

ODW should perform a periodic review of the waterworks' materials survey and LCR monitoring sites, and request updates to the sampling plan when substantial changes have occurred.

6.3. Preferred Sample Sites

(Defined in descending order)

Tier 1:

- Category A → Single family residences (SFRs) with 50% of the sample sites consisting of lead service lines (LSLs) and 50% consisting of either internal lead pipe or copper pipe with lead solder installed between 1983 and 1986. Since lead plumbing materials were banned in 1986, no newly developed waterworks with new homes will meet this category.
- Category B → All SFRs with all LSL sites included and the remainder consisting of homes with lead pipe or copper pipe with lead solder installed between 1983 and 1986. Again, no newly developed waterworks with new homes will meet this category.
- Category C → If the waterworks can prove that there are no LSLs, then 100% of the sample pool should be from tap samples collected from homes with lead pipe or copper pipe with lead solder installed between 1983 and 1986.
- Multiple-Family residences (MFRs) may be included in the Tier 1 sampling pool when they comprise at least 20% of the structures served.

Tier 2:

- Category D → If enough SFRs with LSLs, lead pipe and/or copper pipe with lead solder cannot be identified, then the sample pool may be substituted from sites with MFRs and/or public and private buildings supplied by LSLs or containing lead pipe or copper pipe with lead solder installed between 1983 and 1986.

Tier 3:

- Category E → If the above categories cannot be fully met, then the remainder of the sample sites must be filled with SFRs having copper pipe with lead solder installed prior to 1983.

Exceptions:

- Category F.1 → For those PWSs with only interior plastic plumbing that cannot demonstrate "lead free" conditions due to brass faucets and fittings, monitoring should be at SFRs with brass faucets.

- Other Category F → SFRs with copper piping installed after 1986.

Additional information concerning preferred sample sites:

- Tier 3, Category E may still apply to many new and some existing waterworks that have older homes with lead soldered copper plumbing.
- Category F.1 may be the classification for many new waterworks with new homes due to only having brass that may contain some lead.

The general sample priority can be viewed in descending order as follows:

Lead service lines or lead pipe (LED) SFR → Copper pipe with lead solder (CP/LS) SFRs → CP/LS MFRs → CP/LS plumbed Public/Private buildings → Copper without lead solder SFRs → Copper MFRs → Copper plumbed Public/Private buildings → Plastic SFRs → Plastic MFRs → Plastic plumbed Public/Private buildings.

The pool of sample sites should be made up entirely of the highest tier and category (priority) samples to the greatest extent possible.

The waterworks owner should identify more sites than the minimum number of samples required to ensure sufficient participation to obtain the minimum number of samples.

6.4. Tap Monitoring Sample Procedures

1. All lead and copper tap samples must be collected from locations identified in the approved materials survey/sampling plan.

2. Each sample must be a "first draw" sample and be a volume of 1 L. The sample tap and other taps including the toilet are not to be operated for a period of at least 6 hours to insure that a standing undisturbed sample is collected (note that there is no regulatory maximum holding time and a high lead result cannot be invalidated due to excessive standing times). **Sample taps should not be flushed prior to this 6-hour stagnation time.** [Flushing removes water that may have been in contact with the lead service line for extended periods, which is when lead typically leaches into drinking water.]

3. Faucet aerators (screens) should not be removed just prior to the collection of the "first draw" sample. When otherwise not engaged in LCR tap sampling, consumers should periodically clean aeration screens to remove particles of copper, brass or solder that often accumulate and can increase the levels of lead and copper in their drinking water.

4. The sample tap should be operated as it would during normal use.

5. The time of last water usage and sample collection time and date must be recorded. The "24-hour military" time format is to be used.

6. Residents can collect the lead and copper tap sample with proper instructions from the waterworks owner. Sample preservation requirements include the addition of nitric acid; however, in order to eliminate any hazard with homeowners collecting the samples the LCR allows this preservation to be accomplished within 14 days of sample collection. This sample preservation is normally conducted by the testing laboratory so samples must be delivered to the lab within the 14-day time limit.

6.5. Initial Lead and Copper Tap Monitoring

After review and approval of the waterworks materials survey/sampling plan, the owner must begin initial monitoring for the first time for that waterworks. Initial monitoring consists of collecting two consecutive sets of samples in 6-month sampling periods (January – June and July – December) from the number of routine sample sites specified in the following table:

System Size	Population Served	Minimum Number of Tap Samples	
		Standard Monitoring	**Reduced Monitoring**
Large	>100,000	100	50
	50,001 – 100,000	60	30
Medium	10,001 to 50,000	60	30
	3,301 to 10,000	40	20
Small	501 to 3,300	20	10
	101 to 500	10	5
	≤ 100	5	5

For small systems with a population ≤ 100 and less than 5 acceptable sampling locations that are normally used for human consumption, less than 5 samples may be collected provided that one sample is taken from each available tap. This must be requested by the waterworks and approved by ODW (12VAC5-590-375 B 3 b).

If the 90th percentile results for both lead and copper do not exceed the 0.015 mg/L Action Level for lead or the 1.3 mg/L Action Level for copper during both consecutive initial monitoring periods, then the waterworks can proceed to reduced monitoring when notified to do so by ODW; see Attachment B.1.

If the 90th percentile results for lead and/or copper exceed the 0.015 mg/L Action Level for lead or the 1.3 mg/L Action Level for copper during either of the initial monitoring periods, ODW field staff shall notify the community and NTNC waterworks owners and other health officials regarding the completion of specific action items, using Attachment B.2.

6.6. Reduced Lead and Copper Tap Monitoring

Annual reduced monitoring consists of collecting two additional consecutive sets of annual samples at the reduced number of sample sites indicated in the preceding table on an annual frequency. These samples must be collected between June 1 and September 30. For NTNC waterworks not typically operating during this period, an alternate period that represents a time of normal operation shall be approved by ODW.

Annual reduced lead and copper tap monitoring starts the next year after the 2nd 6-month period of the initial monitoring has been completed:

If 2nd 6-month sampling period is:	Annual Monitoring Begins:
January – June:	June 1 of the next year
July – December:	

Small systems serving a population ≤ 100 with less than 5 acceptable sampling locations that meet the lead and copper Action Levels can monitor at a reduced frequency of once per year BUT at the same number of samples.

If the 90th percentile lead and copper sample concentrations are still below the Action Levels for both sets of annual samples (i.e., considering a total of three years of monitoring), then the waterworks can proceed to ultimate reduced monitoring, using Attachment B.1.

Ultimate reduced (triennial) monitoring consists of collecting samples at the reduced number of sites at 3-year intervals. All samples must be **collected between June 1 and September 30** of the sampling year. The system cannot exceed 3 years between sampling events and sampling cannot be spread out over a 3-year period; samples must be collected within the same year, between June and September.

Accelerated ultimate reduced (triennial) monitoring - Systems can proceed immediately to ultimate reduced (triennial) monitoring at a frequency of once every three calendar years and at a reduced number of sites if the monitoring results for **two consecutive 6-month periods** indicated a 90th percentile concentration of **≤ 0.005 mg/L**[4] for lead and **≤ 0.65 mg/L**[6] for copper.

Return to initial (Standard) monitoring – Any waterworks in reduced monitoring that **exceeds the lead or copper Action Level must return to initial monitoring IMMEDIATELY FOLLOWING THE EXCEEDANCE (two consecutive six-month monitoring periods** with tap samples collected from the number of standard monitoring sites listed in the preceding table). This waterworks is also subject to the requirements detailed in Sections 6.15 through 6.18. With continued monitoring and consecutive 6-month monitoring results that are below both the lead and copper Action Levels, a waterworks can again become eligible for annual reduced monitoring and triennial reduced monitoring upon meeting the applicable reduced monitoring criteria described previously.

ODW should carefully consider allowing a waterworks to return to triennial reduced monitoring. This should only be allowed following a critical review of the waterworks LCR program, including the installed corrosion control treatment, historical monitoring results, operational control monitoring or WQP monitoring, submission of monthly operation reports and WQP monitoring reports, and the technical, managerial and financial capability of the waterworks. If any aspect of the waterworks LCR program is deemed to be lacking, the waterworks should be kept on an annual reduced monitoring frequency.

6.7. Monitoring Waivers and Variances

There is a provision in the LCR and the *Waterworks Regulations* 12VAC5-590-375 B 7 for monitoring waivers. As a matter of policy, waivers will **not** be granted for lead and copper tap monitoring, regardless of size or type of waterworks, with one exception as described below:

Community waterworks that have individual ion-exchange softeners provided at every service connection (Point of Entry treatment devices) may be granted a waiver from lead and copper tap monitoring. The waterworks must give notice to the consumers annually that the ion-exchange treatment units at each house will make the water more corrosive and that they (the consumers) should flush first draw water for a period of time before use. It is recommended that this notice be placed in the annual Consumer Confidence Report (CCR). Such waterworks shall be designated in SDWIS using the appropriate indicator.

6.8. Combined Distribution System Monitoring

Based on EPA guidance WSG 77A, dated January 10, 1992, consolidated monitoring of combined distribution systems (primary and consecutive waterworks) is allowed under the LCR, provided that *written approval by the EPA* is obtained. The following guidelines shall apply:

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[4] PQL – practical quantitation level

1. A combined distribution system can consist of:
   a. Consecutive waterworks only (if they share one or more primary sources)
   b. Consecutive waterworks + primary waterworks
2. The number of lead and copper tap sampling locations selected for LCR monitoring for the combined distribution system shall be consistent with Sections 6.2. and 6.3 of this chapter.
3. A single, ODW-approved monitoring plan covering the entire combined distribution system is required from the constituent waterworks, with signatory concurrence by all participating waterworks. The plan must include specific information identifying:
   a. The waterworks that will be responsible for collecting and reporting to the ODW all of the results of the lead and copper tap, operational control monitoring or WQP monitoring.
   b. The waterworks that will be responsible for required actions in the event of an Action Level Exceedance (ALE). Actions are not limited to public education, optimizing corrosion control treatment, and lead service line replacement. [Note: An ALE impacts all of the constituent waterworks, and the division of responsibility can be tailored and clearly delineated in the monitoring plan for each participating waterworks.]
   c. Consumer Confidence Reports (CCRs) shall remain as each individual waterworks responsibility.
4. All individual sample results are to be recorded under the "primary" waterworks in SDWIS, with the 90^{th} percentile result reported under each of the participating waterworks.
5. The approved monitoring plan shall be filed under the primary ("wholesaler") waterworks. The approval date shall be assigned to the primary and also to the consecutive waterworks. The monitoring plan may incorporate sampling sites from some or all of the consecutive waterworks.
6. The primary and consecutive waterworks shall be designated in SDWIS using the appropriate indicators and "comment" fields to differentiate levels of participation in the monitoring activities. Refer to the SDWIS User's Manual for detailed instructions.

6.9. Determining the 90^{th} Percentile Concentrations

The LCR established Action Levels for both lead and copper. The lead Action Level is exceeded if the concentration of lead in more than 10% of tap water samples collected during any monitoring period is greater than 0.015 mg/L (i.e., if the 90th percentile lead level is greater than 0.015 mg/L). The copper Action Level is exceeded if the concentration of copper in more than 10% of tap water samples collected during any monitoring period is greater than 1.3 mg/L (i.e., if the 90th percentile copper level is greater than 1.3 mg/L).

The 90^{th} percentile concentrations shall be determined for both lead and copper following receipt of all lead and copper sample results for each respective monitoring period. The procedure to determine the 90^{th} percentile concentrations can be found in the *Waterworks Regulations* 12VAC5-590-385.

All valid sample results must be included in the 90^{th} percentile calculation. A valid sample is a sample:

1. Collected from a pre-approved sample location that was identified in the original or in a revised Lead and Copper Monitoring Materials Survey/ Sampling Plan (see Section 6.2)
2. Collected from an approved alternate sample location that meets the same site tier and category as in the Sampling Plan
3. Collected within the respective monitoring period – no exceptions; do not include any sample that was collected outside of the monitoring period

4. If a utility collects consumer-requested samples, the results must be reported to ODW and must be included in the 90th percentile determination if the sample and sample site meets the criteria above (i.e., site is from the appropriate Tier location, a 1.0 L first draw sample with minimum 6-hour holding time, etc.) The sample location will likely not be previously approved.

Samples collected outside the compliance monitoring period (June 1 – September 30 for reduced monitoring) are not to be included in the 90th percentile calculation. However, samples collected outside the monitoring period containing levels of lead >0.015 mg/L must be addressed as a separate issue, and may require the issuance of a monitoring violation and some type of public notice. In addition, in this situation where a lead Action Level Exceedance occurs, follow up monitoring will be required.

If a waterworks collects fewer than the minimum number of samples, the lead and copper 90th percentile concentration must be determined using the number of samples submitted. A monitoring violation must also be issued.

Waterworks can collect samples or review the sample collection information before the sample is analyzed by the laboratory. If something is suspected to be incorrect, the sample should not be tested and another one collected. Once sample results are received, ODW field staff can only invalidate the sample if one or more of the following occurs:

1. Improper sample analysis verified by the laboratory
2. Site selection criteria has not been met (i.e., unapproved sample site)
3. Sample container was damaged in transit
4. Sample subjected to tampering

Note: Any decision and its rationale to invalidate a sample shall be documented in writing. Replacement samples are to be collected within 20 days of the date for any samples that are invalidated.

6.10. Monitoring for Water Quality Parameters (WQPs)

All large waterworks (those serving > 50,000 population), and small (serving ≤ 3,300 population) or medium (serving 3,301 – 50,000 population) waterworks that exceed the lead or copper action levels, must conduct WQP monitoring, in accordance with 12 VAC5-590-375 C.

WQP monitoring includes sampling from representative locations within the distribution system (such as sites used for routine total coliform monitoring) and from all entry points (representative of each source after treatment and during periods of normal operating conditions) to the water distribution system. In order to ensure that the WQP monitoring locations within the distribution system are representative, waterworks shall submit a WQP monitoring plan consisting of a distribution system map showing sample locations, pressure zone boundaries, storage tanks, pump stations, and entry points, and a list of the sample locations (addresses). ODW staff will review the monitoring plan to confirm that the sample locations cover the entire system, address each source and pressure zone, including the ends of the system.

The applicable WQP parameters listed in the following table shall be established / approved by the ODW, to ensure optimal corrosion control treatment for the waterworks. Analyses of WQPs for compliance purposes shall be conducted in accordance with the methods listed in 40 CFR 141.23(k)(1); the alternative methods listed in Appendix A, Subpart C of 40 CFR Part 141; or by an equivalent method as determined by EPA[5]. Field staff should question the waterworks when an equivalent method is cited but cannot be verified.

[5] EPA-approved methods are also cited in the Federal Register and compiled in the CFR, whereas the EPA-accepted methods which are used for compliance monitoring are not so cited. For example, HACH Method 8048 has been accepted by the EPA as being equivalent to EPA 365.1 for orthophosphate. Typically, EPA provides a letter of approval or acceptance of a particular method to the analytical equipment manufacturer.

WQP testing may be performed by any person or party acceptable to the commissioner.

WQP Parameter	Applicability	Initial Sampling	After OCCT Is Installed
pH	All waterworks	EP: Min. Value[1] or Range DS: Minimum value[2]	EP: Min. Value[1] or Range DS: Minimum Value[2]
Orthophosphate[4] (PO_4)	If PO_4 Inhibitor used	EP: Dose & Concentration DS: Concentration	EP: Dose & Concentration DS: Concentration
Silica (Si)	If Si Inhibitor used	EP: Dose & Concentration DS: Concentration	EP: Dose & Concentration DS: Concentration
Alkalinity	If alkalinity adjusted	EP: Dose & Concentration DS: Concentration	EP: Dose & Concentration DS: Concentration
Conductivity	All waterworks	Measured value[3]	Not required
Water Temperature	All waterworks	Measured value[3]	Not required

EP = Entry Point, DS = Distribution System sample taps

1 If orthophosphate or blended phosphate inhibitor is added, then pH > 7.2, per EPA's guide "Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems", dated March 2016.

2 The *Waterworks Regulations* require a minimum pH of 7.0 measured at all tap samples.

3 Value is not established but shall be measured and reported along with the other applicable WQPs.

4 If an orthophosphate compound is used, the WQP analytical result shall be reported as PO_4. If the result is given in terms of orthophosphate as phosphorus (i.e., PO_4-P), then it must be multiplied by a factor of 3.06 to convert to PO_4.

The established WQPs shall be documented in accordance with applicable data management requirements. Failure to maintain any established WQPs as indicated by excursions for more than 9 consecutive days during the 6-month monitoring period is a treatment technique violation (see 12VAC5-590-405 A 1 g).

WQP Monitoring for Small or Medium Waterworks after Exceeding Lead Action Level

Any small or medium waterworks that exceeds either the lead or copper Action Level shall conduct WQP monitoring in accordance with the requirements of 12VAC5-590-375 C. This monitoring must include all applicable water quality parameters (noted in the previous table), and must be conducted during the same six-month monitoring period in which the waterworks exceeded the lead or copper Action Level. This WQP monitoring must include two sets of samples from distribution system taps and at least one set of samples from each entry point (see 12VAC5-590-375 C 1 and C3).

Monitoring after the Commissioner establishes WQP values (12VAC5-590-375 C 4):

<u>Entry Point WQP Monitoring</u>**:**

Monitoring of WQPs at each entry point to the distribution system must include at least **<u>one</u>** sample for <u>each</u> entry point (representative of each source after treatment and during periods of normal operating conditions). Testing shall be no less frequently than <u>every 2 weeks (bi-weekly)</u>. Entry Point WQPs must be monitored and reported in the waterworks' *Monthly Operation Report*. These biweekly entry point WQPs must also be reported using the reporting form in Attachment C.1 unless the results are being reported electronically in SDWIS.

<u>Distribution System WQP Monitoring</u>**:**

Distribution system monitoring includes **<u>two</u>** sets of samples for each applicable WQP collected from each site during each respective 6-month monitoring period. The number of distribution system sites to be sampled is based on population shown in the following table:

System Size	Population Served	Number of WQP Distribution Sample Sites
Large	> 100,000	25
	50,001 – 100,000	10
Medium	10,001 to 50,000	10
	3,301 to 10,000	3
Small	501 to 3,300	2
	101 to 500	1
	≤100	1

Waterworks must **report the results of the WQP distribution system monitoring** to the ODW field office no later than the 10^{th} day of the month following the end of the 6-month monitoring period (to coincide with the compliance periods: January – June and July – December) using the reporting form in Attachment C.1, unless the results are being reported electronically in SDWIS. Monthly reporting of the WQPs is optional.

ODW shall review the WQP monitoring results promptly after the monitoring period. If the results are in compliance with the established WQPs, notify the waterworks in writing (letter template provided in Attachment C.2.). If a treatment technique violation has occurred, follow established enforcement procedures.

6.11. Reduced Monitoring for Water Quality Parameters (WQP's)

As a matter of policy, WQP monitoring at the entry point(s) and in the distribution system will <u>NOT</u> be reduced.

6.12. WQP Treatment Technique Violations

Once ODW field staff has established optimal WQPs, the waterworks must continue to operate within the established range of values or above the established minimum values, measured as average daily values. For all waterworks required to optimize corrosion control treatment, these values shall also be stipulated in the Operation Permit Conditions. Compliance shall be determined after every 6-month monitoring period (i.e., January – June and July – December) and verified by the ODW field office, either by review of the submitted report form or electronic results received. Failure to maintain any established WQPs as indicated by excursions for more than 9 consecutive days during the 6-month monitoring period is a treatment technique violation (see 12VAC5-590-405 A 1 g).

6.13. Consumer Notification

All systems, both community and NTNC, must provide notification of the lead and copper sampling results to the occupants at each sampling site that was tested in the LCR tap monitoring program within 30 days of receipt of results. Consumer notification templates for both community and NTNC waterworks are provided as Attachments D.1 and D.2, respectively. This consumer notice is required even if both lead and copper Action Levels are met. ODW will calculate this 30-day period from the date that the lead and copper results letter is sent to the waterworks. NTNC waterworks must post the results of tap monitoring. In addition to the consumer notification, the **waterworks must provide the ODW field staff with a certification that the consumer notice delivery requirements were met**. *Full copies of the certification shall be maintained in the field office files.* These delivery certification forms (included in Attachments D.1 and D.2) must be provided no later than 3 months from the end of the respective monitoring period.

6.14. Consumer Confidence Report

All CCRs must contain mandatory language concerning lead in drinking water that includes the health effects on children, a flushing recommendation of 30 seconds to 2 minutes prior to using the water, and any monitoring variance. Waterworks can write their own educational statement, but it must be approved by the ODW Field Office.

The CCRs must contain and prominently display the following mandatory language, per *Waterworks Regulations* 12VAC5-590-545 D 5. Any modifications must be approved by the ODW:

> "If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. *[Name of Waterworks]* is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the safe Drinking Water Hotline (800-426-4791) or at http://www.epa.gov/safewater/lead.

6.15. Required Actions if an Action Level is Exceeded

The LCR contains four specific treatment techniques that must be implemented by the waterworks owner if the lead and/or copper Action Levels are exceeded. These are summarized in the following table:

Action Level Exceeded	Required Treatment Technique	*Waterworks Regulations* Citation
Lead, Copper	Corrosion Control Treatment	12VAC5-590-405 A
Lead, Copper	Source Water Monitoring and Treatment	12VAC5-590-405 B
Lead	Lead Service Line Replacement	12VAC5-590-405 C
Lead	Lead Public Education	12VAC5-590-405 D

6.16. Source Water Monitoring and Treatment

Whenever either the lead or copper Action Level is exceeded, the waterworks owner must collect source water samples for lead and/or copper to verify that the elevated levels at consumer's taps is the result of internal pipe corrosion and not from high source water concentrations. These samples must be collected from each entry point to the distribution system within 6 months from the end of the respective monitoring period in which the Action Level was exceeded. Additional guidance for the source water monitoring requirements can be found in the *Waterworks Regulations* 12VAC5-590-375 D.

The lead and copper results of the routine metals monitoring from the waterworks may be substituted for this required source water monitoring if the results are less than one year old.

In the event that elevated lead or copper source water concentrations are found, the waterworks must install an appropriate source water treatment technology and conduct routine source water monitoring. To date no waterworks has been required to install source water treatment. Should this occur in the future, requirements are given in the *Waterworks Regulations* 12VAC5-590-405 B.

6.17. Corrosion Control Treatment

Optimal Corrosion Control Treatment (OCCT) is defined as treatment that minimizes lead and copper concentrations at the users' tap without violating any National Primary Drinking Water Standards. The following three types of treatment must be investigated:

1. pH and alkalinity adjustment
2. Calcium hardness adjustment
3. Phosphate-based or silicate-based corrosion inhibitors

Any size system is considered to have optimized treatment if the results of two consecutive 6-month monitoring periods indicate the difference between the 90th percentile tap water lead concentration and the highest source water lead concentration is less than 0.005 mg/L.

Small- or medium-size systems are considered to have optimized treatment (and are not required to complete the corrosion control treatment steps) after two consecutive 6-month monitoring periods of monitoring indicate both lead and copper are below their 90th percentile action levels. However, as stated in the *Waterworks Regulations*, **if any such waterworks thereafter exceeds the lead or copper action level during any monitoring period, the owner shall recommence completion of the applicable treatment steps.**

Small- or medium-size systems that exceed an Action Level are required to recommend an OCCT to ODW within 6 months from the end of the monitoring period in which the Action Level was exceeded, unless an OCCT study is required *or* ODW decides to perform a "Desktop" evaluation instead.

Corrosion Control Treatment Studies:

All large systems (>50,000 people) shall perform corrosion control treatment studies to investigate treatment options and determine which will provide OCCT. The OCCT study for the large systems must be completed within 18 months following the completion of initial monitoring.

ODW has the option of performing a "Desktop" evaluation for the small- or medium-size waterworks, in lieu of requiring the waterworks to perform the corrosion control treatment studies. (WM 740 provides detailed instructions, review forms, and sample notification letters for performing the "Desktop" evaluation.) Refer to EPA's guide "Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems", dated March 2016, available at Y:\02-Committees\202-Rule Teams\Lead and Copper Rule\OCCT Guidance & Templates\OCCT for States&PWS.3.30.16.pdf. Excel spreadsheet templates for evaluating OCCT are provided with the guidance.

If ODW requires the small- or medium-size waterworks to conduct an OCCT study, or if ODW performs the "Desktop" evaluation, it must be completed within 18 months.

ODW Review & Approval:

If an OCCT study is not required, ODW must review the waterworks' study and treatment recommendation within 6 months from the end of the monitoring period in which the Action Level was exceeded.

If a corrosion control treatment study is required, the ODW field staff must review the submitted study and OCCT recommendation, and must approve or disapprove the OCCT recommendation within 6 months of receiving the study.

OCCT Installation & Follow-Up Monitoring:

The waterworks owner must install the approved OCCT within 24 months following the completion of the Desktop evaluation or ODW's decision on the waterworks' treatment recommendation.

After the waterworks installed the corrosion control treatment, follow-up monitoring shall be conducted. Follow-up monitoring consists of two consecutive 6-month rounds of lead and copper tap samples, and operational control monitoring of WQPs beginning immediately after installation of the OCCT.

Operational Control Monitoring:

Routine operational control monitoring and reporting via the Monthly Operation Report (MOR) must be established by ODW to ensure that OCCT is being continuously operated, particularly for small and medium size waterworks. The operational control parameters should be the same as the WQPs described in section 6.10. However, operational control monitoring may be limited to Entry Points or may include the distribution system when deemed necessary. The minimum monitoring frequency should be twice per week for Entry Point sampling. The owner must be notified of the operational control parameters and monitoring frequency in writing (after the OCCT has been installed and approved). Operational control monitoring shall also be included in the Operation Permit Conditions when the permit is opened for modification (see the *Permit Manual* for further guidance).

6.18. Public Education

Any waterworks that exceeds the lead Action Level is required to complete the prescribed Public Education requirements (see templates in Attachments E.1 and E.2 for community and Attachment E.3 for NTNC waterworks). Public Education requirements will differ depending upon the size and type of waterworks. The initial Public Education tasks must be completed within 60 days of the end of the monitoring period in which the lead Action Level is exceeded (for waterworks in reduced monitoring, the end of the monitoring period is normally September 30 so any required Public Education must be completed no later than November 30). If the waterworks continues to exceed the lead Action Level or ceases to conduct lead and copper tap samples (until corrosion control treatment is installed), then certain Public Education tasks must be repeated either on a 6-month or 12-month frequency.

Following any required Public Education task, **the waterworks must submit a certification to the ODW field office indicating that the required task was satisfactorily completed** (see forms also included in Attachments E.1, E.2, and E.3). ODW field staff must ensure that all applicable categories of thr required Public Education are accounted for in the owner's returned certification. *Full copies of the certification shall be maintained in the field office files.* These delivery certification forms must be submitted within 10 days after the end of each period in which the owner is required to perform a Public Education task.

6.19. Lead Service Replacement

Any waterworks that continues to exceed the lead Action Level after installing corrosion control treatment is required to replace any existing lead service lines (LSLs), at a rate of at least 7% over a 15-year period. To date there are no waterworks that have been required to replace lead service lines under the LCR. There are waterworks that are voluntarily replacing lead service lines when these lines are encountered.

Specific guidance regarding LSL replacement can be found in the *Waterworks Regulations* 12VAC5-590-405 C.

6.20. Advanced Notification and Approval of Any Change in Water Treatment or Addition of a New Water Source

Any waterworks with plans on making any changes in water treatment or adding a new water source must notify and obtain approval from the ODW field office prior to proceeding. Additionally, the ODW field office, in granting approvals, must make an assessment as to whether the addition of a new water source or a change in water treatment may adversely affect optimal corrosion control treatment and result in an increase in distribution system lead or copper levels. ODW's assessment may result in requiring optimal corrosion control studies to be conducted prior to implementing a long-term treatment change or adding a new source and/or requiring that additional lead and copper monitoring be conducted.

The Virginia *Waterworks Regulations* already require waterworks owners to obtain a Construction Permit for any changes in treatment or the addition of a new water source. ODW will effectively be notified of significant treatment changes or new sources. The potential for a new water source or changes in treatment to impact corrosion control and distribution system lead levels must be addressed in the preliminary engineering conference and/or preliminary engineering report.

6.21. Long-term Treatment Changes

Long-term treatment changes do not include chemical dose fluctuations associated with daily raw water quality changes or normal seasonal changes. Some specific examples of long-term changes in treatment include:

1. Changing disinfectants such as chlorine to chloramines
2. Changing primary coagulants such as alum to ferric chloride
3. Changing corrosion inhibitor chemicals such as orthophosphate to a blended phosphate
4. Making a change in dose of an existing chemical if the system is planning long-term changes to its finished water pH or residual inhibitor concentration

Additional examples of long-term treatment changes include the installation of major unit processes such as membrane filtration, ozonation, and enhanced coagulation/enhanced softening to reduce disinfectant by-product precursors, and other treatments or processes or combinations of processes that can greatly affect the pH, oxidation-reduction potential, alkalinity, or the major composition of the ionic background of the water.

The ODW's policy is to evaluate treatment changes on a case-by-case basis to determine if the waterworks must conduct corrosion control studies and/or additional lead and copper tap monitoring. ODW field office makes this evaluation and obtains concurrence from the Division of Technical Services - Central Office. EPA has provided guidance to the states to evaluate the potential impact on corrosion and lead levels resulting from treatment changes. This guidance can be found in Appendix D of the EPA's Simultaneous Compliance Guidance Manual for the Long Term 2 and Stage 2 DBP Rules, dated March 2007, available at :\02-Committees\202-Rule Teams\MDBP & ESWT Rules\02-EPA Guidance Manuals\Stage 2 LT2 Simultaneous Compliance\ST2-LT2 Simultaneous Compliance Guidance 03-2007.pdf.

ODW will require a waterworks to conduct lead and copper "follow-up monitoring" (monitoring for two consecutive 6-month periods at the original number of tap sample sites) following long-term treatment changes that include:

1. Change in disinfection from free chlorine to chloramines
2. Any change in the method of optimum corrosion control treatment (i.e., changing from a corrosion inhibitor to pH and alkalinity adjustment, or from pH and alkalinity adjustment to a corrosion

inhibitor or change in the type of corrosion inhibitor such as from a blended phosphate to a zinc orthophosphate)

3. Any other treatment changes that result in a permanent change to the finished water pH and/or to the corrosion inhibitor concentration.

Prior to implementing a treatment change, ODW may require a waterworks to conduct a corrosion control study to assess the impact of the proposed treatment changes on distribution system lead concentrations. Such a study may benefit the waterworks to avoid making an expensive change in treatment that will result in an increase in distribution system lead concentrations. The need to conduct the corrosion control study must be discussed during the preliminary engineering conference and/or the preliminary engineering report.

Other treatment changes (such as changing coagulants or installing new treatment processes) will be evaluated to assess the impact on corrosion-related water quality parameters. If the evaluation indicates that the treatment change may result in increased distribution system lead or copper levels, the return to "follow-up monitoring" is required. If the evaluation indicates that the treatment change will not have an impact on distribution system lead or copper levels, it is still advisable to require some additional lead and copper tap monitoring. This additional monitoring will provide data to demonstrate that the treatment change did not result in increased lead or copper levels. The number of samples to be collected will be determined by ODW. Suggested additional monitoring would include 5 to 10 lead and copper tap samples to be collected from previously approved locations. This monitoring should be conducted 30 to 60 days after the treatment change has been initiated.

6.22. Addition of a New Water Source

The revisions to the LCR require states to approve the addition of new water sources and to make an assessment as to whether the new water source may adversely affect optimal corrosion control treatment and/or result in an increase in distribution system lead or copper levels. The ODW's policy is to evaluate the addition of new water sources to determine if the waterworks must conduct corrosion control studies and/or additional lead and copper tap monitoring.

A corrosion control study or additional monitoring is required when the new water source is significantly different in water quality characteristics that may impact corrosion. If a waterworks using wells decides to add an additional well source, and the new well has similar water quality to the existing wells, it would not be necessary to conduct a corrosion control study or additional monitoring. However, if the new well is significantly different in water quality, then the OCCT study or additional monitoring should be required. If a waterworks using wells decides to add a surface water source and abandon the wells, then the corrosion control study and/or additional monitoring (based upon both the different, new water source and the addition of new treatment for the surface water source) are required.

In situations where the new water source may adversely affect optimal corrosion control treatment and/or result in an increase in distribution system lead or copper levels, additional lead and copper tap monitoring as described for long-term treatment changes will be required.

EPA has developed guidance to assist States in making decisions related to the impact on lead corrosion resulting from the addition of a new water source or a long-term treatment change; see Appendices C (pg.C-1) and D (pg. D-1 of the Simultaneous Compliance Guidance Manual for the Long Term 2 and Stage 2 DBP Rules, dated March 2007 for the assessment tools, available at :\02-Committees\202-Rule Teams\MDBP & ESWT Rules\02-EPA Guidance Manuals\Stage 2 LT2 Simultaneous Compliance\ST2-LT2 Simultaneous Compliance Guidance 03-2007.pdf. The decision to require the waterworks to conduct a corrosion control study or additional monitoring must be made in consultation with the Division of Technical Services staff in the Central Office.

6.23. Examples

Example 1- Change in corrosion control treatment

Anytown has a 3.0 MGD conventional WTP and is using a zinc orthophosphate inhibitor for corrosion control. Because of new and more stringent zinc limits contained in Anytown's VPDES Permit, they are proposing to change from the zinc orthophosphate inhibitor to a blended phosphate inhibitor.

Because Anytown is changing to a new corrosion inhibitor, they must return to lead and copper "follow-up" monitoring after changing to the blended phosphate inhibitor. Follow-up monitoring consists of lead and copper tap monitoring conducted during two consecutive 6-month monitoring periods (January – June and July – December) at the original, non-reduced number of sites based upon population.

Example 2 – Treatment change

Anytown has a 3.0 MGD conventional WTP and is using liquid alum as the primary coagulant. Anytown wants to improve plant performance to meet the VOP sedimentation and filtration goals and has found that poly-aluminum chloride (PACL) as the primary coagulant provides superior performance. The change to PACL will not result in any changes to the corrosion-related water quality parameters. The finished water pH, alkalinity and blended phosphate inhibitor dosage will remain unchanged, including all of the reporting requirements.

In this situation, we can reasonably assume that this change from alum to PACL will not alter the finished water corrosion characteristics. As such no additional monitoring would be required.

Example 3 – Addition of a new water source

Anytown is experiencing source water deficits during drought conditions and proposes to drill a new well to supplement the WTP. The well will be a new entry point to the distribution system. Anytown proposes to treat the well with chlorine, fluoride, and the same blended phosphate inhibitor used at the WTP.

Even though Anytown proposes to treat the well water with the same blended phosphate inhibitor, some additional lead and copper monitoring should be required to demonstrate that the new source does not result in increased lead concentrations at consumer's taps. In this situation, a return to full "follow-up" monitoring is not appropriate as the well is a new entry point pumping directly into the distribution system and the entire system will not receive the well water. ODW requires Anytown to collect six lead and copper tap samples from the portion of the service area that will receive water from the new well. These samples should be collected from locations that meet the same tier and category as the previously approved lead and copper sample sites for Anytown. Assuming that the results of the six special samples indicate lead and copper concentrations that are below the AL's, no additional actions are necessary.

7. GROUNDWATER MONITORING AND GUDI DETERMINATIONS

7.1. Background

Source water monitoring is required as part of the ODW's continuing efforts to:

a. Detect any changes in a groundwater source quality over time;
b. Determine if the groundwater source is at risk of being directly influenced by surface water; and
c. Determine whether disinfection treatment alone is sufficient to protect public health.

This monitoring program is entirely different and separate from any source water monitoring required by the GWR described in Section 4.2. While the GWR requires treatment techniques to protect against the presence of viruses and bacteria, the SWTR requires treatment techniques to protect against the presence of large-diameter pathogens such as *Giardia lamblia* and *Cryptosporidium* found in surface water and GUDI sources. This section describes sampling required to determine if the SWTR applies to a groundwater source.

This section of the Manual includes detailed procedures for routine monitoring at existing groundwater sources, GUDI determinations, and interim actions for GUDI sources.

7.2. Routine Monitoring at Existing Sources

Routine source water monitoring of groundwater is required in the *Waterworks Regulations* (12VAC5-590-425) for sources that use chlorine disinfection or some other treatment that may alter or affect the bacteriological quality of the source water. ODW must insure that an acceptable source water sample tap is provided for all groundwater sources. An acceptable sample location must be representative of the source water prior to any treatment. The source water monitoring location and sampling procedure shall be reviewed and evaluated during each sanitary survey.

The source water monitoring frequency for existing groundwater sources depends upon geology and whether the source is a well or a spring. Existing groundwater sources shall be grouped as either a karst well, non-karst well, or spring. The *minimum* source water monitoring frequency for these source types is as follows:

Source Type	Minimum Source Water Monitoring Frequency	Parameters
Well located in non-karst geology	One sample per year	Total Coliform and *E. coli*
Well located in karst geology	One sample per quarter	Total Coliform and *E. coli*
Spring	One sample per month	Total Coliform and *E. coli*

The above table contains the minimum source water monitoring frequency. ODW may require more frequent monitoring for any source that is deemed to be "at risk" of being directly influenced by surface water, or subject to bacteriological or other sources of contamination. This determination may be made based upon geology, well construction, historical monitoring results, or any other evidence that the source is susceptible. ODW will notify owners of these source water monitoring requirements and determine whether waterworks provide treatment as described above.

Owners shall be encouraged to conduct some of the sampling within 72 hours after a significant rainfall event to get the best information relative to potential surface water influence or bacteriological contamination.

7.3. Microbial Test Methods

A method yielding a Most Probable Number (MPN) result for both Total Coliform and *E. coli* is required for source water tests. All analyses must be performed using EPA-approved analytical methods found in 40 CFR Part 141 for both Total Coliform and *E. coli* MPN analysis.

All Microscopic Particulate Analysis (MPA) testing and reporting of results shall be in accordance with the USEPA "Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)", dated October 1992. All MPA tests must include both *Giardia lamblia* and *Cryptosporidium.*

7.4. Additional Monitoring (Confirmation Samples)

ODW will ensure that all source water monitoring results are reviewed and evaluated each month. Additional monitoring and other actions may be required depending upon the monitoring results and type of water source.

For any source with a source water monitoring frequency less than monthly, ODW must notify the owner to collect at least one confirmation sample as soon as possible following any single sample result indicating Total Coliform in excess of 50 colonies per 100 ml, or any sample indicating the presence of *E. coli*. ODW may require more than one additional sample.

7.5. Evaluation of Routine Source Water Monitoring Results

The *routine* source water monitoring results, and any additional samples required by section 7.4 above, will be evaluated as follows:

a. Annual or Quarterly Sampling: If results indicate Total Coliform greater than 50 colonies per 100 ml in two or more samples collected during any running 6 calendar month period, routine source water sampling will be increased to monthly.

b. If results indicate total coliform greater than 50 colonies per 100 ml in three or more samples collected during any running 6 calendar month period, additional water quality monitoring is needed to determine if disinfection treatment alone is sufficient. A GUDI re-evaluation is required beginning with the 20 sample MPN series. ODW shall notify the waterworks owner to increase the source water monitoring frequency to weekly for a minimum of 20 weeks.

c. If results indicate the presence of *E. coli* in two or more samples collected during any running 6 calendar month period, the 4-log virus treatment technique and compliance monitoring requirements of the GWR is required. See Working Memo 910 for additional guidance. A GUDI re-evaluation is required beginning with the 20 sample MPN series. ODW shall notify the waterworks owner to increase the source water monitoring frequency to weekly for a minimum of 20 weeks.

7.6. GUDI Determination Procedure

7.6.1. Background

The SWTR and the *Waterworks Regulations* define GUDI sources to mean: *"...any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as Giardia lamblia, or (2) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH that closely correlate to climatological or surface water conditions".*

Once a source is determined to be GUDI, it is subject to the filtration and disinfection treatment technique requirements of the SWTR (Subpart H of the federal regulations) and the requirements of other applicable EPA Regulations.

Groundwater sources can be triggered into a GUDI evaluation (or re-evaluation) based upon three circumstances (see also section 7.6.3):

a. A groundwater source is new;
b. An existing groundwater's source water monitoring results, triggered by the GWR, require a GUDI re-evaluation;
c. An existing groundwater source's routine source water monitoring results indicate a change in water quality that warrant a GUDI re-evaluation.

Use the GUDI Determination Review Sheet posted in...\..\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898- Sampling Manual\GUDI\ to document the evaluation of the source and all monitoring data used. The Review Sheet proceeds stepwise, following the procedures outlined in the following paragraphs. The corresponding steps in the Review Sheet are shown in boxes (Step 1a).

Model letters for transmitting results of GUDI determinations to waterworks owners are also posted in...\..\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898- Sampling Manual\GUDI\.

7.6.2. Initial Assessment (Step 1)

Step 1. The GUDI determination begins with evaluation of the source history, well or spring construction, well or spring protection and location. Has the source been associated with a disease outbreak Step 1a, a chemical contamination event from the surface Step 1b, or evidence of direct surface water intrusion Step1c?

Note: Many of the compounds found in petroleum products are very soluble and can travel for long distances in groundwater. Use caution when applying the "chemical contamination event from the surface" criteria (Step 1b) in declaring a source GUDI based upon a petroleum contamination event.

Most sources cannot be characterized on the basis of source history, construction and location alone, and the evaluation must proceed to Step 2.

7.6.3. Microbial Sampling and Evaluation (Step 2)

Step 2. The **Step 2** evaluation begins with a microbiological sampling series. The microbiological sampling series is usually a minimum of 20 samples analyzed by an approved laboratory, using an MPN test method for both total coliform and *E. coli*. A minimum of 20 weeks of monitoring, to include multiple significant rainfall events, is normally required. The number of samples, frequency, and the duration of sampling will be determined by ODW. Sample collection may be adjusted within the week to collect samples immediately following rainfall events, as practical.

The GUDI evaluation 20 sample MPN series can be triggered by three different circumstances:

a. New source - development sampling results. A new groundwater source that is being developed will require the MPN series. For new wells drilled in non-Karst geology, the 20 samples collected during the well development yield test can be used to make the GUDI determination. For new wells drilled in Karst geology or springs, the development MPN series will provide only a preliminary determination. A second MPN series will be used to make the final GUDI determination, which must start with the minimum 20 weekly samples.

b. Existing source - GWR-triggered monitoring results. If the triggered and additional source water samples required under the Ground Water Rule are *E. coli* positive, additional water quality monitoring is needed to determine if the disinfection treatment to achieve 4-log virus inactivation alone will provide adequate public health protection. A GUDI re-evaluation is required starting with the 20 sample MPN series.

   Note: the GWR requires that treatment be installed to achieve a 4-log inactivation of viruses within 120 days. This requirement must be met by the waterworks owner to comply with the GWR and is considered to be <u>separate</u> from the additional monitoring and GUDI re-evaluation. The purpose of the GUDI re-evaluation is to ensure that the GWR required disinfection treatment alone is sufficient.

c. Existing source - routine source water monitoring results. All groundwater sources with disinfection treatment shall collect periodic source water samples for Total Coliform and *E. coli* MPN analysis. The results from this source water monitoring may indicate that a GUDI re-evaluation is required. In addition, if multiple *E coli* results are positive, the treatment technique requirements of the GWR will be necessary.

7.6.4. Review of Step 2 Total Coliform Results

The presence of high concentrations of Total Coliform is cause for concern and is an indication that the groundwater source is at risk of being directly influenced by surface water.

a. If the 20 sample MPN series indicate Total Coliform greater than 100 colonies/100 mL in three or more samples Step 2a during any time during the 20 weeks of sampling, the source is considered to be at risk and the additional **<u>Step 3</u>** water quality monitoring shall be initiated immediately. In addition, the owner is required to initiate the interim measures during the Step 3 evaluation period.

   Example: Samples are being collected weekly from a well source. The sample collected during the 9th week indicates a Total Coliform of 250 / 100 ml and this is the third sample with Total Coliform exceeding 100 / 100 ml. ODW shall notify the owner that the Step 3 monitoring is required and begin immediately to develop the Step 3 monitoring plan. Do <u>NOT</u> wait until 20 weekly samples are collected.

b. Special Circumstance - Any source with Total Coliform geometric mean greater than 100/100mL (based upon a minimum of 20 weekly samples) is not acceptable for single barrier disinfection treatment alone. The source is considered to be at risk, the additional **<u>Step 3</u>** water quality monitoring is required and the owner is required to initiate the interim measures during the Step 3 evaluation. If the source is **NOT** determined to be GUDI following the Step 3 evaluation, the Field Office must evaluate all of the available water quality data, source construction, geology, degree of source protection and any other relevant factors and shall require appropriate treatment technologies to be installed and operated by the owner. In addition, the owner is required to conduct compliance monitoring specific to the specified treatment technologies if the source is to be utilized as part of a waterworks.

7.6.5. Review of Step 2 E. coli Results

The presence of *E. coli* in multiple source water samples is cause for concern. If the results of the *E. coli* MPN series indicate ≥ 5 *E. coli* / 100 ml in three or more samples Step 2b., <u>or</u> if 5 or more samples indicate *E. coli* to be present Step 2c, then the source is considered to be at risk and the additional **<u>Step 3</u>** water quality monitoring is required. The owner is required to initiate the interim measures during the Step 3 evaluation.

Also, the GWR 4-log virus treatment technique and compliance monitoring is required (see WM 910 for additional guidance).

7.6.6. Mitigation Measures

If the Total Coliform MPN criteria (Section 7.6.4) or the *E. coli* MPN criteria (Section 7.6.5) are exceeded, or if the source has been declared GUDI, the owner may propose mitigation measures and/or a plan to correct deficiencies that may be the cause for the contamination. Any proposed mitigation measures or corrective actions must be detailed in a report that is submitted to the Field Office for approval. The report must also include a follow-up monitoring plan to be implemented upon completion of the mitigation measures or corrective actions.

A final summary report detailing the results of the corrective actions and follow-up monitoring, the conclusions, and recommendations with supporting data, must be submitted to the Field Office for approval. The ODW Field Director will review the report and the commissioner will make a final (or revised) GUDI determination, *or direct that the source must proceed to the Step 3 evaluation.*

Both reports must be prepared by a Virginia licensed professional engineer, Virginia licensed professional geologist, or other licensed professional approved by the Field Director.

7.6.7. Additional Water Quality Data Collection (Step 3)

<u>**Step 3.**</u> Additional water quality and meteorological data may be required to determine if there is a direct connection between the subsurface aquifer and the surface. The Step 3 monitoring and evaluation is time-consuming and may take several months to complete. In addition, the waterworks owner may need to acquire a turbidimeter, pH meter and other water quality monitoring equipment.

A monitoring plan shall be developed by ODW Field Office in cooperation with the owner (or in some cases by the owner and reviewed by ODW), which is site-specific to the source being evaluated. The waterworks owner shall conduct all monitoring prescribed in the approved monitoring plan and shall submit the monitoring data to the Field Office on a frequency defined in the monitoring plan.

The monitoring plan must include Microscopic Particulate Analysis (MPA), and physical water quality parameter monitoring such as source water temperature, pH, turbidity, conductivity, etc. If a surface water source is located nearby, monitoring of the nearby surface water is required, using the same physical parameters and frequency as the groundwater source. In addition to the water quality parameter monitoring, records of rainfall and other meteorological events at the water source location must be recorded.

The following parameters may be included in the monitoring plan. Ideally, monitoring will last for several months to establish seasonal variations, but shorter periods may be allowed. The monitoring period must include significant rainfall events.

<u>Temperature:</u>

- Take measurements daily; minimum of 4 days per week.
- Monitor at the source being evaluated and the nearest surface water source (no more than 1,000 feet distant).
- An alcohol-filled thermometer or electric probe may be used.
- Use an instrument capable of reading ± 0.5° F increments.
- Use the same instrument for all readings.

<u>Conductivity and / or pH:</u>

- Take measurements daily; minimum of 4 days per week.

- Monitor the source being evaluated and the nearest surface water source (no more than 1,000 feet distant).
- Calibrate the instrument per manufacturer's recommendations, or submit to a State-certified laboratory.

Turbidity:
- Take measurements daily; minimum of 4 days per week.
- Monitor the source being evaluated and the nearest surface water source (no more than 1,000 feet distant).
- Use an instrument capable of reading 0.1 NTU increments.
- Standardize and calibrate instrument per manufacturer's recommendations.

Specific Ions:

Any specific ions known to differ in concentration between the surface water and groundwater. ODW will determine applicability of these analyses. Establish frequency, accuracy and calibration requirements on a case-by-case basis.

Rainfall:
- Identify source of rainfall gauging or measure rainfall at the site.
  May need to use more than one rainfall location if utilizing existing gauges not in close proximity to the groundwater source (i.e. compare rainfall data from two wastewater treatment plants, each located greater than 10 miles from the source).

MPA testing shall be conducted by laboratories acceptable to the commissioner and shall include both *Giardia lamblia* and *Cryptosporidium*.

a. All MPA testing and reporting of results must be in accordance with the USEPA *"Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)"* dated October 1992. {There is no Standard Method for the MPA.} This document is available in :\02-Committees\203-Task Teams\GUDI Determination.

b. To optimize the detection of direct surface water influence, MPA samples are typically collected during both wet and dry periods. The purpose of collecting both wet-period and dry-period samples is to analyze water that is most likely to contain indicator organisms typical of surface water, if any exist, at times when conditions for transport to the potential GUDI source are optimal. A minimum of four MPA tests are required, two samples collected each during a wet and a dry period. The MPA tests must be at least 60 days apart.

The waterworks owner must provide the Field Office with all of the monitoring results required in the monitoring plan. MPA results must be provided within 10 days of receipt by the owner if the laboratory does not provide the ODW with the results directly. Other monitoring (physical parameters) can be provided along with applicable rainfall / meteorological data to the Field Office on a monthly or quarterly frequency as stipulated in the monitoring plan. All water quality monitoring data and rainfall data must be detailed and presented in the final report.

If the owner does not perform the monitoring stipulated in the Step 3 monitoring plan, or fails to provide the required monitoring data, the source shall be designated as GUDI and a Boil Water Advisory issued by the commissioner.

7.6.8. Interim Measures During Step 3

The Step 3 data collection and evaluation will take several months to complete. During this time, the waterworks owner must, as a minimum, perform the following interim measures:

a. Provide disinfection treatment to achieve a 4-log inactivation of virus. Chlorine disinfection treatment shall meet the requirements of Working Memo 915.

b. Conduct the GWR compliance monitoring (i.e. daily chlorine residual monitoring).

c. If the owner has to install disinfection treatment to achieve the 4-log virus inactivation, public notice with continuous boil water advisory is required during the design, approval, and installation period.

d. Consider increasing the frequency of routine bacteriological monitoring of the finished water to twice the number of samples required based upon the population served.

Proceeding to Step 3 based on Total Coliform and/or *E. coli* monitoring data indicates that an essential component of the multiple barrier approach to public health protection may have been compromised. Depending upon factors such as the type of waterworks, population served and the technical, financial, and managerial capacity of the waterworks; the Field Office staff may consider consulting with the waterworks owner, waterworks operator, and the District Medical Director to determine if additional interim measures are necessary to provide optimum public health protection.

7.6.9. Evaluation of the Step 3 Sampling Results

The evaluation of Step 3 water quality data will include various physical parameters and MPA test results.

Physical parameters such as water temperature, turbidity, pH, conductivity, etc. may be indicators of direct surface water influence. Examples are a direct correlation between groundwater monitoring results and monitoring results from a nearby surface water source, taking into account significant rainfall or other meteorological events Step 3a, or a fluctuation in source water temperature (or other physical parameters) following a significant rainfall or other meteorological event Step 3b)

Microscopic Particulate Analysis (MPA) is a method to identify organisms that occur only in surface waters, and whose significant occurrence in groundwater clearly indicates that at least some surface water is present. The parameters that are believed to be indicators of surface water contamination of groundwater include *Giardia lamblia* cysts, *Cryptosporidium*, Coccidia, diatoms, algae, insects/larvae, rotifers, and chlorophyll-containing plant debris.

MPA laboratory results must be reported in accordance with the above mentioned EPA consensus method. Application of this method results in relative risk factors (scores) that will be used to determine the degree of risk associated with influence by surface water. The following relative risk factors will be used to make the GUDI determination:

- High risk – A lab-provided MPA risk calculation $\geq$ 20
- Moderate risk – A MPA risk calculation equal to or greater than 10 and $\leq$ 19
- Low risk – A MPA risk calculation $\leq$ 9

EPA Relative Risk Tables are provided in section 7.8.

a. If any single MPA sample result indicates a score greater than or equal to 20, the source is determined to be GUDI Step 3c.

b. If any two MPA sample results indicate scores equal to or greater than 15, the source is determined to be GUDI $\boxed{\text{Step 3d}}$.

c. If all MPA sample results indicate scores of equal to or less than 9, the source is determined to be a groundwater source (NOT GUDI) $\boxed{\text{Step 3e}}$. Note that source water monitoring continues. The District Engineer may increase the frequency of this monitoring or require additional monitoring parameters.

d. If the source is not determined to be GUDI based upon the physical monitoring criteria $\boxed{\text{Step 3a,}}$ and $\boxed{\text{Step 3b,}}$ or the MPA sample results $\boxed{\text{Step 3c,}}$ or $\boxed{\text{Step 3d,}}$; and if all the MPA results are not equal to or less than 9 $\boxed{\text{Step 3e,}}$ a decision on future actions will have to be made.

All of the available water quality data, geology, well construction, and any other relevant factors are to be reviewed and evaluated by the District Engineer. Proceed to one of the following actions with concurrence of the Field Director:

- Consider the source to be "at risk" and continue to monitor. The District Engineer will establish the monitoring parameters and monitoring frequency.

- Declare the source to be a groundwater source (NOT GUDI). Note that even with this action source water monitoring continues.

7.7. Interim Action for GUDI Sources

Any waterworks with a source that has been determined to be GUDI must comply with the requirements of the SWTR and the *Waterworks Regulations* by installing acceptable filtration and disinfection treatment within 18 months of the determination.

During the interim period until filtration and disinfection is installed and in operation, the waterworks owner shall discontinue use of the GUDI source. If the GUDI source must remain in service because discontinuing use of the source is not a viable option, a continuous boil water notice will be required and the waterworks owner shall provide chlorine disinfection during the interim period before filtration is installed as follows:

- Provide disinfection treatment to achieve a 4-log inactivation of virus. Chlorine disinfection treatment shall meet the requirements of Working Memo 915.
- The waterworks owner shall issue a boil water notice through the public notification procedure in the *Waterworks Regulations* until such time as the required filtration and disinfection treatment is installed.
- For waterworks that collect routine distribution system bacteriological samples at a monthly frequency, the waterworks shall collect twice the number of samples required for that population each month. For waterworks that collect routine bacteriological samples at a quarterly frequency, the waterworks shall increase the sampling frequency to monthly.

7.8. EPA Relative Risk Tables

The following tables are excerpted from the USEPA "Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)" dated October 1992.

Table A. Numerical range of each bio-indicator based on numbers counted per 100 gallons filtered water*

Indicators of Surface Water*	Extremely Heavy	Heavy	Moderate	Rare	None Found
Giardia**	>30	16-30	6-15	1-5	0
Coccidia**	>30	16-30	6-15	1-5	0
Diatoms	>150	41-149	11-40	1-10	0
Other Algae	>300	96-299	21-95	1-20	0
Insects/Larvae	>100	31-99	16-30	1-15	0
Rotifers	>150	61-149	21-60	1-20	0
Plant Debris	>200	71-200	26-70	1-25	0

Table B. Relative surface water risk factors associated with scoring of bio-indicators present during MPA of subsurface water sources.

Particulates Indicative of Surface Water*	Extremely Heavy***	Heavy	Moderate	Rare	None Found
Giardia	40	30	25	20	0
Coccidia	35	30	25	20	0
Diatoms	16	13	11	6	0
Other Algae	14	12	9	4	0
Insects/Larvae	9	7	5	3	0
Rotifers	4	3	2	1	0
Plant Debris	3	2	1	0	0

Table C. Risk of Groundwater Contamination by Surface Water Influence

≥20****	High Risk
10-19	Moderate Risk
≤ 9	Low Risk

* According to EPA "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources," March, 1991 ed.

** If *Giardia* cysts, *Cryptosporidium*, or other coccidia are found in any sample, irrespective of volume, score as above.

*** Refer to Table A for range of indicators counted per 100 gallons under 100X.

**** Refer to Table B for numerical relative risk factor.

8. RADIOLOGICAL MONITORING

8.1. Radionuclides Rule

The radionuclides regulation (which excludes radon) effective on December 8, 2003 requires routine monitoring of gross alpha activity, radium-226, radium-228, and uranium at each entry point to the distribution system for all community waterworks. Radiological samples are not required for NTNC or TNC waterworks.

The rule also requires those community waterworks *declared by the state* to be vulnerable to man-made radiological contaminants, and/or using sources contaminated by discharges from nuclear facilities, to sample for beta particle and photon radioactivity. Beta particle and photon radioactivity includes analysis for tritium, strontium-90, and iodine-131, when the screening levels are exceeded [(i.e., >50 pCi/L (vulnerable waterworks) and >15 pCi/L (waterworks with contaminated sources)]. No monitoring waivers are allowed for beta particle and photon radioactivity, and grandfathering of data is no longer allowed.

The rule requires gross alpha and radium-228 analytical results prior to determining whether radium-226 and uranium must be monitored. Specifically, radium-226 analysis must be performed when gross alpha exceeds 5 pCi/L, and uranium analysis must be performed when gross alpha exceeds 15 pCi/L.

Radionuclides to be Monitored	PMCL
Combined Radium-226 + Radium-228	5 pCi/L
Gross alpha activity (excludes radon & uranium)	15 pCi/L
Uranium	30 µg/L
Beta particle & photon radioactivity	See table footnote[1]

1. The standard is limited to an exposure of a dosage not to exceed 4 mrem per year of energy from any combination of beta or photon emitters, using the "sum-of-the-fractions" method exemplified in Section II-B and Appendix I of *the Final Implementation Guidance for the Radionuclides* – EPA January 2003. Monitoring for beta particle and photon radioactivity becomes necessary when the screening level exceeds 50 pCi/L. For more information on the "Total mrem" exposure determination, see Attachments A.2 through A.4.

Radiological samples must be collected at each entry point to the distribution system and must be representative of all sources used under normal operating conditions.

Sample compositing is allowed, but not recommended, for beta emitter, tritium, and strontium-90 monitoring. See Section 8.4. for more details.

8.2. Sample Scheduling

Initial Monitoring

The initial sampling requirement for any new entry point is quarterly for four consecutive quarters, from which the running annual average (RAA) is determined. If a sample result is < the method detection limit, a value of zero is used for that sample in calculating the RAA.

Radionuclide	Detection Limit	Radionuclide	Detection Limit
Cesium-134	10 pCi/L	Radium-228	1 pCi/L
Gross alpha	3 pCi/L	Strontium-89	10 pCi/L
Gross beta	4 pCi/L	Strontium-90	2 pCi/L
Iodine-131	1 pCi/L	Tritium	1,000 pCi/L
Radium-226	1 pCi/L	Uranium	1 µg/L

For a new entry point, initial quarterly sampling is required beginning within the first quarter after the new entry point is put in service.

Monitoring Frequency
The frequency of sampling for each radionuclide contaminant varies between quarterly, annually, every 3 years, every 6 years, and every 9 years. The result of the most recent monitoring period is used to establish the monitoring frequency for subsequent monitoring. Refer to Section 11.8 and Section 12.4.1 of this manual for further details.

Except where quarterly sampling is required, the monitoring frequency for the radionuclides group will be governed by the highest frequency requirement of the component radionuclides. Also, when establishing the actual radionuclides sampling schedule, an effort should be made to integrate the radionuclides schedule to match the Phase II/V schedule, as described in Chapter 11 of this manual.

As long as the PMCL of any radionuclide contaminant is exceeded, continuous quarterly monitoring is required until the average results of 4 consecutive quarters is < PMCL for that contaminant. In quarterly sampling of gross alpha, uranium, radium-226, and radium-228, if the results of the first 2 quarters are less that the detection limit, sampling for the last 2 quarters may be waived.

ODW may require additional monitoring in the event of possible source contamination or changes in the radiological treatment process.

Radiological treatment performance monitoring and reporting in the waterworks' Monthly Operation Report shall be scheduled independently from routine compliance monitoring, in accordance with the *Waterworks Regulations*.

8.3. Beta and Photon Emitter Vulnerability/Contamination Designation

Waterworks using source water contaminated by effluents from nuclear facilities, or in the vicinity of a nuclear facility, are considered vulnerable to contamination from beta and photon emitters[6]. Other potential sources of contamination (PSCs) may be found in the Source Water Assessment.

A. Community waterworks having facilities that handle significant quantities of beta particle and photon emitters located within Zone 1[7] or Zone 2[8] of their water supply may be considered vulnerable to beta particle and photon emitters. The following facilities are considered PSCs:

- Nuclear power facilities,
- Department of Energy facilities, and
- Military bases.

As a first step, staff should review the Source Water Assessment (see \\odwsrv1\odwshare\15-SWAP-Processing) for the PSCs listed above, and where necessary, follow up with the Division of Technical Services on any unusual field conditions that exist for which additional information is needed.

Small quantities of sealed radionuclide sources are not considered a significant threat to waterworks. A list of facilities with Nuclear Regulatory Commission (NRC) licenses in Virginia that require

[6] Waterworks in the vicinity of a nuclear facility can use the facility's environmental surveillance data in lieu of monitoring. In the event of a release from the facility, actual monitoring must occur by the waterworks with sample collection for beta emitters, tritium, and strontium-90 as described in Section 8.4.
[7] Zone 1 - This is an assessment area where contamination events are considered to have the highest risk to impact drinking water supplies. Typically, Zone 1 represents a 5-mile radius upstream from a surface water intake, and a 1,000-ft radius from a groundwater source.
[8] Zone 2 - This is an assessment area beyond Zone 1 where contamination events are considered to possibly exist and may still have an impact on drinking water supplies. Zone 2 represents the watershed area beyond Zone 1 for a surface water intake, and the area between Zone 1 and a 1-mile radius from a groundwater source.

financial assurances is provided in Attachment A.1. Note that military bases *are* included on the NRC list in Attachment A.1. For additional information, consult the VDH-Office of Radiological Health.

B. Review the Source Water Assessment, Zone 1, for specific geology or hydrology characteristics (such as karst formations) that may increase the potential for source water contamination from beta particle and photon emitter sites, due to short circuiting or high porosity in the groundwater aquifer.

C. Review the National Priority List facilities identified as radiation-contaminated sites located within Zone 1 or Zone 2. See https://www.epa.gov/sites/production/files/2014-09/documents/npl-one-pager.pdf

D. Review the Source Water Assessment, Zone 1, for the existence of leaking landfills. Where necessary, follow up with the appropriate DEQ's Regional Office Waste Permit Program [1-800-592-5482 (Toll Free in VA)] (http://www.deq.virginia.gov/Locations.aspx) to inquire about any existing landfills that might be leaking and whether they are monitored for groundwater quality. Any monitoring data associated with a landfill within Zone 1, along with geology and other site-specific information should be considered in making the final vulnerability determination for the waterworks. Since Virginia does not have a radionuclides disposal site, this problem is not anticipated.

All community waterworks must be informed of the results of this vulnerability/contaminated source designation. Use letter B.1.a or B.1.b to notify the waterworks on the "vulnerable" or "contaminated" designation, respectively. Use form letter B.2 to notify the waterworks owner when either designation is not applicable. Record the date of the notification letter in the R & R database.

8.4. Monitoring for Beta Particle and Photon Radioactivity

Follow these procedures for beta particle and photon radioactivity sampling of waterworks' sources that are designated as either "vulnerable" or "contaminated":

A. Sample collection begins in the first quarter after notification, and continues until the designation has been rescinded by ODW.

B. For either "vulnerable' or "contaminated" designation, annual samples must be collected for tritium and strontium-90 at each entry point. For the "vulnerable" designation, only one sample per year is required. However, for the "contaminated" designation, there are 2 options for sample collection: (i) collect quarterly samples for analysis with a RAA determined; or (ii) collect a composite of 4 consecutive quarterly samples for a single analysis. The first option is recommended.

C. For either "vulnerable" or "contaminated" designation, quarterly samples must be collected for beta emitters. For the "vulnerable" designation, only one sample per quarter is required. However, for the "contaminated" designation, there are 2 options: (i) collect and analyze samples monthly and compute the rolling average each quarter; or (ii) collect a composite of three monthly samples each quarter for a single analysis. The first option is recommended.

D. For the "contaminated" designation, a quarterly iodine-131 sample is required. Five consecutive daily samples must be collected, and composited for a single analysis once each quarter. A RAA is then determined. If iodine-131 is detected in the finished water, more frequent monitoring may be required by ODW.

E. Naturally occurring potassium-40 radioactivity must be discounted (subtracted) from the gross beta particle activity to determine the "screening level" which is used to establish the future monitoring frequency. The screening level is calculated using the running annual averages (computed quarterly) based on the following relationship:

[Gross beta particle activity – Potassium-40 = Screening Level]

- “Vulnerable” sources: If screening level ≤ 50 pCi/L, sample every 3 years at each entry point for beta emitters, tritium, and strontium-90..
- “Contaminated” sources (from, or in the vicinity of, nuclear facilities): If screening level ≤ 15pCi/L, sample every 3 years at each entry point for beta emitters, tritium, strontium-90, and iodine-131.

F. For either “vulnerable” or “contaminated” designations, if the screening level is exceeded, the sample must be speciated and analyzed for the most likely emitters, followed by a PMCL determination. (See example in Attachment A.4.)

G. For either “vulnerable” or “contaminated” designations, if the PMCL is exceeded, monthly sampling will be required. Quarterly sampling may be resumed if the rolling average results from 3 consecutive months ≤ PMCL.

Note: Potassium-40 beta particle activity is subtracted from the gross beta particle activity in order to determine the “man-made” impact of the radiation. (A factor of 0.82 converts mg/L to pCi/L.)

ODW must continue to review significant changes that may have occurred involving beta and photon emitters within the source water assessment areas of community waterworks. This review should be documented in routine sanitary surveys, or when new information about facilities that handle significant quantities of man-made radionuclides becomes available. For new community sources, this determination should be made following construction, prior to issuing or amending the waterworks operation permit.

8.5. Monitoring Substitutions and Calculated Values

Substitution entails using the gross alpha particle activity to substitute for the radium-226 and uranium measurements. The rule allows substitution of gross alpha activity as follows:

Gross alpha activity	Substitution Allowed
≤ 15 pCi/L	Yes - Substitute for uranium
≤ 5 pCi/L	Yes - Substitute for radium-226
> 3 pCi/L	No – DCLS to analyze for radium-226

Since the combined radium PMCL is based on the sum of radium-226 and radium-228, DCLS has agreed to analyze for radium-226 when gross alpha activity is > 3 pCi/L. When a sample result exceeds the PMCL, both radium-226 and radium-228 analyses should be specifically required for the follow-up quarterly sampling.

Substituted results can be used to determine future monitoring frequencies. Also, if the gross alpha is < detection limit, then ½ detection limit can be used to determine compliance and future monitoring frequencies.

Some laboratories measure uranium activity when uranium measurement is required. The uranium PMCL is based on mass rather than activity; however, uranium mass may be calculated from activity using a factor of 0.67 pCi/µg (e.g., 20 pCi/L = 30 µg/L). Uranium mass should be analyzed when the value from the uranium activity calculation indicates a uranium exceedance (i.e., >30 µg/L) since the calculated value may be conservative and the actual mass value may be less.

8.6. Monitoring Groups

For simplicity, the intent of ODW is to maintain routine monitoring requirements for radionuclides as a group rather than individual analytes. Also, DCLS routinely analyzes radionuclide samples for gross alpha activity and radium-228 with values for radium-226 and uranium subsequently obtained by substitution and calculation by ODW. DCLS will perform the additional analyses required when the gross alpha triggers are exceeded. The exception to monitoring radionuclides as a group is when a PMCL value is exceeded and quarterly monitoring is required. In this case, quarterly monitoring is only required for those radionuclides which exceeded the PMCL. For practical purposes, these will be two subgroups, one being gross alpha and uranium and the second being radium-226 and radium-228.

8.7. Consumer Confidence Report (CCR)

When reporting sample results to the owner, ODW should provide the owner with an explanation about substitutions and the uranium conversion factor, to be included with their CCR, if applicable. The following may be used for this purpose:

> *Radium-226 and uranium activity values may be obtained by gross alpha substitutions, as allowed by regulation. Combined radium is obtained by the addition of radium-228 and radium-226 activity measurements. If gross alpha activity does not exceed 5 pCi/L, then radium-226 may be obtained by substitution of the gross alpha activity. If the gross alpha activity does not exceed 15 pCi/L, then uranium activity may be obtained by substitution of gross alpha activity. The uranium activity may be converted to uranium mass for compliance evaluation purposes using the relationship of 20 pCi/L ≈ 30 μg/L* (or conversion factor of 0.67 pCi/μg)*.*

The CCR Rule requires reporting of detections of all regulated contaminants including gross alpha and combined radium. There are no individual PMCLs for radium-226 or radium-228. However, since radium-228 is part of combined radium, any time radium-228 is detected, combined radium must be reported, even if radium-226 is not analyzed or not detected. To avoid confusion with application of the CCR Rule, ODW requires only contaminants measured and reported by the laboratory to be included. In the case where radium-228 is analyzed but radium-226 is not, combined radium is reported as the radium-228 value. In cases where radium-226 is detected and reported, but radium-228 is absent or below detection levels, the radium-226 result should be reported in the CCR as combined radium. Keep in mind that whenever a potential violation exists, additional analyses will be required by ODW for compliance determination and reporting.

Where gross beta particle activity and photon emitters are required to be monitored and the owner is required to calculate an annual dose equivalent to the total body or any internal organ (in mrem/year) to determine compliance, then the dose equivalent level should be reported in the CCR. (See example calculations in Attachment A.4).

9. CONTAMINANTS OF CONCERN

Certain contaminants have been identified for further study to determine whether they will be regulated under the SDWA, or regulated by State only (as with MTBE), because of their associated risks to human health and the environment. In other situations, the contaminants may be unknown and need relatively expedient identification to understand the human exposure and public health risk. EPA has released a sampling protocol for this purpose, see https://www.epa.gov/waterlabnetwork/sampling-guidance-unknown-contaminants-drinking-water?utm_medium=email&utm_source=govdelivery
This resource will be useful primarily to waterworks operators, laboratory personnel and emergency responders.

Health advisories may be issued by the EPA and/or the Center for Disease Control for these contaminants of concern, despite not being regulated. The following are some of interest in the public domain.

9.1. Methyl Tertiary Butyl Ether (MTBE)

MTBE is a synthetic volatile organic chemical with no natural sources. It is a blending component of gasoline that started replacing the use of lead in gasoline in the late 1970's. It is used in gasoline and reformulated gasoline (RFG) as an octane enhancer and to promote more complete burning, thereby reducing carbon monoxide and ozone levels in the air. The most common source of groundwater and surface water contamination by MTBE is leakage from storage tanks (both underground and above ground) and pipelines; spills at gasoline stations; disposal at landfill sites and dumps; emissions from marine engines into lakes and reservoirs; and to some extent from air deposition and storm water run-off.

MTBE moves rapidly into groundwater because of its solubility in water, relative mobility in soils, and resistance to decomposition. It generally migrates faster than other organic components of gasoline. As a result, MTBE can serve as an early indicator of potential gasoline contamination. MTBE has been detected in public and private drinking water wells. The reported concentrations of MTBE in wells can vary widely but generally are in the range of 1 to 10 parts per billion (ppb).

According to the Environmental Protection Agency (EPA), based on the limited sampling data available, most concentrations at which MTBE has been found in drinking water sources are unlikely to cause adverse health effects. However, there are no studies on the effects on humans of drinking MTBE-contaminated water.

There are significant uncertainties about the degree of risk associated with human exposure to low concentrations typically found in drinking water.

MTBE has a very unpleasant taste and odor that can make contaminated drinking water unacceptable to the public. Studies have shown that humans vary widely in the concentrations they are able to detect. The EPA has issued a drinking water advisory of 20 to 40 ppb on the basis of odor and taste thresholds. Several states have set their action levels (or remediation trigger level) for MTBE in the 15 to 250 ppb range.

ODW has adopted 15 ppb as a "trigger" level for MTBE in public drinking water. The trigger level means the concentration at which MTBE should be more closely monitored, and increased technical assistance provided to the waterworks. ODW recommends that drinking water exhibiting taste and odor problems attributed to petroleum constituents, including MTBE, not be consumed. When this occurs, treatment or alternate sources of supply should be considered.

The Virginia General Assembly enacted a law in 2004 (15.2-2144 of the Code of Virginia) that requires:

*B. Every public water supply operator shall **at least annually test the public water supply for the presence of methyl tertiary-butyl ether (MTBE)**. The locality shall maintain a record of testing conducted pursuant to this subsection. If the results of any test conducted pursuant to this subsection indicate the presence of **MTBE in excess of 15 parts per billion, the locality shall immediately notify** the Department of Environmental Quality and the **Department of Health**. The Division of Consolidated Laboratory Services shall maintain and make available, upon the request of any person, a list of laboratories, accredited under the provisions of the federal Safe Drinking Water Act (42 U.S.C. § 300f et seq.) to analyze samples, located throughout the Commonwealth that possess the technical expertise to analyze water samples for the presence of MTBE. Any lab seeking accreditation under the Safe Drinking water Act may contact the Division of Consolidated Laboratory Services. The Division of Consolidated Laboratory Services shall establish a fee system to offset the costs of tests performed on behalf of public water supply operators. Such test may be conducted simultaneously with other tests.*

This law does not supersede the Waterworks Regulations, nor does it invoke any action on the part of ODW except to receive the notification from the waterworks that the sample was in excess of 15 ppb. While the law does not specify the exact location of the samples, ODW recommends that each entry point to the distribution system be sampled annually. The **MTBE monitoring requirement shall apply to community waterworks owned by a locality** (i.e., county, city or town). MTBE is included with the VOC test panel.

9.2. Hexavalent Chromium (Chromium-6)

Chromium is an odorless and tasteless metallic element found in rocks, soil, plants, and animals. Chromium is also used in steel making, metal plating, leather tanning, paints, dyes and wood preservatives. The most common forms of chromium in the environment are trivalent (chromium-3), hexavalent (chromium-6) and the metal form, chromium-0.
EPA has established a drinking water Maximum Contaminant Level (MCL) standard of 0.1 mg/L or 100 ppb for total chromium, which includes all forms of chromium. The Virginia Department of Health has adopted this total chromium standard in the *Waterworks Regulations.*

Community and NTNC waterworks currently take a minimum of one sample at each entry point to the distribution system. Samples are taken once every three years for waterworks having solely groundwater sources, and once annually for waterworks with surface water source(s).

States may set more stringent drinking water standards than EPA. California has a 50-µg/L MCL for total chromium. EPA plans to finalize the human health assessment, and after an external scientific peer review, it is likely that drinking water standards for chromium-6 will be established.

EPA recommends that systems voluntarily collect samples and test for chromium-6. Their guidelines are:

Locations to be sampled on the same day:
1) Samples of untreated water at the Intake/well locations,
2) Entry points to the distribution system,
3) Distribution System

Frequency:
1) Surface water sources: quarterly;
2) Ground water sources: semi-annually.

Sampling for Chromium-6 is voluntary in Virginia. However, ODW suggests that any waterworks that detects Total Chromium should test for chromium-6. Waterworks that test for Chromium-6 should request that the modified version of EPA Method 218.6, "Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater and Industrial Wastewater Effluents by Ion

Chromatography" be used. It is recommended that waterworks first look for total chromium using a more accessible method, then use the more complex EPA method to further refine any results requiring such testing.

9.3. Perchlorate

Perchlorate is both a naturally occurring and man-made chemical that is used to produce rocket fuel, fireworks, flares and explosives. Perchlorate can also be present in bleach and in some fertilizers. Scientific research indicates that this contaminant can disrupt the thyroid's ability to produce hormones needed for normal growth and development. EPA has included perchlorate on the first, second, and third Contaminant Candidate Lists (CCLs) published in the Federal Register on March 2, 1998, February 24, 2005, and October 8, 2009, respectively.

Perchlorate has been found in just over 4 % of public water systems nationally. Perchlorate was sampled in drinking water supplies as part of the Unregulated Contaminant Monitoring Regulation 1 (UCMR 1) program. EPA collected data on perchlorate from 3,865 public water supplies between 2001 and 2005. This included all large public water systems (serving more than 10,000 people), and a statistical sample of 800 small water systems, which together serve more than 80% of the population. In this, 4.1% of the systems reported a detection of perchlorate (in at least 1 entry/sampling point) at levels greater than or equal to 4 µg/L (the minimum reporting level of the test).

The EPA decision to propose a formal rule for perchlorate was published in the Federal Register on February 11, 2011. This action initiates a process to develop and establish a national primary drinking water regulation (NPDWR). Since that time, EPA has been reviewing the best available scientific data on a range of issues related to perchlorate in drinking water including its occurrence, treatment technologies, analytical methods and the costs and benefits of potential standards. A Fact Sheet is available in https://www.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant_perchlorate_january2014_final.pdf

9.4. Harmful Algal Blooms (HABs)

Harmful algal blooms (HABs) are accumulations of phytoplankton that can produce toxins harmful to humans, animals, and ecosystems. Freshwater HABs often produce a scum or unusual color on the surface of the water. Cyanobacteria, sometimes referred to as "blue-green algae", are photosynthetic bacteria that share some properties with algae and have the capacity to produce toxins. Cyanobacteria are found naturally in lakes, streams, ponds, and other surface waters.

The scientific community agrees that the incidence of HABs is increasing both in the U.S. and worldwide. Increased concentrations of nitrogen and phosphorus have been related to HABs occurrence, particularly during summer. These nutrients are found in agricultural runoff and sewage treatment discharges.

Human exposure to cyanotoxins found in drinking water can occur through dermal contact, inhalation, and ingestion of water containing the toxin. Illnesses caused by cyanotoxins include poisoning from Anatoxin-a, Cylindrospermopsin, Lyngbyatoxin, and Microcystin. There are no federal standards for cyanotoxins in drinking water. Microcystins in drinking water are not yet regulated by the US EPA but is expected to be addressed in the near future. The World Health Organization has a provisional drinking water guideline of 1 µg/L for microcystin-LR. Ten microcystins, including total microcystins, will be sampled under the UCMR 4 (2018-2020) using EPA Methods 544, 545, and 546. Recognizing the limitations of the Method 546 (ELISA), AWWA recommends its use for screening in the finished water with a threshold entry point sample at 0.3 µg/L as a trigger for analysis using the LC/MS/MS method.

9.5 Fluorinated Organic Chemicals

Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS) are fluorinated organic chemicals that are part of a larger group of chemicals referred to as perfluoroalkyl substances. PFOA and PFOS have been the most extensively produced and studied of these chemicals. They have been used to make carpets, clothing, fabrics for furniture, paper packaging for food and other materials (e.g., cookware) that are resistant to water, grease or stains. They are also used for firefighting at airfields and in a number of industrial processes. Because these chemicals have been used in an array of consumer products, most people have been exposed to them. While consumer products and food are a large source of exposure to these chemicals for most people, drinking water can be an additional source in the small percentage of communities where these chemicals have contaminated water supplies. Such contamination is typically localized and associated with a specific facility; by example, an industrial facility where these chemicals were produced or used to manufacture other products, or an airfield at which they were used for firefighting.

Studies indicate that exposure to PFOA and PFOS over certain levels may result in adverse health effects, including developmental effects to fetuses during pregnancy or to breastfed infants (e.g., low birth weight, accelerated puberty, skeletal variations), cancer (e.g., testicular, kidney), liver tissue damage, immune effects (e.g., antibody production and immunity), thyroid effects, and cholesterol changes. In May 2016, EPA established a health advisory level at 70 parts per trillion, to provide a margin of protection from a lifetime of exposure to PFOA and PFOS from drinking water. See Fact Sheet for additional information:

https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfos_updated_5.31.16.pdf

9.6 Legionella

Legionella is a pathogenic group of Gram-negative bacteria found throughout the world, mostly in aquatic and moist environments (lakes, rivers, ground water and soil). It can adversely impact public health, by causing legionellosis, a pneumonia-type illness called Legionnaires' disease, and a mild flu-like illness called Pontiac fever. People are exposed to *Legionella* when they inhale water droplets containing the bacteria.

Legionella bacteria grow well in conditions that support the growth of biofilms, such as in distribution systems and premise plumbing[9]. Documented sources of *Legionella* include cooling towers, swimming pools, domestic water systems and showers, ice-making machines, refrigerated cabinets, whirlpool spas, hot springs, fountains, dental equipment, soil, automobile windshield washer fluid, and industrial coolant. Design and maintenance guidelines for controlling the growth and proliferation of *Legionella* within cooling towers and other sources are in development.

Most healthy people do not become infected with *Legionella* after exposure. People at higher risk of getting sick are people 50 years or older, current or former smokers, people with a chronic lung disease (like chronic obstructive pulmonary disease or emphysema), and people with a weakened immune system from diseases like cancer, diabetes or kidney failure.

Legionella is traditionally detected by culture, but new techniques for rapid detection are emerging, including the use of polymerase chain reaction and rapid immunological assays. Immunological techniques are used to establish the species and/or serogroups of bacteria present in the sample.

Control of *Legionella* growth can occur through focal or systemic methods. Focal disinfection is directed at a specific portion of the system, and includes UV, instantaneous heating systems, and ozonation.

[9] The term "premise plumbing system" refers to the portion of the water distribution system from the water meter to the tap in homes and buildings.

Systemic methods disinfect the entire system, and include hyper-chlorination and copper-silver ionization. Selecting a combination of focal and systemic disinfection techniques ensures eradication of present *Legionella* colonies and prevents recolonization of the water distribution system. Some of the methods currently in use:

(1) Chlorination is used to penetrate the biofilm, killing both the *Legionella* bacteria and the host organisms. Annual hyper-chlorination (e.g., shock chlorination) involves raising chlorine levels throughout the system for 1 – 2 hours. Note that trihalomethanes may increase in the hot water system when chlorine levels exceed 4 mg/L.

(2) Copper-Silver (CuAg) Ionization is used to control *Legionella* in in the plumbing systems of health facilities, hotels, nursing homes, and most large buildings. CuAg ionization denatures proteins, leading to lysis and cell death. It is less expensive than hyper-chlorination and provides residual protection throughout the water distribution system. A disadvantage of this method is that the system's performance will suffer unless scale is removed regularly from the electrodes, and the pH of the system must be maintained below 8. It is not intended for cooling towers because at elevated pH (> 8.6) it is less effective.

(3) Chlorine Dioxide is used in cold and hot water systems. Its ability as a biocide is not affected by pH, or water corrosion inhibitors such as silica or phosphate.

(4) Ultraviolet (UV) light kills *Legionella* by disrupting its cellular DNA synthesis. No chemical by-products are produced, and the taste and odor of water from a water distribution system containing a UV sterilizer are not affected. The UV sterilization system requires continuous maintenance in order to prevent scale from coating the UV lamps. The system does not provide residual protection, so distal areas must be disinfected.

(5) Ozone, which is generated on-site with liquid oxygen, can be used to kill *Legionella*. Ozone inactivates *Legionella instantly*; however, it has a short half-life and decomposes quickly. Ozonation is more expensive than hyper-chlorination, and a large amount of space is required for the air preparation equipment or oxygen tanks and contacting tank.

(6) Thermal destruction of the *Legionella* through super heat and flush is a common practice for water distribution systems in hospitals, hotels, and other institutional buildings. The hot water temperature is elevated to above 70°C (158° F), and the distal sites, such as faucets and showerheads, are flushed for 30 minutes.

(7) Instantaneous steam heating systems entail flash heating water to temperatures greater than 88°C (190°F), and then blending the hot water with cold water to attain a designated water temperature. Instantaneous steam heating systems work best when installed as the original system of a building rather than when the building has already been contaminated by *Legionella.* Another drawback to this system is that it can only be used to control *Legionella* in the hot water supply system. The cold water portion of the distribution system is not disinfected. In addition, any *Legionella* that may have colonized the system downstream of the heater will be unaffected.

Temperature control [i.e., keeping all cold water below 25°C (78°F) and all hot water above 51°C (124°F)] is costly due to the extensive retrofitting required in large facilities, and the energy cost maintaining the required temperatures at all times and at all distal points within the system.

9.7. Endocrine Disruptors

Endocrine-disrupting chemicals (EDCs) are chemicals that, at certain doses, can interfere with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body. Scientific research on human epidemiology, laboratory animals, fish and wildlife suggests that these contaminants can disrupt the endocrine system leading to a range of reproductive and other health problems. EDCs and potential EDCs are mostly man-made, and are found in various materials such as drugs, pesticides, metals, additives or contaminants in food, and personal care products. Some are pervasive and widely dispersed in the environment and may bio-accumulate. A number of EDCs are already on the SDWA regulatory watch list. In UCMR 3 and UCMR 4, for example, microcystins, perfluorinated organic compounds, pesticides, and other organic compounds have been identified for further studies.

9.8. Pesticides & Human Health Benchmarks

The *Waterworks Regulations* includes MCLs for a number of pesticides. However, there are numerous other pesticides in use that are not regulated. The EPA has established Human Health Benchmarks for Pesticides (HHBPs), for which there is no drinking water regulation or health advisory. HHBPs are levels of certain food use pesticides in water at or below for which adverse health effects are not anticipated from one-day or lifetime exposures. HHBPs have been developed for acute (one-day), chronic (non-cancer), and carcinogenic effects (10^{-6} -10^{-4} risk level) to protect against adverse health effects from exposure to pesticides that may be found in surface or ground water used for drinking. HHBPs are not legally enforceable federal standards, but they may help to interpret monitoring data for pesticides that have no drinking water standards or health advisories. See

https://www.epa.gov/sites/production/files/2015-10/documents/hh-benchmarks-techdoc.pdf, and https://iaspub.epa.gov/apex/pesticides/f?p=HHBP:home.

A "Human Health Benchmarks for Pesticides" Fact Sheet is provided in

https://www.epa.gov/sites/production/files/2015-10/documents/hh-benchmarks-factsheet.pdf

The application of pesticides is regulated by the Virginia Department of Agriculture and Consumer Services (VADACS), Office of Pesticide Services. VADACS certifies applicators, registers pesticide products, and licenses pesticide businesses. These activities provide for the safe and effective control of pests that impact crops, structures, and health.

The Department of Environmental Quality (DEQ) issues a VPDES General Permit (VAG87 permit), for pesticide discharges, to pesticide applicators regulated by VADACS. For additional information, see

- DEQ regulations 9VAC25-260-30 and 9VAC25-800;
- Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) (7 USC § 136 et seq.); and
- The Virginia Pesticide Control Act (Title 3.2. Agriculture, Animal Care, and Food, Chapter 39. Pesticide Control).

10. MONITORING WAIVERS

10.1. Background

Monitoring waivers originated with the Phase II/V Rule, with various effective dates from 1989 through 1994. The *Waterworks Regulations* allow Community and Non-transient, Non-community (NTNC) waterworks to apply for Monitoring Waivers for Volatile Organic Chemicals (VOCs), Inorganic Chemicals (IOCs), and Synthetic Organic Chemicals (SOCs) contaminants. However, it is ODW's policy to consider monitoring waivers for SOCs and cyanide only, and to prescribe monitoring schedules for IOCs (with cyanide and asbestos excluded) and VOCs based on analytical results and in accordance with guidance on the Standardized Monitoring Framework outlined in Chapter 11 "Sample Scheduling" of this manual. Contaminants can be waived by contaminant group, region, or statewide.

Waterworks that are not granted waivers must comply with the minimum sampling requirements defined in Section 12VAC5-590-370 of the *Waterworks Regulations*. Waivers may be granted for a maximum of 3, 6 (for VOCs but not used), or 9 years, depending on the contaminant and waterworks' specific conditions of the waterworks' source water assessment (or "evaluation") area.

10.2. Types of Waivers

There are two types of waivers – "Use Waiver" and "Susceptibility Waiver" – that are available to all community and NTNC waterworks.

<u>*Use waivers*</u> may be granted when there is no previous use of the contaminant within the watershed or delineated source water assessment area, including transport, storage, or disposal.

<u>*Susceptibility waivers*</u> may be granted where the contaminant has been used or where the extent of its use is unknown, after considering several factors that would influence the probability of its occurrence in the source water. When the probability of occurrence is high, sampling and analysis should be required to establish baseline data before a monitoring waiver can be considered.

10.3. Statewide-Specific Waivers

The State Health Commissioner (or Commissioner), under the *Waterworks Regulations*, has allowed a statewide waiver for Dioxin, Endothall, Asbestos, and Glyphosate based on geographic vulnerability assessments. Therefore, no monitoring for these contaminants is required by the waterworks owners.

10.4. Contaminant-Specific Waiver

The Commissioner has also granted waivers for three SOCs and one IOC, based on a statewide use and susceptibility determination. The SOCs are dibromochloropropane (DBCP), ethylene dibromide (EDB), and diquat; and the IOC is cyanide. Cyanide can only be waived <u>after</u> the initial monitoring requirements have been completed with no detection. Specific waiver requirements for these contaminants are as follows:

- <u>Diquat:</u> Diquat binds readily to clay particles, is absorbed by aquatic plants, is rapidly degraded by sunlight, and is rendered biologically unavailable in clay soils. Most soils in the Commonwealth contain a high percentage of clay, except in the Tidewater region. Therefore, for sandy soils, as with waterworks in the Tidewater region, a monitoring waiver <u>will not</u> be granted.

- <u>Ethylene Dibromide (EDB):</u> Studies have found concentrations of EDB associated with gasoline contamination, and EDB has been added to some leaded gasolines. Therefore, well samples detecting any of the following VOCs: benzene, ethylbenzene, toluene, xylene, 1,2-dichloroethane, or MTBE must analyze for EDB at least once before a monitoring waiver can be considered.

- Dibromochloropropane (DBCP): DBCP may have been used as a soil fumigant (notably as a pesticide); its use was discontinued in 1979.

- Cyanide: Cyanide monitoring may be waived after the initial monitoring requirements have been completed with no detection. For new sources, three rounds of annual monitoring must first be completed before a monitoring waiver can be considered. For an existing waterworks that have monitored previously for cyanide, a waiver can be granted for a complete compliance cycle (i.e., 9 years). However, a condition of this waiver requires the waterworks owner to collect a minimum of one sample while the waiver is effective. A decision flow chart for cyanide monitoring is provided in Chapter 12 of this manual.

10.5. Waiver Application Form and Letters

The waiver review process follows the schedule outlined in the Standard Monitoring Framework (see Chapter 11 of this manual), which is based on a 9-year compliance cycle consisting of three 3-year compliance periods. This framework initially started in 1993. (1st cycle: 1993-1998; 2nd cycle: 2002-2010; 3rd cycle: 2011-2019; 4th cycle: 2020-2028; and so on, repeating every 9 years.) Typically, SOC waivers are granted over a compliance period (i.e., 3 years), and cyanide waivers are granted over a compliance cycle (9 years), with the condition that the owner take a minimum of one sample while the cyanide waiver is in effect.

The waterworks owner is responsible for submitting the monitoring waiver requests to the ODW for consideration. However, in practice, ODW initiates the waiver process by sending a letter to the owner with the application form. ODW is required to review the waiver application and decide if the monitoring requirements can be reduced through the granting of an appropriate contaminant waiver. The following attachments are available for field staff to assemble a waiver application package to the waterworks for their use:

- Attachment A.1. *Instructions and General Information* to the waterworks owners for the completion of the waiver application.

- Attachment A.2. Waiver Application Form.

- Attachment A.3. VDH SWAP User Guide: SOC Monitoring Waiver Evaluations.

Use the following letter templates to initiate and document the waiver determination:

- Attachment B.1. Reminder letter to the waterworks on the expiring monitoring waivers in the last year of the compliance period, as well as transmitting an application form for "new" monitoring waivers for the next compliance period.

- Attachment B.2. Letter stating that all or some of the SOC and cyanide (if applicable) waivers for the next compliance period or cycle have been approved/denied to the subject waterworks.

10.6. ODW Review and Waiver Determination

The source water assessment area is defined as the watershed drainage area associated with a surface water intake or a groundwater well, typically represented geographically by zones.

Zone 1 - This is an assessment area where contamination events are considered to have the highest risk to impact drinking water supplies under VDH Source Water Assessment Program (SWAP). Typically, Zone 1 represents a 5-mile radius from the surface water intake to the treatment facility, and a 1,000-ft radius from the groundwater source.

Zone 2 - This is an assessment area beyond Zone 1 where contamination events are considered to possibly exist and may still have an impact on drinking water supplies under the VDH SWAP. Zone 2 represents the watershed area beyond Zone 1 for a surface water intake, and the area between Zone 1 and a 1-mile radius from the groundwater source.

ODW staff should review available Source Water Assessment (SWA) information for existing sources (i.e., Zone 1 and Zone 2) to validate/corroborate a monitoring waiver request. This information includes maps, GIS locational data on potential sources of contamination, etc. It is located on the ODW shared drive at …\15-SWAP-Processing\08-SWA_Outputs. The proximity of the waterworks to potential sources of contamination is most important in evaluating a monitoring waiver. Potential spills or leaks at or near the water treatment facility from commercial or industrial use, disposal, or storage of contaminants; and from hazardous and municipal waste landfills and other waste handling facilities need to be considered. Guidance on using the SWA information is provided in Attachment A.3.

There are five SOC contaminant groups (volatile fumigants, carbamates, chlorinated acid herbicides, semi-volatiles, and diquat) and one IOC (cyanide) for which contaminant waivers can be considered. A listing of the regulated SOC contaminants in these groups is provided in Attachment A.1, Table 1. Generally, these contaminants include insecticides, herbicides, pesticides, fungicides, and others used on agricultural areas, forest lands, home and gardens, and other land application uses. The relationship between land use/activity and these contaminants and how water quality can be impacted is also provided in Attachment A.1, Table 3.

Additional waiver considerations should include, but are not limited to the following:

- Elevated nitrate levels may be an indicator of the potential for pesticide contamination.
- The presence of polychlorinated biphenyls (PCBs) may be due to the proximity of water pumps, electrical transformers or other equipment that may contain PCBs.
- All previous analytical results of a contaminant, the degree of variation in the contaminant concentration, and other factors affecting concentration; e.g., changes in well pumping rates, system configuration, waterworks' operating procedures, and in-stream flows or characteristics.
- Environmental persistence and transport of a contaminant in the source water assessment area.
- Groundwater source features including depth of the well and integrity of its casing, and type of soil in the Zone 1 and Zone 2 areas.

10.7. Monitoring Schedules

The standard monitoring schedule (framework) associated with VOCs, IOCs, and SOCs is to be used to establish monitoring schedules, except when a monitoring waiver has been granted. These contaminants are discussed in Chapters 11 and 12 of this manual, and summarized in Sections 11.5 and 11.6 and tabulated in Section 11.8. All waiver determinations shall be entered in R&R. For additional guidance, see WM 824, "R&R User's Guide".

11. SAMPLE SCHEDULING

Compliance sampling at each waterworks is based on the type of waterworks (TNC, NTNC or Community); the type of sources (Groundwater, Groundwater Under the Direct Influence of Surface Water (GUDI), Surface Water, Purchased); population; and the type of treatment provided.

Tables 11.2 through 11.7 include a listing of initial and reduced compliance chemical and bacteriological sampling at the three types of waterworks using groundwater, groundwater under direct influence of surface water (GUDI), surface water or purchased water sources. These tables assume the waterworks have one type of source.

The Entry Point compliance schedule for waterworks with a combination of GUDI or surface water sources with groundwater, and/or purchased water sources must collect routine compliance chemical samples at a frequency listed for the GUDI/surface water sources. For example, a waterworks with a surface water source and a groundwater source will have to collect entry point samples annually for metals, and inorganic chemicals from the surface water source entry point and the groundwater source entry point.

11.1. Standardized Monitoring Framework

In order to standardize monitoring requirements across rules and contaminant groups, EPA established a nine-year (based on a calendar year) compliance cycle, with the first cycle beginning on January 1, 1993. The 3rd nine year compliance cycle contains three three-year compliance periods:

- 1st period: 2011 to 2013
- 2nd period: 2014 to 2016
- 3rd period: 2017 to 2019

The Standard Monitoring Framework encompasses both sampling and vulnerability assessment activities.

The Standardized Monitoring Framework only applies to entry point sampling for inorganic contaminants, synthetic and volatile organic contaminants, radionuclides, Nitrate + Nitrite (Combined), Nitrite, Cyanide and Asbestos. Table 11.8 is a table of the Standardized Monitoring Framework for the third cycle which began on January 1, 2011 and ends December 31, 2019. This section is provided as a tool to determine the appropriate sampling cycle or period the entry point is currently in and will aid in determining when a violation for failure to sample has occurred.

The *Waterworks Regulations* and the Standardized Monitoring Framework use the terms “Reliably and Consistently” when establishing sample schedules for entry points based on an initial sample result exceeding a trigger value, such as an MCL or ½ MCL or the detection of, various inorganic, synthetic organic, volatile organic, nitrate + nitrite (combined) and nitrite contaminants. Listed below are procedures for interpreting when “Reliably and Consistently” applies.

- <u>Initial Required Samples (Routine + any required Confirmation samples) > MCL</u>
  Quarterly water samples must be collected from the entry point for a minimum of 4 additional quarters. If the running annual average is less than the MCL and not trending toward the MCL, the District Engineer has the discretion to reduce sampling as indicated in the Standardized Monitoring Framework.

- <u>Detection of Synthetic Organic or Volatile Organic Contaminants < MCL</u>

Quarterly water samples must be collected from the entry point. If the first two subsequent quarterly samples do not detect the organic contaminant, the District Engineer has the discretion of reducing the sampling to the previous routine frequency or to annually.

- If the SOC/VOC contaminant continues to be detected and is less than or equal to the MCL, sampling must continue for a minimum of 4 quarters. At the end of 4 quarters, the District Engineer has the discretion of reducing the sampling to annually during the quarter with the highest detection.

- <u>Nitrate + Nitrite (Combined) or Nitrite ≥ ½ MCL and ≤ MCL</u>
  Quarterly water samples must be collected from the entry point for a minimum of 4 quarters. If all samples are below the MCL and not trending toward the MCL, the District Engineer has the discretion of reducing sampling to annually during the quarter with the highest result detected.

11.2. Compliance Monitoring Requirements: TNC with a Groundwater Source

Parameter	Frequency	Locations	Sample schedule comments
Bacteria - distribution system	Quarterly[1]	Requires approved plan	The approved plan provides a repeat monitoring schedule should a positive result occur.
Bacteria (MPN), source	See (2) below	Source tap	Samples are collected at the source tap prior to treatment as indicated in (2) below.
Chlorine (for systems that use chlorine as a disinfectant or oxidant) – distribution system	Same as Bacteria – distribution system	Same as Bacteria Requires approved plan	A chlorine residual measurement shall be performed and recorded at the same time and location as each required bacteriological sample collection.
Chlorine Dioxide (for systems that use chlorine dioxide as a disinfectant or oxidant)	Daily	Entry points[3] Requires approved plan	If the chlorine dioxide residual exceeds MRDL of 0.8 mg/l, a minimum of three chlorine dioxide residual analysis will be performed at a sample site as close to the first customer as possible, at intervals of at least 6 hours.
Nitrates + Nitrites (Combined)	Once per year	Entry points[3]	If analysis result is > 5 ppm and ≤ 10 ppm, quarterly monitoring is required for at least 4 consecutive quarters. If all 4 quarterly samples are below 10 ppm and not trending toward 10 ppm, the District Engineer has the discretion of reducing sampling to annually during the quarter with the highest result detected. If analysis result is >10ppm, a confirmation sample must be collected within 24 hours and quarterly monitoring must begin and continue for the duration of the MCL exceedance
Nitrites	One sample	Entry points[3]	If the sample is < 0.5 ppm no further sampling is required; otherwise increase to quarterly for at least one year.

Notes:

(1) Most systems are required to collect only one routine sample per quarter. However, if the population served is > or = 1001 the sample frequency increases to monthly in accordance with 12 VAC5-590-370 A. of the Waterworks Regulations.

(2) Groundwater sources with treatment which could alter bacteriological quality are required to collect MPN raw source water samples as follows :

- Springs, collect one sample per month prior to treatment.
- Karstian wells, collect one sample per quarter prior to treatment.
- Non-karstian well, one sample per year prior to treatment.

(3) Entry points are either at water source downstream of treatment or at a point where more than one water source is mixed before entering system.

11.3. Compliance Monitoring Requirements: TNC with a Surface Water or GUDI Source

Parameter	Initial Frequencies	Locations	Sample schedule comments
Bacteria[1] – distribution system	Monthly	Requires approved plan	The approved plan provides a repeat monitoring schedule should a positive result occur
Chlorine (for systems that use chlorine as a disinfectant or oxidant) – distribution system	Same as Bacteria	Same as Bacteria Requires approved plan	A chlorine residual measurement shall be performed and recorded at the same time and location as each required bacteriological sample collection.
Nitrates + Nitrites (Combined)	Yearly	Entry point tap[2]	If analysis result is > 5 ppm and ≤ 10 ppm, quarterly monitoring is required for at least 4 consecutive quarters. If all 4 quarterly samples are below 10 ppm and not trending toward 10 ppm, the District Engineer has the discretion of reducing sampling to annually during the quarter with the highest result detected. If analysis result is >10ppm, a confirmation sample must be collected within 24 hours and quarterly monitoring must begin and continue for the duration of the MCL exceedance
Nitrites	One sample	Entry point tap[2]	If the sample is < 0.5 mg/l no further sampling is required; otherwise increase to quarterly for at least one year.
Chlorine Dioxide (for systems that use chlorine dioxide as a disinfectant or oxidant)	Daily	Entry point tap[2]	If the chlorine dioxide residual exceeds MRDL of 0.8 mg/l, a minimum of three chlorine dioxide residual analysis will be performed at a sample site as close to the first customer as possible, at intervals of at least 6 hours.

Notes:
(1) The number of samples required per quarter or per month is dependent on the population served. See 12 VAC5-590-370 A. of the *Waterworks Regulations*.
(2) Entry points are either at water source downstream of treatment or at a point where more than one water source is mixed before entering system.

11.4. Compliance Monitoring Requirements: TNC Consecutive Waterworks

Parameter	Frequency	Locations	Sample schedule comments
Bacteria - distribution system	Quarterly[1]	Requires approved plan	The approved plan provides a repeat monitoring schedule should a positive result occur.
Chlorine (for systems that receive chlorine as a disinfectant or oxidant) – distribution system	Same as Bacteria	Same as Bacteria Requires approved plan	A chlorine residual measurement shall be performed and recorded at the same time and location as each required bacteriological sample collection.
Notes: (1)Systems are required to collect routine samples based on population served in accordance with 12 VAC5-590-370 A. of the *Waterworks Regulations*.			

11.5. Compliance Monitoring Requirements: Community or NTNC with a Groundwater Source

Parameter	Initial Frequency	Locations	Sample schedule comments
Bacteria - distribution system[1]	Monthly	Requires approved plan	The approved monitoring plan requires additional monitoring should a positive result occur.
Bacteria (MPN), source water	See (2) below	Source tap	Samples are collected at the source tap prior to treatment as indicated in (2) below.
Chlorine (for systems that use chlorine as a disinfectant or oxidant) – distribution system	Same as Bacteria	Same as Bacteria Requires approved plan	A chlorine residual measurement shall be performed and recorded at the same time and location as each required bacteriological sample collection.
Chlorine Dioxide (for systems that use chlorine dioxide as a disinfectant or oxidant)	Daily	Entry points Requires approved plan	If the chlorine dioxide residual exceeds MRDL of 0.8 mg/l, a minimum of three chlorine dioxide residual analysis will be performed. These samples must be collected as close to the first customer as possible at 6 hour intervals. If booster chlorination (re-chlorination) is provided, the samples must be collected as close to the first customer as possible, at a location representative of average residence time and as close to the end of the distribution system as possible reflecting maximum residence time.
Nitrates + Nitrites (Combined)	Once per year	Entry points	If analysis result is > 5 ppm and ≤ 10 ppm, quarterly monitoring is required for at least 4 consecutive quarters. If all 4 quarterly samples are below 10 ppm and not trending toward 10 ppm, the District Engineer has the discretion of reducing sampling to annually during the quarter with the highest result detected. If analysis result is >10ppm, a confirmation sample must be collected within 24 hours and quarterly monitoring must begin and continue for the duration of the MCL exceedance
Nitrites	One sample	Entry points	If the sample is < 0.5 mg/l no further sampling is required; otherwise increase to quarterly for at least one year.
Metals	Once per 3 year compliance period	Entry points	Increase to quarterly if a PMCL is exceeded. Samples must be collected in a 3 year window.
Inorganics	Once per 3 year compliance period	Entry points	Increase to quarterly if a PMCL is exceeded. Samples must be collected in a 3 year window.
VOCs	Quarterly	Entry points	If no detects after the initial 4 quarters, reduce to yearly at highest previous quarter; after an additional 2 annual samples with no detects, reduce to once per 3 year compliance period. If detected, see (5) below.
Radionuclides[3] -Community only (includes Gross Alpha, Combined Radium-226/228 and Uranium, also see (3*) below)	Quarterly[2]	Entry point tap	If the initial 4 consecutive quarterly average exceeds the MCL the system shall continue to sample quarterly until the average is equal to or below the MCL then see (3) below.
SOCs[4]	Quarterly[4]	Entry points	If not detected after the initial 4 quarters see (4) below; if detected, see (5) below.
Cyanide	Once every 3 years	Entry points	After 3 samples with no detects a waiver is granted where only one sample per 9 year cycle is required.
Disinfection Byproducts[6]	Population dependent	Requires approved plan	See (6) below if chlorine, Chloramination, Chlorine Dioxide or Ozone is used.
Lead & Copper[7]	See (7) below	Requires approved plan	Sampling locations are based on the population and plumbing materials survey.

11.5. Compliance Monitoring Requirements: Community or NTNC with a Groundwater Source (continued)

Parameter	Initial Frequency	Locations	Sample schedule comments

Notes:

(1) The number of samples required per month is dependent on the population served. See 12 VAC5-590-370 A. of the *Waterworks Regulations*.

(2) Groundwater sources with treatment which could alter bacteriological quality are required to collect MPN raw source water samples as follows :
- Springs, collect one sample per month prior to treatment.
- Karstian wells, collect one sample per quarter prior to treatment.
- Non-karstian well, one sample per year prior to treatment.

(3) The running average of 4 consecutive quarterly samples determines compliance and sampling frequency for each contaminant.
a) If the average of initial monitoring results is below detection limits, the sampling frequency will reduce to one sample every 9 years (because of substitutions a 9 year schedule will not normally apply).
b) If the average of initial monitoring results is greater than or equal to the detection limit but less than or equal to one half the MCL, the sampling frequency will reduce to one sample every 6 years.
c) If the average of initial monitoring results is greater than one half the MCL but less than or equal to the MCL , the sampling frequency will reduce to one sample every 3 years.

* Systems determined to have vulnerable or contaminated source water from manmade Radionuclides shall sample on a frequency established by the *Waterworks Regulations.*

(4) Waterworks may request a waiver to SOC monitoring requirements for each water source. Waivers must be renewed by submission of an application for each source every 3 years. Waterworks denied a monitoring waiver may reduce the monitoring frequency if SOCs are not detected in the initial 4 quarters as follows:
a) For populations > 3300, two quarterly samples within a one year window during the 3 year compliance period, or
b) For populations < or = 3300, one sample per 3 year compliance period.

(5) Waterworks which detect a VOC or SOC must continue to collect quarterly samples for a minimum of four consecutive quarters. If the concentration of the detected contaminant is reliably and consistently below the MCL, sampling may be reduced to annually during the quarter with the highest analytical result. Waterworks which previously detected SOC's but have collected 3 annual samples with no detection of contaminants may apply for SOC Waivers as indicated in (4) above. Waterworks which previously detected VOC's but have collected 3 annual samples with no detection of contaminants may be reduced to once every 3 year compliance period.

(6) Please refer to Section 5 for information on Disinfection Byproducts Monitoring, and to ..\..\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898-Sampling Manual\

(7) Lead & Copper monitoring is required for 2 successive 6 month periods. If the 90th percentile lead & copper levels do not exceed the action levels, then at least two sets of subsequent satisfactory annual samples are required before reducing the monitoring to every 3 years. Also, samples collected annually and every three years can be reduced to half (but not< 5) of the number required during the initial sampling, but must be collected between June and September. If the initial results exceed action levels, then source treatment or lead containing service line replacement are potential required solutions.

11.6. Compliance Monitoring Requirements: Community or NTNC with a Surface Water or GUDI Source

Parameter	Initial Frequencies	Locations	Sample schedule comments
Bacteria – distribution system	Monthly[1]	Requires approved plan	The approved plan provides a repeat monitoring schedule should a positive result occur
Chlorine (for systems that use chlorine as a disinfectant or oxidant) – distribution system	Same as Bacteria	Same as Bacteria Requires approved plan	A chlorine residual measurement shall be performed and recorded at the same time and location as each required bacteriological sample collection.
Nitrates + Nitrites (Combined)	Quarterly	Entry point tap	If analysis result is > 5 ppm and ≤ 10 ppm, quarterly monitoring is required for at least 4 consecutive quarters. If all 4 quarterly samples are below 10 ppm and not trending toward 10 ppm, the District Engineer has the discretion of reducing sampling to annually during the quarter with the highest result detected. If analysis result is >10ppm, a confirmation sample must be collected within 24 hours and quarterly monitoring must begin and continue for the duration of the MCL exceedance
Nitrites	One sample	Entry point tap	If the sample is < 0.5 mg/l no further sampling is required; otherwise increase to quarterly for at least one year.
Metals	Yearly	Entry point tap	Increase to quarterly if a PMCL is exceeded
Inorganics	Yearly	Entry point tap	Increase to quarterly if a PMCL is exceeded
VOCs	Quarterly	Entry point tap	If not detected in the initial 4 quarters, reduce to yearly; if detected , see (4) below.
Radionuclides[2] -Community only (includes Gross Alpha, Combined Radium-226/228 and Uranium, also see (2*) below)	Quarterly[2]	Entry point tap	If the initial 4 consecutive quarterly average exceeds the MCL the system shall continue to sample quarterly until the average is equal to or below the MCL then see (2) below.
SOCs[3]	Quarterly[3]	Entry point tap	If not detected after the initial 4 quarters see (3) below; if detected see (4) below.
Cyanide	Once every year	Entry point tap	After 3 years with no detects a waiver is granted where only one sample per 9 year cycle is required.
Disinfection Byproducts[5]	Population dependent	Requires approved plan	See (5) below.
TOC & Alkalinity6	Monthly	Raw & combined filter effluent taps Requires approved plan	A paired set of samples shall be collected each month demonstrating the removal ratio for TOCs . A removal ratio of 1.00 or greater is required on a running quarterly average to be in compliance. The % removal requirements are based on the source water alkalinity and TOC concentrations as listed in the *Waterworks Regulations*.
Bromate (only if using Ozone)	Monthly	Entry point	Compliance is based on a running annual average
Bromide (if using Ozone)	Monthly	Source water	Collection required to reduce the required Bromate samples to that noted above

11.6. Compliance Monitoring Requirements: Community or NTNC with a Surface Water or GUDI Source (continued)

Parameter	Initial Frequencies	Location	Sample Schedule Comments
Chlorine Dioxide (for systems that use chlorine dioxide as a disinfectant or oxidant)	Daily	Entry points Requires approved plan	If the chlorine dioxide residual exceeds MRDL of 0.8 mg/l, a minimum of three chlorine dioxide residual analysis will be performed. These samples must be collected as close to the first customer as possible at 6 hour intervals. If booster chlorination (re-chlorination) is provided, the samples must be collected as close to the first customer as possible, at a location representative of average residence time and as close to the end of the distribution system as possible reflecting maximum residence time.
Lead & Copper[7]	See (6) below	Requires approved plan	Sampling locations are based on the population and plumbing materials survey.

Notes:

(1) The number of samples required per month is dependent on the population served. See 12 VAC5-590-370 A. of the *Waterworks Regulations.*

(2) The running average of 4 consecutive quarterly samples determines compliance for each contaminant.

a) If the average of initial monitoring results is below detection limits, the sampling frequency will reduce to one sample every 9 years (because of substitutions a 9 year schedule will not normally apply).

b) If the average of initial monitoring results is greater than or equal to the detection limit but less than or equal to one half the MCL, the sampling frequency will reduce to one sample every 6 years.

c) If the average of initial monitoring results is greater than one half the MCL but less than or equal to the MCL , the sampling frequency will reduce to one sample every3 years.

* Systems determined to have vulnerable or contaminated source water from manmade Radionuclides shall sample on a frequency established by the *Waterworks Regulations.*

(3) Waterworks may request a waiver to SOC monitoring requirements for each water source. Waivers must be renewed by submission of an application for each source every 3 years. Waterworks denied a monitoring waiver may reduce the monitoring frequency if SOCs are not detected in the initial 4 quarters as follows:

a) For populations > 3300, two quarterly samples within a one year window during the 3 year compliance period, or

b) For populations < or = 3300, one sample per 3 year compliance period.

(4) Waterworks which detect a VOC or SOC must continue to collect quarterly samples for a minimum of four consecutive quarters. If the concentration of the detected contaminant is reliably and consistently below the MCL, sampling may be reduced to annually during the quarter with the highest analytical result. Waterworks which previously detected SOC's but have collected 3 annual samples with no detection of contaminants may apply for SOC Waivers as indicated in (3) above.

(5) Please refer to Y:\03-Memos\301-Active Working Memos\301.02-Forms Letters Manuals\WM898- Sampling Manual for Disinfection Byproducts Monitoring Plans, Review forms and Approval Letters

(6)Alkalinity monitoring is only required at the raw water tap.

(7) Lead & Copper monitoring is required for 2 successive 6 month periods. If the 90^{th} percentile lead & copper levels do not exceed the action levels, then at least two sets of subsequent satisfactory annual samples are required before reducing the monitoring to every 3 years. Also, samples collected annually and every three years can be reduced to half of the number required during the initial sampling but must be collected between June and September. If the initial results exceed action levels, then source treatment or lead containing service line replacement are potential required solutions.

11.7. Compliance Monitoring Requirements: Community or NTNC Consecutive Waterworks

Parameter	Frequency	Locations	Sample schedule comments
Bacteria, distribution system	Monthly[1]	Requires approved plan	The approved plan provides a repeat monitoring schedule should a positive result occur.
Chlorine (for systems that receive chlorine as a disinfectant or oxidant) – distribution system	Same as Bacteria	Same as Bacteria Requires approved plan	A chlorine residual measurement shall be performed and recorded at the same time and location as each required bacteriological sample collection.
Disinfection Byproducts (for systems receiving disinfected water from their supplier or providing disinfection)[3]	Population dependent	Requires approved plan	See Chapter 5 for Disinfection Byproducts Monitoring Plans, Review Forms and Approval Letters.
Chlorine Dioxide (for systems that use chlorine dioxide as a disinfectant or oxidant)	Daily	Entry points Requires approved plan	If the chlorine dioxide residual exceeds MRDL of 0.8 mg/l, a minimum of three chlorine dioxide residual analysis will be performed. These samples must be collected as close to the first customer as possible at 6 hour intervals. If booster chlorination (re-chlorination) is provided, the samples must be collected as close to the first customer as possible, at a location representative of average residence time and as close to the end of the distribution system as possible reflecting maximum residence time.
Chlorite (only if using Chlorine dioxide)	Daily	Entry point - Requires approved plan	If daily samples exceed MRDL, then must collect 3 samples from distribution system
Lead & Copper[2]	See (2) below	Requires approved plan	Sampling locations are based on the population and plumbing materials survey.

Notes:
(1) Systems are required to collect routine samples based on population served in accordance with 12 VAC5-590-370 A. of the *Waterworks Regulations*.

(2) Lead & Copper monitoring is required for 2 successive 6 month periods. If the 90th percentile lead & copper levels do not exceed the action levels, then at least two sets of subsequent satisfactory annual samples are required before reducing the monitoring to every 3 years. Also both annual and samples collected every three years can be reduced to half (but not< 5) of the number required during the initial sampling, but must be collected between June and September. If the initial results exceed action levels, then source treatment or lead containing service line replacement are potential required solutions.

11.8. Standard Monitoring Schedule

		THIRD CYCLE									FOURTH CYCLE								
		1ST Period			2nd Period			3rd Period			1ST Period			2nd Period			3rd Period		
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Inorganic IOCs	Groundwater < MCL		*			*			*			*			*			*	
	Surface Water < MCL	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Groundwater & Surface Water > MCL[1]																		
	Groundwater Reliably and Consistently ≤ MCL		*			*			*			*			*			*	
	Surface Water Reliably and Consistently ≤ MCL	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Groundwater & Surface Water > MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
Synthetic Organic SOCs	Population > 3,300 – No Waivers < Detection Limit		**			**			**			**			**			**	
	Population ≤ 3,300 – No Waivers < Detection Limit		*			*			*			*			*			*	
	≥ Detection Limit[1] and																		
	Reliably and Consistently ≤ MCL[2]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Not Reliably and Consistently ≤ MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
Volatile Organic VOC's	< Detection Limit and																		
	Groundwater (after collection of 4 initial quarterly samples)[3]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Surface Water (after collection of 4 initial quarterly samples)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	≥ Detection Limit[1] and																		
	Reliably and Consistently < MCL[2]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Not Reliably and Consistently ≤ MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
Nitrate + Nitrite (Combined)	Community/NTNC Waterworks																		
	Surface Water with 4 Quarters of Results < ½ MCL[4]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Groundwater Reliably and Consistently < MCL[4]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	≥ ½ MCL or not Reliably and Consistently < MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
	Transient Noncommunity Waterworks																		
	Standard Monitoring	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

**** See Legend on next page

11.8. Standard Monitoring Schedule (continued)

		THIRD CYCLE									FOURTH CYCLE								
		1ST Period			2nd Period			3rd Period			1ST Period			2nd Period			3rd Period		
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Nitrite	< ½ MCL	Established by Commissioner									Established by Commissioner								
	Reliably and Consistently < MCL[4]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	≥ ½ MCL or not Reliably and Consistently < MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
Radionuclides[5]	Community Waterworks																		
	< Detection Limit [6] ***(9-yr schedule)***	*									*								
	≥ Detection Limit and ≤ ½ MCL ***(6-yr schedule)***	*						*						*					
	> ½ MCL and ≤ MCL ***(3-yr schedule)***	*			*			*			*			*			*		
	> MCL [7]	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****

Legend		
* 1 sample at each entry point to distribution system	** 2 quarterly samples at distribution system entry points. Samples must be taken during 1 calendar year during each 3-year compliance period.	**** 4 quarterly samples at each distribution system entry point within time frame.

Notes

[1] A system with a sampling point result above the MCL (IOC) or Detection Level (SOC, VOC) must collect quarterly samples, at that sampling point, until the system is determined to be reliably and consistently below the MCL.

[2] Samples must be taken during the quarter which previously resulted in the highest analytical result. Systems can apply for a waiver after 3 consecutive annual sampling results are below the detection limit.

[3] If all monitoring results during initial quarterly monitoring are less than the detection limit, the system can take annual samples. If after a minimum of 3 years of annual sampling with all analytical results less than the detection limit, the system may be allowed to take 1 sample during each compliance period.

[4] Samples must be taken during the quarter which previously resulted in the highest analytical result.

[5] Radionuclides – Gross Alpha, Combined Radium and Uranium.

[6] To obtain a nine-year reduced monitoring schedule, all required radionuclides (gross alpha, radium-226, radium-228 and uranium) must be below detection level from direct testing, not obtained by substitution. Where substitutions are used and measured results (typically gross alpha and radium-228) are below detection limit, the resulting reduced monitoring schedule would be a six-year schedule.

[7] When a radionuclide MCL is exceeded, quarterly sampling must be conducted at that entry point until four consecutive quarterly results are below the MCL. The result of the four-quarter average is used to determine the new monitoring schedule.

12. ENTRY POINT MONITORING DECISION FLOW CHARTS

Provided in the following pages are various chemical and radiological monitoring flow charts for assisting staff in determining compliance with the various rules, and for assisting staff in determining if and/or when reduced monitoring is allowed.

This section should be used as follows:

Use the Section contents to locate the flow chart, description, or form that best describes your need. For instance, the waterworks has completed their first quarter or their 4 consecutive quarterly (baseline) monitoring for a SOC that had been denied a waiver - one would go to the SOC Baseline flow chart, or a waterworks detected a VOC - one would go to the VOC Detected flow chart. Note that the charts are divided as the rules for each contaminant require.

Follow the logical flow of the flow chart by answering the questions in the decision diamonds and perform the process (example, Confirmation Procedure or procedure). The flow charts are an aid for you to determine the next action that needs to be taken that applies to that particular waterworks for that particular circumstance. In most cases the sampling is to be done quarterly. The quarterly chart will then lead to an annual flow chart or other reduced monitoring frequency.

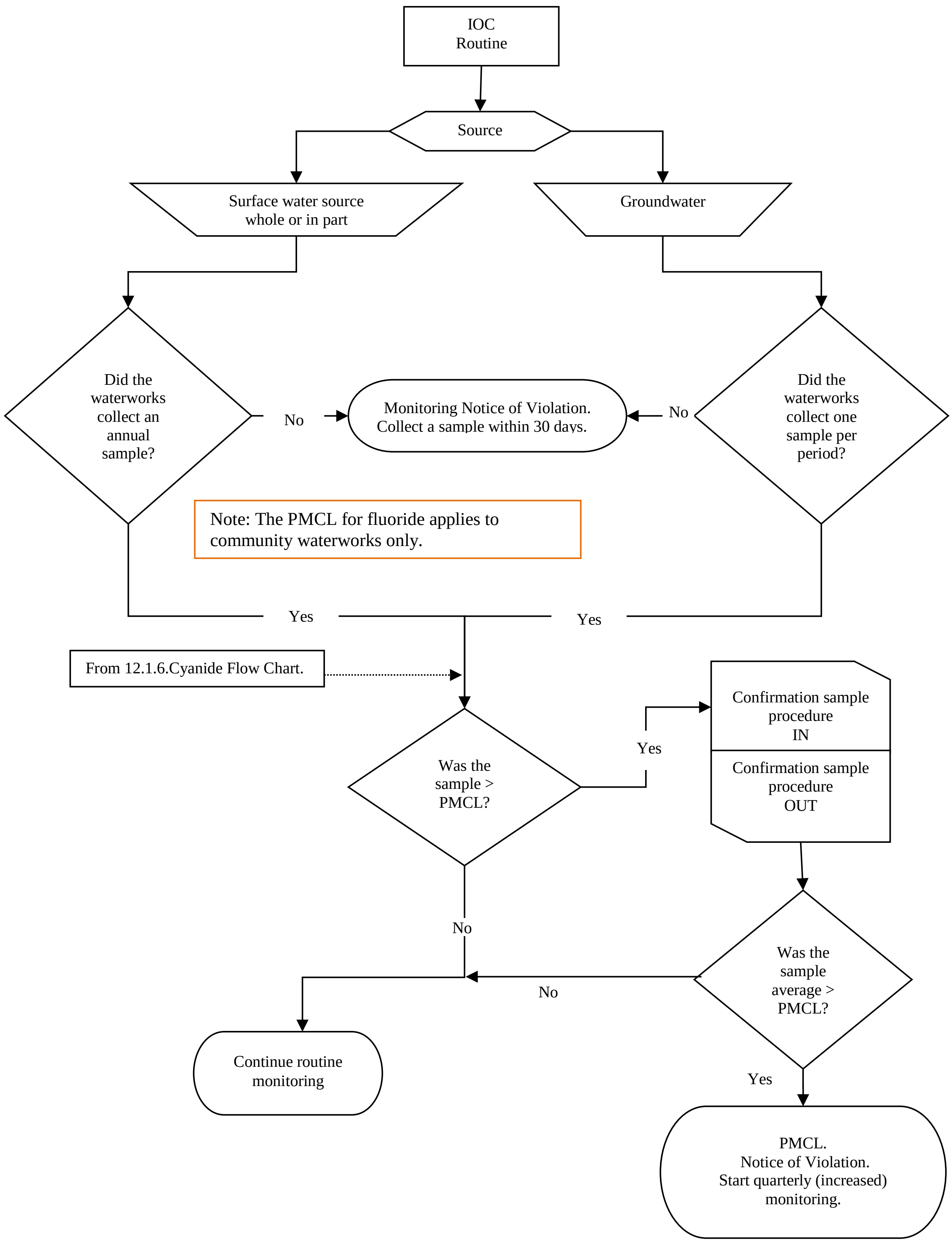
> Note that Ttere are also provisions in the reduced monitoring charts to increase the frequency of monitoring.

EPA has also published “NPDWR Violations and RTC Definitions” that provide this information in a tabular format. The latest release is dated March 9, 2012. Please consult with the SDWIS Administrator for status and availability of this resource.

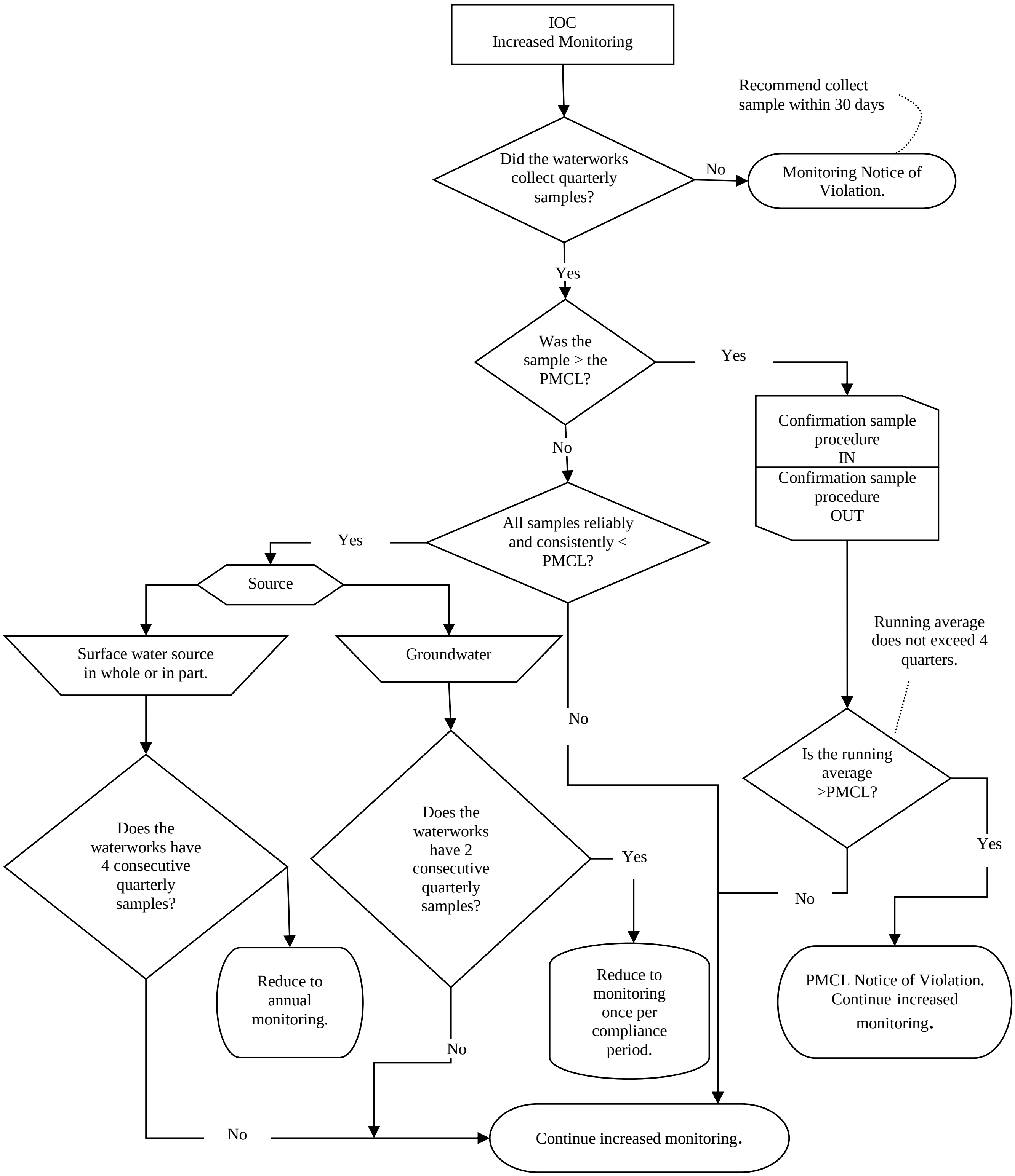
12.1. IOCs (Inorganic Chemicals) Metals & Nonmetals

12.1.1. IOC Routine Monitoring
12.1.2. IOC Increased Monitoring
12.1.3. Nitrates + Nitrites (Combined) – Quarterly
12.1.4. Nitrates + Nitrites (Combined) – Annual
12.1.5. Nitrite
12.1.6. Cyanide

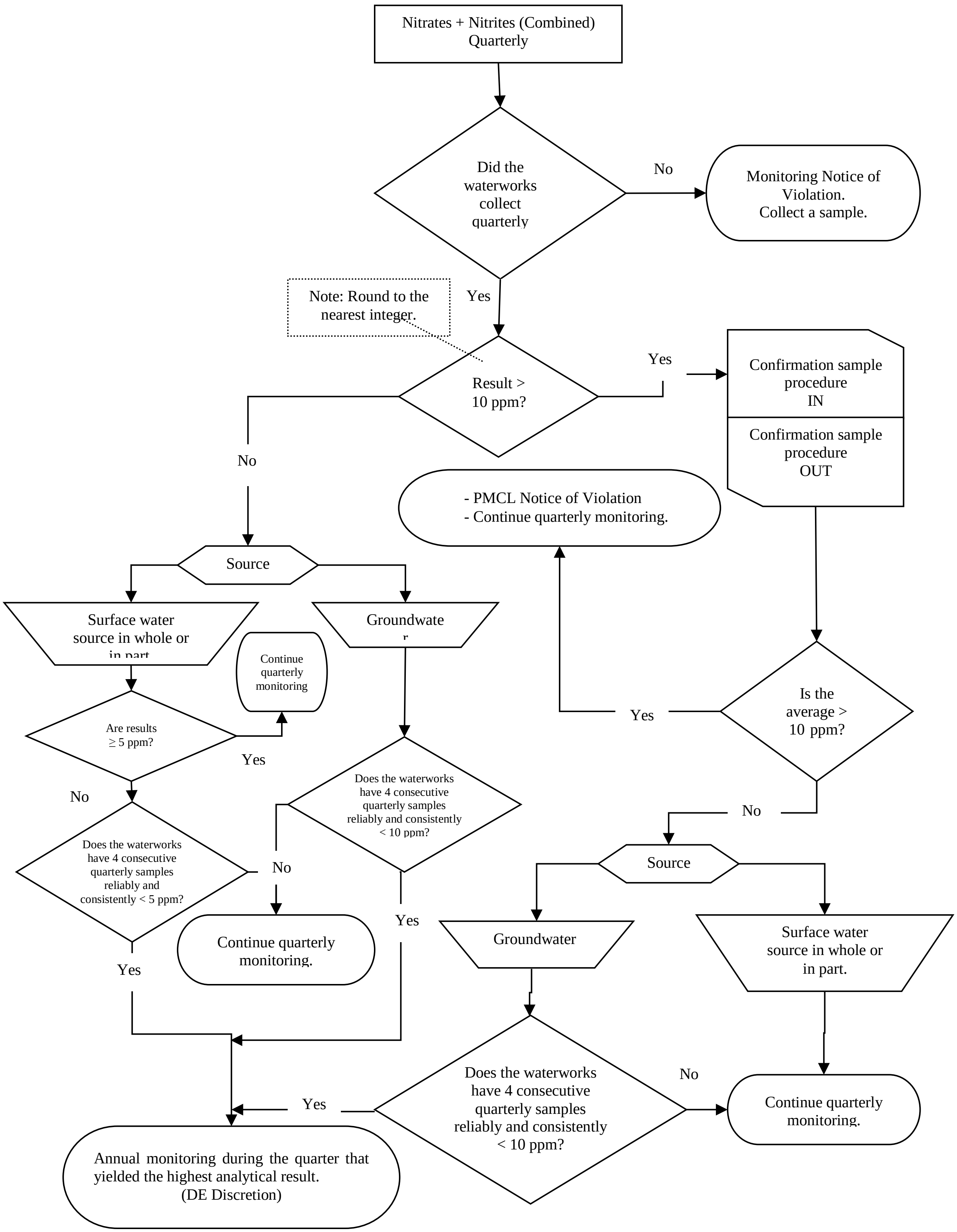
12.1.1. IOC Routine Monitoring



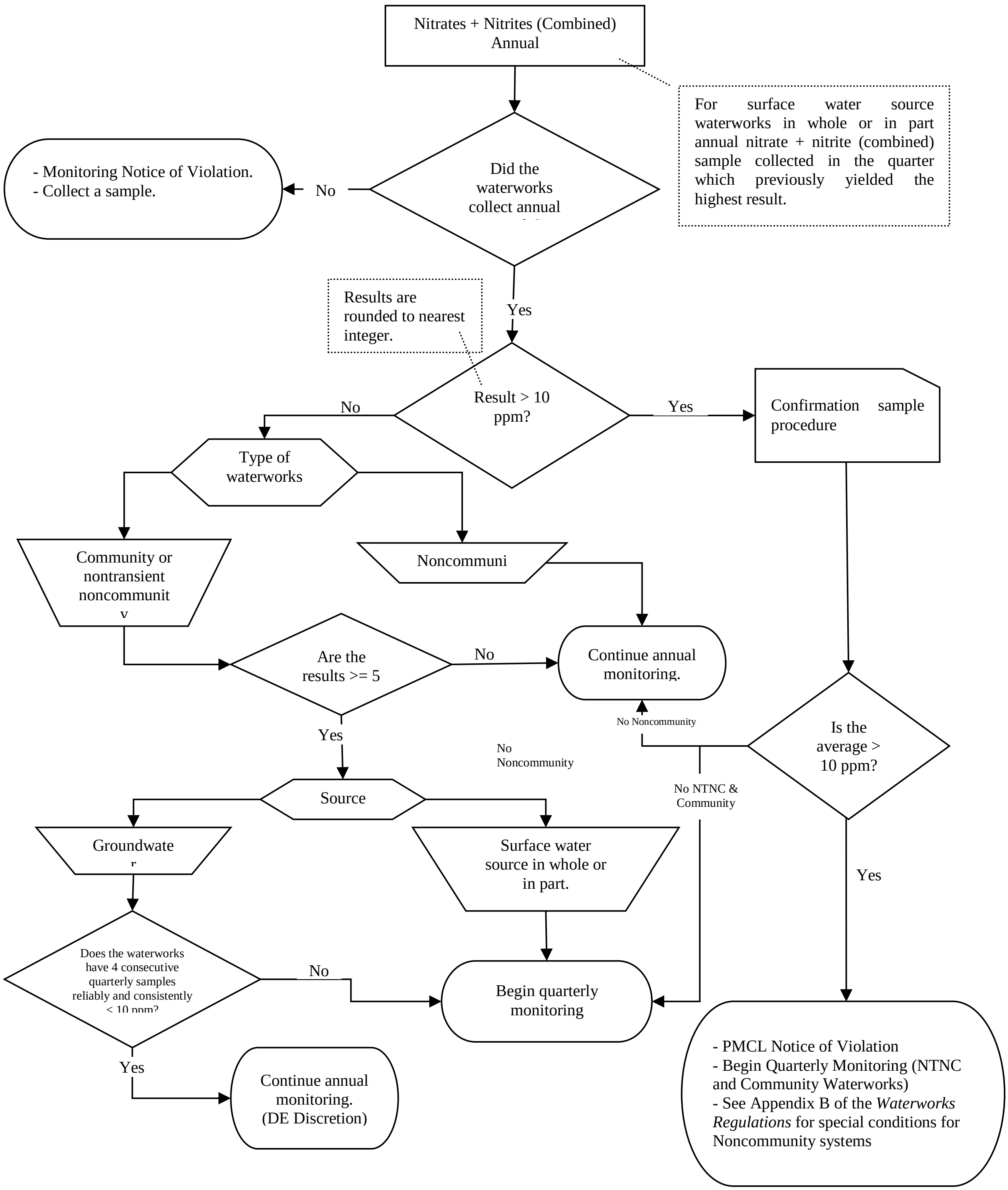
12.1.2. IOC Increased Monitoring



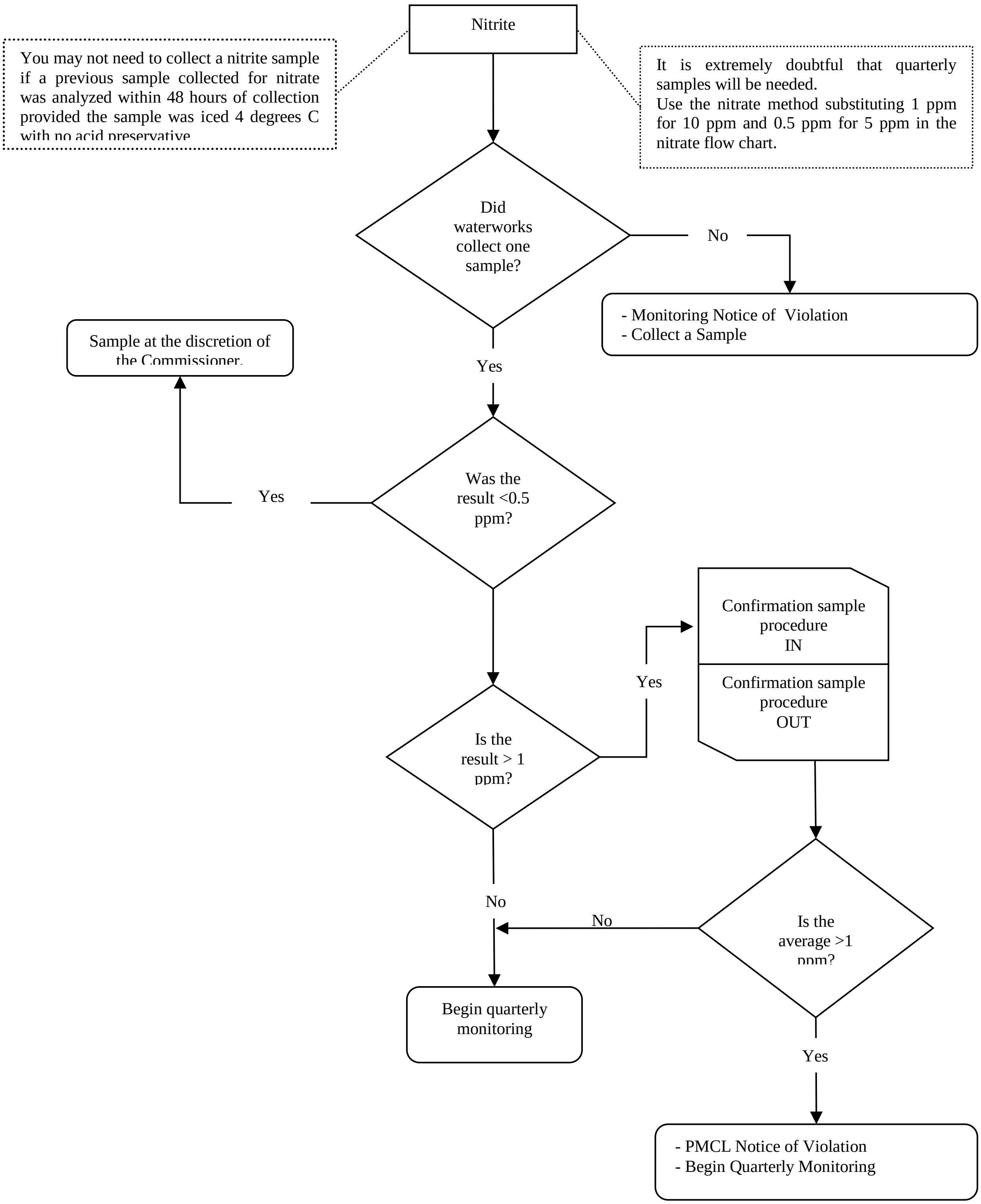
12.1.3. Nitrates + Nitrites (Combined) – Quarterly Monitoring



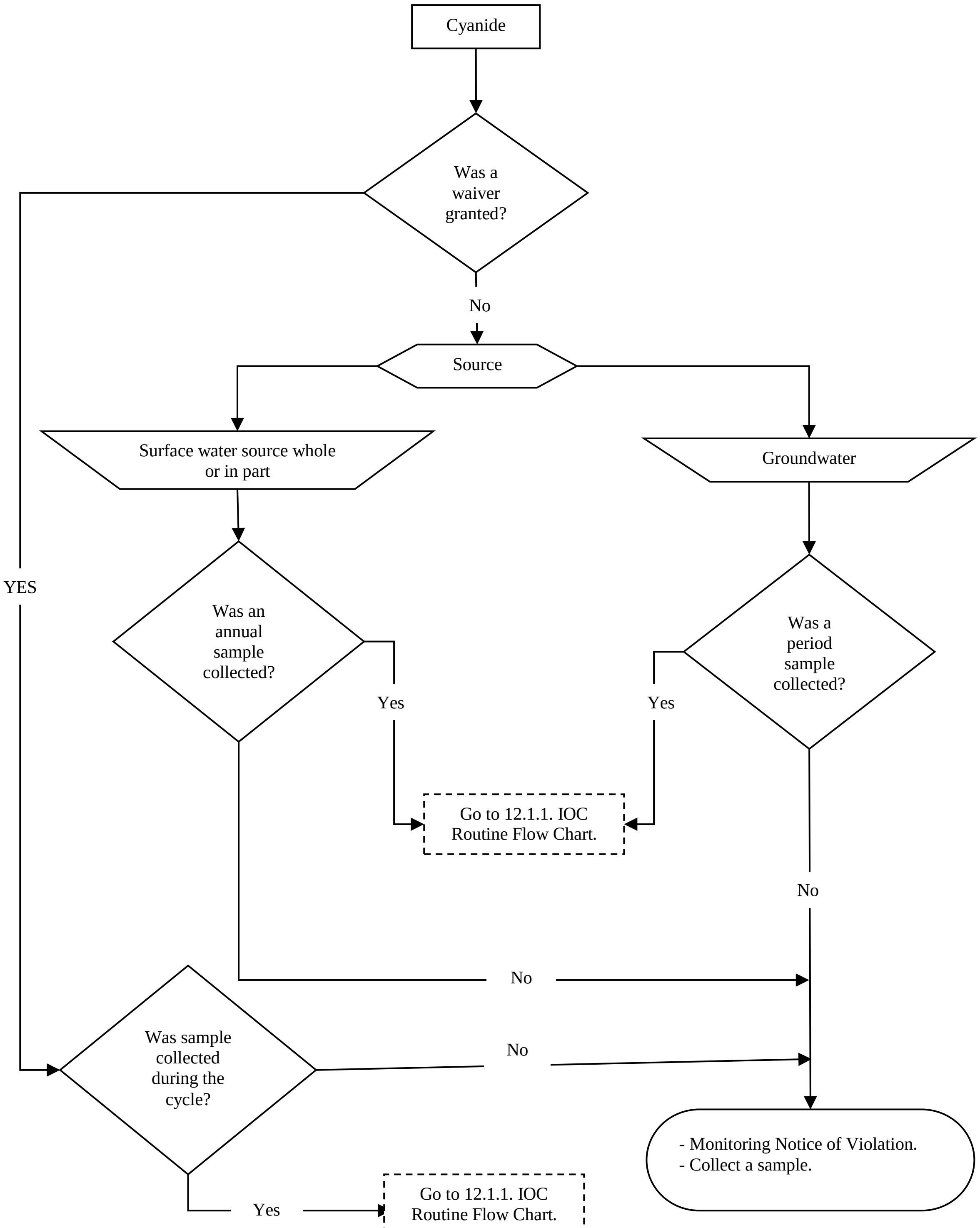
12.1.4. Nitrates + Nitrites (Combined) – Annual Monitoring



12.1.5. Nitrite Monitoring



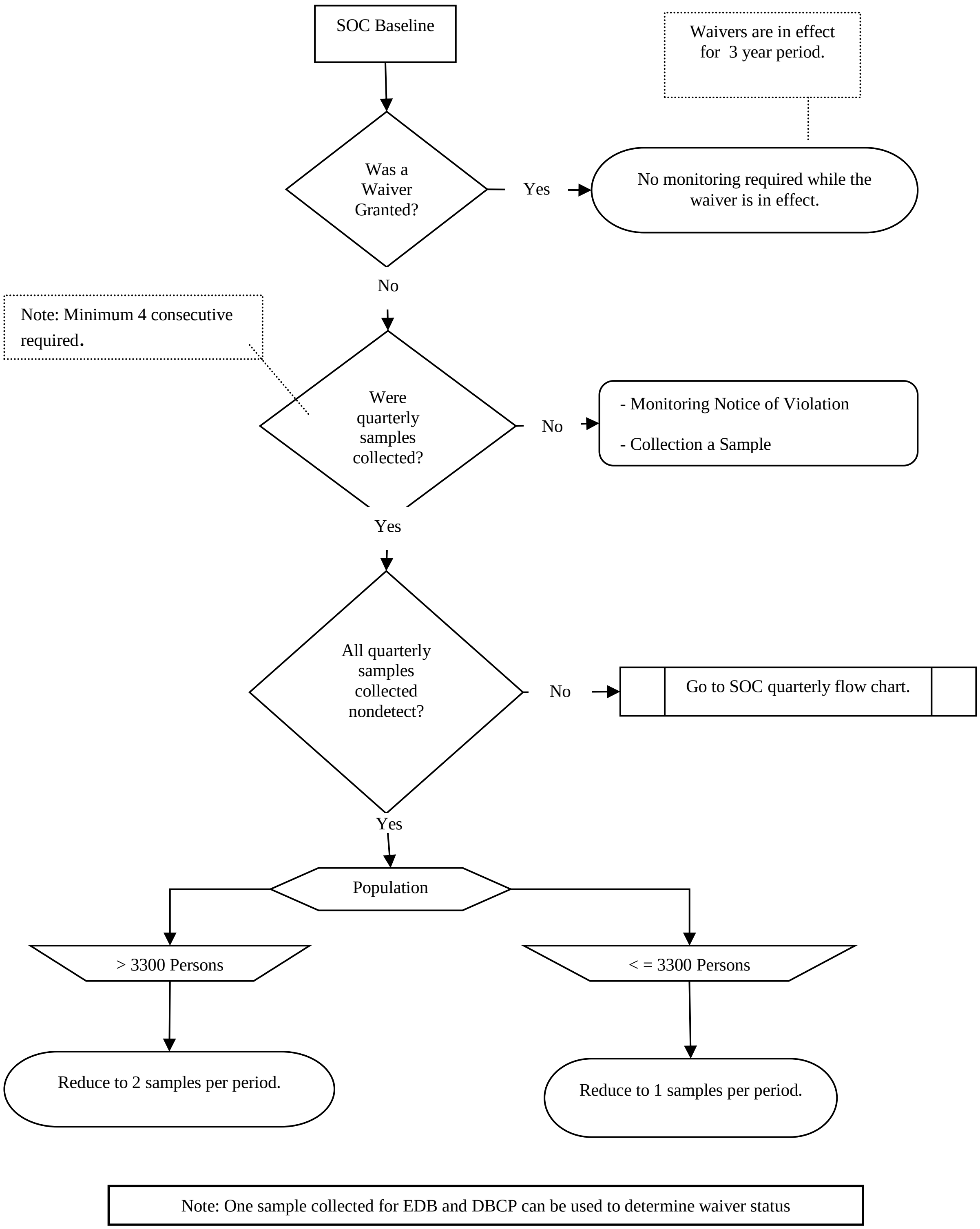
12.1.6. Cyanide Monitoring



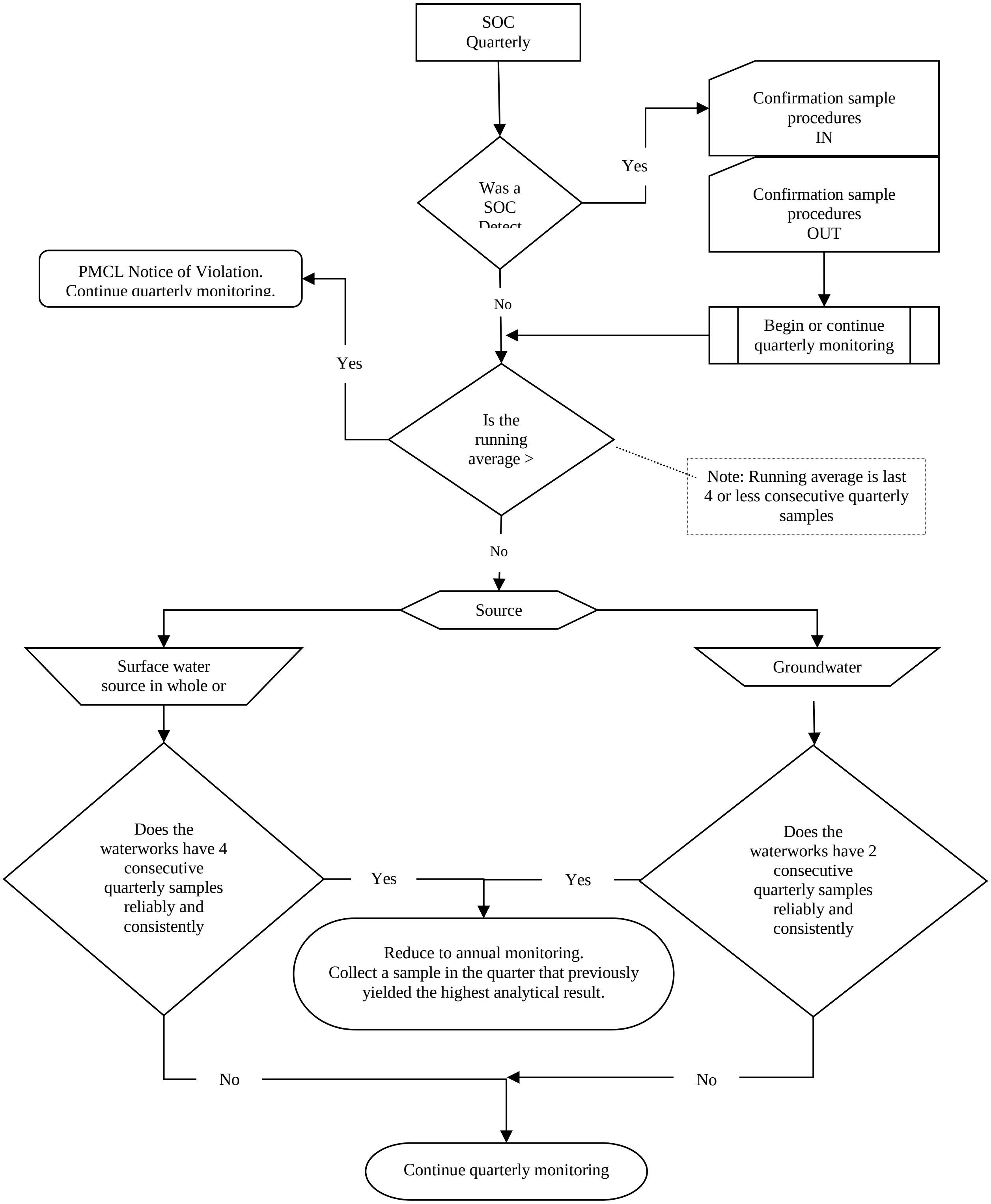
12.2. SOCs (Synthetic Organic Chemicals)

12.2.1. SOC – Baseline
12.2.2. SOC – Quarterly
12.2.3. SOC Annual

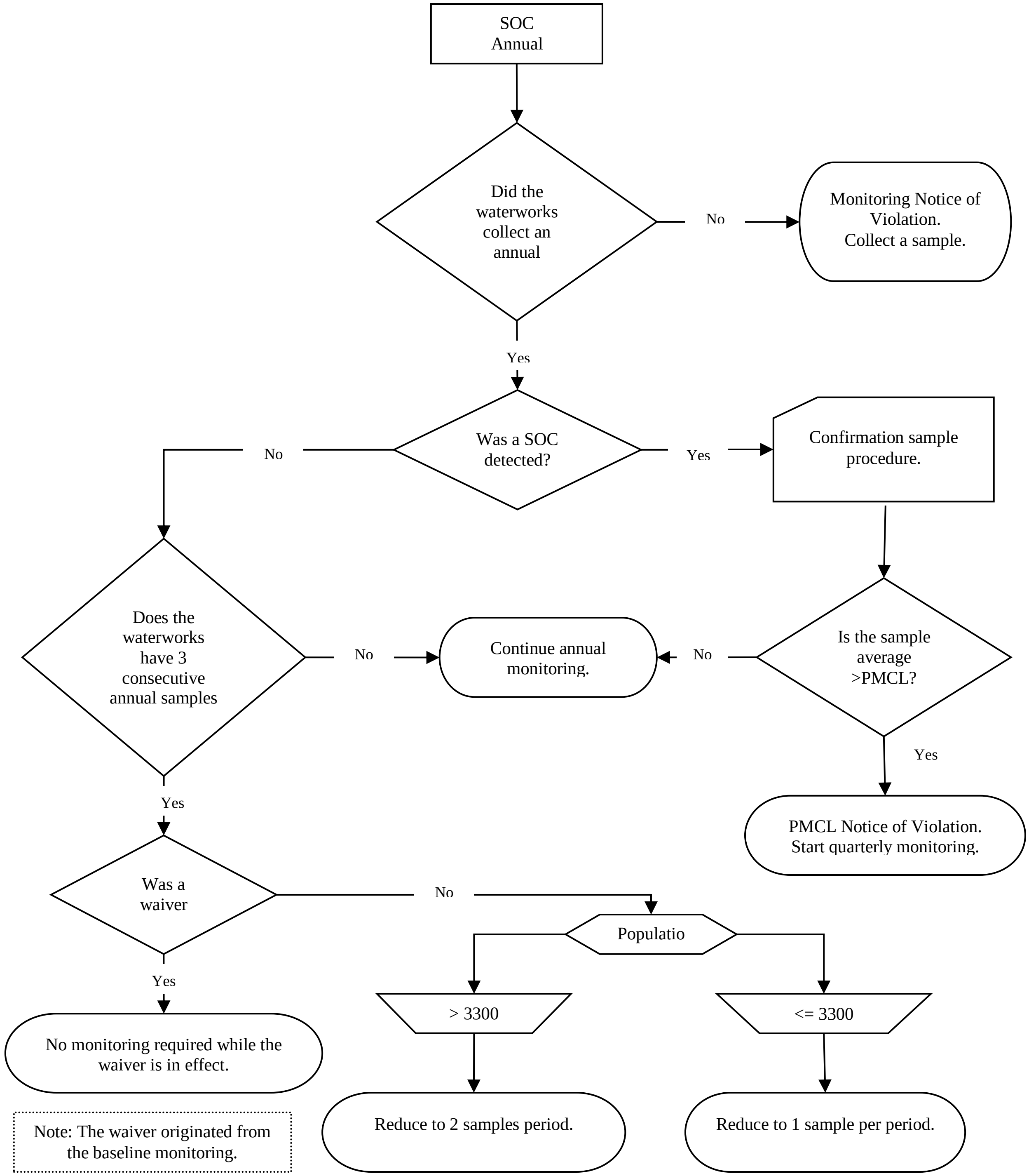
12.2.1. SOC – Baseline Monitoring



12.2.2. SOC – Quarterly Monitoring



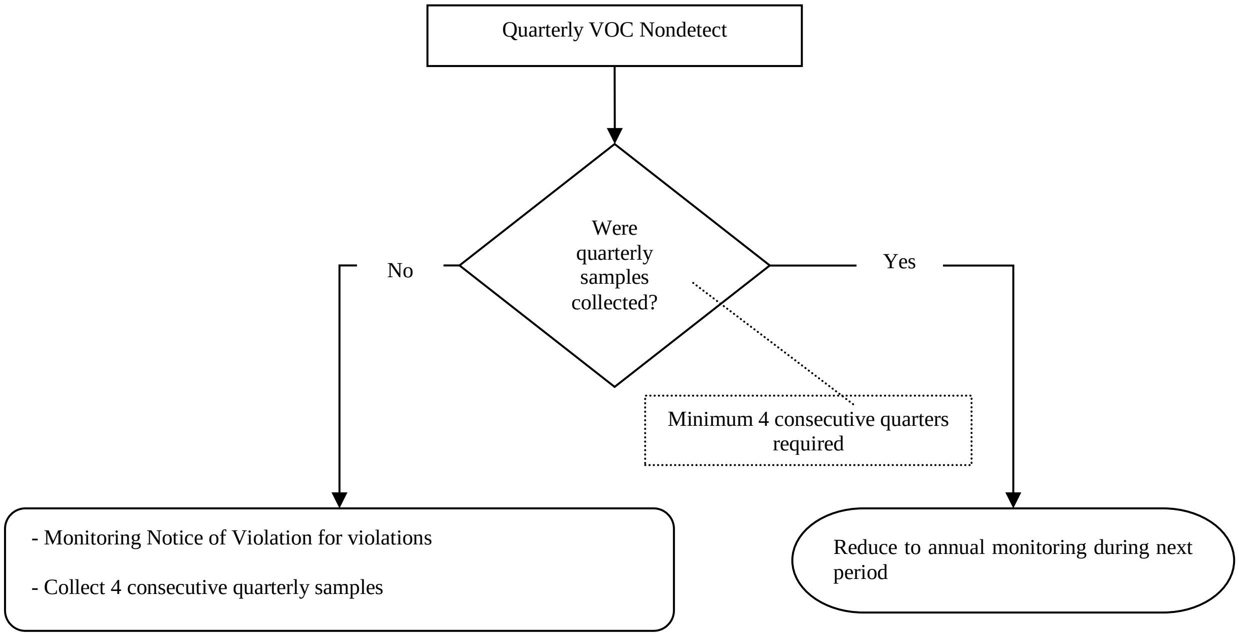
12.2.3. SOC Annual Monitoring



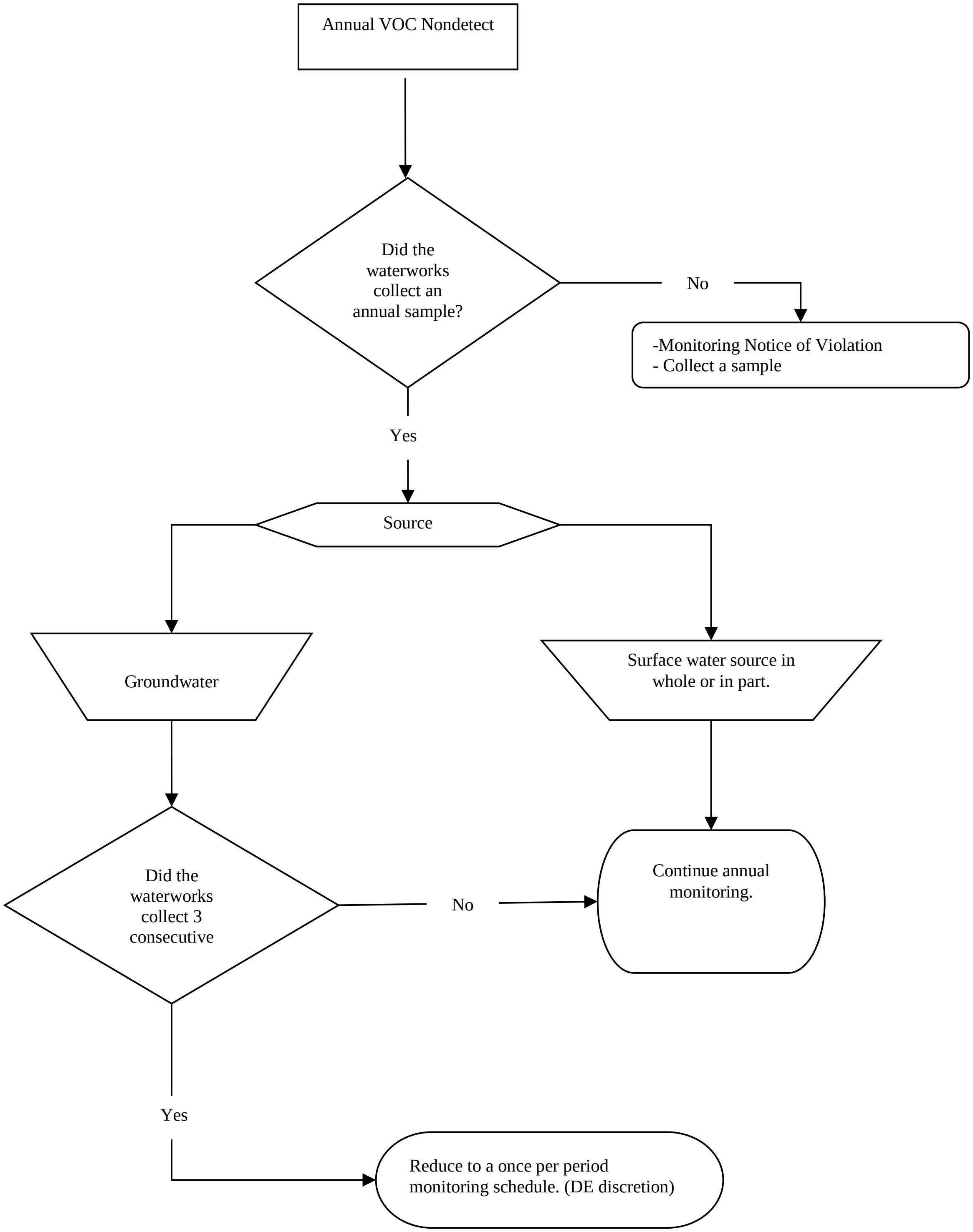
12.3. VOCs (Volatile Organic Chemicals)

12.3.1. VOC - Quarterly, Nondetect
12.3.2. VOC - Annual, Nondetect
12.3.3. VOC Detected
12.3.4. Check for Vinyl Chloride
12.3.5. Confirmation Sample Procedure

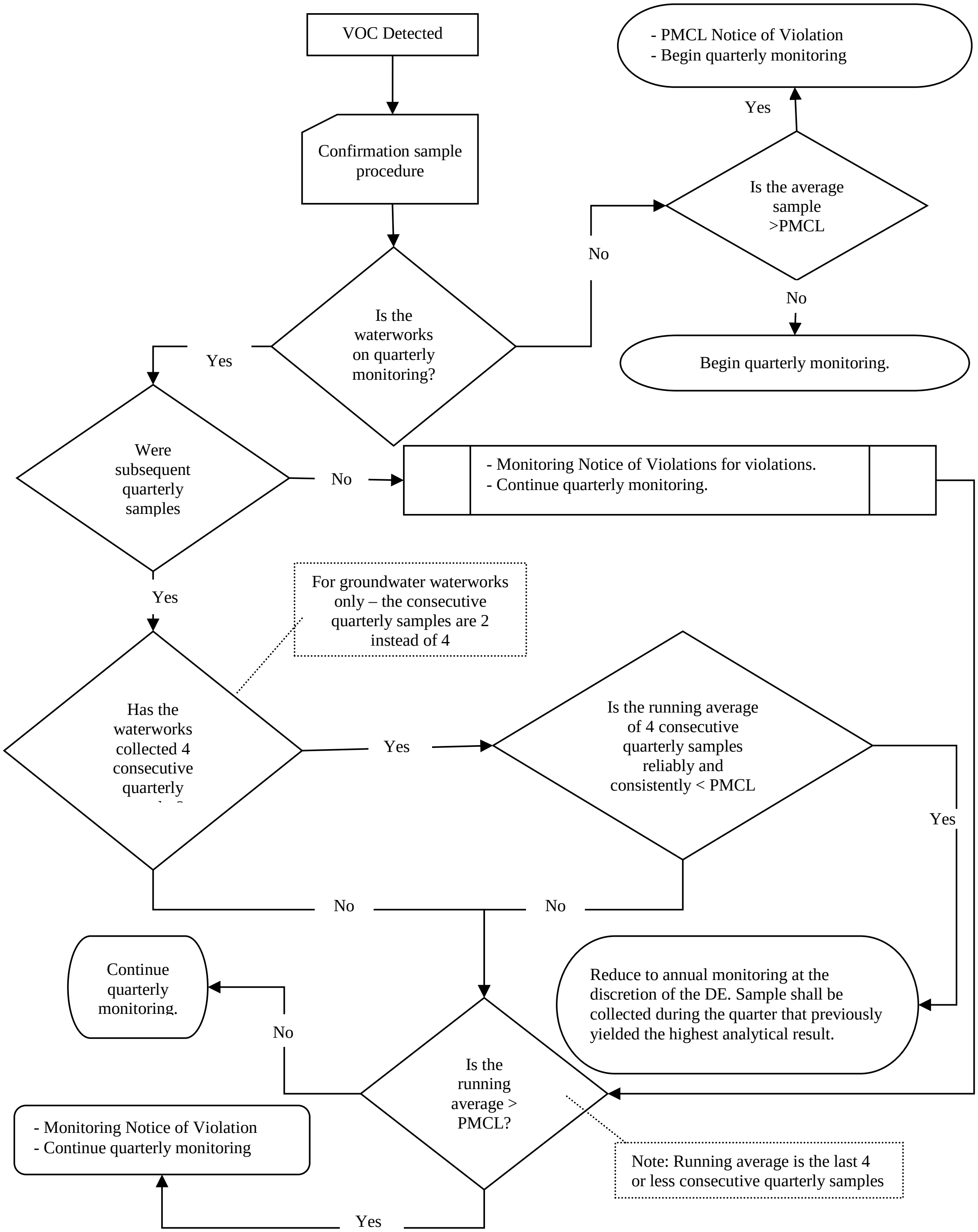
12.3.1. VOC - Quarterly, Non-detect Monitoring



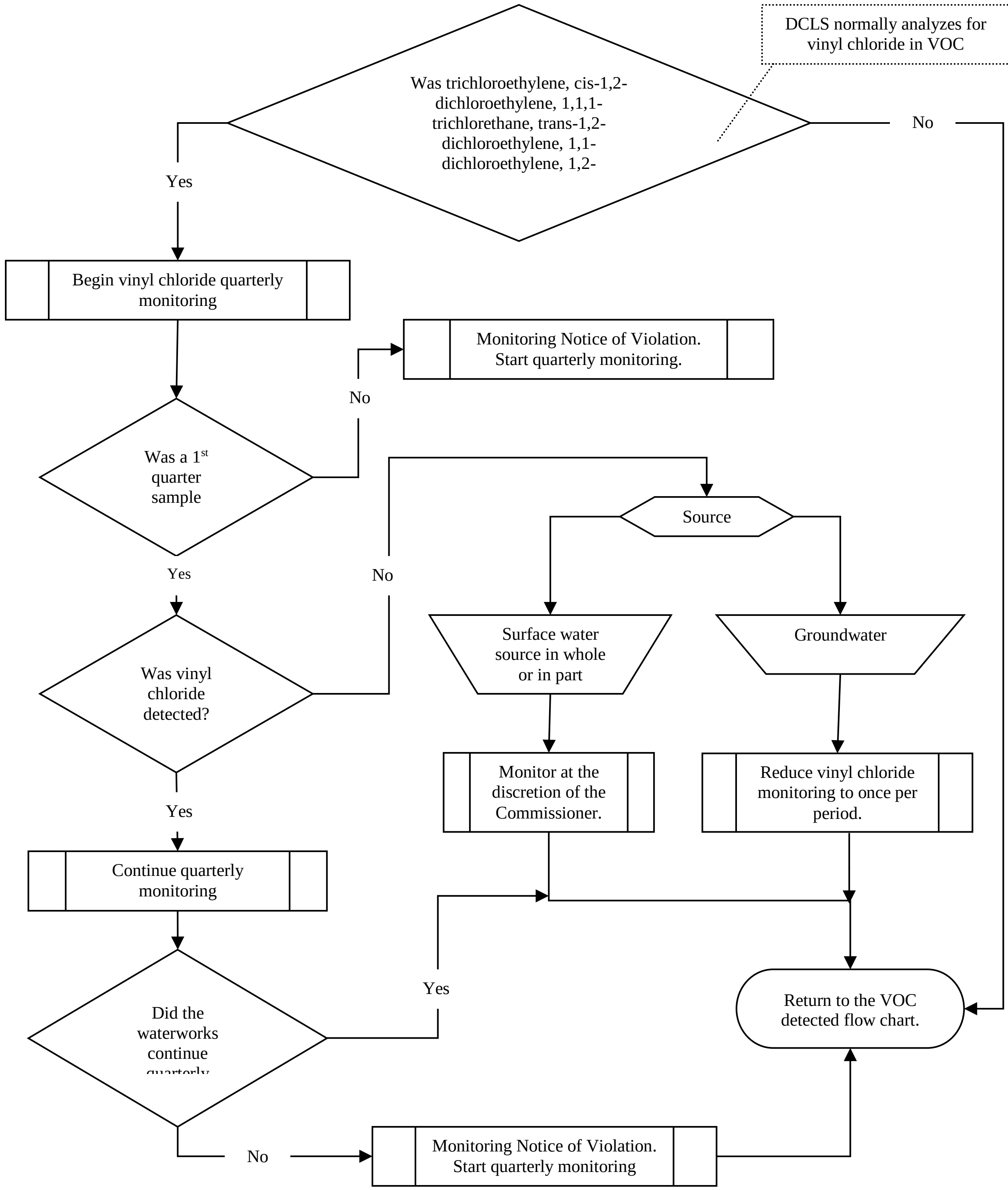
12.3.2. VOC - Annual, Non-detect Monitoring



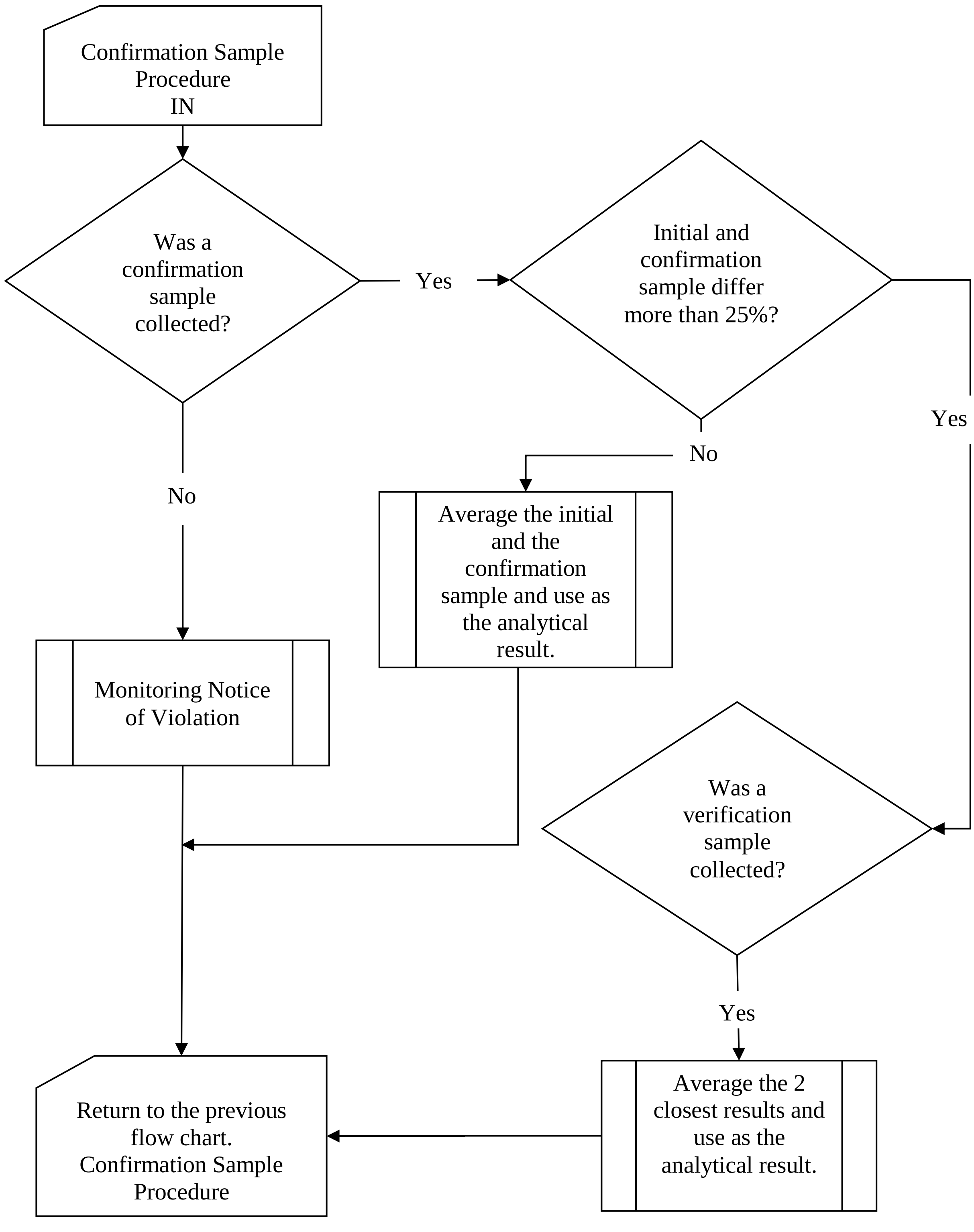
12.3.3. VOC Detected Monitoring



12.3.4. Check for Vinyl Chloride Monitoring Flow Chart



12.3.5. Confirmation Sample Procedure Flow Chart

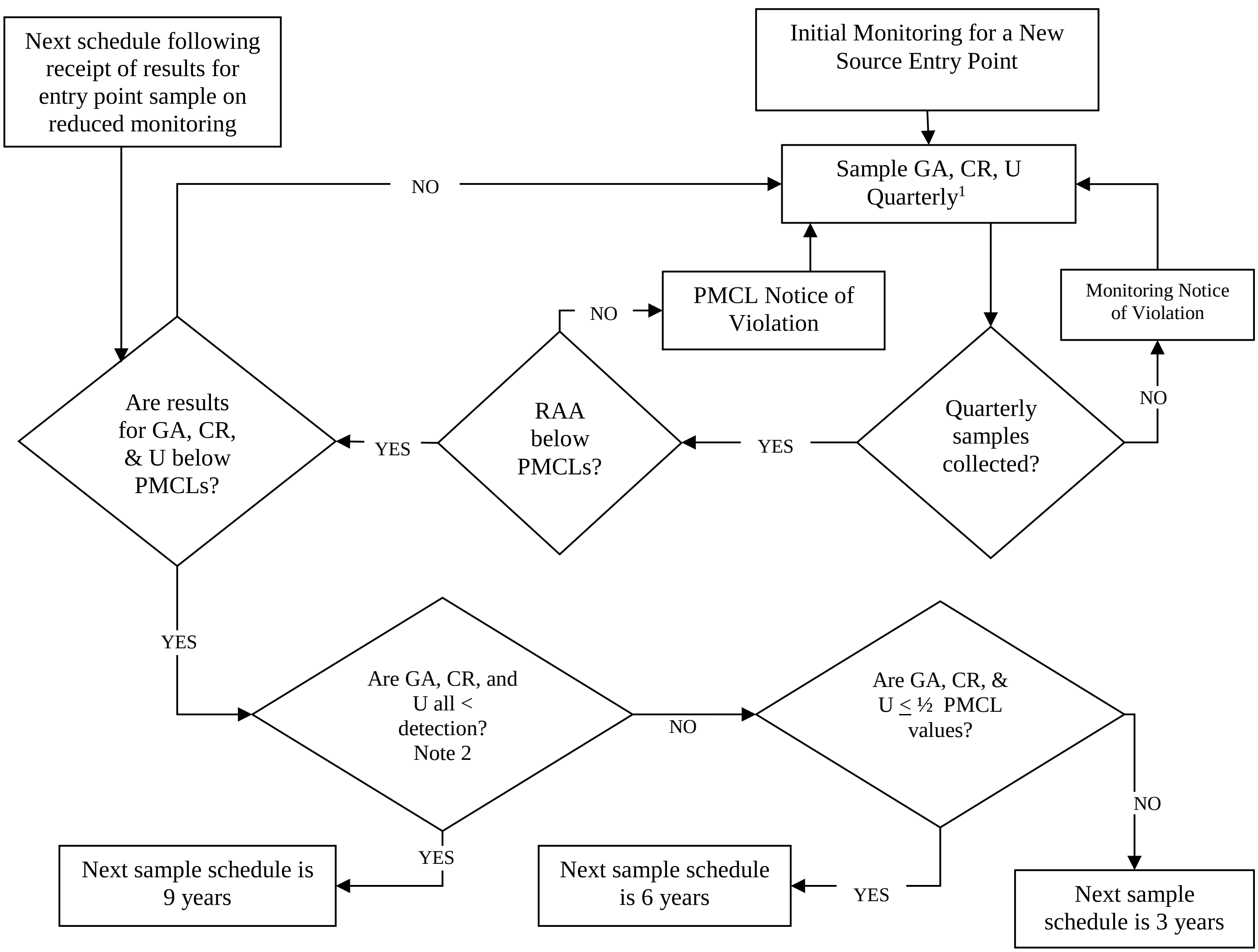


12.4. Radionuclides

12.4.1. Radionuclides Rule Routine Monitoring Requirements: Community Waterworks Only / Entry Point Sampling

12.4.2 New Source Startup Chemical and Radionuclides Entry Point Monitoring Requirements

12.4.1. Radionuclides Rule Routine Monitoring Requirements
Community Waterworks Only - Entry Point Sampling Flowchart



Abbreviations: GA (Gross Alpha Activity), CR (Combined Radium Ra226 + Ra228), U (Uranium), RAA (Running Annual Average)

1. When GA is ≤ 15 pCi/L, GA may be substituted for U. Divide uranium activity (pCi/L) by 0.67 to obtain Uranium mass (µg/L). When GA is ≤ 5 pCi/L, GA may be substituted for Ra226. DCLS has agreed to analyze for Ra226 when GA is ≥ 3 pCi/L.
2. Unless Ra226 and Uranium were measured directly and not obtained by GA substitution, "less than detection" for CR and U cannot be established. Detection limits are: Gross alpha particle activity (3 pCi/L), Radium 226 (1 pCi/L), Radium 228 (1 pCi/L), and Uranium (1µg/L).
3. If an individual radionuclide contaminant exceeds the PMCL for an entry point following initial four-quarter monitoring, only that contaminant must be placed on or continue with quarterly monitoring. When using DCLS, quarterly monitoring options are uranium or the radionuclides panel, since these are the service options available at this time. Otherwise, VDH has chosen to maintain schedules (3, 6, or 9 year) based on the most restrictive schedule for the group of radionuclide contaminants in order to reduce sample schedule complexity. The owner has the option to monitor each parameter on a schedule based on requirements established by the Waterworks Regulations. The ODW database is not set up to track such individual parameter schedules.

12.4.2. New Source Start Up Entry Point Monitoring Requirements

It is recommended that these samples be collected within 30 days of the startup of the new source.

Groundwater – Community:

IOCs:	One sample per period (3 years)
Nitrates + Nitrites (Combined):	Begin annual monitoring
Nitrites:	Collect period sample
VOCs:	Begin quarterly monitoring
SOCs:	If required, begin quarterly monitoring (based on waiver status)
Cyanide:	One sample per period (3 years)
Radionuclides:	Begin quarterly monitoring (4 qtrs)

Groundwater – Nontransient Noncommunity (NTNC):

IOCs:	One sample per period (3 years)
Nitrates + Nitrites (Combined):	Begin annual monitoring
Nitrites:	Collect period sample
VOCs:	Begin quarterly monitoring
SOCs:	If required, begin quarterly monitoring (based on waiver status)
Cyanide:	One sample per period (3 years)

Groundwater – Transient Noncommunity (TNC):

Nitrates + Nitrites:	Begin annual monitoring

Surface Water Sources - Community:

IOCs:	Begin annual sampling
Nitrates + Nitrites (Combined):	Begin quarterly monitoring (4 qtrs)
Nitrites:	Collect period sample
VOCs:	Begin quarterly monitoring (4 qtrs)
SOCs:	If required, begin quarterly monitoring (based on waiver status)
Cyanide:	Begin annual sampling
Radionuclides:	Begin quarterly monitoring (4 qtrs)

Surface Water Sources – Nontransient Noncommunity (NTNC):

IOCs:	Begin annual sampling
Nitrates + Nitrites (Combined):	Begin quarterly monitoring (4 qtrs)
Nitrites:	Collect period sample
VOCs:	Begin quarterly monitoring (4 qtrs)
SOCs:	If required, begin quarterly monitoring (based on waiver status)
Cyanide:	Begin annual sampling

Surface Water Sources – Transient Noncommunity (TNC):

Nitrates + Nitrites (Combined):	Begin quarterly monitoring (4 qtrs)

NOTE: These sampling requirements do not include the daily testing at the waterworks

13. MONITORING OF SURFACE WATER SOURCES

13.1. LT2 Rule Monitoring Requirements

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR or LT2 Rule) requires all public waterworks using surface water or groundwater under the direct influence (GUDI) of surface water to conduct two rounds of source water monitoring for each plant that treats a surface water or GUDI source. This monitoring includes *Cryptosporidium*, *E. coli*, and turbidity. The results of this monitoring are used to determine the level, if any, of additional *Cryptosporidium* treatment that must be provided in a process referred to as "binning" the waterworks, using a "microbial toolbox" of treatment options.

13.2. LT2 Rule Background

The Surface Water Treatment Rule (SWTR) was promulgated in 1989. The SWTR required filtration and disinfection treatment and performance standards of 3-log removal of *Giardia lamblia* and 4-log virus inactivation.

In 1998, the Interim Enhanced Surface Water Treatment Rule (IESWTR) was promulgated. The IESWTR added *Cryptosporidium* for WTPs serving >10,000 population, and required performance standards of 3-log removal of *Giardia lamblia*, 4-log virus inactivation, and 2-log removal of *Cryptosporidium*.

In 2002, the Long-Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR or LT1 Rule) was promulgated to address WTPs serving <10,000 population.

In 2006, the LT2 Rule was promulgated to reduce illness linked with the contaminant *Cryptosporidium* and other disease-causing microorganisms in drinking water. The LT2 Rule established *Cryptosporidium* concentration and source vulnerability and whether additional treatment was needed (if any), based on the two (2) rounds of source water monitoring collected six years apart.

13.3. Existing Water Sources (as of March 2014)

All waterworks and sources in existence as of March 2014 have now established their source water monitoring plans. The second round of source water monitoring must be completed between 2015 and 2019, depending upon the size or assigned schedule of the waterworks.

SCHEDULE	Waterworks Service Population (as of March 14, 2014)	2nd Round Monitoring Plan Deadline	Begin 2nd Round Source Water Monitoring
1	≥100,000	January 1, 2015	April 1, 2015
2	50,000-99,999	July 1, 2015	October 1, 2015
3	10,000-49,999	July 1, 2016	October 1, 2016
4	<10,000 monitor for *E. coli* [1]	July 1, 2017	October 1, 2017
4	<10,000 monitor for *Cryptosporidium*[2]	January 1, 2019[2]	April 1, 2019

[1]Applies only to waterworks that have filters.
[2]Applies to filtered waterworks that elect to monitor for *Cryptosporidium* instead of *E. coli*. Owners must notify ODW no later than July 1, 2017.

Note: Schedule 4 waterworks (serving < 10,000 population) must monitor for *Cryptosporidium* if either of the following conditions are determined following the second round of *E. coli* monitoring:

- For waterworks using lakes/reservoirs sources, the annual mean *E. coli* concentration > 10 *E. coli* /100 mL.

- For waterworks using free-flowing stream sources, the annual mean *E. coli* concentration > 50 *E. coli* /100 mL.

13.4. New Water Sources

Under the LT2 Rule, all waterworks that use surface water or GUDI sources are required to conduct source water monitoring, unless they provide 5.5-log *Cryptosporidium* inactivation. ODW field staff shall inform the waterworks of this option, and must obtain a written statement from the waterworks of its intent to provide treatment instead of performing source water monitoring, no later than the date established for submission of the monitoring plan.

All owners of waterworks serving ≥10,000 persons will sample for *Cryptosporidium* at least once per month for 24 months. Owners of waterworks serving <10,000 persons required to monitor for *Cryptosporidium* have a choice of monitoring once per month for 24 months or twice a month for 12 months.

Owners of waterworks (serving <10,000 persons) with filtration will normally begin by conducting *E. coli* monitoring every two weeks for 12 months, for a total of 26 samples. If the waterworks fails to conduct the required source water monitoring, according to 12VAC5-590-420 B 3 a, the waterworks is required to conduct *Cryptosporidium* monitoring.

13.5. Source Water Monitoring Plans and Schedules

The LT2 Rule requires the submission of a Source Water Monitoring Plan consisting of a sampling schedule and sampling locations identified (Use notification letter provided in Attachment A.1).

For sources which did not previously conduct Round 1 monitoring, the waterworks shall conduct Round 1 monitoring starting on a schedule established by the ODW field office and the owner. The schedule must specify the calendar dates when the owner shall collect each required sample.
Round 1 monitoring of new sources shall begin no later than six (6) months after issuance/re-issuance of the operation permit for new waterworks/new sources on existing waterworks. The schedule is due no later than three (3) months prior to the required start date for monitoring (sampling).

Round 2 monitoring shall start 6 years after the first round of monitoring ends, and a bin determination has been made.

Monitoring Plan Review Procedure
Waterworks shall submit their monitoring plans in written (paper or electronic) format to the appropriate ODW field office for review. The ODW field office will review the proposed plan (use review sheet in Attachment B.1) and approve it (use approval letter template in Attachment A.2) no later than 30 days prior to the scheduled start of monitoring. If the ODW field office takes no action on the proposed plan, the waterworks must begin sampling according to the schedule submitted.

Sample Collection
The samples shall be collected within 2 days before or 2 days after the dates indicated in the sampling schedule (i.e., within a 5-day period around the schedule date). If a sample cannot be collected during this 5-day period due to conditions that pose a danger to the sample collector, the owner shall submit an explanation for the delayed sampling date. If an analytical result cannot be validated, a replacement sample can be collected not later than 21 days after receiving information about the invalid result.

13.6. Sampling Locations

The following guidelines are to be used in evaluating the sample location:

1. Each water plant must monitor separately, except where multiple plants draw water from the same influent pipeline or intake. In such cases, a representative sample for all of the plants may be used.
2. Samples are to be collected prior to any chemical treatment, unless the ODW field office makes a specific determination that:
   a. Sampling prior to chemical treatment is not feasible; and
   b. The chemical treatment will not have any adverse impact on analysis of the sample.
3. If a waterworks practices recycle of the filter backwash, all samples must be collected prior to the point of any filter backwash water addition.
4. Plants with multiple water sources which include multiple surface water sources and blended surface water and ground water sources must use the following criteria:
   a. The use of multiple sources during monitoring must be consistent with routine operational practice.
   b. Must use a sample tap where the sources are combined prior to treatment, if available.
   c. If a combined sample tap is not available then samples must be collected at each source intake on the same day and must either:
      - Composite the samples into one sample prior to analysis. (This composite must be flow weighted based on the proportion of the source in the total plant flow at the time the sample was collected.), or
      - Analyze each sample and calculate a weighted average of the analysis results for each sampling date. The weighted average must be calculated by multiplying the analysis result for each source by the fraction the source contributed to total plant flow at the time the sample was collected and then summing these values.

13.7. Analytical Requirements

Laboratories utilized for the analytical work must either be certified or accredited for *Cryptosporidium* by DCLS. Laboratories performing *Cryptosporidium* analyses must use EPA Method 1622, EPA Method 1623, or EPA Method 1623.1. Laboratories performing *E. coli* analyses must be certified or accredited by DCLS. The certification must be for an *E. coli* enumeration method; <u>presence/absence is not acceptable</u>. Turbidity measurements can be performed by the waterworks.

13.8. Reporting Source Water Monitoring Results

The results must be reported no later than the tenth day of the month following the month in which the sample was collected (e.g., a January sample must be reported no later than February 10th).

<u>*Cryptosporidium*</u>

The complete laboratory report containing the *Cryptosporidium* results for all waterworks will be reported by the laboratory directly to the ODW Central Office. Analytical laboratories will note the field turbidity result(s) in the laboratory report for *Cryptosporidium*. Analytical laboratories will email their *Cryptoporidium* analytical reports to: <u>labadmin@vdh.virginia.gov</u> with the subject of their email: "Cryptosporidium Results for VApwsid#".

ODW Central Office data management will receive the *Cryptosporidium* and turbidity results from the laboratory, enter them into SDWIS, send an email back to the laboratory confirming receipt, and will copy the appropriate ODW Field Office Data Manager with the results attached. The ODW Field Office Data Manager will forward the email with the *Cryptosporidium* and turbidity results to the appropriate field office staff.

Each Field Office shall create a folder for each waterworks conducting Source Water Monitoring to hold the *Cryptosporidium* paper result forms until the "binning" occurs. The results can then be moved to the correspondence folder with the letter summarizing the results. The District Engineer should review the results as they are received to ensure that the data meets EPA requirements. ODW does not need to comment on the individual results, unless it appears that they do not meet the EPA requirements or the owner's approved monitoring plan.

E. Coli

Analytical laboratories should submit *E. coli* results electronically using ODW's standard template for data submittals. ODW Central Office data management will upload data into SDWIS. A confirmation email will be sent back to the laboratory once results have been accepted. If field offices receive data, they must forward it to labadmin@vdh.virginia.gov. Each field office will keep track of the results and notify waterworks if/when their *E.coli* results exceed trigger levels and direct them to proceed with *Cryptosporidium* monitoring.

13.9. Evaluation on Monitoring Results

Once the ODW field office has received all of the results (whether *Cryptosporidium* or *E. coli*), it will then perform a "binning" calculation (use review checklists provided in Attachments B.2 and B.3 to evaluate the *Cryptosporidium* and *E. coli* sampling data, respectively). "Binning" is to be completed within 3 months of the completion of sampling for *Cryptosporidium* and within 1 month for *E. coli.* Refer to the table in 12VAC5-590-420 B 3 c for the listing of bin classification, type of filtration currently practiced, and the additional treatment required. A water treatment plant placed into Bin 2 or higher must provide the increased level of treatment within 3-5 years of the initial round Bin Classification Acceptance.

Round 1Results

Once the waterworks owner submits the form accepting the bin classification, the ODW field office will send the letter provided in Attachment A.3. This letter formally establishes the bin classification. If the water treatment plant is placed into Bin 2 or higher, this letter also advises of the additional log "inactivation + removal" requirement for the plant.

If the water treatment plant is classified as Bin 2 or higher, the ODW field office will need to meet with the waterworks owner and their consultant to begin discussions about which microbial toolbox options will be appropriate for the particular waterworks. Refer to 12VAC5-590-420 B 3 d for further information on additional treatment requirements and removal credits, and the EPA's Guidance Manuals (Toolbox, UV Disinfection, Membrane Filtration, etc.) for more details on the various treatment technologies. These Guidance Manuals are found at ..\..\..\02-Committees\202-Rule Teams\MDBP & ESWT Rules\02-EPA Guidance Manuals.

Round 2 Results

If the bin classification for a water treatment plant changes following the Round 2 source water monitoring, then the waterworks must provide the additional "inactivation + removal" requirement based on bin classification. The ODW field office staff must have an engineering conference with the waterworks within 6 months of the bin determination date. During this conference, a schedule of activities (i.e. prepare engineering report, submit plans and specs) and completion dates must be developed and agreed to by the waterworks and ODW. It is recommended that the schedule provides for the additional treatment to be installed and operational within 3-5 years (see 12VAC5-590-420 B 3 d).

13.10. Bin Classification for Filtered Waterworks

Using *E.coli* Data

Once all the data for a waterworks serving <10,000 persons is received, the ODW field office will calculate the annual mean *E. coli* concentration[10]. The annual mean will be compared to the following trigger levels:

1. For waterworks using lake or reservoir sources: the trigger level is an annual mean *E. coli* concentration of 10 *E. coli* /100 mL.
2. For waterworks using free-flowing stream sources: the trigger level is an annual mean *E. coli* concentration of 50 *E. coli* /100 mL.
3. GUDI waterworks need to use the trigger level for the surface water body closest to the water source. If there is no surface water body nearby, the trigger level for lake or reservoir sources is to be used.

If the annual mean *E. coli* concentration equals or is below the trigger level, the waterworks is classified as a "Bin 1" waterworks. If the annual mean *E. coli* concentration is above the trigger level, the waterworks must move to *Cryptosporidium* monitoring, or the system may elect to provide full *Cryptosporidium* treatment. Use the letter template provided in Attachment A.5 to advise the waterworks of the results of the annual mean *E. coli* calculation and bin classification.

Using *Cryptosporidium* Data

Once all the Cryptosporidium data (whether Round 1 or Round 2 source monitoring) is received and determined to be acceptable, the ODW field office will perform the bin classification (refer to 12VAC5-590 B 3 c.) Use the letter template provided in Attachment A.4 to advise the waterworks of the results of the annual mean *Cryptosporidium* calculation and bin classification.

E. coli and turbidity data collected during *Cryptosporidium* monitoring may be used by EPA for non-binning purposes. EPA has provided Excel workbooks to be used in the binning calculation. Each workbook includes instructions, a worksheet to use for data input (to be "personalized" for each individual water plant), and examples. Those workbooks are found at..\..\..\02-Committees\202-Rule Teams\MDBP & ESWT Rules\09-LT2 Resources\LT2 Crypto Calculators. There are three separate versions, as follows:

- Version 1 - systems that collect 24 to 47 samples; to be used for Schedule 4 systems that collect 2 samples per month for only 12 months (according to EPA, the spreadsheet calculates correctly for this situation).
- Version 2 - systems that collect 48 or more samples, with an equal number of samples each month.
- Version 3 - systems that collect 48 or more samples, with an unequal distribution of samples.

Choose the correct workbook for the waterworks being evaluated, and follow the instructions provided on the first sheet of the workbook. Note that the worksheets require entry of oocyst concentration, not oocyst count. The result reports will provide a count but may not provide concentration – so a calculation

[10] Note - *E. coli* results will not be accepted for waterworks serving >10,000.

to convert to concentration (#oocyst/L) may be necessary. Cells are to be left blank if there was no sample.

If a water plant has only one raw water source, or if there are several water sources and the plant sampled from the combined raw water, enter the sample results directly into the appropriate spreadsheet. If the water treatment plant is served by multiple water sources and each water source was sampled individually, then a flow-weighted average result for each month's sampling event(s) must be developed and entered into the spreadsheet.

A copy of the completed workbook (with the example worksheets deleted) should be renamed and saved to the ODW field office local server, in the district directory along with other LT2 materials for the waterworks. Do NOT over-write the files on ODWSHARE! The spreadsheet will automatically calculate the mean *Cryptosporidium* concentration and the appropriate bin into which the water treatment plant is to be placed.

13.11. Maintaining the Log Treatment Requirements

The ODW has adopted an "anti-backsliding" policy which requires waterworks to maintain the log treatment requirements mandated by the results of their Round 1 monitoring if Round 2 monitoring results in a lower bin classification. This policy is in agreement with EPA's guidance (WSG 198 dated April 8, 2016), which maintains that there can be method-recovery and temporal-variability challenges and given that the Round 1 results may represent an underestimate of *Cryptosporidium* levels. Consequently, the potential to adversely impact public health from *Cryptosporidium* can still exist in the source water. Only on rare cases, where there are documented changes in the watershed or documented reduction in discharges or pollutant loadings to the watershed, will the ODW consider assigning a lower bin than determined in the Round 1 monitoring. If a system is placed into a higher bin at the end of Round 2, they must meet the additional log treatment requirements set by the higher bin.

Attachment A.6 provides a letter informing the waterworks owner of the mean oocyst concentration and the proposed bin classification (see the table in 12VAC5-590 420 B 3 c for the listing of oocyst concentration vs. bin classification). The letter will propose the bin classification and ask the owner to accept that classification, using the template provided in Attachment A.6, or provide justification for not accepting it.

The ODW field office will provide a deadline (i.e., six months after scheduled completion of Round 2 source water monitoring for *Cryptosporidium*) for the owners to submit the bin classification acceptance back. Once the statement of acceptance is received, ODW shall provide a letter of approval of the bin classification to the owner (Attachment A.3).

13.12. Time Accounting and Project Tracking

Time spent reviewing data submitted following an approved source water monitoring plan will be charged to time accounting under "Surveillance" in the TimeTrac data base. Time spent in preparing the final bin classification letter will be charged to "SDWA Reports".

The "bin classification statement" form received back from a waterworks owner will be entered to PT Log as an SDWA Report. Enter the date of the final "Bin Classification" letter to the owner (use template provided in Attachment A.3) into SDWIS, as well as the bin classification. (Refer to the SDWIS manual on how to enter Round 1 and Round 2 bin classification into SDWIS.) Round 2 bin classification should never be lower than Round 1 bin classification (Refer to section 13.10, Bin Classification for Filtered Waterworks).

14. DCLS SAMPLE KIT REQUEST PROCEDURES

Requesting Bacteriological / Chemical / Radiological Sample Kits from DCLS:

14.1. Routine Kit Requests

Routine sample kit orders are prepared quarterly for every waterworks, approximately 45 days prior to the start of a calendar quarter. The data gathered only includes samples that are required to be taken in the upcoming quarter. Field Office electronically transmit this order to the Central Office. These orders are based on the monitoring schedules maintained in SDWIS (RTCR & Raw Water MPN) and R&R (Chemical/Radiological). ODW shall maintain these schedules with guidance from the corresponding manuals:

- ODW SDWIS Manual referenced in WM 823
- R&R User's Guide referenced in WM 824

The monitoring schedules for all waterworks are posted on the ODW Website under the "Information for Laboratories" tab.

An electronic data file is also submitted to DCLS that only includes monitoring schedules that meet one or more of the following criteria:

- DCLS analytical services were used in the past 40 months
- Waterworks activated or reactivated in the past 12 months
- Waterworks has radiological monitoring schedules

14.2. Ad Hoc Kit Requests

The RTCR requires **three** repeat samples for every positive routine sample. Repeat and triggered source water sample locations have been defined in the waterworks BSSP and these samples are to be collected in a timely manner, typically within 24 hours after learning of the results. Notify the waterworks of the sampling requirement using Attachment C.3.

Kits needed outside of the quarterly order event are ordered through the Ad Hoc Order feature of R&R. The most common example of an Ad-Hoc order is the required additional temporary routine water samples for the monitoring period following a coliform present analysis result of a distribution system sample. Ad Hoc Orders may also be submitted for other non-routine sample kits, for example, in the case of the two special bacteriological samples required by a seasonal waterworks as part of its start-up procedure. In all cases, these requests result in DCLS generating an invoice sent to the waterworks. The invoice must be paid prior to DCLS sending the kits.

14.3. Bacteriological Repeat and Triggered Source Water Monitoring Kit Dispatch

Time sensitive repeat and triggered source water monitoring bacteriological sample containers are dispatched to waterworks by the Field Office staff. Sample collection input forms generated from the R&R Ad Hoc module, and DCLS-provided sample containers and labels are given to the waterworks representative. Because of the time sensitivity of these samples, DCLS will perform the analysis prior to payment and submit an invoice to the waterworks afterwards. Field Office staff should routinely take inventory of DCLS labels and sample container supplies. To replenish stock, staff should send a request to "LabAdmin" with the quantity of labels and bottles needed.

15. EVALUATION AND DISTRIBUTION OF SAMPLE RESULTS

ODW staff are required to review and evaluate all bacteriological, chemical, physical, and radiological analysis results. Where necessary, staff must inform waterworks when repeat and/or special samples will be required as well as providing required notices of violations for any exceedance of maximum contaminant levels.

15.1. Distribution of Bacteriological Analysis Results

It is not normally necessary for ODW to inform waterworks of bacteriological results unless a problem has been found and/or the laboratory has failed to provide a copy of the results to the owner. Use Attachment C.3. to notify a waterworks on repeat, triggered, and additional monitoring requirements.

15.2. Distribution of Chemical / Physical / Radiological Analysis Results

It is the policy of the ODW to inform waterworks in writing of the receipt and evaluation of all chemical, physical and radionuclides analysis results by generating and signing the Owner's Report generated by R&R.

Please refer to the various enforcement and public notification working memos when issuing a Notice of Violation for failure to collect samples and/or for issuing a Notice of Violation for exceeding maximum contaminant levels.

Revised Total Coliform Rule

Alternative Upstream/Downstream Repeat Site Selection Criteria

&

Ad Hoc Selection of Repeat Sample Site

Alternative Site

- Background – Repeat monitoring, is required subsequent to a total coliform-positive routine distribution system sample. Three samples are required with the approved monitoring sites listed in the Bacteriological Sample Site Plan (BSSP) as the 'originating' routine site plus two sites located within five service connections of the representative site; one upstream and one downstream. The terms "upstream" and "downstream" refer to the direction of water flow by the sample site or flow path. The purpose of repeat bacteriological monitoring is to identify a current pathway or entrance of contamination into the distribution system. Consequently, the use of repeat monitoring sites outside the default five service connection area may be useful to characterize a contamination pathway. Sites listed in the BSSP outside the five service connection area are known as alternative repeat monitoring sites.
- Situations for Use of an Alternative Site – There are two situations where the use of an alternative site may better determine a contamination pathway in lieu of the defined repeat monitoring sites criteria. First, when the representative site is at the end or within one service connection of the end of a distribution system pipe. Second, when there is knowledge of activities or conditions that fall outside the five service connection distance criteria which put the distribution system at risk for contamination.
- Situation 1 – ODW staff is to discourage selection of an end of line or within one service connection of an end of line tap as a routine sample site during review of a BSSP. Selection of a representative site is dependent on factors that will lead to targeting a general location. Subsequently, a tap must be found in the targeted area. A suitable tap, one that will not modify water quality during sample collection, must also have unrestricted accessibility. Consequently, the suitable tap may be at the end or within one service connection of the end of a distribution system pipe. Obviously, a suitable downstream repeat location tap is likely not available. A site further upstream, a site on a branch line also fed by the main supplying the representative site, or a site in the general area that does not exhibit sufficient chlorine residual, may be considered for an alternative site. In all cases, the alternative site must be in the same pressure zone as the originating site.
- Situation 2 – As stated for Situation 1, locating the representative site is the primary objective. Knowledge of activities or conditions in the area of the representative site may indicate a higher than normal risk for a potential contamination pathway but the activity or condition is not within the five service connection criteria location. Conditions of higher risk that should lead to this consideration of alternative sites are: nearby service connections with high risk water use protected by backflow prevention devices; water mains crossing under or parallel to large streams or rivers; areas where main breaks and pipe repairs are above the

normal frequency compared to the rest of the system, or a location where past vandalism to waterworks equipment causes a concern for higher risk to the distribution system. Some activities near water mains may pose a potential risk to pipe integrity such as: moving live loads from trains, excessively loaded vehicles or a quarry operation that has blasting operations, just to give a few examples.

Ad Hoc Substitute Repeat Site

Waterworks operators, under normal circumstances, do not routinely check on the status of repeat sample sites, as a total coliform-positive sample result is not a routine event. However, the repeat site associated with a routine site may not be available due to unforeseen circumstances and require ad hoc actions by the operator. Some of these circumstances may be:

- Access is unavailable due to the absence of the home or building owner
- The building site is undergoing plumbing renovations
- The only acceptable tap/faucet is inoperable

In these circumstances, the operator will need to make immediate decisions to select a substitute repeat site so as not to delay sample collection. ODW staff is to be amenable to allow the use of the ad hoc site to meet the repeat monitoring requirement subsequent to the operator providing an explanation of the circumstances. In addition, the operator may not be able to find a substitute site within the five service connections. Consequently, the substitute site is subject to the guidelines for selecting an alternative site.

B.1. BSSP GW 1000 or Fewer People (rev.10.7.2021)

BACTERIOLOGICAL SAMPLE SITING PLAN (BSSP)
(For GW Waterworks Serving 1,000 or Fewer People)

Waterworks Name: ___________________________________
PWSID: ___________________________________

[Note: If a waterworks provides 4-log virus inactivation treatment either voluntarily or as required by the Waterworks Regulations, triggered source water monitoring is not required for the sources being treated. Delete references below where applicable.]

Purpose: The purpose of this plan is to identify specific bacteriological sampling sites and monitoring requirements for routine, repeat, triggered and routine source water monitoring. (***If applicable:*** In addition, this plan identifies disinfectant residual monitoring requirements (for compliance determination as well as) for distribution system quality control measures.)

Sampling Plan:

1. The ___________________________waterworks is currently required to collect ____________ routine water sample(s) for total coliform analysis each (month)(quarter). (***If the waterworks has components that are not in operation year round, include the following, otherwise delete:*** This waterworks shuts down some components during the year, consequently, prior to opening the shutdown components, an approved Start-up Procedure must be completed.)

2. The routine, repeat and triggered source water sampling sites are identified below and are shown on the attached waterworks piping map. The routine sites were chosen to be representative of the water quality throughout the distribution system.

Routine Sample Sites (911 Address or Location)		**Repeat and Triggered Source Water Sample Sites (911 Address or Location)**	
010		**01U**	
		01D	
		Source(s)	
020		**02U**	
		02D	
		Source(s)	
030		**03U**	
		03D	
		Source(s)	

3. Routine bacteriological samples will be collected from each of the above routine sites on a rotating basis.

4. Repeat and triggered source water samples will be collected when a routine total coliform-positive result occurs. Collection is required within 24 hours of notification. Any total coliform-positive routine, repeat or triggered source water sample will also be analyzed for *E. coli* in accordance with the *Waterworks Regulations*.

B.1. BSSP GW 1000 or Fewer People (rev.10.7.2021)

[Include No. 5 for waterworks that purchase groundwater. If groundwater is not purchased delete No. 5)

5. The wholesaler waterworks, ____________________, will be notified within 24-hours of the routine total coliform-positive distribution system sample so that the triggered source water sample(s) is(are) collected from the wholesaler's well(s) raw water sample tap, located prior to treatment.

6. Triggered source water samples will be collected from each groundwater source in service at the time of collection of the routine total coliform-positive sample. Triggered source water samples will be collected from the well ***[or spring, if applicable]*** raw water sample tap, located prior to treatment.

7. ***Choose either a. or b.***
   a. [Repeat sampling instruction for waterworks with repeat sample sites. Delete if not applicable.] The routine sample sites are chosen to allow for the collection of required upstream and downstream repeat samples when necessary. Three repeat samples will be collected on the same day from:
   (a) the total coliform-positive sample location; and
   (b) a location within five service connections upstream of the total coliform-positive sample location; and ***[Alternate Option: if waterworks has a single untreated groundwater well and serves a population of 1000 or fewer people, the triggered source water sample can be counted as the upstream repeat sample.]***
   (c) a location within five service connections downstream of the total coliform-positive sample location.

   b. [Repeat sampling instructions for waterworks with only a single approved sample site. Delete if not applicable]
   The three repeat samples will be collected from the routine site over a three-day period (one sample per day) ***<u>or</u>*** the three repeat samples will be collected approximately 15 minutes apart from the routine site on the same day.

8. The waterworks will notify the appropriate ODW Field Office if any repeat sample is *E.coli-positive* <u>or</u> any repeat sample is total coliform-positive following a routine *E.coli-positive* sample. Notification is due by the end of the business day after the waterworks has been notified of the monitoring result.

9. Five additional source water samples will be collected from the same raw water source of any *E.coli-positive* triggered source water sample. Sampling will be within 24 hours of notification. These samples are to be collected approximately 15 minutes apart while the well pump is running. In addition, consumers will be notified within 24 hours of notification of the *E.coli-positive* triggered sample result. The ODW will be contacted for assistance in preparing the public notice text and the distribution requirements.

10. ***[Applies only to year-round transient noncommunity waterworks]*** For waterworks collecting routine samples on a quarterly frequency, a minimum of three routine samples are required in the month following a routine total coliform-positive result. All three samples may be collected on a single day if the samples are taken from different approved sites. Otherwise, the samples must be collected at regular time intervals throughout the month.

[Comments 11 through 14 apply to waterworks that chlorinate/disinfect. Delete if not applicable]

11. Disinfectant residual will be measured at the same time and from the same location as each routine and repeat bacteriological sample.

12. All disinfectant residuals will be measured with testing equipment using approved methods.

13. Where applicable, the disinfectant residuals will be reported to the _________ Field Office by the 10th of the month following the month during which samples were taken. The disinfectant residual results must also be included along with the bacteriological results as reported by the laboratory.

14. ***[Optional]*** For quality control, the disinfectant residual will be monitored in the distribution system at a frequency of _____ days per week. These disinfectant residual results will be reported in the Monthly Operation Report.

[Comments 15 and 16 apply to waterworks that chlorinate/disinfect or have other applicable treatment processes as determined by VDH Office of Drinking Water. Delete if not applicable]

15. Separate from triggered source water sampling requirements, a raw water sample from each groundwater source will be collected every ________ (month)(quarter)(year) at a minimum from each groundwater source. These samples will be analyzed by a test method that provides a Most Probable Number (MPN) determination for both total coliform and *E.coli*.

16. Additional monitoring may be required based on the results of source water samples.

Owner/Representative Name: ______________________________

Signature: ______________________________

Title: ______________________________

Date: ______________________________

Attachment: System piping map

B.2. BSSP GW More Than 1000 People (rev.10.7.2021).

BACTERIOLOGICAL SAMPLE SITING PLAN (BSSP)
(For GW Waterworks Systems Serving More Than 1,000 People)

Waterworks Name: ______________________________

PWSID: ______________________________

Population Served: ______________________________

[Note: If a waterworks provides 4-log virus inactivation treatment either voluntarily or as required by the Waterworks Regulations, triggered source water monitoring is not required for the sources being treated. Delete references below where applicable.]

Purpose: The purpose of this plan is to identify specific bacteriological sampling sites and monitoring requirements for routine, repeat, and triggered source water monitoring. ***[If applicable**:* In addition, this plan identifies disinfectant residual monitoring requirements (for compliance determination as well as) for distribution system quality control measures.]

Sampling Plan:

1. The ______________________waterworks is currently required to collect ________ routine water samples for total coliform analysis each month. (***If the waterworks has components that are not in operation year round, include the following, otherwise delete:*** This waterworks shuts down some components during the year, consequently, prior to opening the shutdown components, an approved Start-up Procedure will be completed.)

2. The routine, repeat and triggered source water sample sites are identified below and are shown on the attached system piping map. The routine sites were chosen to be representative of the water quality throughout the distribution system.

Routine Sample Site (911 Address or Site)		**Repeat and Triggered Source Water Sample Sites (911 Address or Site)**	
010		**01U**	
		01D	
		Sources	
020		**02U**	
		02D	
		Sources	
030		**03U**	
		03D	
		Sources	
040		**04U**	
		04D	
		Sources	
050		**05U**	
		05D	
		Sources	
060	***Add rows as needed***	**06U**	
		06D	
		Sources	

3. Routine bacteriological samples will be collected from each of the above routine sites on a rotating basis. The samples will be collected at regular time intervals throughout the month. [***Optional for waterworks serving 4900 or fewer:*** *All required samples may be collected on a single day if they are collected from different sites.]*

4. Repeat and triggered source water samples are required to be collected when a routine total coliform-positive result occurs. Collection is required within 24 hours of notification. Any total coliform-positive routine, repeat or triggered source water sample will also be analyzed for *E. coli* in accordance with the *Waterworks Regulations*.

[Include No. 5 for waterworks that purchase groundwater. If groundwater is not purchased delete No. 5)

5. The wholesaler waterworks, ____________________, will be notified within 24-hours of the routine total coliform-positive distribution system sample so that the triggered source water sample(s) is(are) collected from the wholesaler's well(s).

6. Triggered source water samples will be collected from each groundwater source in service at the time of collection of the routine total coliform-positive sample. Triggered source water samples will be collected from the well ***[or spring, if applicable]*** raw water sample tap, located prior to treatment.

7. The routine sample sites are chosen to allow for the collection of required upstream and downstream repeat samples when necessary. Three repeat samples will be collected on the same day from:
   (a) the total coliform-positive sample location; and
   (b) a location within 5 service connections upstream of the total coliform-positive sample location; and
   (c) a location within 5 service connections downstream of the total coliform-positive sample location.

8. ***[Only for waterworks with a population ≥ 33,001. Delete for population < 33,001]*** A minimum of one set of repeat samples is required for each routine total coliform-positive sample. If one or more repeat samples are total coliform-positive, an additional set(s) of repeat samples are due within 24 hours of notification unless the requirement for a Level 1 or 2 Assessment is generated. Additional sets of repeat samples will be collected until either total coliforms are not detected in one complete set of repeat samples or the requirement for a Level 1 or 2 Assessment is generated.

9. The waterworks will notify the appropriate ODW Field Office if any repeat sample is *E. coli* positive <u>or</u> any repeat sample is total coliform-positive following a routine *E. coli* positive sample. Notification is due by the end of the business day after the waterworks has been notified of the monitoring result.

10. Five additional source water samples will be collected from the same raw water source of any *E. coli* positive triggered source water sample. Sampling will be within 24 hours of notification. These samples are to be collected approximately 15 minutes apart while the well pump is running. In addition, (customers/employees/students) provided drinking water will be notified within 24 hours of notification of the *E. coli* positive triggered sample result. The ODW will be contacted for assistance in preparing the public notice text and the distribution requirements.

B.2. BSSP GW More Than 1000 People (rev.10.7.2021).

[Comments 11 through 13 apply to waterworks that chlorinate/disinfect. Delete if not applicable]

11. Disinfectant residual will be measured at the same time and from the same site as each routine and repeat bacteriological sample.

12. All disinfectant residuals will be measured with testing equipment using approved methods.

13. Where applicable, the disinfectant residuals will be reported to the _________ Field Office by the 10^{th} of the month following the month during which samples were taken. The disinfectant residual results must also be included along with the bacteriological results as reported by the laboratory.

14. ***[Optional]*** For quality control, the free chlorine residual will be monitored in the distribution system at a frequency of _____ days per week. The chlorine residual results will be reported in the Monthly Operation Report.

[Comments 15 and 16 apply to waterworks that chlorinate/disinfect or have other applicable treatment processes as determined by VDH Office of Drinking Water. Delete if not applicable]

15. Separate from triggered source water sampling requirements, a raw water sample from each groundwater source will be collected every ________ (month)(quarter)(year) at a minimum from each groundwater source. These samples will be analyzed by a test method that provides a Most Probable Number (MPN) determination for both total coliform and *E.coli*.

16. Additional monitoring may be required based on the results of source water samples.

Owner/Representative Name: ______________________________

Signature: ______________________________

Title: ______________________________

Date: ______________________________

Attachment: System piping Map

B.3. BSSP SW & GUDI Sources (rev.10.7.2021).

BACTERIOLOGICAL SAMPLE SITING PLAN (BSSP)
(For Surface Water or GUDI Source Waterworks)

Waterworks Name: ______________________________
PWSID: ______________________________
Population Served: ______________________________

Purpose: The purpose of this plan is to identify specific bacteriological sampling sites and monitoring requirements for routine and repeat source water monitoring. In addition this plan identifies disinfectant residual monitoring requirements for compliance determination as well as for distribution system quality control measures.

Sampling Plan:

1. The ______________________waterworks is currently required to collect __________ water samples for total coliform analysis each month.

2. The routine and repeat sampling sites are identified below and are shown on the attached waterworks piping map. The routine sites were chosen to be representative of the water quality throughout the distribution system.

Routine Sample Site Locations (911 Address)		**Repeat Sample Site Locations (911 Address)**	
010		**01U**	
		01D	
020		**02U**	
		02D	
030		**03U**	
		03D	
040		**04U**	
		04D	
050		**05U**	
		05D	
060	***Add rows as needed***	**06U**	
		06D	

3. Routine bacteriological samples will be collected from each of the above routine sites on a rotating basis. Samples will be collected at regular intervals throughout the month.

4. Repeat samples are required to be collected when a routine total coliform-positive result occurs. Collection is required within 24 hours of notification. Any routine or repeat total coliform-positive sample must also be analyzed for *E. coli* in accordance with the *Waterworks Regulations*.

5. The routine sample sites are chosen to allow for the collection of required upstream and downstream repeat samples when necessary. Three repeat samples will be collected on the same day from:
   a) the total coliform-positive sample location; and
   b) a location within 5 service connections upstream of the total coliform-positive sample location; and

c) a location within 5 service connections downstream of the total coliform-positive sample location.

6. ***[Only for waterworks population ≥ 33,001. Delete for < 33,001]*** A minimum of one set of repeat samples is required for each routine total coliform-positive sample. If one or more repeat samples are total coliform-positive, an additional set(s) of repeat samples are due within 24 hours of notification unless the requirement for a Level 1 or 2 Assessment is generated. Additional sets of repeat samples will be collected until either total coliforms are not detected in one complete set of repeat samples or the requirement for a Level 1 or 2 Assessment is generated.

7. The waterworks will notify the appropriate ODW field office if any repeat sample is *E. coli* positive or any repeat sample is total coliform-positive following a routine *E. coli* positive sample. Notification is due by the end of the business day after the waterworks has been notified of the monitoring result.

[Include Nos. 8 and 9 for waterworks that purchase groundwater. NOTE: Add triggered source water sample site in above table. If groundwater is not purchased delete Nos. 8 and 9]

8. The wholesaler waterworks, ____________________, will be notified within 24-hours of the routine total coliform-positive distribution system sample so that the triggered source water sample(s) is(are) collected from the wholesaler's well(s) raw water sample tap(s), located prior to treatment.

9. Five additional source water samples will be collected from the same groundwater source of any *E. coli* positive triggered source water sample. Sampling will be within 24 hours of notification. These samples are to be collected approximately 15 minutes apart while the well pump is running. In addition, consumers will be notified within 24 hours of the *E. coli* positive triggered sample result. The ODW will be contacted for assistance in preparing the public notice text and the distribution requirements.

10. The disinfectant residual will be measured at the same time and from the same location as each routine and repeat bacteriological sample.

11. All disinfectant residuals will be measured with testing equipment using approved methods.

12. Where applicable, the disinfectant residuals will be reported to the _________ Field Office by the 10th of the month following the month during which samples were taken. The disinfectant residual results must also be included along with the bacteriological results as reported by the laboratory.

13. ***[Optional]*** For quality control, the free chlorine residual will be monitored in the distribution system at a frequency of ______ days per week. The chlorine residual results will be reported in the Monthly Operation Report.

Owner/Representative Name: ____________________________________
Signature: ____________________________________
Title: ____________________________________
Date: ____________________________________

Attachment: System piping map

B.4. BSSP TNC Seasonal Waterworks (rev. 10/7/2021)

BACTERIOLOGICAL SAMPLE SITING PLAN (BSSP)
(for Seasonal Waterworks)

Waterworks Name: ____________________________________
PWSID: ____________________________________
Population Served: ____________________________________

[Note: If a waterworks provides 4-log virus inactivation treatment either voluntarily or as required by the Waterworks Regulations, triggered source water monitoring is not required for the sources being treated. Delete references below where applicable.]

Purpose: The purpose of this plan is to identify specific bacteriological sampling sites and monitoring requirements for routine, repeat, triggered and routine source water monitoring. [***If applicable***: In addition, this plan identifies disinfectant residual monitoring requirements (for compliance determination as well as) for distribution system quality control measures.]

Sampling Plan:

1. The ____________________________ waterworks is currently required to collect ___________ routine water sample(s) for total coliform analysis each month that the waterworks is in operation. Prior to startup each season, the approved Seasonal Start-up Procedures must be completed.

2. The routine, repeat and triggered source water sampling sites are identified below and are shown on the attached waterworks piping map. The routine sites were chosen to be representative of the water quality throughout the distribution system.

Routine Sample Sites (911 Address or Location)		**Repeat and Triggered Source Water Sample Sites (911 Address or Location)**	
010		**01U**	
		01D	
		Source(s)	
020		**02U**	
		02D	
		Source(s)	
030		**03U**	
		03D	
		Source(s)	

3. Routine bacteriological samples will be collected from each of the above Routine Locations on a rotating basis.

4. Repeat and triggered source water samples will be collected when a routine total coliform-positive result occurs. Collection is required within 24 hours of notification. Any total coliform-positive routine, repeat or triggered source water sample will also be analyzed for *E. coli* in accordance with the *Waterworks Regulations*.

5. Triggered source water samples will be collected from each groundwater source in service at the time of collection of the routine total coliform-positive sample. Triggered source water samples will be collected from the well ***[or spring, if applicable]*** raw water sample tap, located prior to treatment.

6. ***Choose either a. or b.***
a. [Repeat sampling instruction for waterworks with repeat sample sites. Delete if not applicable.] The routine sample sites are chosen to allow for the collection of required upstream and downstream repeat samples when necessary. Three repeat samples will be collected on the same day from:
(a) the total coliform-positive sample location; and
(b) a location within five service connections upstream of the total coliform-positive sample location; and ***[Alternate Option: if waterworks has a single untreated groundwater well and serves a population of ≤ 1000, the triggered source water sample can be counted as the upstream repeat sample.]***
(c) a location within five service connections downstream of the total coliform-positive sample location.

b. [Repeat sampling instructions for waterworks with only a single approved sample site. Delete if not applicable]
The three repeat samples will be collected from the routine site over a three-day period (one sample per day) ***or*** the three repeat samples will be collected approximately 15 minutes apart from the routine site on the same day.

7. The waterworks will notify the appropriate ODW Field Office if any repeat sample is *E. coli* positive or any repeat sample is total coliform-positive following a routine *E. coli* positive sample. Notification is due by the end of the business day after the waterworks has been notified of the monitoring result.

8. Five additional source water samples will be collected from the same raw water source of any *E. coli* positive triggered source water sample. Sampling will be within 24 hours of notification. These samples will be collected approximately 15 minutes apart while the well pump is running. In addition, consumers will be notified within 24 hours of the *E. coli* positive triggered sample result. The ODW will be contacted for assistance in preparing the public notice text and the distribution requirements.

[Comments 9 through 12 apply to waterworks that chlorinate/disinfect. Delete if not applicable]

9. Disinfectant residual will be measured at the same time and from the same location as each routine and repeat bacteriological sample.

10. All disinfectant residuals will be measured with testing equipment using approved methods.

11. Where applicable, the disinfectant residuals will be reported to the _________ Field Office by the 10th of the month following the month during which samples were taken. The disinfectant residual results must also be included along with the bacteriological results as reported by the laboratory.

12. ***[Optional]*** For quality control, the disinfectant residual will be monitored in the distribution system at a frequency of ____ days per week. These disinfectant residual results will be reported in the Monthly Operation Report.

B.4. BSSP TNC Seasonal Waterworks (rev. 10/7/2021)

[Comments 13 and 14 apply to waterworks that chlorinate/disinfect or have other applicable treatment processes as determined by VDH Office of Drinking Water. Delete if not applicable]

13. Separate from triggered source water sampling requirements, a raw water sample from each groundwater source will be collected every ________ (month)(quarter)(year) at a minimum from each groundwater source. These samples will be analyzed by a test method that provides a Most Probable Number (MPN) determination for both total coliform and *E.coli*.

14. Additional monitoring may be required based on the results of source water samples.

Owner/Representative Name: ______________________________

Signature: ______________________________

Title: ______________________________

Date: ______________________________

Attachment: System piping map

Attachment B.5. BSSP Table for Multiple Pressure Zones - Example

Example BSSP Table for Multiple Pressure Zones

The following tables are examples that can be used if the waterworks has more than one pressure zone. Cut and paste into BSSP template that will be used.

Routine Sample Site (911 Address or Site)		**Repeat and Triggered Source Water Sample Sites (911 Address or Site)**	
Downtown Zone			
010	***123 Main Street***	**010U**	
		010D	
		Source(s)	
020	***456 1st Street***	**020U**	
		020D	
		Source(s)	
030	***789 Cross Street***	**030U**	
		030D	
		Source(s)	
High Elevation Zone			
050	***1034 High Street***	**050U**	
		040D	
		Source(s)	
060	***4501 Ridgeline Way***	**060U**	
		060D	
		Source(s)	
070	***3241 Peak Drive***	**070U**	
		070D	
		Source(s)	

Routine Sample Site (911 Address or Site)		**Repeat and Triggered Source Water Sample Sites (911 Address or Site)**	
010	***123 Main Street*** **(Downtown Zone)**	**010U**	
		010D	
		Source(s)	
020	***456 1st Street*** **(Downtown Zone)**	**020U**	
		020D	
		Source(s)	
030	***789 Cross Street*** **(Downtown Zone)**	**030U**	
		030D	
		Source(s)	
040	***1034 High Street*** **(High Elevation Zone)**	**040U**	
		040D	
		Source(s)	
050	***4501 Ridgeline Way*** **(High Elevation Zone)**	**050U**	
		040D	
		Source(s)	
060	***3241 Peak Drive*** **(High Elevation Zone)**	**060U**	
		060D	
		Source(s)	

REVIEW SHEET FOR THE BACTERIOLOGICAL SAMPLE SITING PLAN (BSSP)

City/County:____

Waterworks: _______________________________________

PWSID#: ____

Prepared By: _______________________________________

Date Received: ____________________________________

Reviewed By: ______________________________________

Original Plan ( )   Revision ( ) Prior Approval Date_______

A. BACTERIOLOGICAL SAMPLE SITING PLAN

1. Waterworks population: ____

2. Required number of bacteriological samples:____

3. Frequency of monitoring: ____

4. Source of water (Surface, GUDI, Well, Spring): ____

5. Wholesale waterworks? { } Yes { } No

   If yes, name of consecutive waterworks____

6. Consecutive waterworks? { } Yes { } No

   If yes, name of wholesale waterworks____

7. Year round operated waterworks with some components shutdown during the year? { } Yes { } No

   Start-up Procedure approval date: ____

Seasonal Waterworks: { } N/A

8. Seasonal waterworks dates of operation:____

9. Start-up Procedure approval date: ____

Routine Sample Sites:

10. Required number of routine sample sites: ____

11. Is the number of routine sample sites provided adequate? { } Yes { } No

12. Does the waterworks have multiple pressure zones? { } Yes { } No

If yes, are samples collected from each pressure zone? { } Yes { } No

13. Do routine sample sites provide representative monitoring of the distribution system? { } Yes { } No

Repeat Sample Sites:

14. Are repeat sample sites located within 5 connections upstream and downstream of each routine site?

    { } Yes { } No

    If no, have alternative repeat locations been approved? { } Yes { } No

15. Are all repeat sites in the same pressure zone as the routine sample site? { } Yes { } No

16. Map showing sample sites provided? { } Yes { } No

Comments: ____
____

B. TRIGGERED AND ROUTINE SOURCE WATER MONITORING PLAN { } N/A

1. All groundwater sources identified on plan (Including purchased GW sources)? { } Yes { } No

2. Is this a single untreated groundwater source serving 1,000 or Fewer People? { }Yes { } No

   If yes, will the triggered source water sample be counted as the upstream repeat sample? { }Yes { } No

3. Map showing location of groundwater sources provided? { } Yes { } No

4. Additional source water monitoring requirements identified (MPNs)? { } Yes { } No

5. Public notification requirements identified for triggered *E. coli*-positive sample? { } Yes { } No

Comments: ____
____

C. DISINFECTANT RESIDUAL MONITORING PLAN { } N/A

1. Disinfectant residual monitoring and reporting requirements identified for compliance purposes.

   { } Yes { } No

2. Disinfectant residual monitoring and reporting requirements identified for quality control purposes.

   { } Yes { } No

3. Approved methods for measuring disinfectant residuals identified. { } Yes { } No

Comments: ____
____

ATTACHMENT C.2. BSSP APPROVAL LETTER

INSTRUCTIONS: Complete / select items shown with *italics*, and convert to regular font. Print on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have reviewed the Bacteriological Sample Siting Plan (BSSP) dated *(date)*, for the subject waterworks. The BSSP satisfies the requirements of the *Waterworks Regulations* and is approved. A copy of the approved plan is enclosed.

The enclosed plan refers to the use of SITE ID NUMBERS to identify approved sampling locations. Please use the Site ID number on the bacteriological form submitted with each sample. Identify repeat sample locations by changing the last digit in the number to a U for samples collected upstream of the original sample location, a D for samples collected downstream of the original sample location, and an R for the repeat sample at the original sample location. For example:

Original sample	code number = 010
Repeat sample at same site	code number = 01R
Sample collected upstream	code number = 01U
Sample collected downstream	code number = 01D
Source water sample	code number = RW

Using these code numbers will help you keep track of the required bacteriological samples in accordance with the *Waterworks Regulations*.

If we may be of any assistance to you in implementing the BSSP, please contact *(name)*, District Engineer at *(phone, email)*.

Sincerely,

Engineering Field Director
Field office name

Enclosure: Approved BSSP
Cc: *Local Health Department, attn: (Insert name), Health Director*

ATTACHMENT C.3. REQUIRED ACTIONS DUE TO ROUTINE TC+ RESULTS

INSTRUCTIONS: Complete / select items shown with *italics*, and convert to regular font. Print on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

This office has been advised that the routine bacteriological water sample collected on *(date)* from the *(sample location)* indicated the presence of total coliform bacteria. In accordance with the Commonwealth of Virginia *Waterworks Regulations* and your waterworks approved Bacteriological Sample Siting Plan (BSSP), you are required to take the following action(s):

Select the Appropriate Actions:

Action 1: Collect three **repeat** samples within 24 hours of receipt of this notification. These samples must be collected on the same day from locations identified in your approved BSSP. Enclosed are three bacteriological sample test kits for your use.

Action 2: Collect one **triggered** source water sample from each groundwater source in use, prior to any treatment or chemical addition, using the raw water source sampling location(s) identified in your BSSP. This sample must be collected on the same day as the repeat samples. Enclosed is a sample test kit for your use.

Action 3: Collect three **routine** samples during the month of *(month).* These samples can be collected at regular time intervals during the month, or may be collected on a single day if the samples are collected from different sample locations identified in the approved BSSP.

Action 4 *(A single well without treatment may use the GWR triggered source water monitoring sample to meet the upstream repeat sample requirement.)*: Collect two **repeat** samples and one **triggered** source water sample within 24 hours of receipt of this letter, for a total of three samples, on the same day. Samples must be collected from the following locations:

1. One sample from the same sample location as the original positive sample
2. One sample downstream from the sample location as the original positive sample
3. One triggered source water sample from the well raw water sample tap

ATTACHMENT C.3. REQUIRED ACTIONS DUE TO ROUTINE TC+ RESULTS

INSTRUCTIONS: Complete / select items shown with *italics*, and convert to regular font. Print on VDH letterhead. Pages are 1" top, bottom, and side margins.

Enclosed are *(number of kits)* bacteriological sample kits with input forms and labels for you to complete at the time of each sample collection, to ensure proper processing and analysis. *[Other specific instructions if appropriate for any specific waterworks.]*

If you have any questions or concerns, please contact me at *(phone number)* or email at *(email address).*

Sincerely,

Name & Title
Name of Field Office

Enclosure: *(number)* Bacteriological Sample Kits

cc: *Local Health Department, attn: (Insert name), Health Director*
VDH, ODW-Central Office

Instructions: *This file contains a generic D/DBP Monitoring Plan template that addresses monitoring for disinfectant residuals, disinfection byproducts, and disinfection byproduct precursors. To customize a plan for a specific waterworks, complete items shown in italics, and delete those items that are not applicable.*

DISINFECTANTS / DISINFECTION BYPRODUCTS MONITORING PLAN

Waterworks Name: ______________________________

PWSID #: ______________________________

Source Type: ______________________________

Population Served: ______________________________

DISINFECTANT RESIDUALS *{exclude if already included with BSSP}*

1. The disinfectant residual will be measured at the same time and from the same location as each routine bacteriological sample, as identified in the current Bacteriological Sample Siting Plan.
2. *{For waterworks using chlorine dioxide}* The chlorine dioxide residual will be routinely monitored once per day at the entry point(s) into the distribution system. If a routine result exceeds the MRDL (0.8 mg/L), special sampling and reporting will be done in accordance with the *Waterworks Regulations*.
3. Compliance will be calculated in accordance with the *Waterworks Regulations.*
4. The disinfectant residual will be reported to the *{insert field office}* Field Office by the 10th of the month following the month during which samples were taken. The disinfection residual results will be reported by the laboratory along with the bacteriological results or on the Monthly Operating Report.
5. *{Optional}* For quality control, the *{pick one: (free chlorine) (chlorine dioxide})* residual will be monitored in the distribution system at a frequency of *{insert #}* days per week. The *{pick one: (free chlorine) (chlorine dioxide)}* residual results will be reported in the Monthly Operation Report.

Instructions: *This file contains a generic D/DBP Monitoring Plan template that addresses monitoring for disinfectant residuals, disinfection byproducts, and disinfection byproduct precursors. To customize a plan for a specific waterworks, complete items shown in italics, and delete those items that are not applicable.*

CONTROL OF DISINFECTION BY-PRODUCTS PRECURSORS

1. For routine monitoring, TOC and alkalinity (source water only) parameters will be monitored from the following locations on a monthly *{or greater frequency if the owner chooses}* basis. *{one entry for each source}*

{SWTP with combined filter monitoring location}

	Code No.	Source/Treatment Plant	Sample Tap Location
Source Water	RW001		
Treated Water	UP001		

{SWTP with individual filter sample locations}

	Code No.	Source/Treatment Plant	Sample Tap Location
Source Water	RW001		
Treated Water	UP001	Filter No. 1	
Treated Water	UP002	Filter No. 2	

2. For reduced monitoring, parameters will be monitored on a quarterly basis.
3. Paired samples will be taken at a time representative of normal operating conditions and influent (raw) water quality.
4. Compliance will be calculated in accordance with the *Waterworks Regulations.*
5. The sample results will be reported to the *{field office name}* Field Office by the 10th of the month following the month during which samples were taken.

DISINFECTION BYPRODUCTS - TTHM and HAA5 *(Insert the appropriate template)*

1. Use Template #1 for GW < 500.
   Use Template #2 for GW 500-9,999.
   Use Template #3 for GW $\geq$10,000.
   Use Template #4 for SW < 500.
   Use Template #5 for SW 500-3,300.
   Use Template #6 for SW > 3,300.

2. Compliance calculations for the Location Running Annual Average (LRAA) and the Operational Evaluation Level (OEL) will be made in accordance with the *Waterworks Regulations.*
3. The location, date, and result of each sample taken will be reported to the *{field office name}* Field Office by the 10th of the month following the month that the samples were collected.
4. Analyses shall be made by a certified laboratory.
5. If a waterworks qualifies for reduced monitoring, this plan shall be amended to include the locations and time of such monitoring.

Instructions: *This file contains a generic D/DBP Monitoring Plan template that addresses monitoring for disinfectant residuals, disinfection byproducts, and disinfection byproduct precursors. To customize a plan for a specific waterworks, complete items shown in italics, and delete those items that are not applicable.*

DISINFECTION BYPRODUCTS – {pick one: (BROMATE) (CHLORITE)}

*{For each SWTP/GUDI that uses **ozone**}*

1. For routine monitoring, bromate will be monitored at the Entry Point on a monthly basis. Bromate monitoring may be reduced to quarterly, if the Waterworks Regulations criteria is met.
2. Analyses shall be made by a certified laboratory

*{For waterworks using **chlorine dioxide**}*

1. The chlorite residual will be routinely monitored once per day at the **entry point(s)** into the distribution system. If a routine result exceeds the MCL (0.8 mg/L), special sampling and reporting will be done in accordance with the *Waterworks Regulations*. There is no reduced monitoring allowed for entry point sampling.
2. The chlorite residual will be routinely monitored once per month at the three locations noted below in the **distribution system**. If a routine result exceeds the MCL (0.8 mg/L), special sampling and reporting will be done in accordance with the *Waterworks Regulations*. For reduced monitoring, the *Waterworks Regulations* will be followed.
3. Analyses shall be made by a certified laboratory

Site Closest to 1st Customer	
Site Representing Average Residence Time	
Site Representing Maximum Residence Time	

{For either ozone or chlorine dioxide users, add}

4. Compliance will be calculated in accordance with the *Waterworks Regulations.*
5. The sample results will be reported to the *{field office name}* Field Office by the 10th of the month following the month during which samples were taken.

Signature: ________________________

Name: ________________________

Title: ________________________

Date: ________________________

Instructions: *This file contains a generic D/DBP Monitoring Plan template that addresses monitoring for disinfectant residuals, disinfection byproducts, and disinfection byproduct precursors. To customize a plan for a specific waterworks, complete items shown in italics, and delete those items that are not applicable.*

TEMPLATE 1: GROUNDWATER SYSTEM, POPULATION < 500

1. For routine monitoring, annual disinfection byproduct samples will be taken at the location(s) listed below. The individual/dual *{pick one}* TTHM and HAA5 samples will be taken during normal operations in *{month(s) of highest DBP formation}*.

{Pick individual - if high TTHM and HAA5 sites are different}

Site ID	Site Location / Address	Comments
		Individual - TTHM only
		Individual - HAA5 only

{Pick dual – if high TTHM and HAA5 site are the same}

Site ID	Site Location / Address	Comments
		Dual TTHM and HAA5

TEMPLATE 2: GROUNDWATER SYSTEM, POPULATION = 500-9,999

1. For routine monitoring, annual disinfection byproduct samples will be taken at the locations listed below. The dual TTHM and HAA5 samples will be taken at the same time during normal operations in *{month of highest DBP formation}*.

Site ID	Site Location / Address	Comments

TEMPLATE 3: GROUNDWATER SYSTEM, POPULATION ≥10,000

1. For routine monitoring, quarterly disinfection byproduct samples will be taken at the locations listed below. The dual TTHM and HAA5 samples will be taken at the same time during normal operations in {January, April, July and October} / {February, May, August and November} / {March, June, September and December} *{pick group with month of highest DBP formation}.*

Site ID	Site Location / Address	Comments

Instructions: *This file contains a generic D/DBP Monitoring Plan template that addresses monitoring for disinfectant residuals, disinfection byproducts, and disinfection byproduct precursors. To customize a plan for a specific waterworks, complete items shown in italics, and delete those items that are not applicable.*

TEMPLATE 4: SURFACE WATER SYSTEM, POPULATION < 500

1. For routine monitoring, annual disinfection byproduct samples will be taken at the location(s) listed below. The individual/dual *{pick one}* TTHM and HAA5 samples will be taken at the same time during normal operations in *{month of highest DBP formation}*.

{Pick individual - if high TTHM and HAA5 sites are different}

Site ID	Site Location / Address	Comments
		Individual - TTHM only
		Individual - HAA5 only

{Pick dual – if high TTHM and HAA5 site are the same}

Site ID	Site Location / Address	Comments
		Dual TTHM and HAA5

There is no reduced sampling for surface water systems serving < 500 people.

TEMPLATE 5: SURFACE WATER SYSTEM, POPULATION = 500-3,300

1. For routine monitoring, quarterly disinfection byproduct samples will be taken at the location(s) listed below. The individual/dual *{pick one}* TTHM and HAA5 samples will be taken at the same time during normal operations in {January, April, July and October }{ February, May, August and November}{March, June, September and December}. *{pick group with month of highest DBP formation}.*

{Pick individual - if high TTHM and HAA5 sites are different}

Site ID	Site Location / Address	Comments
		Individual - TTHM only
		Individual - HHA5 only

{Pick dual – if high TTHM and HAA5 site are the same}

Site ID	Site Location / Address	Comments
		Dual TTHM and HAA5

Instructions: *This file contains a generic D/DBP Monitoring Plan template that addresses monitoring for disinfectant residuals, disinfection byproducts, and disinfection byproduct precursors. To customize a plan for a specific waterworks, complete items shown in italics, and delete those items that are not applicable.*

TEMPLATE 6: SURFACE WATER SYSTEM, POPULATION > 3,300

1. For routine monitoring, quarterly disinfection byproduct samples will be taken at the locations listed below. The dual TTHM and HAA5 samples will be taken at the same time during normal operations in *{pick group with month of highest DBP formation:* January, April, July and October / February, May, August and November / March, June, September and December}.

Site ID	Site Location / Address	Comments

Add rows as needed

Owner Name:____________________________________

Signature: ____________________________________

Title: ____________________________________

Date: ____________________________________

STAGE 2 REVISED MONITORING PLAN - REVIEW SHEET

City/County ______________________ PWSID# ______________________________
Waterworks ______________________ Reviewed By: ______________________________

I. GENERAL INFORMATION		COMMENTS
Population Served? __________ Source Water ☐ GW ☐ SW		☐Reduced: # site = ____ Frequency = ____ ☐Routine: # site = ____ Frequency = ____ ☐Increased: # site = ____ Frequency = ____
Revision Due to:		

II. NON-TTHM/HAA5 CONTENT		COMMENTS
Disinfectant residuals-same as before?	☐ Yes ☐ No ☐ n/a	
Precursors (TOC) -same as before?	☐ Yes ☐ No ☐ n/a	
Bromate/chlorite-same as before?	☐ Yes ☐ No ☐ n/a	
If no, justified? (explain)	☐ Yes ☐ No ☐ n/a	

III. TTHM/HAA5 CONTENT		COMMENTS
Any changes since last plan approved		
Monitoring Dates & Locations Listed		
Compliance Calculations Referenced		
Peak Month? ___________ Included in plan? ☐ Yes ☐ No		
Frequency adequate & equally spaced?		
Location and Justification (alternating highest remaining TTHM – HAA5) ☐ Yes ☐ No Site 1- Site 2- Site 3- Site 4-		
Non-highest sites included? ☐ Yes ☐ No Justified? ☐ Yes ☐ No		

<u>General comments & discussion</u>:

DETERMINATION:
Monitoring Plan ☐ **IS** ☐ **IS NOT** acceptable. Date Review Completed: __________

Operational Evaluation Reporting Form

I. GENERAL INFORMATION

A. Facility Information

Facility Name: ______________________ PWSID: ______________

Facility Address: ______________________

City: ______________________ State: _____ Zip: _______

B. Report Prepared by:

(Print): ______________________ Date prepared: ______________

(Signature): ______________________

Contact Telephone Number: ______________________

II. MONITORING RESULTS

A. Provide the Compliance Monitoring Site(s) where the OEL was Exceeded.

____

Note: The site name or number should correspond to a site in your Stage 2 DBPR compliance monitoring plan.

B. Monitoring Results for the Site(s) Identified in II.A (include duplicate pages if there was more than one exceedance)

1. Check TTHM or HAA5 to indicate which result caused the OEL exceedance. ☐ TTHM ☐ HAA5
2. Enter your results for TTHM or HAA5 (whichever you checked above).

	Quarter			**Operational Evaluation Value**
	Results from Two Quarters Ago	Prior Quarter's Results	Current Quarter	
	A	B	C	D = (A+B+(2*C))/4
Date sample was collected				
TTHM (mg/L)				
HAA5 (mg/L)				

Note: *The operational evaluation value is calculated by summing the two previous quarters of TTHM or HAA5 values plus twice the current quarter value, divided by four. If the value exceeds 0.080 mg/L for TTHM or 0.060 mg/L for HAA5, an OEL exceedance has occurred.*

C. Has an OEL exceedance occurred at this location in the past?	☐ Yes	☐ No
If NO, proceed to item D. If YES, when did exceedance occur?		
Was the cause determined for the previous exceedance(s)?	☐ Yes	☐ No
Are the previous evaluations/determinations applicable to the current OEL exceedance?	☐ Yes	☐ No

Operational Evaluation Reporting Form

III. OPERATIONAL EVALUATION FINDINGS

A. Did the State allow you to limit the scope of the operational evaluation? ☐ Yes ☐ No

If NO, proceed to item B. If YES, attach written correspondence from the State.

B. Did **the distribution system** cause or contribute to your OEL exceedance(s)? ☐ Yes ☐ No ☐ Possibly

If NO, proceed to item C. If YES or POSSIBLY, explain (attach additional pages if necessary):

____

____

____

C. Did the **treatment** system cause or contribute to your OEL exceedance(s)? ☐ Yes ☐ No ☐ Possibly

If NO, proceed to item D. If YES or POSSIBLY, explain (attach additional pages if necessary):

____

____

____

D. Did **source water quality** cause or contribute to your OEL exceedance(s)? ☐ Yes ☐ No ☐ Possibly

If NO, proceed to item E. If YES or POSSIBLY, explain (attach additional pages if necessary):

____

____

____

E. Attach all supporting operational or other data that support the determination of the cause(s) of your OEL exceedance(s).

F. If you are unable to determine the cause(s) of the OEL exceedance(s), list the steps that you can use to better identify the cause(s) in the future (attach additional pages if necessary):

____

____

____

G. List steps that could be considered to minimize future OEL exceedances (attach additional pages if necessary)

____

____

____

H. Total **Number of Pages** Submitted, Including Attachments and Checklists: ____________

Distribution System Evaluation Checklist

System Name: ____________________

Checklist Completed by: ____________________ Date: __________

A. Do you have disinfectant residual or temperature data for the monitoring location where you experienced the OEL exceedance? ☐ Yes ☐ No

If NO, proceed to item B. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Was the water temperature higher than normal for that time of the year at that location?
☐	☐	Was the disinfectant residual lower than normal for that time of the year at that location?
☐	☐	Was the disinfectant residual higher than normal for that time of the year at that location?

B. Do you have maintenance records available for the time period just prior to the OEL exceedance? ☐ Yes ☐ No

If NO, proceed to item C. If YES, answer the following questions:

Yes	No	
☐	☐	Did any line breaks or replacements occur in the vicinity of the exceedance?
☐	☐	Were any storage tanks or reservoirs taken off-line and cleaned?
☐	☐	Did flushing or other hydraulic disturbances (e.g., fires) occur in the vicinity of the exceedance?
☐	☐	Were any valves operated in the vicinity of the OEL exceedances?

C. If your system is metered, do you have access to historical records showing water use at individual service connections? ☐ Yes ☐ No

If NO, proceed to item D. If YES, was overall water use in your system unusually low, indicating higher than normal water age? ☐ Yes ☐ No

D. Do you have high-volume customers in your system (e.g., an industrial processing plant)? ☐ Yes ☐ No

If NO, proceed to item E. If YES, was there a change in water use by a high-volume customer? ☐ Yes ☐ No

E. Is there a finished water storage facility hydraulically upstream from the monitoring location where you experienced the OEL exceedance? ☐ Yes ☐ No

If NO, proceed to item F. If YES, review storage facility operations and water quality data to answer the following questions for the period in which the OEL exceedance occurred:

Yes	No	
☐	☐	Was a disinfectant residual detected in the stored water or at the tank outlet?
☐	☐	Do you know of any mixing problems with the tank or reservoir?
☐	☐	Does the facility operate in “last in-first out” mode?
☐	☐	Was the tank or reservoir drawn down more than usual prior to OEL exceedance, indicating a possible discharge of stagnant water?
☐	☐	Was there a change in water level fluctuations that would have resulted in increased water age within the tank or reservoir?

Distribution System Evaluation Checklist

F. Does your system practice booster chlorination? ☐ Yes ☐ No

If NO, proceed to item G. If YES, was there an increase in booster chlorination feed rates? ☐ Yes ☐ No

G. Did you have customer complaints in the vicinity of the OEL exceedance? ☐ Yes ☐ No

If NO, proceed to item H. If YES, explain.

____

____

____

____

____

H. Did concern about complying with a rule other than Stage 2 DBPR, such as the Lead and Copper rule, the RTCR, or any other rule constrain your options to reduce the DBP levels at this site? For example, are you limited by the need to maintain a detectable disinfectant residual in your ability to control DBP levels in the distribution system? ☐ Yes ☐ No

If NO, proceed to item I. If YES, explain below and consult EPA's *Simultaneous Compliance Guidance Manual* for alternative compliance approaches.

____

____

____

____

____

I. Conclusion

Did the distribution system cause or contribute to the OEL exceedance(s)? ☐ Yes ☐ No ☐ Possibly

If NO, proceed to evaluations of treatment systems and source water. If YES or POSSIBLY, explain below.

____

____

____

____

____

Treatment Process Evaluation Checklist

☐ **NO DATA AVAILABLE**

Facility Name: ____________________

Checklist Completed by: ____________________ Date: ____________

A. Review finished water data for the time period prior to the OEL exceedance(s) and compare to historical finished water data using the following questions:

Question		
Were DBP precursors (TOC, DOC, SUVA, bromide, etc.) higher than normal?	☐ Yes	☐ No
Was finished water pH higher or lower than normal?	☐ Yes	☐ No
Was the finished water temperature higher than normal?	☐ Yes	☐ No
Was finished water turbidity higher than normal?	☐ Yes	☐ No
Was the disinfectant concentration leaving the plant(s) higher than normal?	☐ Yes	☐ No
Were finished water TTHM/HAA5 levels higher than normal?	☐ Yes	☐ No
Were operational and water quality data available to the system operator for effective decision making?	☐ Yes	☐ No

B. Does the treatment process include predisinfection? ☐ Yes ☐ No

If NO, proceed to item C. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Was disinfected raw water stored for an unusually long time?
☐	☐	Were treatment plant flows lower than normal?
☐	☐	Were treatment plant flows equally distributed among different trains?
☐	☐	Were water temperatures high or warmer than usual?
☐	☐	Were chlorine feed rates outside the normal range?
☐	☐	Was a disinfectant residual present in the treatment train following predisinfection?
☐	☐	Were online instruments utilized for process control?
☐	☐	Did you switch to free chlorine as the oxidant?
☐	☐	Was there a recent change (or addition) of pre-oxidant?
☐	☐	Did you change the location of the predisinfection application?

C. Does your treatment process include presedimentation? ☐ Yes ☐ No

If NO, proceed to item D. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Were flows low?
☐	☐	Were flows high?
☐	☐	Were online instruments utilized for process control?
☐	☐	Was sludge removed from the presedimentation basin?
☐	☐	Was sludge allowed to accumulate for an excessively long time?
☐	☐	Do you add a coagulant to your presedimentation basin?
☐	☐	Was there a problem with the coagulant feed?

Treatment Process Evaluation Checklist

D. Does your treatment process include coagulation and/or flocculation? ☐ Yes ☐ No

If NO, proceed to item E. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Were there any feed pump failures or were feed pumps operating at improper feed rates?
☐	☐	Were chemical feed systems controlled by flow pacing?
☐	☐	Were there changes in coagulation practices or the feed point?
☐	☐	Did you change the type or manufacturer of the coagulant?
☐	☐	Do you suspect that the coagulant in use at the time of the OEL exceedance did not meet industry standards?
☐	☐	Did the pH or alkalinity change at the point of coagulant addition?
☐	☐	Were there broken or plugged mixers?
☐	☐	Were flow rates above the design rate or was there short-circuiting?

E. Does your treatment process include sedimentation or clarification? ☐ Yes ☐ No

If NO, proceed to item F. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Were there changes in plant flow rate that may have resulted in a decrease in settling time or carryover of process solids?
☐	☐	Were settled water turbidities higher than normal?
☐	☐	Was there any disruption in the sludge blanket that may have resulted in carryover to the point of disinfection?
☐	☐	Was there any maintenance in the basin that may have stirred sludge from the bottom of the basin and caused it to carry over to the point of disinfectant addition?
☐	☐	Was sludge allowed to accumulate for an excessively long time or was there a malfunction in the sludge removal equipment?

Treatment Process Evaluation Checklist

F. Does your treatment process include filtration? ☐ Yes ☐ No

If NO, proceed to item G. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Was there an increase in individual or combined filter effluent turbidity or particle counts?
☐	☐	Was there an increase in turbidity or particle loading onto the filters?
☐	☐	Was there an increase in flow onto the filters or malfunction of the rate of flow controllers?
☐	☐	Were any filters taken off-line for an extended period of time that caused the other filters to operate near maximum design capacity and creating the conditions for possible breakthrough?
☐	☐	Were any filters operated beyond their normal filter run time?
☐	☐	Were there any unusual spikes in individual filter effluent turbidity (which may indicate particulate or colloidal TOC breakthrough) in the days leading to the excursion?
☐	☐	Were all filters run in a filter-to-waste mode during initial filter ripening?
☐	☐	If GAC filters are used, is it possible the adsorptive capacity of the GAC bed was reached before reactivation occurred (leave blank if not applicable)?
☐	☐	If biological filtration is used, were there any process upsets that may have resulted in the breakthrough of TOC (leave blank if not applicable)?

G. Does your treatment process include primary disinfection by injecting chlorine prior to a clearwell? ☐ Yes ☐ No

If NO, proceed to item H. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Was there a sudden increase in the amount of chlorine fed or an increase in the chlorine residual?
☐	☐	Was there an increase in clearwell holding time?
☐	☐	Was the plant shut down or were plant flows low?
☐	☐	Was there an increase in clearwell water temperature?
☐	☐	Did you switch to free chlorine recently as the primary disinfectant?
☐	☐	Was the inactivation of *Giardia* and/or viruses exceptionally high?
☐	☐	Was there a change in the mixing strategy (i.e. mixers not used, adjustment of tank level)?

H. Does your plant recycle spent filter backwash or other streams? ☐ Yes ☐ No

If NO, proceed to item I. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Did a change in the recycle stream quality contribute to increased DBP precursor loading that was not addressed by treatment plant processes?
☐	☐	Did a recycle event result in flows in excess of typical or design flows?

Treatment Process Evaluation Checklist

I. Do you inject a disinfectant after your clearwell to maintain a distribution system residual? ☐ Yes ☐ No

If NO, proceed to item J. If YES, answer the following questions for the period in which an OEL exceedance occurred:

Yes	No	
☐	☐	Was there a sudden increase in the amount of chlorine fed?
☐	☐	Was there a switch from chloramines to free chlorine for a burnout period?
☐	☐	If using chloramines, was the chlorine-to-ammonia ratio in the proper range?
☐	☐	Was there a problem with either chlorine or ammonia mixing?

J. Did concern about complying with a rule other than Stage 2 DBPR, such as the Lead and Copper rule, the LT2ESWTR, or any other rule constrain your options to reduce the DBP levels at this site? For example, are you limited by other treatment targets/requirements in your ability to control precursors in coagulation/flocculation? ☐ Yes ☐ No

If NO, proceed to item K. If YES, explain below and consult EPA's *Simultaneous Compliance Guidance Manual* for alternative compliance approaches.

____

____

____

____

K. Conclusion

Did treatment factors and/or variations in the plant performance contribute to the OEL exceedance(s)? ☐ Yes ☐ No ☐ Possibly

If YES or POSSIBLY, explain below.

____

____

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Source Water Evaluation Checklist

☐ **NO DATA AVAILABLE**

System Name: ______________________________

Checklist Completed by: ______________________ Date: ______________

A. Do you have source water temperature data? ☐ Yes ☐ No

If NO, proceed to item B. If YES, was the source water temperature high? ☐ Yes ☐ No

If NO, proceed to item B. If YES, answer the following questions for the time period prior to the OEL exceedance.

Yes	No	
☐	☐	Was the raw water storage time longer than usual?
☐	☐	Did you place another water source on-line?
☐	☐	Were river/reservoir flow rates lower than usual? If yes, indicate the location of lower flow rates and the anticipated impact on the OEL exceedance.
☐	☐	Did point or non-point sources in the watershed contribute to the OEL exceedance?

B. Do you have data that characterizes organic matter in your source water (e.g., TOC, DOC, SUVA, color, THM formation potential)? ☐ Yes ☐ No

If NO, proceed to item C. If YES, were these values higher than normal? ☐ Yes ☐ No

If NO, proceed to item C. If YES, answer the following questions for the time period prior to the OEL exceedance.

Yes	No	
☐	☐	Did heavy rainfall or snowmelt occur in the watershed?
☐	☐	Did you place another water source on-line?
☐	☐	Did lake or reservoir turnover occur?
☐	☐	Did point or non-point sources in the watershed contribute to the OEL exceedance?
☐	☐	Did an algal bloom occur in the source water?
☐	☐	If algal blooms were present, were appropriate algae control measures employed (e.g. addition of copper sulfate)?
☐	☐	Did a taste and odor incident occur?

C. Do you have source water bromide data? ☐ Yes ☐ No

If NO, proceed to item D. If YES, were the bromide levels higher or lower than normal? ☐ Yes ☐ No

If NO, proceed to item D. If YES, answer the following questions for the time period prior to the OEL exceedance.

Yes	No	
☐	☐	Has saltwater intrusion occurred?
☐	☐	Are you experiencing a long-term drought?
☐	☐	Did heavy rainfall or snowmelt occur in the watershed?
☐	☐	Did you place another water source on-line?
☐	☐	Are you aware of any industrial spills in the watershed?

Source Water Evaluation Checklist

D. Do you have source water turbidity or particle count data? ☐ Yes ☐ No

If NO, proceed to item E. If YES, were the turbidity values or particle counts higher than normal? ☐ Yes ☐ No

If NO, proceed to item E. If YES, answer the following questions for the time period prior to the OEL exceedance.

Yes	No	
☐	☐	Did lake or reservoir turnover occur?
☐	☐	Did heavy rainfall or snowmelt occur in the watershed?
☐	☐	Did logging, fires, or landslides occur in the watershed?
☐	☐	Were river/reservoir flow rates higher than normal?

E. Do you have source water pH or alkalinity data? ☐ Yes ☐ No

If NO, proceed to item F. If YES, was the pH or alkalinity different from normal values? ☐ Yes ☐ No

If NO, proceed to item F. If YES, answer the following questions for the time period prior to the OEL exceedance.

Yes	No	
☐	☐	Was there an algal bloom in the source water?
☐	☐	If algal blooms were present, were algae control measures employed?
☐	☐	Did heavy rainfall or snowmelt occur in the watershed?
☐	☐	Has the PWS experienced diurnal pH changes in source water?

F. Conclusion

Did source water quality factors contribute to your OEL exceedance? ☐ Yes ☐ No ☐ Possibly

If YES or POSSIBLY, explain below.

____
____
____
____
____
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____
____

OPERATIONAL EVALUATION REPORT REVIEW SHEET

City / County ________________________________

Waterworks ________________________________

PWSID # ______________________

Consecutive waterworks ☐ Yes ☐ No

Reviewed By: ________________________________

	Date
OEL Exceeded Letter	
Report Received	
Modifications Requested	
Revisions Received	
Approved	

I. GENERAL INFORMATION		**COMMENT**
Report submitted within 90 days of OEL exceedance?	☐ Yes ☐ No	
Did waterworks request to limit scope?	☐ Yes ☐ No	
Was request to limit scope approved by ODW?	☐ Yes ☐ No	☐ NA
II. MONITORING RESULTS		
Which contaminants exceeded the OEL?	☐ TTHM	☐ HAA5
All sites where OELs were exceeded listed in report?	☐ Yes ☐ No	
Previous OEL exceedances at these sites discussed?	☐ Yes ☐ No	☐ NA
III. REPORT DISCUSSION		
Distribution System addressed?	☐ Yes ☐ No	☐ NA
Storage Tank operations/capacity	☐ Yes ☐ No	
Flushing	☐ Yes ☐ No	
Source Water addressed?	☐ Yes ☐ No	☐ NA
Sources	☐ Yes ☐ No	
Raw water quality	☐ Yes ☐ No	
Treatment Processes addressed?	☐ Yes ☐ No	☐ NA
Treatment	☐ Yes ☐ No	
Finished water quality	☐ Yes ☐ No	
IV. FUTURE PLANNING		
Plan to minimize future OEL exceedances presented?	☐ Yes ☐ No	
V. ATTACHMENTS		
Any attachments provided?	☐ Yes ☐ No	

Refer to the *EPA Operational Evaluation Guidance Manual* for further information located at Y:\02-Committees\202-Rule Teams\MDBP & ESWT Rules\02-EPA Guidance Manuals\Stage 2 Operational Evaluation Guidance\Operational Evaluation Guidance Manual.pdf

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have reviewed the *(proposed/revised)* Stage 2 Disinfectants and Disinfection Byproducts (D/DBP) Rule monitoring plan for the subject waterworks dated *(date)*. The plan meets the requirements of the *Waterworks Regulations* and is approved. A copy of the approved plan is enclosed.

Your waterworks is now under *(routine/increased/reduced)* monitoring for disinfection byproducts. Your next *(triennial/annual/quarterly)* samples for disinfection byproducts are due to be collected in *(month, year)*.

If you have any questions regarding this matter, please contact *(name)*, District Engineer, at *(phone #)* or *(email)*.

Sincerely,

(Name), Engineering Field Director
Name of field office

ABC:xyz

Enclosure: Approved Stage 2 D/DBP Rule Monitoring Plan

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have evaluated the results of the Total Organic Carbon (TOC) and alkalinity analyses performed on water sample collected during the quarter ending *(insert date)*.

(Select the appropriate option)

(Option 1) Compliance with the disinfection byproduct precursors (DBPP) treatment technique is determined quarterly and is verified by the running annual average (RAA) of the TOC Removal Ratio being ≥1. The average TOC Removal Ratio for the subject waterworks for the past four quarters is *(insert value)*. Therefore, this waterworks is in compliance with the treatment technique for the control of disinfection byproduct precursors.

(Option 2) Compliance with the disinfection byproduct precursors (DBPP) treatment technique is verified by the four-quarters running annual average (RAA) of the TOC Removal Ratio when the ratio ≥1 or when any one of the following six alternative compliance criteria is met:

- Source water TOC < 2.0 mg/L calculated quarterly as a RAA.
- Treated water TOC < 2.0 mg/L calculated quarterly as a RAA.
- Raw water SUVA ≤ 2.0 L/mg-m calculated quarterly as a RAA.
- Treated water SUVA ≤ 2.0 L/mg-m calculated quarterly as a RAA.
- Raw water TOC < 4.0 mg/L; Raw water alkalinity > 60 mg/L (as $CaCO_3$); TTHM < 40 µg/L; HAA5 < 30 µg/L each calculated quarterly as a RAA.
- TTHM < 40 µg/L and HAA5 < 30 µg/L each calculated quarterly as a RAA (this applies to plants that use only chlorine for disinfection).

Therefore, based on these results, this waterworks *(is/is not)* in compliance with the treatment technique for the control of disinfection byproduct precursors. *[If not in compliance, insert list of actions that the waterworks will need to perform.]*

(Option 3) The average TOC Removal Ratio for the subject waterworks for the past four quarters is *(insert value)* based on the following results *(select as appropriate):* [the average source water TOC for the past four quarters is _______ mg/L.] [the average treated water TOC for the past four quarters is ______ mg/L.] [the average raw water SUVA for the past four quarters is _______ L/mg-m.] [the average raw water TOC for the past four quarters is _______mg/L, the average raw water alkalinity for the past four quarters is ______ mg/L, the average distribution system trihalomethanes (TTHM) concentration at this waterworks

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

over the past four quarters is _______ mg/L, and the average haloacetic acid (HAA5) concentration over the past four quarters is ______ mg/L.] [the average trihalomethanes (TTHM) concentration at this waterworks over the past four quarters is _______ mg/L, and the average haloacetic acid (HAA5) concentration at this waterworks over the past four quarters is ______ mg/L.]

Therefore, this waterworks *(is/is not)* in compliance with the treatment technique for the control of disinfection byproduct precursors. *[If not in compliance, insert list of actions that the waterworks will need to perform.]*

If you have any questions, please do not hesitate to contact me at *(phone#)* or *(email)*.

Sincerely,

(Name), District Engineer
Name of field office

ABC:xyz

cc: VDH, ODW-Central Office

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have evaluated your request to limit the scope of the operational evaluation of your waterworks by letter dated *(date),* subsequent to the determination that the operational evaluation level (OEL) has been exceeded *(select as appropriate:0.080 mg/L for TTHM and 0.060 mg/L for HAA5, respectively).*

(Select the appropriate option)

(Option 1)

Your request is approved. Please submit the completed OEL report within 30 days of receipt of this letter, along with a copy of this approval, so that we may complete our review.

(Option 2)

Your request is not approved. Please complete the checklists that were previously provided to the best of your ability and submit the completed OEL report within 30 days of receipt of this letter, along with a copy of this letter, so that we may complete our review.

(Option 3)

We have evaluated your request and have the following comments/recommendations *(from the list below, select and describe as appropriate)*:

1. *In order to complete our review, we are requesting the following information:(List)*
2. *The following revisions are necessary to comply with the Waterworks Regulations:(List)*
3. *The following recommendations are offered:(List)*
4. *Other comments by field office (if applicable): (List)*

Please address these comments/recommendations and submit the completed report within 30 days of receipt of this letter, so that we may complete our review.

If you have any questions or desire further information regarding this matter, please do not hesitate to contact *(name & title)*, at *(phone)* or *(email)*.

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

Sincerely,

District Engineer (Deputy Field Director)
Field office name

ABC:xyz

cc: VDH, ODW-Central Office

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have received the Operational Evaluation Level (OEL) report dated *(date)*, for the subject waterworks. Following our review, we have determined that the report satisfies the requirements of the *Waterworks Regulations* and is approved.

Should you have any questions regarding operational evaluation or need any assistance in mitigating OEL issues at your waterworks, please contact *(name & title)*, at *(phone)* or *(email).*

Sincerely,

Engineering Field Director/Deputy Field Director
Field office name

ABC:xyz

cc:

Instructions: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner*:

We are in receipt of the Operational Evaluation Level (OEL) report dated *(date)* for the subject waterworks, as prepared by *(name)*. We have completed our review of the documents and have the following comments/recommendations *(from the list below, select and describe as appropriate)*:

1. *In order to complete our review, we are requesting the following information:(List)*

2. *The following revisions are necessary to comply with the Waterworks Regulations:(List)*

3. *The following recommendations are offered:(List)*

4. *Other comments by field office (if applicable): (List)*

Please address these comments and re-submit the completed OEL report within 30 days, so that we may complete our review. If you have any questions concerning the above comments/recommendations or desire further information regarding this matter, please do not hesitate to contact me at *(phone)* or *(email)*.

Sincerely,

District Engineer
Field office name

ABC:xyz

cc: VDH, ODW-Central Office

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font.

(NAME) WATERWORKS
PWSID #
LEAD & COPPER MATERIALS SURVEY

The *(Name)* waterworks has completed the Materials Survey and the required number of lead and copper sampling sites have been selected and approved by the property owners for inclusion in our lead and copper sampling plan. This is intended to comply with Section 12 VAC 5-590-375 B 1 of the *Waterworks Regulations*, as it pertains to lead and copper monitoring.

The following details the categories of the sites selected with the corresponding number of structures for each category:

	Tier	No. of Possible Sites	No. of Selected Sites
Single- Family Structures with lead service lines	1		
Single-Family Structures with lead pipes	1		
Single- Family Structures with copper pipe and lead solder constructed between January 1983 and April 1986 [11]	1		
Multi-Family Residences with copper pipe and lead solder constructed between January 1983 and April 1986[1]	2		
Single-Family Structures with copper pipes and lead solder constructed before January 1983	3		
Others [e.g., plastic pipe (PVC, Polyethylene) or copper pipe constructed after April 1986]	Other		
TOTALS			

The following sources have been explored in the Materials Survey to determine the above breakdown of structures:

___ Plumbing and/or Building Codes [2]
___ Plumbing and/or Building Permits [2]
___ Distribution system maps [2]
___ Utility records (meter installation, maintenance, complaints, etc.) [2]
___ Meter readers
___ Senior/Retired staff
___ Community Survey
___ Interviews with Building Inspectors
___ Survey of service area plumbers
___ Interview with local contractors and/or developers
___ Others

Please advise me if the Material Survey is acceptable to the Virginia Department of Health and if I am approved to begin the required routine lead and copper sampling.

[1] Assumes plumbing installed after this date used lead-free solder.
[2] Required by the *Waterworks Regulations.*

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font.

LEAD & COPPER SAMPLING LOCATIONS

WATERWORKS NAME ______________________________ PWSID# _________________________

INSTRUCTIONS:

1. *For each selected sample site, provide the type and year of construction to justify the choice of tier classification for that site; e.g., single family residence, 1985.*
2. *A single-family structure is a building used as a residence. One characteristic of this structure is that there is a direct entrance to the street or thoroughfare and there are no shared features; e.g., townhomes.*
3. *If a selected sample site becomes unavailable in the future, the replacement site must be of the same tier classification. Provide for extra sites in the sample pool.*
4. *A site not listed in this sample pool must first be approved by the ODW before it can be used for lead and copper monitoring.*
5. *For the purposes of site selection, a multi-family residence (MFR) is considered a building or structure configured to house several different families living as year-round residents in separate housing units. These units can be built one on top of another (such as multiplexes and apartment buildings), or side-by-side. One characteristic of this structure is a shared entrance to the street or thoroughfare, and possibly shared amenities. Other similar structures, where there might be individuals "residing on a year round" basis, may need to be evaluated on a case-by-case basis; e.g., boarding schools, hospitals, nursing homes, etc. to determine the tier classification of the sample site.*
6. *If the number of selected tiered sites (i.e., Tier 1, Tier 2, and Tier 3) is insufficient, representative sites can be added to make up the sampling pool. A representative site is a site in which the plumbing materials used at that site would be commonly found at other sites served by the waterworks.*

Tier 1,2,3 or Other	Describe Tier Classification	Location (911 address)

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font.

Tier 1,2,3 or Other	Describe Tier Classification	Location (911 address)

(NAME) WATERWORKS
PWSID #
LEAD & COPPER MATERIALS SURVEY

The *(Name)* waterworks has completed the Materials Survey and the required number of lead and copper sampling sites have been selected for inclusion in our lead and copper sampling plan. This is intended to comply with Section 12 VAC 5-590-375 B 1of the *Waterworks Regulations*, as it pertains to lead and copper monitoring.

The following details the categories of the sites selected with the corresponding number of structures for each category:

	Tier	No. of Possible Sites	No. of Selected Sites
Buildings served by a lead service line or containing lead pipe, or with copper pipe and lead solder constructed between January 1983 and April 1986[11]	1		
Buildings with copper pipe and lead solder constructed before January 1983	2		
Others [e.g., plastic pipe (PVC, Polyethylene), copper pipe constructed after April 1986]	Other		
TOTALS			

The following sources have been explored in the Materials Survey to determine the above breakdown of structures:

___ Plumbing and/or Building Codes [2]
___ Plumbing and/or Building Permits [2]
___ Distribution system maps [2]
___ Utility records (meter installation, maintenance, complaints, etc.) [2]
___ Senior/Retired staff
___ Interviews with Building Inspectors
___ Survey of service area plumbers
___ Interview with local contractors and/or developers
___ Others

Please advise me if the Material Survey is acceptable to the Virginia Department of Health and if I am approved to begin the required routine lead and copper sampling.

[1] Assumes plumbing installed after this date used lead-free solder.
[2] Required by the *Waterworks Regulations.*

LEAD & COPPER SAMPLING LOCATIONS

WATERWORKS NAME ______________________________ PWSID# _________________________

INSTRUCTIONS:

1. *For each selected sample site, provide the type and year of construction to justify the choice of tier classification for that site; e.g., a commercial building, 1985.*
2. *If a selected sample site becomes unavailable in the future, the replacement site must be of the same tier classification. Provide for extra sites in the sample pool.*
3. *A site not listed in this sample pool must first be approved by the ODW before it can be used for lead and copper monitoring.*
4. *If the number of selected tiered sites (i.e., Tier 1 and Tier 2) is insufficient, representative sites can be added to make up the sampling pool. A representative site is a site in which the plumbing materials used at that site would be commonly found at other sites served by the waterworks.*

Tier 1,2 or Other	Describe Tier Classification	Location

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner*:

We have reviewed the Lead and Copper Rule (LCR) Material Survey and the Sampling Plan for the subject waterworks, dated *(date)*.

The Material Survey and the Sampling Plan appear to satisfy the monitoring requirements of the Virginia *Waterworks Regulations* concerning sampling for lead and copper under the LCR. A copy of the approved Sampling Plan is enclosed.

Based on our records, the *(insert name of waterworks)* waterworks will serve a population of *(insert number of persons served)* persons at the facility and is therefore classified as a *(insert size description; i.e., large, medium, or small as appropriate)* waterworks under the LCR. The LCR requires *(insert the number of samples required as appropriate)* samples to be collected, one from each routine site during the *(describe monitoring period as appropriate; e.g., two initial 6-month)* monitoring periods.

Should you need to add or change sites to the sampling pool to meet the required number of sample locations, then you must submit a revised report listing the changes and the reasons for any changes. This office must approve the revised report before any samples are collected from a site that was not addressed in the original report. *[ODW field staff may adapt this template to address sample site changes.]*

Compliance with the rule will be based on the 90th percentile of the lead and copper sample results. For this waterworks, the 90th percentile will be determined as the *(insert information as appropriate).*

The next step is to begin collecting the samples. We request that the first set of *(insert the appropriate number)* samples be collected by *(insert the appropriate date)*. Each sample must be a "first draw" sample and be a volume of 1 liter. The sample tap and other taps including the toilet are not to be operated for a period of at least 6 hours to insure that a standing undisturbed sample is collected (note that there is no regulatory maximum holding time and a high lead result cannot be invalidated due to excessive standing times).

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

Be sure to fill in the "Sample Location" on each form. The samples must be received by the certified laboratory performing the analyses within 14 days of collection. If the 90th percentile results of the analyses meet EPA's Action Levels for lead and copper (0.015 mg/L and 1.3 mg/L, respectively), we will request you to collect another set of *(insert the appropriate number)* samples during the *(insert the appropriate compliance period)* compliance period.

If we may be of any assistance to you in implementing this sampling plan, please contact *(insert name of field office contact, phone number, and email address).*

Sincerely,

Name, Field Office Director
Name of field office

ABC:xyz

Enclosures: 1. Approved Sampling Plan with List of Sample Locations
2. Certification of Collection Methods

ec/enc: *(electronic copy if applicable)*
cc: *Consulting engineer (if applicable)*
Name, County Administrator *(if applicable)*

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Water: *Waterworks Name*
PWSID No.: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have received *(number of sample results)* lead and copper "first draw" tap sample results for the subject waterworks. You submitted these results in accordance with Lead and Copper Rule monitoring requirements of the Virginia *Waterworks Regulations*, 12VAC5-590-10 et seq. With these results, the waterworks has now completed the *(describe the specific LCR monitoring period and whether initial, reduced, etc.)*. We have summarized the results of this monitoring in the table below:

Monitoring Period	Lead 90th Percentile (Action Level: 0.015 mg/L)	Copper 90th Percentile (Action Level: 1.3 mg/L)
(Insert LCR monitoring period)	*(Insert lead 90th percentile)*	*(Insert copper 90th percentile)*

Since the above summarized results indicate 90th percentile lead and copper concentrations below the established Action Levels, the waterworks will *proceed to / continue with (describe the next compliance period; i.e., 2nd round of initial monitoring OR whatever level of reduced monitoring, etc.)*. The next required monitoring will be to collect *(number)* samples during the *(describe)* monitoring period. Please note that you must collect all lead and copper "first draw" tap samples from the same approved sample sites. If you find it necessary to change any tap sample sites, the new site should be of the same tier and category as the initial site and you must submit written justification to this office for approval.

This is a reminder that the waterworks owner is required to provide consumer notification to the occupants of the residence or building where the tap was tested by *direct mail or hand delivery / posting or direct delivery (choose appropriate methods for Community or NTNC)* as soon as practical, but no later than **30 days** from the date the laboratory informed you of the sample results. See 12VAC5-590-405 D 4.

After you notify the consumers at each sample location, you must complete a "Lead Results Delivery Certification" form and return it to us along with a sample of the notification sent to participating consumers. The Certification form and a copy of one sample notification must be submitted to us within three months from the end of the monitoring period or no later than *(insert the date that is 3 months from the end of the monitoring period, March 31 or September 30 for 6-month, December 31 for annual/triennial)*. See 12VAC5-590-532 G 3.

You may obtain the consumer notification template and delivery certification form from our website: https://www.vdh.virginia.gov/drinking-water/office-of-drinking-water/information-for-waterworks-owners/

We are available to assist you with complying with the requirements of the Lead and Copper Rule. Should you have any questions, please do not hesitate to contact *(insert name of contact person)* at *(insert contact phone number)* or *(insert email address)*.

Sincerely,

Name & Title
Name of Field Office

ABC:xyz

cc: *Local Health Department, attn: (Insert name), Health Director*

INSTRUCTIONS: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

We have received *(number of sample results)* lead and copper "first draw" tap sample results for the subject waterworks. You submitted these results in accordance with Lead and Copper Rule monitoring requirements of the Virginia *Waterworks Regulations*, 12VAC5-590-10 et seq. With these results, the waterworks has now completed the *(describe the specific LCR monitoring period and whether initial, reduced, etc.)*. We have summarized the results of this monitoring in the table below:

Monitoring Period	Lead 90th Percentile (Action Level: 0.015 mg/L)	Copper 90th Percentile (Action Level: 1.3 mg/L)
(Insert LCR monitoring period)	*(Insert lead 90th percentile)*	*(Insert copper 90th percentile)*

This is a reminder that the waterworks owner is required to provide consumer notification to the occupants of the residence or building where the tap was tested by *direct mail or hand delivery / posting or direct delivery (choose appropriate methods for Community or NTNC)* as soon as practical, but no later than **30 days** from the date the laboratory informed you of the sample results. See 12VAC5-590-405 D 4.

After you notify the consumers at each sample location, you must complete a "Lead Results Delivery Certification" form and return it to us along with a sample of the notification sent to participating consumers. The Certification form and a copy of one sample notification must be submitted to us within three months from the end of the monitoring period or no later than *(insert the date that is 3 months from the end of the monitoring period, March 31 or September 30 for 6-month, December 31 for annual/triennial)*. See 12VAC5-590-532 G 3.

You may access the consumer notification template and delivery certification form on our website: https://www.vdh.virginia.gov/drinking-water/office-of-drinking-water/information-for-waterworks-owners/

Since the results from the *(describe the specific LCR monitoring period and whether initial, reduced, etc.)* indicate 90th percentile lead and/or copper concentrations above the established Action Level(s) (see 12VAC5-590-385), you must initiate the following actions to maintain compliance with the *Waterworks Regulations*:

1. Water Quality Parameter (WQP) Analysis, 12VAC5-590-375 C. You are required to collect samples for Water Quality Parameter (WQP) analyses. You must collect these samples from representative

locations within the distribution system and from each entry point into the distribution system. The following WQP monitoring is required for the waterworks:

- Required Parameters: *(Refer to Sampling Manual, Chapter 6 for parameter list)*
- Distribution System: Two (2) sets of samples from *X* sites *(Refer to Sampling Manual, Chapter 6 for number of sites)*
- Each Entry Point - Two (2) sets of samples.

You must complete WQP monitoring within six months from the beginning of the current lead and copper monitoring period or no later than *(insert date – 6 months from the beginning of the current monitoring period)* and you must perform all tests utilizing approved methods. {*Optional – Staff from this office will be available to assist you with collection and analysis of these samples.*}

2. Source Water Analysis, 12VAC5-590-375 D. You are required to collect samples for source water *(lead and/or copper)* analysis. You must collect these samples from each entry point serving the waterworks within six months from the end of the current lead and copper monitoring period or no later than *(insert date – 6 months from the end of the current monitoring period)*.

3. Public Education, 12VAC5-590-405 D. *(Include if the lead Action Level is exceeded)* Due to the lead Action Level exceedance, you are required to complete public education as defined by the Lead and Copper Rule. You must complete initial aspects of public education no later than 60 days from the end of the current monitoring period or by *(insert date – 60 days from the end of the current monitoring period)*. You must complete other portions of the required public education no less than once per 12 months and repeated notification must be completed in regular water bills or as a separate mailing no less than once per quarter. These requirements are separate from the consumer notification requirements described above. We have enclosed a package of information that will assist you with the required public education steps.

   After you complete distribution of the public education materials, you must complete the enclosed "Public Education Delivery Certification" form and return it to us along with a sample of the public education materials sent to all consumers. You must submit the Certification form and a copy of the distributed materials to this office within ten days after you completed public education.

4. Optimized Corrosion Control, 12VAC5-590-405 A. You are required to install and operate optimized corrosion control treatment. *[Select from below as appropriate].*

   Case 1 – Within six months from the end of the current monitoring period or no later than [insert date – 6 months from the end of the current monitoring period], you must submit a written corrosion control treatment recommendation to this office.

   Case 2 – In order to assist you with the installation of corrosion control treatment, personnel from this office will complete a Corrosion Control Treatment Desktop Evaluation. This evaluation will utilize WQP and source water monitoring results from your waterworks and recommend a corrosion control treatment strategy for your specific situation.

   Case 3 – This waterworks has existing corrosion control treatment that may not be functioning properly or is not operating the treatment in an optimal manner. We will evaluate the WQP results and provide you with technical assistance to try to optimize your treatment. However, it may be necessary to install additional corrosion control treatment if optimization is unsuccessful.

Optimized corrosion control treatment should be installed as soon as possible, but must be installed and in operation by *[Insert Date]*. *[Note that we should encourage a waterworks that has exceeded an Action Level to install treatment as soon as possible. The regulatory requirement is for treatment to be installed no later than 2 years (24 months) from the date the ODW field staff designates the optimal corrosion control treatment].*

5. *(Applicable only if this is the first Action Level exceedance)* Although no further tap sample monitoring for lead and copper is required at this time, we recommend that you continue voluntary monitoring for lead and copper during the six-month monitoring period XX through XX. Collect XX tap samples from the previously sampled locations. If the results of voluntary monitoring for two consecutive six-month monitoring periods show 90th percentile results below the Action Levels, then we will declare that the subject waterworks has achieved optimized corrosion control. This will also allow a return to reduced lead and copper monitoring and a pause on the requirement to provide additional water treatment. *(Applicable only for a lead AL exceedance only:)* If the lead 90th percentile concentration is at or below the Action Level, then the distribution of the lead public education materials may cease. However, if the results in a voluntary monitoring period exceed an Action Level, installation of optimized corrosion control treatment remains a requirement per the timeframe noted in item No. *(choose 3 or 4 as applicable)* stated above.

   OR:

   (Applicable if this is not the first Action Level exceedance) The waterworks must proceed with installation and operation of optimized corrosion control treatment. Although no further monitoring for lead and copper is required until after treatment is online, we recommend that you continue voluntary monitoring for lead and copper during the six-month monitoring period XX through XX. Collect XX tap samples from the previously sampled locations. *(Applicable only for a lead AL exceedance only:)* If the lead 90th percentile concentration is at or below the Action Level, then the distribution of the lead public education materials may cease.

6. Monitoring Frequency, 12VAC5-590-375 B 4 b. Because you exceeded an Action Level, monitoring will resume after installation of corrosion control treatment, at which time you will be required to resume lead and copper tap sampling on a six-month frequency. You are required to collect *(insert number of required samples)* samples in this next round of follow-up monitoring. We will determine when the next round of sampling is due upon completion of installation of corrosion control treatment. Please note that you must collect all lead and copper "first draw" tap samples from the highest tier sample sites available from your approved monitoring plan. If you find it necessary to change any tap sample sites, the new site should be of the same tier and category as the initial site and you must submit written justification to this office for approval.

7. *(If applicable)* Lead Service Line Replacement, 12VAC5-590-405 C. We received results that indicate one or more sample sites associated with lead service lines exceeded the lead Action Level even after the installation of Optimized Corrosion Control Treatment (OCCT). You must begin developing a lead service line replacement plan as defined by the Lead and Copper Rule. *[There has never been a situation in Virginia where the lead service line replacement treatment technique has been required, and replacement has been voluntary. However, if you should have a waterworks exceed the lead Action Level under these circumstances, ODW field staff would need to include the LSL replacement requirement into this letter. ODW field staff may optionally include links to LSLR FAQs and funding on ODW's website.]*

INSTRUCTIONS: Complete/select items shown with *italics*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

We are available to assist you with the requirements of the Lead Copper Rule. Should you have any questions, please do not hesitate to contact *(insert name of contact person)* at *(insert contact phone number)* or *(insert email address)*.

Sincerely,

Name & Title
Name of Field Office

ABC:xyz

Enclosures:
1. *(if lead AL exceeded)* Public Education package
2. 90th percentile results summary

cc: *Local Health Department, attn: (insert name), Health Director*

INSTRUCTIONS: Send to waterworks in advance of LCR tap sampling. Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No.: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

ODW's goal with respect to lead and copper in drinking water is to ensure the highest level of public health protection. Compliance with all parts of the Lead and Copper Rule is a priority for ODW, including the consumer notification requirements. Section 12VAC5-590-405 D 4 of the Virginia *Waterworks Regulations* states, "...An owner shall provide this consumer notice as soon as practical, but no later than 30 days after the owner learns of the tap monitoring results."

You are required to notify the occupants of each participating sampling location of the lead result for that location. You must also provide an explanation of the health effects of lead, list steps consumers can take to reduce exposure to lead in drinking water, and provide water utility contact information. We recommend that you also report the copper result for each participating sampling location.

Previously, ODW had prepared letters to waterworks with the 90th percentile results and consumer notification forms after we received all of the monitoring results. Going forward, you must distribute the consumer notification to each sampling location by direct mail or hand delivery (or posting if allowed at nontransient noncommunity waterworks) as soon as practical, but no later than 30 days after the receipt of each monitoring result from the laboratory. This may be before you receive the results analysis from ODW. To assist you in meeting this notification requirement, enclosed are a sample results notification letter and a fact sheet that meets the EPA mandatory requirements. Copies of these templates are available on our website: https://www.vdh.virginia.gov/drinking-water/office-of-drinking-water/information-for-waterworks-owners/

After you have distributed the customer notifications, you must complete the enclosed "Lead Results Delivery Certification" form and return it to us along with a sample of the notification sent to the occupants at the sampling locations. Return these within three months of the end of the monitoring period.

This office remains available to provide assistance to you in complying with consumer notification requirements of the Lead and Copper Rule. Should you have any questions, please do not hesitate to contact *(insert name of contact person)* at *(insert contact phone number)* or *(insert email address)*.

Sincerely,

Name & Title
Name of Field Office

ABC:xyz
Attachments: Sample Results Notification Letter, Lead Fact Sheet, Lead Results Delivery Certification Form
cc: *Local Health Department, Attn: (Insert name), Health Director*

INSTRUCTIONS: Customize WQP parameters as required for individual waterworks. Repeat 1st Table for multiple Entry Points, as necessary.
Water System Facility (WSF) State Assigned ID from SDWIS

VDH – Office of Drinking Water
Lead & Copper Rule - Water Quality Parameter (WQP) Report
Page 1 of 2

Waterworks Name: ______________________________________ **PWSID:** ________________

WQP Compliance Period: *(Jan – Jun) or (Jul – Dec) (Year)*

Facility Name:____ **Entry Point WSF State Assigned ID:**_________

Bi-weekly samples are required at each Entry Point.

Week	Collection Date	pH	Orthophosphate (mg/L)	Alkalinity, Total (mg/L)		Collection Date	pH	Orthophosphate (mg/L)	Alkalinity, Total (mg/L)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
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18									
19									
20									
21									
22									
23									
24									
25									
26									

VDH – Office of Drinking Water

Lead & Copper Rule - Water Quality Parameter (WQP) Report

Page 2 of 2

Waterworks Name: ____ **PWSID: _________________**

WQP Compliance Period: *(Jan – Jun) or (Jul – Dec)* *(Year)* **Distribution System WSF State Assigned ID:_________**

Two (2) samples are required from each of *(specify number)* distribution system sample site locations.

Collection Date	Sampling * Point	Collection Address	pH	Orthophosphate, Total (mg/L)	Alkalinity, Total (mg/L)

*Sampling Point = Number that uniquely identifies a sampling point within a water distribution system where the sample is drawn. Refer to the monitoring schedule posted on ODW's webpage, or contact your respective ODW field office for this information.

INSTRUCTIONS: Complete/select items with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

We are in receipt of the results of the Lead and Copper Rule required entry point and distribution system Water Quality Parameter (WQP) monitoring results for the *(January through June)(July through December) (year)* monitoring period. These results indicate values that *(meet)(does not meet)* the established values defining optimal corrosion control treatment.

Two sets of WQP samples are required from *(number)* distribution sites on a semi-annual frequency. Entry point WQP monitoring is required on a biweekly frequency. More frequent monitoring is encouraged but not required.

Minimum values for applicable WQPs that define optimal corrosion control treatment have been established for your waterworks. Failure to maintain these minimum WQPs, both at the entry points and within the distribution system, will constitute a treatment technique violation.

Should you have any questions please do not hesitate to contact this office.

Sincerely,

Name,Title
Name of Field Office

ABC/xyz

cc: *Local Health Department, attn: (Insert name), Health Director*
VDH, ODW – Central Office

Instructions: Insert specific information where noted with *[brackets and italics]*. The required content for this notice is: 1. Health effects; 2. Steps to reduce exposure; 3. MCLG and AL definitions; 4. Contact info.

[Date]

Dear *[Consumer's Name]*,

[Waterworks' name] appreciates your participation in the lead and copper tap monitoring program. This letter is to report the lead and copper results from the sample collected at your residence, *[address of customer]* on *[date]*. The reported lead result for your residence is *[select one & insert result- xxx parts per billion (ppb) or xxx mg/L]*. The Action Level for lead is 15 ppb or 0.015 mg/L.

Some individual homes may have high lead concentrations while the 90th percentile value for the entire waterworks is below the Action Level. These individual site lead levels may be due to conditions unique to the individual home, such as the presence of lead solder or brass faucets, fittings, and valves that may contain lead. Our waterworks strives to keep the corrosivity of our water as low as possible (since corrosive water can cause lead to leach from plumbing materials that contain lead). Additionally, there are actions you can take to reduce your exposure. We strongly urge you to review the enclosed Consumer Notice and take the steps listed to reduce your exposure to lead in drinking water.

Optional: The reported copper result for your residence is *[select one & insert result- xxx parts per billion (ppb) or xxx mg/L]*. The Action Level for copper is 1.3 mg/L.

Optional: Copper is an essential nutrient, but some people who drink water containing copper in excess of the Action Level over a relatively short amount of time could experience gastrointestinal distress. Some people who drink water containing copper in excess of the Action Level over many years could suffer liver or kidney damage. People with Wilson's Disease should consult their personal doctor.

If you have any questions, please contact *[name of waterworks contact]* at *[phone number]* or *[email address]*.

Sincerely

(Waterworks Signature Block)

Enclosure: Consumer Notice

Instructions: Insert specific information where noted with *[brackets and italics]*. The required content for this notice is: 1. Health effects; 2. Steps to reduce exposure; 3. MCLG and AL definitions; 4. Contact info.

Consumer Notice
LEAD IN DRINKING WATER

Lead is a common metal that has been in many consumer products but is now known to be harmful to human health if ingested or inhaled. It can be found in lead-based paint, air, soil, household dust, food, some types of pottery, and drinking water. Lead is rarely found in natural sources of water such as rivers, lakes, wells or springs.

Health Effects of Lead

Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

Steps You Can Take To Reduce Your Exposure to Lead in Your Water

Lead may work its way into drinking water after the water entered the distribution system and is on its way to consumers taps. This usually happens through the corrosion of materials containing lead in household plumbing. These materials include brass faucets, lead solder on copper pipes, lead pipes, or lead service lines connecting the water main to the inside plumbing. Lead pipes are no longer installed for service lines or in household plumbing and lead solder has been outlawed in Virginia since 1985. If you live in a building in which the inside plumbing contains lead-based materials, there are several steps you can take to reduce your exposure to lead in drinking water.

1. ***Run your water to flush out lead.*** If water hasn't been used for several hours, allow the water to run at the tap for 30 seconds to 2 minutes before using it for drinking or cooking. This action flushes the lead-containing water from the pipes. The water you run from drinking water taps does not have to be wasted. You can use this water for cleaning purposes or for watering plants. You may want to keep a container of drinking water in your refrigerator, so you don't have to run water every time you need it.
2. ***Use water from the cold water tap for cooking and preparing baby formula.*** Do not cook with or drink water from the hot water tap; lead dissolves more easily in hot water. Do not use water from the hot water tap to make baby formula.
3. ***Do not boil water to remove lead.*** Boiling water will not reduce or remove lead.
4. ***Consider installing a filter.*** You may want to consider installing a water filter. Ensure that the filter is approved to reduce lead or contact the National Sanitation Foundation at 800-NSF-8010 or **www.nsf.org** for information on performance standards for these types of water filters. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.
5. ***Get your child tested.*** Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.
6. ***Identify and replace any plumbing fixtures that contain lead.*** Brass faucets, fittings, and valves manufactured *before January 4, 2014,* may contribute lead to drinking water, including those advertised as "lead-free." Under current law, "lead free" means no more than 0.2% lead in solder and

Instructions: Insert specific information where noted with *[brackets and italics]*. The required content for this notice is: 1. Health effects; 2. Steps to reduce exposure; 3. MCLG and AL definitions; 4. Contact info.

flux, and 0.25% lead for pipe, pipe fittings, and components. Visit the National Sanitation Foundation Web site at **www.nsf.org** to learn more about lead-containing plumbing fixtures.

7. ***Test your water for lead.*** Call us at *[insert phone number for your waterworks]* to find out how to get your water tested for lead. *[Include information on your waterworks testing program; e.g., costs of testing and availability of labs in your area that are certified to do testing for lead in drinking water for any consumer who requests it.]*

Definitions

Under the authority of the Safe Drinking Water Act, the Environmental Protection Agency (EPA) set the Action Level for lead in drinking water at 15 ppb (or 0.015 mg/L). This means utilities must ensure that water from the customer's tap does not exceed this level in at least 90 percent of the locations sampled (this is referred to as the 90th percentile value). The Action Level is the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

Because lead may pose serious health risks, the EPA also set a Maximum Contaminant Level Goal (MCLG) for lead of zero. The MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

For More Information

Call us at *[Insert Waterworks Owner's Contact Phone Number],* or *[if applicable]* visit our Website at *[insert Waterworks Website Here]*. For more information on reducing lead exposure around your home/building and the health effects of lead:

1. Visit EPA's website at http://www.epa.gov/lead;
2. Visit VDH's website at http://www.vdh.virginia.gov/leadsafe/
3. Contact your health care provider;
4. Contact the National Lead Information Center at 800-424-LEAD

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your water system's ID number.*

Instructions: Insert specific information where noted with *[brackets and italics]*. The required content for this notice is: 1. Health effects; 2. Steps to reduce exposure; 3. MCLG and AL definitions; 4. Contact info.

Lead Results Delivery Certification

INSTRUCTIONS: Waterworks owner must
1. Complete this form.
2. Attach a copy of an example consumer letter and the consumer notice to this form.
3. Within 3 months from the end of the monitoring period, email or mail this form to:
   Email: ODWFieldOffice#@vdh.virginia.gov
   VDH - Office of Drinking Water
   [Name] Field Office
   [Field Office Address]

Waterworks Name: ________________________________ PWSID: ____________________

Population: ________________________

DELIVERY METHOD – Community Waterworks *(Choose as appropriate)*

Waterworks serving a population greater than 3,300 people:

☐ The occupants of each lead and copper sampling location were notified by U.S. Mail within 30 days of receiving the laboratory result.

Waterworks serving a population of 3,300 or fewer people (choose either delivery method):

☐ The occupants of each lead and copper sampling location were notified by U.S. Mail within 30 days of receiving the laboratory result.

☐ The occupants of each lead and copper sampling location were notified by hand/direct delivery within 30 days of receiving the laboratory result. Notification was made by: (describe) ____

I certify that the occupants of each residence where lead tap water samples were collected have been informed of their lead monitoring results within 30 days after we were notified of the results by the laboratory along with the following information: MCLGs, ALs and their definitions, the health effects of lead which includes steps to reduce exposure to lead in drinking water, and contact information for the water utility.

Signature: _________________________ Print Name: ___________________________

Title: _______________________ Phone: ______________ Date________________

Consumer Notice
LEAD IN DRINKING WATER

The *[name of your facility]* is a public water system and we are responsible for providing you with water at this location and ensuring that the drinking water we provide to you meets state and federal standards. We recently collected drinking water samples to test for lead and copper. The results of this testing are as follows:

Sample Location	Sample Date	Lead Concentration *[Select one]* (ppb) or (mg/L)	*Optional:* Copper Concentration (mg/L)

Definitions

Under the authority of the Safe Drinking Water Act, the Environmental Protection Agency (EPA) set the Action Level (AL) for lead in drinking water at 15 ppb (or 0.015 mg/L). The AL for copper in drinking water is set at 1.3 mg/L. This means utilities must ensure that water from the customer's tap does not exceed this level in at least 90 percent of the locations sampled (this is referred to as the 90th percentile value). The Action Level is the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

Because lead may pose serious health risks, the EPA also set a Maximum Contaminant Level Goal (MCLG) for lead of zero. The MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

Health Effects of Lead

Lead is a common metal that has been in many consumer products but is now known to be harmful to human health if ingested or inhaled. It can be found in lead-based paint, air, soil, household dust, food, some types of pottery, and drinking water. Lead is rarely found in natural sources of water such as rivers, lakes, wells or springs.

Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

Steps You Can Take To Reduce Your Exposure to Lead in Your Water

1. ***Run your water to flush out lead.*** If water hasn't been used for several hours, allow the water to run at the tap for 30 seconds to 2 minutes before using it for drinking or cooking. This action flushes the lead-containing water from the pipes. The water you run from drinking water taps does not have to be

wasted. You can use this water for cleaning purposes or for watering plants. You may want to keep a container of drinking water in your refrigerator, so you don't have to run water every time you need it.

2. ***Use water from the cold water tap for cooking and preparing baby formula.*** Do not cook with or drink water from the hot water tap; lead dissolves more easily in hot water. Do not use water from the hot water tap to make baby formula.

3. ***Do not boil water to remove lead.*** Boiling water will not reduce or remove lead.

4. ***Consider installing a filter.*** You may want to consider installing a water filter. Ensure that the filter is approved to reduce lead or contact the National Sanitation Foundation at 800-NSF-8010 or **www.nsf.org** for information on performance standards for these types of water filters. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

5. ***Get your child tested.*** Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

6. ***Identify and replace any plumbing fixtures that contain lead.*** Brass faucets, fittings, and valves manufactured *before January 4, 2014,* may contribute lead to drinking water, including those advertised as "lead-free." Under current law, "lead free" means no more than 0.2% lead in solder and flux, and 0.25% lead for pipe, pipe fittings, and components. Visit the National Sanitation Foundation Web site at **www.nsf.org** to learn more about lead-containing plumbing fixtures.

[Optional:]
Copper
Copper is an essential nutrient, but some people who drink water containing copper in excess of the action level over a relatively short amount of time could experience gastrointestinal distress. Some people who drink water containing copper in excess of the action level over many years could suffer liver or kidney damage. People with Wilson's Disease should consult their personal doctor.

For More Information

Call us at *[Insert Waterworks Owner's Contact Phone Number]*. For more information on reducing lead exposure around your home/building and the health effects of lead:
1. Visit EPA's website at http://www.epa.gov/lead;
2. Visit VDH's website at http://www.vdh.virginia.gov/leadsafe/
3. Contact your health care provider;
4. Contact the National Lead Information Center at 800-424-LEAD

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your water system's ID number.* Date *[Insert the date distributed]*

Lead and Copper Results Delivery Certification

INSTRUCTIONS: Waterworks owner must
1. Complete this form.
2. Attach a copy of the consumer notice to this form.
3. Within three months from the end of the monitoring period, mail or email this form to:

    Email: ODWFieldOffice#@vdh.virginia.gov or:
    VDH - Office of Drinking Water
    ***[Name]* Field Office**
    [Field Office Address]

Waterworks Name: ______________________ PWSID: _________________________

DELIVERY METHOD –Nontransient NoncommunityWaterworks

Either of the following is acceptable consumer notification:

☐ Posted in all facilities in which the samples were collected within 30 days of receiving the laboratory results.

☐ All persons served within the facilities in which the lead and copper samples were collected were notified within 30 days of receiving the laboratory results. Notification was made by: (describe notification method) ____

I certify that persons served at the locations from where the lead and copper tap water samples were collected have been informed of the lead and copper monitoring results within 30 days of receiving the laboratory results, along with the following information: MCLGs, ALs and their definitions, a fact sheet on the health effects of lead which includes steps to reduce exposure to lead in drinking water, and contact information for the water utility.

Signature: ______________________________ Print Name: _________________________

Title: _____________________ Phone: ___________________ Date: ___________

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

Required Public Education Delivery for Large Community Waterworks (> 3,300 population)	
Delivery Requirement	**Timing of Delivery**
Deliver public education written materials to all bill paying customers Note: For service areas with non-English speaking consumers, appropriately translated materials must also be included as part of the overall delivery	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months.
Deliver public education written materials to the following organizations that are located within your service area, along with a cover letter encouraging distribution to all potentially affected customers or users: 1. Public and private schools or school boards 2. Public and private pre schools 3. Women Infants and Children (WIC) and Head Start programs 4. Public and private hospitals and medical clinics 5. Obstetricians-Gynecologists and Midwives 6. Pediatricians 7. Family planning clinics 8. Local welfare agencies 9. Licensed childcare centers	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months
Deliver public education written materials to the City or County Local Health Department (LHD). Contact with the local health agency must be either by telephone or in person. The LHD may provide the waterworks with a list of additional organizations serving target populations. If the LHD provides such a list, deliver the public education materials to all organizations on the list even if they are not located within the system's service area.	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months
Provide information on or in each water bill or in a separate mailing no less than quarterly.	Each billing cycle for as long as the system exceeds the lead action level – but no less than quarterly
Post material on the water system's Web site (for systems serving >100,000 individuals)	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded. Posting must remain as long as the lead Action Level is exceeded.
Implement **at least three of the additional Public Education activities** from the following after consultation with the ODW field office : • Public Service Announcements • Paid advertisements • Public Area Information Displays • E-mails to customers • Public Meetings • Household Deliveries • Targeted Individual Customer Contact • Direct material distribution to all multi-family homes and institutions • Other methods approved by the commissioner	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

Water Bill Language Insert Template

INSTRUCTIONS: The following paragraph includes language that meets the revisions to the LCR Public Education requirements and must be included in water bill notification in the event of a lead action level exceedance. Please note, the following statement may be placed directly on the water bill itself or included as an insert. A separate mailing may also be utilized. This alert must be included with every billing cycle or no less than quarterly for as long as the action level is exceeded.

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of waterworks] found high levels of lead in drinking water in some homes. Lead can cause serious health problems. For more information, please call *[insert name and phone number of waterworks* or visit *[if applicable insert waterworks website]*.

Website Announcement Template

INSTRUCTIONS: Large community water systems (serving greater than 100,000 people) are **required** to provide a Public Education notice on their Website. The following language can serve as an announcement on the Website.

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of waterworks] found elevated levels of lead in drinking water in some homes/buildings. Lead can cause serious health problems, especially for pregnant women and young children. Please read this information *[insert link to Public Education Notice]* closely to see what you can do to reduce lead in your drinking water and to learn what *[Insert name of your waterworks]* is doing to address this problem.

Call us at *[insert your waterworks phone number]* for more information

Date *[Insert the date posted]*

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

Press Release Template

INSTRUCTIONS: The LCR **requires** community waterworks serving > 3,300 persons to provide 2 press releases per year during a lead action level exceedance. The following template contains information that is consistent with the LCR requirements. Providing local information, quotes from a local water system and/or public health official, and information about actions your system is taking to address the exceedance can help the media to accurately convey information about the exceedance and your system's action steps.

The waterworks owner may insert own language, subject to approval by ODW, **except for the language in blue text**. This is mandatory language and must be included exactly as written, except for the text in brackets for which the waterworks owner shall include system-specific information.

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER
[Insert name of waterworks]

Recent drinking water quality monitoring conducted by *[insert name of waterworks]* has found elevated levels of lead in drinking water in some homes/buildings in *[insert name of community or area served by your waterworks]*. Although the primary sources of lead exposure are lead-based paint and lead-contaminated dust or soil, the U.S. Environmental Protection Agency estimates that 10 to 20 percent of a person's potential exposure to lead may come from drinking water.

[Insert name of community] is concerned about the health of their residents because lead can cause serious health problems if too much enters your body from drinking water or other sources, especially for pregnant women and young children. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

[Insert information about what happened and what is being done? You may wish to include information about the exceedance and the history of lead levels in tap water samples in your community. For example, have they declined substantially over time? Have they been low and risen recently? Is there a known reason for any lead level changes? Explain the steps being taken to reduce lead levels, such as corrosion control treatment and/or lead service line replacement.]

There are steps you can take to reduce your exposure to lead in your water:

Run your water to flush out lead. If it hasn't been used for several hours, allow the water to run for 30 seconds to 2 minutes before using it for drinking or cooking.This action flushes the lead-containing water from the pipes.

Use water from the cold water tap for cooking and preparing baby formula.

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

PRESS RELEASE (CONTINUED)

Do not boil water to remove lead. Boiling water will not reduce or remove lead.

Consider installing a filter. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

Test your water for lead. Call us at *[insert phone number for your waterworks]* to find out how to get your water tested for lead.

Get your child tested. Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

Identify and replace any plumbing fixtures that contain lead.

There are several actions that *[insert name of waterworks/community]* are taking to address the concerns about lead in drinking water. *[Insert a quote from a waterworks official letting the public know what actions the system is taking to address the lead action level exceedance or insert a list of action steps.]*

Call *[insert name of your waterworks]* at *[insert number]* or *[if applicable]* visit *[insert name of your waterworks]* Website at *[insert Website Here]* to find out how to get your water tested for lead, or for more information on steps *[insert name of your waterworks]* is taking to address the lead action level exceedance. For more information on reducing lead exposure around your home/building and the health effects of lead, visit EPA's Website at **www.epa.gov/lead,** contact your healthcare provider, or your County/City Local Health Department.

Public Service Announcement Template

INSTRUCTIONS: Public Service Announcements (PSA) are not required. However, PSAs are one of the additional activities that large and small water systems can produce to meet the additional public education (PE) requirements. You should include the following information, which is consistent with the PE requirements under the LCR revisions in any PSA.

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of your waterworks] found elevated levels of lead in drinking water in some homes/buildings in our community. Lead can cause serious health problems, especially for pregnant women and young children.

Lead is a common metal found in the environment. Drinking water is one possible source of lead exposure. The main sources of lead exposure are lead-based paint and lead-contaminated dust or soil. The following are some of the steps you can take to reduce your exposure to lead in your drinking water:

Run your water for 30 seconds to 2 minutes to flush out lead.

Use water from the cold water tap for cooking and preparing baby formula.

Do not boil water to remove lead as boiling does not reduce or remove lead levels.

Consider installing a filter. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

Test your Water for Lead. Call us at *[insert phone number for your waterworks]* to find out how to get your water tested.

Get your child tested. Contact your local heath department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

Identify and replace any plumbing fixtures that contain lead.

Call *[insert name of your waterworks]* at *[insert number]* or *[if applicable]* visit our Website at *[insert Website Here*] to find out how to get your water tested for lead or for more information. For more information on reducing lead exposure around your home/building and the health effects of lead, visit EPA's Website at **www.epa.gov/lead** contact your healthcare provider, or your County/City Local Health Department.

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your waterworks ID number]* Date *[insert the date distributed]*

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

Local Health Department Notification
(Recommended for use by the waterworks owner)

Date

District Medical Director
Address 1
Address 2
City, State, Zip

Dear Dr. *Medical Director:*

The *[insert waterworks name]* waterworks routinely monitors drinking water at consumer's taps for lead and copper. This monitoring is conducted in accordance with the Environmental Protection Agency's (EPA) Lead and Copper Rule (LCR) and the Commonwealth of Virginia *Waterworks Regulations*.

Under the authority of the Safe Drinking Water Act, the EPA set the Action Level for lead in drinking water at 0.015 mg/L (or 15 parts per billion (ppb)). This means utilities must ensure that water from the customer's tap does not exceed this level in at least 90 percent of the homes sampled (i.e., the 90th percentile value). The Action Level is the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

The most recent results of our lead and copper monitoring indicate that the lead Action Level has been exceeded. The results of this most recent monitoring are summarized in the table below.

(Insert name of waterworks) **Waterworks: Lead & Copper Results**

Monitoring Period	Lead 90th Percentile (Action Level: 0.015 mg/L)	Copper 90th Percentile (Action Level: 1.3 mg/L)
Insert LCR monitoring period	*Insert lead 90th percentile*	*Insert copper 90th percentile*

Because the lead Action Level has been exceeded, we are required to initiate a public education program that will alert our customers to the potential public health impacts of elevated lead in drinking water and provide information on ways to reduce exposure. A copy of the public education materials that are being sent to our customers is attached for your information.

We are requesting your assistance in distributing the public education materials to organizations that may serve the "at-risk" customers of our waterworks. Such organizations may include WIC programs, Head Start programs, pediatricians, and others that may serve pregnant women and young children. A list of your specific contacts with these organizations will be helpful to us in this outreach effort.

If you have any questions, please contact me at (*insert contact phone number*).

Sincerely,

Insert Waterworks Owner Name

Enclosure: Public Education Materials (Fact Sheet)

Fact Sheet
LEAD IN DRINKING WATER

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of water system] found elevated levels of lead in drinking water in some homes/buildings. Lead can cause serious health problems, especially for pregnant women and young children. Please read this information closely to see what you can do to reduce lead in your drinking water.

Health Effects of Lead

Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

Sources of Lead

Lead is a common metal found in the environment that has been in many consumer products but is now known to be harmful to human health if ingested or inhaled. Drinking water is one possible source of lead exposure. The main sources of lead exposure are lead-based paint and lead-contaminated dust or soil, and some plumbing materials. In addition, lead can be found in certain types of pottery, pewter, brass fixtures, food, and cosmetics. Other sources include exposure in the work place and exposure from certain hobbies (lead can be carried on clothing or shoes). Wash your children's hands and toys often as they can come into contact with dirt and dust containing lead. Lead is rarely found in natural sources of water such as rivers, lakes, wells or springs.

New brass faucets, fittings, and valves, including those advertised as "lead-free," may contribute lead to drinking water. The Safe Drinking Water Act defines "lead free" as no more than 0.2 percent lead when used with respect to solder and flux; and no more than 0.25 percent for pipes, pipe fittings, plumbing fittings, and fixtures based on a weighted average of the wetted surfaces. Consumers should be aware of this when choosing fixtures and take appropriate precautions.

[Insert utility specific information describing your community's source water – e.g. "The source of water from XX Reservoir does not contain lead" or "Community XX does not have any lead in its source water or water mains in the street."] When water is in contact with pipes [or service lines] or plumbing that contains lead for several hours, the lead may enter drinking water. Homes built before 1986 are more likely to have plumbing containing lead. New homes may also have lead; even "lead-free" plumbing may contain some lead.

EPA estimates that 10 to 20 percent of a person's potential exposure to lead may come from drinking water. Infants who consume mostly formula mixed with lead-containing water can receive 40 to 60 percent of their exposure to lead from drinking water.

Steps You Can Take To Reduce Your Exposure to Lead in Your Water

Lead may work its way into drinking water after the water entered the distribution system and is on its way to consumers taps. This usually happens through the corrosion of materials containing lead in household plumbing. These materials include brass faucets, lead solder on copper pipes, lead pipes, or lead service lines connecting the water main to the inside plumbing. Lead pipes are no longer installed for service lines or in household plumbing and lead solder has been outlawed in Virginia since 1985. If you live in a building in which the inside plumbing contains lead-based materials, there are several steps you can take to reduce your exposure to lead in drinking water.

1. ***Run your water to flush out lead.*** If water hasn't been used for several hours, allow the water to run at the tap for 30 seconds to 2 minutes before using it for drinking or cooking. This action flushes the lead-containing water from the pipes. The water you run from drinking water taps does not have to be wasted. You can use this water for cleaning purposes or for watering plants. You may want to keep a container of drinking water in your refrigerator, so you don't have to run water every time you need it.

2. ***Use water from the cold water tap for cooking and preparing baby formula.*** Do not cook with or drink water from the hot water tap; lead dissolves more easily in hot water. Do not use water from the hot water tap to make baby formula.

3. ***Do not boil water to remove lead.*** Boiling water will not reduce or remove lead.

4. ***Consider installing a filter.*** You may want to consider installing a water filter. Ensure that the filter is approved to reduce lead or contact the National Sanitation Foundation at 800-NSF-8010 or **www.nsf.org** for information on performance standards for these types of water filters. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

5. ***Get your child tested.*** Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

6. ***Identify and replace any plumbing fixtures that contain lead.*** Brass faucets, fittings, and valves
manufactured *before January 4, 2014,* may contribute lead to drinking water, including those advertised as "lead-free." Under current law, "lead free" means no more than 0.2% lead in solder and flux, and 0.25% lead for pipe, pipe fittings, and components. Visit the National Sanitation Foundation Web site at **www.nsf.org** to learn more about lead-containing plumbing fixtures.

7. ***Test your water for lead.*** Call us at *[insert phone number for your waterworks]* to find out how to get your water tested for lead. *[Include information on your waterworks testing program; e.g., costs of testing and availability of labs in your area that are certified to do testing for lead in drinking water for any consumer who requests it.]*

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

What Happened? What is Being Done?

[Insert information about how and when the exceedance was discovered in your waterworks and provide information on the source(s) of lead in the drinking water, if known.]
[Insert information about what your waterworks is doing to reduce lead levels in the homes/buildings, etc.]
[Insert information about lead service lines in your community served by your waterworks, how a consumer can find out if they have a lead service line, what your waterworks is doing to replace lead service lines, etc.]
[Insert information about the history of lead levels in tap water samples in your waterworks. For example, have they declined substantially over time? Have they been low and risen recently? Is there a known reason for any lead level changes?]

For More Information

Call us at *[Insert Waterworks Owner's Contact Phone Number]*, or *[if applicable]* visit our Website at *[insert Waterworks' Website URL here]*. For more information on reducing lead exposure around your home/building and the health effects of lead:

1. Visit EPA's website at http://www.epa.gov/lead;
2. Contact your health care provider;
3. Contact the National Lead Information Center at 800-424-LEAD; or
4. Contact the *[County/City]* Local Health Department at *[insert the appropriate phone number]*.

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your water system's ID number.* Date *[Insert the date distributed]*

Public Education Delivery Certification

INSTRUCTIONS: Waterworks owner must
1. Complete this form
2. Attach a copy of the residence (consumer) notification to this form
3. Within 3 months from the end of the monitoring period, mail to

District Engineer Name
VDH-Office of Drinking Water
Name Field Office
Field Office Address

PWS Name: ______________________ PWSID: ____________________________
Population: _______________________

DELIVERY METHOD – Community Waterworks Serving > 3,300 Population

☐ Written Public Education material regarding lead in drinking water was delivered to each bill paying customer on _________________________(date). This delivery was completed by:

☐ Inclusion in the regular water bill mailing
☐ Separate direct mailing to each bill paying customer
☐ Inclusion of translated material for non-English speaking consumers (if applicable)

☐ Written Public Education material regarding lead in drinking water was delivered to the following organizations that are served by the waterworks on________________(date):

- ☐ Public and private schools or school boards
- ☐ Public and private pre schools
- ☐ Women Infants and Children (WIC) and Head Start programs
- ☐ Public and private hospitals and medical clinics
- ☐ Obstetricians- Gynecologists and Midwives
- ☐ Pediatricians
- ☐ Family planning clinics
- ☐ Local welfare agencies
- ☐ Licensed childcare centers

A list of all organizations that were provided with the public education materials is attached.

☐ Written Public Education material regarding lead in drinking water was delivered to the __________________________ Local Health Department on ________________________ (date). The health department was also contacted:

- ☐ By personal visit on _________________________(date).
- ☐ By telephone on ___________________________ (date).

☐ Written Public Education material regarding lead in drinking water was delivered to all community based organizations indicated by the local health department on __________________(date).

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

☐ A press release was provided to newspapers, television stations, and radio stations on _________________________(date).

☐ The written Public Education material regarding lead in drinking water was posted on the waterworks website on __________(date). This web posting will remain for as long as the lead Action Level is exceeded. *[Required for waterworks serving > 100,000 population]*.

☐ The following additional Public Education activities were initiated on __________(date). At least three of the following must be completed:

- ☐ Public Service Announcements
- ☐ Paid advertisements
- ☐ Public area informational displays
- ☐ E-mails to customers
- ☐ Public meetings
- ☐ Household deliveries
- ☐ Targeted individual customer contact
- ☐ Direct material distribution to all multi-family homes and institutions
- ☐ Other methods approved by the commissioner ______________________

I certify that all of the required Public Education delivery activities have been completed as indicated above within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded. I further certify that an informational notice regarding lead in drinking water will be provided to each billing customer either with the normal water bills or as a separate mailing. This notification will be provided with each billing cycle but no less than once each calendar quarter for as long as the lead Action Level is exceeded.

Signature: ________________________________ Print Name: __________________________

Title: _______________________ Phone: _____________________ Date: _____________

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font

Required Public Education Delivery for Small/Medium Community Waterworks (≤ 3,300 population)	
Delivery Requirement	**Timing of Delivery**
Deliver public education written materials to all bill paying customers Note: For service areas with non-English speaking consumers, appropriately translated materials must also be included as part of the overall delivery	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months
Deliver public education written materials to the following facilities and organizations that are served by the waterworks and that are most likely to be visited regularly by pregnant women and children. 1. Public and private schools or school boards 2. Public and private pre schools 3. Women Infants and Children (WIC) and Head Start programs 4. Public and private hospitals and medical clinics 5. Obstetricians-Gynecologists and Midwives 6. Pediatricians 7. Family planning clinics 8. Local welfare agencies 9. Licensed childcare centers	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months
Deliver public education written materials to the City or County Local Health Department. Contact with the local health agency must be either by telephone or in person. The LHD may provide the waterworks with a list of additional organizations serving target populations. If the LHD provides such a list, deliver the public education materials to all organizations on the list that are located within the system's service area.	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months
Provide information on or in each water bill or in a separate mailing no less than quarterly.	Each billing cycle for as long as the system exceeds the lead action level – but no less than quarterly
Submit press release to newspaper, television, and radio stations. This requirement can be waived if the waterworks provides the written material to each household served.	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated twice every 12 months
Implement at least one of the additional Public Education activities from the following : • Public Service Announcements • Paid advertisements • Public Area Information Displays • E-mails to customers • Public Meetings • Household Deliveries • Targeted Individual customer Contact • Direct material distribution to all multi-family homes and institutions • Other methods approved by the commissioner	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months

Water Bill Language Insert Template

INSTRUCTIONS:
The following paragraph includes language that meets the LCR Public Education (PE) requirements and must be included in water bill notification in the event of a lead action level exceedance. Please note, the following statement may be placed directly on the water bill itself or included as an insert. A separate mailing may also be utilized. This alert must be included with every billing cycle or no less than quarterly for as long as the Action level is exceeded.

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of waterworks] found high levels of lead in drinking water in some homes. Lead can cause serious health problems. For more information, please call *[insert name and phone number of waterworks]* or visit [if applicable *insert waterworks website]*.

Press Release Template

INSTRUCTIONS:
The LCR **requires** community waterworks serving ≤ 3,300 persons to provide 2 press releases per year during a lead action level exceedance. *This requirement can be waived if the waterworks provides the Public Education (PE) written material to each household served.* The following template contains information that is consistent with the LCR requirements. Providing local information, quotes from a local water system and/or public health official, and information about actions your system is taking to address the exceedance can help the media to accurately convey information about the exceedance and your system's action steps.

The waterworks owner may insert own language, subject to approval by ODW, **except for the language in blue text**. This is mandatory language and must be included exactly as written, except for the text in brackets for which the waterworks owner shall include system-specific information.

IMPORTANT INFORMATION ABOUT LEAD IN *[INSERT NAME OF YOUR COMMUNITY]* DRINKING WATER

Recent drinking water quality monitoring conducted by *[insert name of waterworks/community]* has found elevated levels of lead in drinking water in some homes/buildings in *[insert name of community or area served by your waterworks]*. Although the primary sources of lead exposure are lead-based paint and lead-contaminated dust or soil, the U.S. Environmental Protection Agency estimates that 10 to 20 percent of a person's potential exposure to lead may come from drinking water.

[Insert name of community] is concerned about the health of their residents because lead can cause serious health problems if too much enters your body from drinking water or other sources, especially for pregnant women and young children. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

[Insert information about what happened and what is being done? You may wish to include information about the exceedance and the history of lead levels in tap water samples in your community. For example, have they declined substantially over time? Have they been low and risen recently? Is there a known reason for any lead level changes? Explain the steps being taken to reduce lead levels, such as corrosion control treatment and/or lead service line replacement.]

There are steps you can take to reduce your exposure to lead in your water:

Run your water to flush out lead. If it hasn't been used for several hours, allow the water to run for 30 seconds to 2 minutes before using it for drinking or cooking.This action flushes the lead-containing water from the pipes.

PRESS RELEASE (CONTINUED)

Use water from the cold water tap for cooking and preparing baby formula.

Do not boil water to remove lead. Boiling water will not reduce or remove lead.

Consider installing a filter. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

Test your water for lead. Call us at *[insert phone number for your waterworks]* to find out how to get your water tested for lead.

Get your child tested. Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

Identify and replace any plumbing fixtures that contain lead.

There are several actions that *[insert name of waterworks/community]* are taking to address this lead in drinking water concern. *[Insert a quote from a waterworks official letting the public know what actions the system is taking to address the lead action level exceedance or insert a list of action steps.]*

Call *[insert name of your waterworks]* at *[insert number] or [if applicable]* visit *[insert name of your waterworks]* Website at *[insert Website Here]* to find out how to get your water tested for

Public Service Announcement Template

INSTRUCTIONS:
Public Service Announcements (PSA) are not required. However, PSAs are one of the additional activities that large and small water systems can produce to meet the additional public education (PE) requirements. You should include the following information, which is consistent with the PE requirements under the LCR revisions in any PSA.

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of waterworks] found elevated levels of lead in drinking water in some homes/buildings in our community. Lead can cause serious health problems, especially for pregnant women and young children.

Lead is a common metal found in the environment. Drinking water is one possible source of lead exposure. The main sources of lead exposure are lead-based paint and lead-contaminated dust or soil. The following are some of the steps you can take to reduce your exposure to lead in your drinking water:

Run your water for 30 seconds to 2 minutes to flush out lead.

Use water from the cold water tap for cooking and preparing baby formula.

Do not boil water to remove lead as boiling does not reduce or remove lead levels.

Consider installing a filter. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

Test your Water for Lead. Call us at *[insert phone number for your waterworks]* to find out how to get your water tested.

Get your child tested. Contact your local heath department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

Identify and replace any plumbing fixtures that contain lead.

Call *[insert name of your waterworks]* at *[insert number]* or *[if applicable]* visit our Website at *[insert Website Here]* to find out how to get your water tested for lead or for more information. For more information on reducing lead exposure around your home/building and the health effects of lead, visit EPA's Website at **www.epa.gov/lead** or contact your healthcare provider, or your County/City Local Health Department.

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your waterworks ID number]* Date *[insert the date distributed]*

Local Health Department Notification
(Recommended for use by the waterworks owner)

Date

District Medical Director
Address 1
Address 2
City, State, Zip

Dear Dr. *Medical Director:*

The *[insert waterworks name]* waterworks routinely monitors drinking water at consumer's taps for lead and copper. This monitoring is conducted in accordance with the Environmental Protection Agency's (EPA) Lead and Copper Rule (LCR) and the Commonwealth of Virginia *Waterworks Regulations*.

Under the authority of the Safe Drinking Water Act, the EPA set the Action Level for lead in drinking water at 0.015 mg/L (or 15 parts per billion (ppb)). This means utilities must ensure that water from the customer's tap does not exceed this level in at least 90 percent of the homes sampled (i.e., the 90th percentile value). The Action Level is the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

The most recent results of our lead and copper monitoring indicate that the lead Action Level has been exceeded. The results of this most recent monitoring are summarized in the table below.

(Insert name of waterworks) **Waterworks: Lead & Copper Results**

Monitoring Period	Lead 90th Percentile (Action Level: 0.015 mg/L)	Copper 90th Percentile (Action Level: 1.3 mg/L)
Insert LCR monitoring period	*Insert lead 90th percentile*	*Insert copper 90th percentile*

Because the lead Action Level has been exceeded we are required to initiate a public education program that will alert our customers to the potential public health impacts of elevated lead in drinking water and provide information on ways to reduce exposure. A copy of the public education materials that are being sent to our customers is attached for your information.

We are requesting your assistance in distributing the public education materials to organizations that may serve "at-risk" customers of our waterworks. Such organizations may include WIC programs, Head Start programs, pediatricians, and others that may serve pregnant women and young children. A list of your specific contacts with these organizations will be helpful to us in this outreach effort.

If you have any questions, please contact me at (*insert contact phone number*).

Sincerely,

(*Insert Waterworks Owner Name & Title)*

Enclosure: Public Education Materials (Fact Sheet)

Fact Sheet
LEAD IN DRINKING WATER

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of water system] found elevated levels of lead in drinking water in some homes/buildings. Lead can cause serious health problems, especially for pregnant women and young children. Please read this information closely to see what you can do to reduce lead in your drinking water.

Health Effects of Lead

Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

Sources of Lead

Lead is a common metal found in the environment that has been in many consumer products but is now known to be harmful to human health if ingested or inhaled. Drinking water is one possible source of lead exposure. The main sources of lead exposure are lead-based paint and lead-contaminated dust or soil, and some plumbing materials. In addition, lead can be found in certain types of pottery, pewter, brass fixtures, food, and cosmetics. Other sources include exposure in the work place and exposure from certain hobbies (lead can be carried on clothing or shoes). Wash your children's hands and toys often as they can come into contact with dirt and dust containing lead. Lead is rarely found in natural sources of water such as rivers, lakes, wells or springs.

New brass faucets, fittings, and valves, including those advertised as "lead-free," may contribute lead to drinking water. The Safe Drinking Water Act defines "lead free" as no more than 0.2 percent lead when used with respect to solder and flux; and no more than 0.25 percent for pipes, pipe fittings, plumbing fittings, and fixtures based on a weighted average of the wetted surfaces. Consumers should be aware of this when choosing fixtures and take appropriate precautions.

[Insert utility specific information describing your community's source water – e.g. "The source of water from XX Reservoir does not contain lead" or "Community XX does not have any lead in its source water or water mains in the street."] When water is in contact with pipes [or service lines] or plumbing that contains lead for several hours, the lead may enter drinking water. Homes built before 1986 are more likely to have plumbing containing lead. New homes may also have lead; even "lead-free" plumbing may contain some lead.

EPA estimates that 10 to 20 percent of a person's potential exposure to lead may come from drinking water. Infants who consume mostly formula mixed with lead-containing water can receive 40 to 60 percent of their exposure to lead from drinking water.

Steps You Can Take To Reduce Your Exposure to Lead in Your Water

Lead may work its way into drinking water after the water entered the distribution system and is on its way to consumers taps. This usually happens through the corrosion of materials containing lead in household plumbing. These materials include brass faucets, lead solder on copper pipes, lead pipes, or lead service lines connecting the water main to the inside plumbing. Lead pipes are no longer installed for service lines or in household plumbing and lead solder has been outlawed in Virginia since 1985. If you live in a building in which the inside plumbing contains lead-based materials, there are several steps you can take to reduce your exposure to lead in drinking water.

1. ***Run your water to flush out lead.*** If water hasn't been used for several hours, allow the water to run at the tap for 30 seconds to 2 minutes before using it for drinking or cooking. This action flushes the lead-containing water from the pipes. The water you run from drinking water taps does not have to be wasted. You can use this water for cleaning purposes or for watering plants. You may want to keep a container of drinking water in your refrigerator, so you don't have to run water every time you need it.

2. ***Use water from the cold water tap for cooking and preparing baby formula.*** Do not cook with or drink water from the hot water tap; lead dissolves more easily in hot water. Do not use water from the hot water tap to make baby formula.

3. ***Do not boil water to remove lead.*** Boiling water will not reduce or remove lead.

4. ***Consider installing a filter.*** You may want to consider installing a water filter. Ensure that the filter is approved to reduce lead or contact the National Sanitation Foundation at 800-NSF-8010 or **www.nsf.org** for information on performance standards for these types of water filters. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

5. ***Get your child tested.*** Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

6. ***Identify and replace any plumbing fixtures that contain lead.*** Brass faucets, fittings, and valves manufactured *before January 4, 2014,* may contribute lead to drinking water, including those advertised as "lead-free." Under current law, "lead free" means no more than 0.2% lead in solder and flux, and 0.25% lead for pipe, pipe fittings, and components. Visit the National Sanitation Foundation Web site at **www.nsf.org** to learn more about lead-containing plumbing fixtures.

7. ***Test your water for lead.*** Call us at *[insert phone number for your waterworks]* to find out how to get your water tested for lead. *[Include information on your waterworks testing program; e.g., costs of testing and availability of labs in your area that are certified to do testing for lead in drinking water for any consumer who requests it.]*

What Happened? What is Being Done?

[Insert information about how and when the exceedance was discovered in your waterworks and provide information on the source(s) of lead in the drinking water, if known.]
[Insert information about what your waterworks is doing to reduce lead levels in the homes/buildings, etc.]

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font

[Insert information about lead service lines in your community served by your waterworks, how a consumer can find out if they have a lead service line, what your waterworks is doing to replace lead service lines, etc.]
[Insert information about the history of lead levels in tap water samples in your waterworks. For example, have they declined substantially over time? Have they been low and risen recently? Is there a known reason for any lead level changes?]

For More Information

Call us at *[Insert Waterworks Owner's Contact Phone Number]*, or *[if applicable]* visit our Website at *[insert Waterworks Website Here]*. For more information on reducing lead exposure around your home/building and the health effects of lead:

i. Visit EPA's website at http://www.epa.gov/lead;
ii. Contact your health care provider;
iii. Contact the National Lead Information Center at 800-424-LEAD; or
iv. Contact the *[County/City]* Local Health Department at *[insert the appropriate phone number]*.

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your water system's ID number*. Date *[Insert the date distributed]*

Public Education Delivery Certification

INSTRUCTIONS: Waterworks owner must
1. Complete this form.
2. Attach a copy of the residence (consumer) notification to this form.
3. Within 3 months from the end of the monitoring period, mail this form to:

   [District Engineer]
   VDH - Office of Drinking Water
   [Name] Field Office
   [Field Office Address]

PWS Name: ______________________ PWSID: ____________________________
Population: _______________________

DELIVERY METHOD – Community Waterworks Serving 3,300 or Fewer Population

☐ Written Public Education material regarding lead in drinking water was delivered to each bill paying customer on ______________________(date). This delivery was completed by:

- ☐ Inclusion in the regular water bill mailing
- ☐ Separate direct mailing to each bill paying customer
- ☐ Inclusion of translated material for non-English speaking consumers (if applicable)
- ☐ Direct hand delivery

☐ Written Public Education material regarding lead in drinking water was delivered to the following organizations that are served by the waterworks on________________(date):

- ☐ Public and private schools or school boards
- ☐ Public and private pre schools
- ☐ Women Infants and Children (WIC) and Head Start programs
- ☐ Public and private hospitals and medical clinics
- ☐ Obstetricians- Gynecologists and Midwives
- ☐ Pediatricians
- ☐ Family planning clinics
- ☐ Local welfare agencies
- ☐ Licensed childcare centers

A list of all organizations that were provided with the public education materials is attached.

☐ Written Public Education material regarding lead in drinking water was delivered to the __________________________ Local Health Department on _________________________(date). The health department was also contacted:

- ☐ By personal visit on _______________________(date).
- ☐ By telephone on __________________________(date).

☐ Written Public Education material regarding lead in drinking water was delivered to all community based organizations that are served by the waterworks indicated by the local health department on ______________(date).

☐ A press release was provided to newspapers, television stations, and radio stations on __________________________(date). *[not required if the waterworks delivered the written materials to every household served]*

☐ The following additional Public Education activities were initiated on ________________(date).
At least one of the following must be completed:

- ☐ Public Service Announcements
- ☐ Paid advertisements
- ☐ Public area informational displays
- ☐ E-mails to customers
- ☐ Public meetings
- ☐ Household deliveries
- ☐ Targeted individual customer contacts
- ☐ Direct material distribution to all multi-family homes and institutions
- ☐ Other methods approved by the commissioner____

I certify that all of the required Public Education delivery activities have been completed as indicated above within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded.. I further certify that an informational notice regarding lead in drinking water will be provided to each billing customer either with the normal water bills or as a separate mailing. This notification will be provided with each billing cycle but no less than once each calendar quarter for as long as the lead Action Level is exceeded.

Signature: ________________________________ Print Name:__________________________

Title: _______________________ Phone: _____________________ Date: _____________

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

Required Public Education Delivery for Non-transient Non-community (NTNC) Waterworks	
Delivery Requirement	**Timing of Delivery**
Post informational posters containing required written materials in a public place or common area in each of the buildings served by the waterworks	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months
Distribute* the written materials to each person served by the waterworks	Within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded Delivery must be repeated once every 12 months

Note that posting of the Public Education written materials **and** distribution to each person served by the waterworks is required. Electronic transmission may be allowed as long as it achieves at least the same coverage.

* Informational pamphlets and/or brochures.

Fact Sheet
LEAD IN DRINKING WATER

IMPORTANT INFORMATION ABOUT LEAD IN YOUR DRINKING WATER

[Insert name of water system] found elevated levels of lead in drinking water in some homes/buildings. Lead can cause serious health problems, especially for pregnant women and young children. Please read this information closely to see what you can do to reduce lead in your drinking water.

Health Effects of Lead

Lead can cause serious health problems if too much enters your body from drinking water or other sources. It can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body. The greatest risk of lead exposure is to infants, young children, and pregnant women. Scientists have linked the effects of lead on the brain with lowered IQ in children. Adults with kidney problems and high blood pressure can be affected by low levels of lead more than healthy adults. Lead is stored in the bones and it can be released later in life. During pregnancy, the child receives lead from the mother's bones, which may affect brain development.

Sources of Lead

Lead is a common metal found in the environment that has been in many consumer products but is now known to be harmful to human health if ingested or inhaled. Drinking water is one possible source of lead exposure. The main sources of lead exposure are lead-based paint and lead-contaminated dust or soil, and some plumbing materials. In addition, lead can be found in certain types of pottery, pewter, brass fixtures, food, and cosmetics. Other sources include exposure in the work place and exposure from certain hobbies (lead can be carried on clothing or shoes). Wash your children's hands and toys often as they can come into contact with dirt and dust containing lead. Lead is rarely found in natural sources of water such as rivers, lakes, wells or springs.

New brass faucets, fittings, and valves, including those advertised as "lead-free," may contribute lead to drinking water. The Safe Drinking Water Act defines "lead free" as no more than 0.2 percent lead when used with respect to solder and flux; and no more than 0.25 percent for pipes, pipe fittings, plumbing fittings, and fixtures based on a weighted average of the wetted surfaces. Consumers should be aware of this when choosing fixtures and take appropriate precautions.

[Insert utility specific information describing your community's source water – e.g. "The source of water from XX Reservoir does not contain lead" or "Community XX does not have any lead in its source water or water mains in the street."] When water is in contact with pipes [or service lines] or plumbing that contains lead for several hours, the lead may enter drinking water. Homes built before 1986 are more likely to have plumbing containing lead. New homes may also have lead; even "lead-free" plumbing may contain some lead.

EPA estimates that 10 to 20 percent of a person's potential exposure to lead may come from drinking water. Infants who consume mostly formula mixed with lead-containing water can receive 40 to 60 percent of their exposure to lead from drinking water.

Steps You Can Take To Reduce Your Exposure to Lead in Your Water

Lead may work its way into drinking water after the water entered the distribution system and is on its way to consumers taps. This usually happens through the corrosion of materials containing lead in household plumbing. These materials include brass faucets, lead solder on copper pipes, lead pipes, or lead service lines connecting the water main to the inside plumbing. Lead pipes are no longer installed for service lines or in household plumbing and lead solder has been outlawed in Virginia since 1985. If you live in a building in which the inside plumbing contains lead-based materials, there are several steps you can take to reduce your exposure to lead in drinking water. These include:

[Depending on the nature of drinking water use at the buildings (or sampling locations), select the most appropriate items that apply; e.g., in a manufacturing facility, items #2 & 5 will typically not apply.]

1. ***Run your water to flush out lead.*** If water hasn't been used for several hours, allow the water to run at the tap for 30 seconds to 2 minutes before using it for drinking or cooking. This action flushes the lead-containing water from the pipes. The water you run from drinking water taps does not have to be wasted. You can use this water for cleaning purposes or for watering plants. You may want to keep a container of drinking water in your refrigerator, so you don't have to run water every time you need it.

2. ***Use water from the cold water tap for cooking and preparing baby formula.*** Do not cook with or drink water from the hot water tap; lead dissolves more easily in hot water. Do not use water from the hot water tap to make baby formula.

3. ***Do not boil water to remove lead.*** Boiling water will not reduce or remove lead.

4. ***Consider installing a filter.*** You may want to consider installing a water filter. Ensure that the filter is approved to reduce lead or contact the National Sanitation Foundation at 800-NSF-8010 or **www.nsf.org** for information on performance standards for these types of water filters. If you choose to install a lead removal filter, be sure to maintain and replace the filter in accordance with the manufacturer's instructions to protect water quality.

5. ***Get your child tested.*** Contact your local health department or healthcare provider to find out how you can get your child's blood tested for lead if you are concerned about exposure.

6. ***Identify and replace any plumbing fixtures that contain lead.*** Brass faucets, fittings, and valves
manufactured *before January 4, 2014,* may contribute lead to drinking water, including those advertised as "lead-free." Under current law, "lead free" means no more than 0.2% lead in

solder and flux, and 0.25% lead for pipe, pipe fittings, and components. Visit the National Sanitation Foundation Web site at **www.nsf.org** to learn more about lead-containing plumbing fixtures.

7. ***Test your water for lead.*** Call us at *[insert phone number for your waterworks]* to find out how to get your water tested for lead. *[Include information on your waterworks testing program; e.g., costs of testing and availability of labs in your area that are certified to do testing for lead in drinking water for any consumer who requests it.]*

What Happened? What is Being Done?

[Insert information about how and when the exceedance was discovered in your waterworks and provide information on the source(s) of lead in the drinking water, if known.]
[Insert information about what your waterworks is doing to reduce lead levels in the homes/buildings, etc.]
[Insert information about lead service lines in your community served by your waterworks, how a consumer can find out if they have a lead service line, what your waterworks is doing to replace lead service lines, etc.]
[Insert information about the history of lead levels in tap water samples in your waterworks. For example, have they declined substantially over time? Have they been low and risen recently? Is there a known reason for any lead level changes?]

For More Information

Call us at *[Insert Waterworks Owner's Contact Phone Number]*, or *[if applicable]* visit our Website at *[insert Waterworks Website Here]*. For more information on reducing lead exposure around your home/building and the health effects of lead:

1. Visit EPA's website at http://www.epa.gov/lead;
2. Contact your health care provider;
3. Contact the National Lead Information Center at 800-424-LEAD; or
4. Contact the *[County/City]* Local Health Department at *[insert the appropriate phone number]*.

This notice is brought to you by *[insert the name of your waterworks]*. State Water System ID# *[insert your water system's ID number.* Date *[Insert the date distributed]*

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Regular text in blue font is mandatory and must not be changed.

Public Education Delivery Certification

INSTRUCTIONS:
1. Complete this form
2. Attach a copy of the Public Education materials that were posted/distributed.
3. Within 10 days after posting/distribution has been completed, mail this certification form to

    District Engineer Name
    VDH-Office of Drinking Water
    Name Field Office
    Address of Field Office

PWS Name: ____ PWSID: ____________________

Population: ________________________

DELIVERY METHOD – Nontransient Noncommunity Waterworks

☐ Written Public Education material regarding lead in drinking water was posted in a public place or common area in each building served by the waterworks on (date).

AND

☐ Written Public Education material regarding lead in drinking water was provided to each person served by the waterworks on _____________(date).
This notification was made by:

- ☐ Regular Mail
- ☐ Hand/direct delivery
- ☐ Email
- ☐ Other: ____

I certify that the attached Public Education written material was delivered in the manner and dates indicated above and a good faith effort was made to deliver the materials to each consumer served by the waterworks. I further certify that notification was completed within 60 days after the end of the lead and copper monitoring period in which the lead Action Level was exceeded.

Signature: ___________________________________Print Name: ___________________________

Title: __________________________________Phone: _____________________ Date: _________

GUDI Determination Review Sheet
(Initial Source Water and GUDI Re-evaluations)

Date: ____________________

Waterworks Name: ____

PWSID: ____

City / County: ____ Determined By: ____________________

Source Name: ____ Reviewed By: ____________________

STEP 1 of the evaluation procedure consists of reviewing the source history, construction and location.

	Step 1: Source History	Yes / No
a.	Has this source been directly associated with a biological waterborne disease outbreak?	
b.	Has this source been directly impacted by a chemical contamination incident from the surface?	
c.	Do surveys, reports or studies demonstrate a connection[1] between the source and surface water?	

[1]This connection must be *DIRECT* and afford little or no natural filtration through a soil horizon, as determined by empirical data. These connections might include: sinkholes, sinking creeks, troughs, drainage features, high porosity soils (sands and gravels), fracture zones, or other geologic features that have a high transmissivity. Evaluate these features and consider the well or spring construction and protection.

Step 1 Summary:

- If the answer to 1a, 1b, or 1c is **YES** – **STOP** – the source is GUDI.
- If the answers to 1a, 1b, and 1c are **NO** proceed to Step 2

STEP 2 consists of evaluating the results of bacteriological monitoring – a minimum 20 sample series of source water microbiological samples. Results must include both Total Coliform MPN's and *E. coli* MPN's.

	Step 2: Total Coliform and *E. coli* Sampling	Yes / No
a.	Do the results indicate 3 or more samples with Total Coliform greater than 100/100mL?	
b.	Do the results indicate 3 or more samples with *E. coli* equal to or greater than 5/100mL?	
c.	Do the results indicate *E .coli* to be present in 5 or more samples?	
d.	Geometric mean total coliform concentration = *Insert* CFU/100 mL Is geometric mean > 3 but < 100 CFU/100 mL?	

NOTE: If the Total Coliform geometric mean of 20 samples is greater than 100 /100 mL, the source must be evaluated under Step 3 to make a GUDI determination. If the source is NOT determined to be GUDI after the Step 3, evaluation of the requirements in Section 1.3.1. will apply. Geometric mean < 3 CFUs/100 mL will not require disinfection but waterworks may install treatment voluntarily and conduct source water monitoring.

Step 2 Summary:

- If the answer to Step 2a, 2b, or 2c, is **YES** proceed to Step 3.
- If the answer to Step 2a, 2b, and 2c is **NO - STOP** – the source is a groundwater source, and is not GUDI.
  - If the answer to Step 2d is **YES**, disinfection treatment is required. If **NO**, disinfection treatment is not required.

STEP 3 consists of evaluating the results of additional water quality monitoring conducted in accordance with an approved monitoring plan. The monitoring must include source water Microscopic Particulate Analysis (MPA) and physical parameter monitoring (turbidity, water temperature, pH and/or conductivity) of the source water and, if applicable, of a nearby surface water source. A minimum of four MPA tests must be conducted: two each during wet and dry conditions within a 12 month period. The MPA tests must be at least 60 days apart.

	Step 3: Additional Water Quality Monitoring	**Yes / No**
a.	Do the source water physical parameter monitoring results (turbidity, pH, temperature and/or conductivity) indicate a high correlation to the physical parameter monitoring results of a nearby surface water source taking into account significant rainfall or other meteorological events?	
b.	Does the source water physical parameter monitoring results (turbidity, pH, temperature and/or conductivity) fluctuate during or following a rainfall or other meteorological event?	
c.	Does any single sample MPA result indicate a score of equal to or greater than 20?	
d.	Do any two MPA sample results indicate a score of equal to or greater than 15?	
e.	Do **ALL** MPA sample results indicate a score of equal to or less than 9?	

Step 3 Summary:

- If the answer to Step 3a, 3b, 3c, <u>or</u> 3d, is **YES - STOP** – the source is GUDI
- If the answer to Step 3a and 3b is **NO** and the answer to Step 3e is **YES** – **STOP** - the source is a groundwater source, and is <u>not</u> GUDI.
- If the answer to Step 3e is **NO,** the District Engineer must evaluate all of the water quality monitoring data, well construction, geology, and any other relevant factors. Proceed to one of the following actions <u>with concurrence of the Field Director</u>:

  1) Consider the source to be "at risk" and continue to monitor. The District Engineer will establish the monitoring parameters and monitoring frequency.

  2) Declare the source to be a groundwater source (NOT GUDI). Note that even with this action source water monitoring continues.

CONCLUSION:

☐ Based upon the criteria established in STEP________, question(s) ____ this source is determined to be GUDI. Filtration and disinfection treatment must be installed within 18 months and the waterworks owner must initiate the interim requirements.

☐ Based upon the criteria established in STEP________, question(s) ____ this source is determined to be a groundwater source and is NOT GUDI. Additionally:

☐ Disinfection treatment is required, but is sufficient alone. Source water monitoring must continue.

☐ Disinfection treatment is not required (geometric mean total coliform ≤ 3 CFU/100 mL).

☐ Existing disinfection treatment installed voluntarily can continue operation with source water monitoring.

☐ This source is determined to be "at risk" for surface water influence. Source water monitoring must continue as directed by the Field Director.

____

Field Director

Attach all relevant water quality results.

GUDI Determination - Step 3 Monitoring Plan Worksheet

Waterworks Name:		PWSID:	
Date prepared:		Prepared by:	
Sources being evaluated, and distance to nearest surface water source:			

☐ Source water MPN for Total Coliform and *E. coli*	
Frequency:	
Duration:	
Locations:	
Laboratory:	
Special instructions: • Use only laboratories state-certified to perform Total Coliform and *E. coli* analysis • Report results as densities (Most Probable Number) rather than present /absent	

☐ Temperature	
Frequency:	
Duration:	
Locations:	
Special instructions: • An alcohol-filled thermometer or electric probe may be used. • Use an instrument capable of reading ± 0.5° F increments. • Use the same instrument for all readings.	

☐ Conductivity	
Frequency:	
Duration:	
Locations:	
Special instructions: Calibrate the instrument per manufacturer's recommendations, or submit to a State-certified laboratory.	

☐ Turbidity	
Frequency:	
Duration:	
Locations:	
Special instructions: • Use an instrument capable of reading 0.1 NTU increments. • Standardize and calibrate instrument per manufacturer's recommendations.	

☐ Specific Ions	
Frequency:	
Duration:	
Locations:	
Special instructions:	

☐ Rainfall	
Duration:	
Locations:	Identify sources of rainfall gauging. May need to use more than one rainfall location if utilizing existing gauges not in close proximity to the groundwater source (i.e. compare rainfall data from two wastewater treatment plants, each located greater than 10 miles from the source)
Special instructions:	

☐ Other Parameters (specify)	
Frequency:	
Duration:	
Locations:	
Special instructions:	

☐ Microscopic Particulate Analysis	
Frequency:	
Duration:	
Locations:	
Laboratory:	

Special instructions:

- Collect samples during both dry periods and wet periods.
- Wet period sample shall be taken between 12-48 hours following a significant rainfall event.
- Collect samples from the source prior to any treatment.
- Sample shall be analyzed by an EPA certified lab per USEPA “Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)”
- All MPA analyses must include both *Giardia lamblia*, and *Cryptosporidium*.
- Lab shall submit results per the Consensus Method’s risk rating protocol.

☐ Reporting Requirements (specify)

- Laboratories should report results directly to ODW Field Office

NOTIFICATION LETTER - “NOT GUDI”

SUBJECT:
Waterworks:
PWSID No.:

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner (SDWIS Administrative Contact):*

This notice is to inform you that in accordance with the Commonwealth of Virginia *Waterworks Regulations* 12 VAC 5-590-430 the following determinations was made for the *Waterworks Name* waterworks.

> ***Source name*** **was determined to be a groundwater source and is NOT under the direct influence of surface water**.

(Disinfected well sources) You must continue to conduct periodic source water (prior to any treatment) monitoring of the *source name*. One sample is to be collected each *source water monitoring frequency (year, quarter, month, week)*. All samples must be analyzed for Total Coliform and *E. coli* by an approved laboratory and by a test method that yields a most probable number (MPN) result. Depending upon the results of this source water monitoring, a re-evaluation of the source for direct surface water influence may be necessary in the future.

(Well sources without disinfection) Since this source is not treated by disinfection, additional source water monitoring is not required at this time.

If you have any questions or concerns, please contact me at *(phone number)* or *(name of District Engineer)* at *(phone number of District Engineer).*

Sincerely,

Name, Field Director
Field office name

ABC:xyz

Enclosure(s): *(If applicable, insert relevant information)*

ec or *cc: Insert name of LHD, Attn: Insert name of Environmental Health Manager/Health Director. Add other copyholders where applicable.*

GUDI NOTIFICATION - SAMPLE LETTER

SUBJECT:
Waterworks:
PWSID:

Date

Waterworks Owner name
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner (SDWIS Administrative Contact)*:

This notice is to inform you that our records and laboratory testing results indicate that *GUDI source name* is under the direct influence of surface water pursuant to 12 VAC 5-590-430 of the *Virginia Waterworks Regulations*. Attached is a summary of the source water sample results for *GUDI source name*. A water source is determined to be under the influence of surface water if *insert GUDI determination criteria*.

We request that you install filtration and disinfection treatment within 18 months of this notice receipt (or by *letter date plus 18 months)*, in accordance with 12 VAC 5-590-420 of the *Waterworks Regulations.* Additional options that you might wish to pursue are: 1) permanent disconnection of the surface influenced source, 2) development of new sources, or 3) the connection to a regional waterworks.

Effective upon receipt of this notice, please initiate the attached interim requirements until filtration is installed and operational, or an acceptable alternative to continued use of the source is approved.

(Note: If the waterworks has an existing operation permit, then send the letter with the attached interim action requirements. If the waterworks has no permit, issue a temporary operation permit that lists the interim action requirements as conditions of the permit.)

Please notify this office by *letter date plus 10 days* of your intentions with regard to discontinuing use of this GUDI source, or the installation of acceptable filtration and disinfection treatment. If you must continue use of this GUDI source we will coordinate the requirements and issuance of a Boil Water Notice with you. If you dispute the Office's determination that your groundwater source is under the direct influence of surface water, you have the right to an informal fact finding proceeding (IFFP), pursuant to *VA Code § 2.2-4019*, to present evidence and argument to refute this conclusion. Please contact this Office within 30 days of the date of this letter if you wish us to schedule an IFFP.

If you have any questions or concerns, please contact me at *(phone number)* or *(name of District Engineer)* at *(phone number of District Engineer).*

Sincerely,

Name, Field Director
Field office name

ABC:xyz

Enclosure(s): *(If applicable, insert relevant information)*

GUDI NOTIFICATION - SAMPLE LETTER

(Optional for Copyholders: Apply as needed; ec = electronic copy)
ec or *cc: Insert name of LHD - Attn: Insert name of Environmental Health Manager/Health Director. Add other copyholders where applicable.*
cc: *Local Health Department, ATTN – District Medical Director*

<u>GUDI NOTIFICATION - SAMPLE LETTER</u>

Letter Attachment
INTERIM ACTION REQUIREMENTS

Under the Commonwealth of Virginia *Waterworks Regulations* 12 VAC 5-590-420 the following interim requirements must be followed by a waterworks owner utilizing unfiltered surface water sources or groundwater sources that have been determined to be under the direct influence of surface water (GUDI) during the period before filtration is installed.

1. The owner shall discontinue use of the *<u>GUDI source name</u>* until such time as acceptable filtration and disinfection treatment is installed and is in operation.

2. If the *<u>GUDI source name</u>* must remain in service because discontinuing use of the source is not a viable option, the waterworks owner shall comply with the following requirements:

   a. Provide continuous chlorine disinfection treatment to achieve a 4-log inactivation of virus, and conduct daily chlorine residual monitoring.

   b. Issue a boil water notice through the public notification procedure in 12 VAC 5-590-540 until such time as the required filtration and disinfection treatment is installed.

   c. Increase the bacteriological sampling frequency in the distribution system. [*<u>Select one as appropriate:</u> 1) for waterworks that collect routine distribution system bacteriological samples at a monthly frequency*- The waterworks shall collect twice the number of samples required for that population each month. *2) for waterworks that collect routine bacteriological samples at a quarterly frequency*-, The waterworks shall increase the sampling frequency to monthly.]

NOTIFICATION LETTER-SOURCE WATER MONITORING REQUIRED

SUBJECT:
Waterworks:
PWSID No.:

Date

Waterworks Owner

Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner(SDWIS Administrative Contact):*

The results of routine source water bacteriological monitoring from the *source name* over the past *monitoring time frame* have indicated the presence of Total Coliform and / or *E. coli*. A summary of these monitoring results are attached.

In accordance the *Waterworks Regulations* 12VAC5-590-425 E and 12 VAC 5-590-430, we request that *waterworks name* begin a more aggressive source water monitoring program to better assess the potential of surface water influence of this groundwater source.

The source water monitoring program must include one sample per week (collected prior to any treatment) from the *source name*. All samples must be analyzed for Total Coliform and *E. coli* by an approved laboratory and by a test method that yields a most probable number (MPN) result. A minimum of 20 samples are required, however additional samples may be necessary. Sample collection may be adjusted within the week to collect samples immediately following rainfall events, as practical.

Please notify me if you wish to use the state laboratory (DCLS) for this monitoring so that sample container distribution and scheduling can be coordinated. Feel free to call me at *phone number* should you have any concerns or additional questions.

Sincerely,

District Engineer
Field Office Name Field Office

Attachments: *itemize*
CC: VDH-ODW-Central Office

GUDI STEP 3 ACTION REQUIRED- SAMPLE LETTER

SUBJECT: *County / City*
Waterworks: *Waterworks Name*
PWSID: *Waterworks PWSID*

Date

Waterworks Owner name
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner (SDWIS Administrative Contact)*:

The results of routine source water bacteriological monitoring from the *source name* over the past *monitoring time frame* have indicated elevated levels of Total Coliform and / or *E. coli*. These results suggest that *source name* may be at risk being directly influenced by surface water. In accordance the *Waterworks Regulations* 12 VAC 5-590-360 we request that *waterworks name* initiate additional source water monitoring to allow for a groundwater under direct influence of surface water (GUDI) determination pursuant to 12 VAC 5-590-430 of the *Virginia Waterworks Regulations* to be made.

Staff may wish to provide options available to the waterworks: Site-specific conditions will dictate viable options. Adapt and expand on all viable options as necessary.

Option 1-
Attached is a summary of the source water bacteriological sample results for *source name* and ODW's review. Based upon our data evaluation, additional water quality testing, referred to as *Step 3,* is necessary to determine if *source name* is under the direct influence of surface water and if additional treatment is necessary to protect public health.

Attached is a supplement that describes the additional water quality testing requirements and how the results will be evaluated. A Step 3 Monitoring Plan must be developed specifically for *source name* that contains the specific parameters to be monitored, the monitoring frequency, and the reporting of all monitoring results to ODW. A draft Step 3 Monitoring Plan for *source name* is attached for your information and review.

Option 2-
Attached is a summary of the source water bacteriological sample results for *source name* and ODW's data evaluation review. Based on our data evaluation, additional action is required as this source may be subject to Surface Water Treatment Rule filtration and disinfection requirements. The identified options for your waterworks are as follows:

1. Assume that the source is GUDI and proceed with installing filtration and disinfection treatment,
2. Permanently disconnect this well *or spring* and develop a replacement source or connect to a regional waterworks,
3. Correct any deficiencies that may be the cause of the contamination, or
4. Conduct additional water quality monitoring to complete the GUDI determination, referred to as Step 3 Sampling. A Step 3 Monitoring Plan must be developed specifically for *source* name that contains the specific parameters to be monitored, the monitoring frequency, and the reporting of all monitoring results to ODW.

GUDI STEP 3 ACTION REQUIRED- SAMPLE LETTER

If *source name* is to remain in service during the interim period until the Step 3 water quality data is gathered and a GUDI determination is made, we request that you initiate the following interim requirements, effective upon receipt of this notice:

1. Provide disinfection treatment to achieve a 4-log inactivation of virus. Until disinfection is designed, constructed and operational, public notice with continuous boil water advisory is required.

2. Conduct daily chlorine residual monitoring.

3. Increase the frequency of routine bacteriological monitoring of the finished water to twice the number of samples required based upon the population served.

Please contact me at *phone number* within the next 5 working days to discuss this issue and your available options. We are also available to meet with you to discuss this further.

Sincerely,

District Engineer, PE,
Field Office Name Field Office

Enclosure: Step 3 for GUDI Determinations

cc *Local Health Department, ATTN – District Medical Director*
VDH – ODW – Central Office

Groundwater Under the Direct Influence of Surface Water

STEP 3 - Water Quality Data Collection

Overview

Step 3 of the GUDI evaluation procedure consists of gathering additional water quality and meteorological data to determine if there is a direct connection between the subsurface aquifer and the surface. The Step 3 monitoring and evaluation is time-consuming and may take several months to complete. In addition, the waterworks owner may need to acquire a turbidimeter, pH meter and other water quality monitoring equipment.

Developing a Monitoring Plan and Conducting the Sampling

A monitoring plan will be developed by ODW Field Office in cooperation with the owner, which is site-specific to the source being evaluated. The waterworks owner will conduct all monitoring prescribed in the approved monitoring plan and shall submit the monitoring data to the Field Office on a frequency defined in the monitoring plan.

STEP 3 consists of evaluating the results of additional water quality monitoring conducted in accordance with the approved monitoring plan. The monitoring must include source water Microscopic Particulate Analysis (MPA) and physical parameter monitoring (turbidity, water temperature, pH and/or conductivity) of the source water and, if applicable, of a nearby surface water source. In addition to the water quality parameter monitoring, records of rainfall and other meteorological events at the water source location must be recorded.

MPA testing shall be conducted by laboratories acceptable to the commissioner and shall include both *Giardia lamblia* and *Cryptosporidium*.

a. All MPA testing and reporting of results must be in accordance with the USEPA *"Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)"* dated October 1992.
b. To optimize the detection of direct surface water influence, MPA samples are typically collected during both wet and dry periods. The purpose of collecting both wet-period and dry-period samples is to analyze water that is most likely to contain indicator organisms typical of surface water, if any exist, at times when conditions for transport to the potential GUDI source are optimal. A minimum of four MPA tests are required, two samples collected each during a wet and a dry period. The MPA tests must be at least 60 days apart.

The waterworks owner must provide the Field Office with all of the monitoring results required in the monitoring plan. MPA results must be provided within 10 days of receipt by the owner if the laboratory does not provide the ODW with the results directly. Other monitoring (physical parameters) can be provided along with applicable rainfall / meteorological data to the Field Office on a monthly or quarterly frequency as stipulated in the monitoring plan. All water quality monitoring data and rainfall data must be detailed and presented in the final report.

Evaluation of the Step 3 Sampling Results

Physical parameters (turbidity, water temperature, pH and/or conductivity) are indicators of direct surface water influence and will be evaluated for a direct correlation between groundwater monitoring results and monitoring results from a nearby surface water source, taking into account significant rainfall or other meteorological events, or a fluctuation in source water following a significant rainfall or other meteorological event.

The MPA laboratory results must be reported in accordance with the above mentioned EPA consensus method. Application of this method results in relative risk factors (scores) that will be used to determine the degree of risk associated with influence by surface water. The following relative risk factors will be used to make the GUDI determination:

- High risk – A lab-provided MPA risk calculation $\geq$ 20
- Moderate risk – A MPA risk calculation equal to or greater than 10 and $\leq$ 19
- Low risk – A MPA risk calculation $\leq$ 9

1. If any single MPA sample result indicates a score greater than or equal to 20, the source is determined to be GUDI.

2. If any two MPA sample results indicate scores equal to or greater than 15, the source is determined to be GUDI.

3. If <u>all</u> MPA sample results indicate scores of equal to or less than 9, the source is determined to be a groundwater source (NOT GUDI). Note that source water monitoring continues. ODW may increase the frequency of this monitoring or require additional monitoring parameters.

4. If the source is not determined to be GUDI based upon the physical monitoring criteria or the MPA sample results; and if all the MPA results are not equal to or less than 9, a decision on future actions will be made. All of the available water quality data, geology, well construction, and any other relevant factors are reviewed and evaluated by ODW and either (1) the source is “at risk” and continued monitoring will be required, or (2) the source to be a declared a groundwater source (NOT GUDI). Note that even with this action source water monitoring continues.

EPA Relative Risk Tables

The following tables are excerpted from the USEPA "Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA)" dated October 1992.

Table A. Numerical range of each bio-indicator based on numbers counted per 100 gallons filtered water*

Indicators of Surface Water*	Extremely Heavy	Heavy	Moderate	Rare	None Found
Giardia**	>30	16-30	6-15	1-5	0
Coccidia**	>30	16-30	6-15	1-5	0
Diatoms	>150	41-149	11-40	1-10	0
Other Algae	>300	96-299	21-95	1-20	0
Insects/Larvae	>100	31-99	16-30	1-15	0
Rotifers	>150	61-149	21-60	1-20	0
Plant Debris	>200	71-200	26-70	1-25	0

Table B. Relative surface water risk factors associated with scoring of bio-indicators present during MPA of subsurface water sources.

Particulates Indicative of Surface Water*	Extremely Heavy***	Heavy	Moderate	Rare	None Found
Giardia	40	30	25	20	0
Coccidia	35	30	25	20	0
Diatoms	16	13	11	6	0
Other Algae	14	12	9	4	0
Insects/Larvae	9	7	5	3	0
Rotifers	4	3	2	1	0
Plant Debris	3	2	1	0	0

Table C. Risk of Groundwater Contamination by Surface Water Influence

≥20****	High Risk
10-19	Moderate Risk
≤ 9	Low Risk

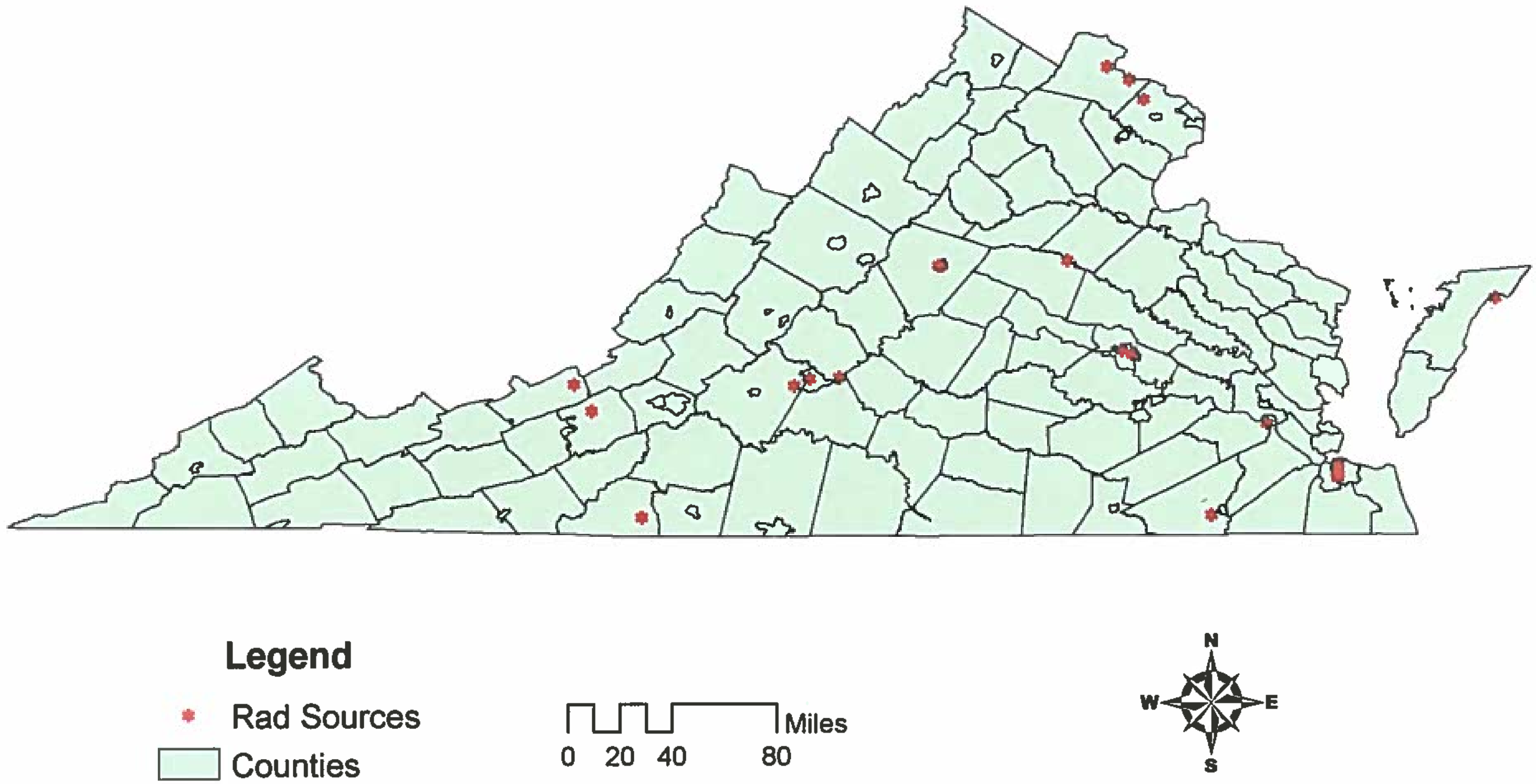
* According to EPA "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources," March, 1991 ed.

** If *Giardia* cysts, *Cryptosporidium*, or other coccidia are found in any sample, irrespective of volume, score as above.

*** Refer to Table A for range of indicators counted per 100 gallons under 100X.

**** Refer to Table B for numerical relative risk factor.

Radioactive Emitters - Virginia



Latitude	Longitude	Facility Name	Jurisdiction	Contact	Phone No	License No
36.933	-76.301	Norfolk Naval Shipyard	Norfolk	Phyllis C. Campbell	(717) 7704762	373006201
38.948	-77.366	DOI Geologic Survey National Center	Reston	Tim Debey	(303) 2364726	50139908
37.851	-75.437	NASA Wallops Flight Facility	Wallops Island	Patrick A Hancock	(301) 2862281	190574802
37.411	-79.053	BWX Technologies	Lynchburg	Carl Yates	(434) 5335325	SNM42
36.859	-76.304	Eastern Virginia Medical School	Norfolk	Lamarr G. Beuchler	(804) 4465798	451587701
36.859	-76.304	Eastern Virginia Medical School Medical College of Hampton Roads	Norfolk	Lamarr G. Beuchler	(804) 4465798	451587701
36.859	-76.304	Eastern Virginia Medical School Pediatric Research Center	Norfolk	Lamarr G. Beuchler	(804) 4465798	451587701
36.859	-76.304	Eastern Virginia Medical School H & G Jones Institute of Reproductive	Norfolk	Lamarr G. Beuchler	(804) 4465798	451587701
36.859	-76.304	Eastern Virginia Medical School Diabetes Institutes	Norfolk	Lamarr G. Beuchler	(804) 4465798	451587701
36.652	-76.999	Eastman Chemical Resins	Courtland	Michael Crouch	(757) 5623121	452551201
37.407	-79.213	Framatome ANP, Inc.	Lynchburg	Bill Sharkey	(434) 8325276	SNM1168
37.367	-79.300	Gannapar, LLC	Forest	James J. J. Myron, Ph. D.	(434) 5255252	451149602
39.060	-77.446	George Washington University	Ashburn	Terry A. Johnson, CHP, RSO	(202) 9942995	80021622
36.889	-76.303	ODU	Norfolk	Derek S. Krepp	(757) 6834495	450959903
36.876	-76.302	ODU Research Vessels	Norfolk	Derek S. Krepp	(757) 6834495	450959903
37.543	-77.432	VCU Animal Research Facility	Ashland	Dean Broga, Ph. D.	(804) 8286347	450004817
37.540	-77.430	VCU Campuses	Richmond	Dean Broga, Ph. D.	(804) 8286347	450004817
37.559	-77.491	VCU Richmond Eye & Ear	Richmond	Dean Broga, Ph. D.	(804) 8286347	450004817
37.158	-76.692	Virginia Electric and Power	Surry	David Sommers	(804) 2732823	SNM2501
38.060	-77.790	Virginia Electric and Power	Mineral	David Sommers	(804) 2732823	SNM2507
37.231	-80.424	Virginia Tech	Blacksburg	Douglas C. Smiley, RSO	(540) 2315364	450947530
36.643	-80.149	Virginia Tech Reynolds Homestead	Critz	Douglas C. Smiley, RSO	(540) 2315364	450947530
39.131	-77.569	Virginia Tech DuPont Scott Equine Center	Leesburg	Douglas C. Smiley, RSO	(540) 2315364	450947530
38.033	-78.483	UVA	Charlottesville	Ralph O. Allen, RSC	(434) 9824911	450003426
37.376	-80.522	UVA Mountain Lake Biological Station	Giles County	Ralph O. Allen, RSC	(434) 9824911	450003426
38.033	-78.500	UVA Albermarle County	Albermarle County	Ralph O. Allen, RSC	(434) 9824911	450003426

Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure

U.S. Department of Commerce
National Bureau of Standards
Handbook 69

August 1963

Addendum 1 to National Bureau of Standards Handbook 69

Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure

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Subcommittee 2 of NCRP has offered the following material in revision of Handbook 69. In some cases the changes correct errors which were not detected in proof; in other cases they provide estimates based on better data or provide interpretation for use of the Handbook.

1. *Skin of the Whole Body:* In accordance with the Release of Statements by the National Committee on Radiation Protection and Measurements (NCRP), the first item under subheading B (p. 5) should be changed to read:

> B. *External exposure to other organs. Skin of whole body:* The maximum permissible dose to the skin of the whole body shall not exceed 30 rems per year and the dose in any 13 consecutive weeks shall not exceed 10 rems.

COMMENT: This change affects, also, the statements pertaining to skin in the last paragraph of page 6. By the above rule NCRP now allows the skin 10 rems instead of 6 rems in any 13-week period. The values with skin as critical organ in table 1 of Handbook 69, however, are based on 30 rems/yr and do not require adjustment.

2. *Curie of Natural Uranium:* The definition of the curie of natural uranium as it appears in the last paragraph of page 14 is in error and should be changed to read:

> In accordance with long established usage [13a] in internal dose calculations, however, a curie of recently extracted uranium is considered to correspond to the sum of 3.7×10^{10} dis/sec from U^{238}, 3.7×10^{10} dis/sec from U^{234}, and 1.7×10^{9} dis/sec from U^{235}

COMMENT: Since the activity of U^{235} is relatively unimportant in the natural uranium mixture, the MPC and q values in table 1 are unaffected by this change.

[13a] Since the $(MPC)_a$ for soluble natural uranium is based on its chemical toxicity (see paragraph 3.1.j) and is therefore primarily stipulated in units of micro-micrograms of uranium 238 per cc air, the conversion to microcurie per cc units by convention takes into account only the activity of U^{238}. The latter practice was believed to facilitate interconversion between gravimetric and activity units for natural uranium. The activity of natural thorium is similarly defined since it presents an analogous fixed isotope combination. The toxicity criterion is radioactive and not chemical in the case of thorium.

3. *$(MPC)_a$ for Ra^{226}:* **The following line is to be added on page 80 above the last line for Ra^{226} (the last line for Ra^{226} is repeated here to indicate the position in the table):**

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body q (μc)	Maximum permissible concentrations: For 40 hr week $(MPC)_w$ $\mu c/cc$	For 40 hr week $(MPC)_a$ $\mu c/cc$	For 168 hr week $(MPC)_w$ $\mu c/cc$	For 168 hr week $(MPC)_a$ $\mu c/cc$
${}_{88}Ra^{226}$ (α,β^-,γ) (Insol)	**Lung**	....	....	**5×10^{-11}**	....	**2×10^{-11}**
	GI(LLI)	....	9×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}

COMMENT: The internal dose handbooks have not previously given a concentration value for Ra^{226} with lung as the organ of reference. However, in response to requests, a value based on the data available was determined. This value has been incorporated in the Federal Register (Nov. 17, 1960). Because these added values will be the smaller ones in the insoluble grouping, they, rather than the (insol) GI(LLI) values, should be in boldface type.

4. *$(MPC)_a$ and $(MPC)_w$ for Cf^{252}:* The entries for Cf^{252} in table 1 (page 91) should be replaced by the following:

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body q (μc)	Maximum permissible concentrations: For 40 hr week $(MPC)_w$ $\mu c/cc$	For 40 hr week $(MPC)_a$ $\mu c/cc$	For 168 hr week $(MPC)_w$ $\mu c/cc$	For 168 hr week $(MPC)_a$ $\mu c/cc$
${}_{98}Cf^{252}$ (α,γ,SF) (Sol)	GI(LLI)	....	2×10^{-4}	4×10^{-8}	7×10^{-5}	2×10^{-8}
	Bone	0.01	5×10^{-4}	**6×10^{-12}**	2×10^{-4}	**2×10^{-12}**
	Total body	0.09	4×10^{-3}	5×10^{-11}	10^{-3}	2×10^{-11}
(Insol)	**Lung**	....	....	**3×10^{-11}**	....	**10^{-11}**
	GI(LLI)	....	**2×10^{-4}**	4×10^{-8}	**7×10^{-5}**	10^{-8}

COMMENT: Since the publication of Handbook 69, more recent decay schemes for Cf^{252} have been found which indicate considerable spontaneous fission (SF) that was not given in the earlier decay schemes.

5. *MPC Values for Unidentified Radionuclides:* Tables 3 and 4 (pages 93 and 94) should be replaced by tables 3a and 4a as given on the following page.

TABLE 3a. *Maximum permissible concentration of unidentified radionuclides in water,* $(MPCU)_w$ *values*, for continuous occupational exposure*

Limitations	$\mu c/cm^3$ of water**
If no one of the radionuclides Sr^{90}, I^{126}, I^{129}, I^{131}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ra^{228}, Ac^{227}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat is present, then the $(MPCU)_w$ is	3×10^{-5}
If no one of the radionuclides Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat is present, then the $(MPCU)_w$ is	2×10^{-5}
If no one of the radionuclides Sr^{90}, I^{129}, Pb^{210}, Ra^{226}, and Ra^{228} is present, then the $(MPCU)_w$ is	7×10^{-6}
If neither Ra^{226} nor Ra^{228} is present, then the $(MPCU)_w$ is	10^{-6}
If no analysis of the water is made, then the $(MPCU)_w$ is	10^{-7}

*Each $(MPCU)_w$ value is the smallest value of $(MPC)_w$ in table 1 for radionuclides other than those listed opposite the value. Thus these $(MPCU)_w$ values are permissible levels for continuous occupational exposure (168 hr/wk) for any radionuclide or mixture of radionuclides where the indicated isotopes are not present (i.e., where the concentration of the radionuclide in water is small compared with the $(MPC)_w$ value for this radionuclide). The $(MPCU)_w$ may be much smaller than the more exact maximum permissible concentration of the material, but the determination of this $(MPC)_w$ requires identification of the radionuclides present and the concentration of each.

**Use one-tenth of these values for interim application in the neighborhood of a controlled exposure area.

TABLE 4a. *Maximum permissible concentration of unidentified radionuclides in air,* $(MPCU)_a$ *values*, for continuous occupational exposure*

Limitations	$\mu c/cm^3$ of air**
If there are no α-emitting radionuclides and if no one of the β-emitting radionuclides Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} is present, then the $(MPCU)_a$ is	10^{-9}
If there are no α-emitting radionuclides and if no one of the β-emitting radionuclides Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} is present, then the $(MPCU)_a$ is	10^{-10}
If there are no α-emitting radionuclides and if the β-emitting radionuclide Ac^{227} is not present, then the $(MPCU)_a$ is	10^{-11}
If no one of the radionuclides Ac^{227}, Th^{230}, Pa^{231}, Th^{232}, Th-nat, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{242}, and Cf^{249} is present, then the $(MPCU)_a$ is	10^{-12}
If no one of the radionuclides Pa^{231}, Th-nat, Pu^{239}, Pu^{240}, Pu^{242}, and Cf^{249} is present, then the $(MPCU)_a$ is	7×10^{-13}
If no analysis of the air is made, then the $(MPCU)_a$ is	4×10^{-13}

*Each $(MPCU)_a$ value is the smallest value of $(MPC)_a$ in table 1 for radionuclides other than those listed opposite the value. Thus these $(MPCU)_a$ values are permissible levels for continuous occupational exposure (168 hr/wk) for any radionuclide or mixture of radionuclides where the indicated isotopes are not present (i.e., where the concentration of the radionuclide in air is small compared with the $(MPC)_a$ value for this radionuclide). The $(MPCU)_a$ value may be much smaller than the more exact maximum permissible concentration of the material, but the determination of this $(MPC)_a$ requires identification of the radionuclides present and the concentration of each.

**Use one-tenth of these values for interim application in the neighborhood of a controlled exposure area.

COMMENT: The format and wording of tables 3 and 4 have occasioned some confusion. However, the grouping has been changed slightly in the revised version to be more in accord with the values in table 1 and the needs of applied health physics. No change in principle is involved since every user of Handbook 69 can construct his own MPCU table to match any possible mixture of radionuclides he may need to consider.

6. *Typographical Errors:* The following typographical errors have been noted and are listed to prevent misinterpretation:

a. Page 24, first entry in column 1 – Change "$_1H^3(H_2^3O)(\beta^-)$" to read "$_1H^3$(HTO or H_2^3O)(β^-)."

Also, the $(MPC)_a$ values should be changed to read:

Radio-nuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body q (μc)	Maximum permissible concentrations			
			For 40 hr week		For 168 hr week	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_1H^3$ (HTO or H_2^3O) (β^-)(Sol)	**Body tissue**			5×10^{-6}		2×10^{-6}
	Total body			8×10^{-6}		3×10^{-6}

b. Page 36, second entry in column 1 – Change "$_{34}Br^{82}(\beta^-,\gamma)$" to "$_{35}Br^{82}(\beta^-,\gamma)$."

c. Page 37, for $_{38}Sr^{89}(\beta^-)$, second entry for Sr^{89} in column 4 – Value is not clear; it should be "10^{-3}"

d. Page 51, for $_{52}Te^{125m}(\gamma,e^-)$, first entry for Te^{125m} in column 3 – Replace "29" with "20."

e. Page 86, the last subheading in the last column – "$(PMPC)_a$" should be "$(MPC)_a$."

Second entry in column 1 – "$_{92}Np^{237}$" should be "$_{93}Np^{237}$"

f. Page 88, for $_{95}Am^{241}(\alpha,\gamma)$, last entry for Am^{241} in column 6 – "2×10^{-4}" should be "3×10^{-4}."

g. Page 89, for $_{96}Cm^{242}(\alpha,\gamma)$, last entry for Cm^{242} in column 6 – "3×10^{-4}" should be "2×10^{-4}."

AFP 160-6-7

U.S. Department of Commerce, Lewis L. Strauss, Secretary
National Bureau of Standards, A. V. Astin, Director

Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure

Recommendations of the
National Committee on Radiation Protection

NCRP Report No. 22

National Bureau of Standards Handbook 69
Issued June 5, 1959
(Supersedes Handbook 52)

Preface

The present Handbook and its predecessors stem from the Second International Congress of Radiology, held in Stockholm in 1928. At that time, under the auspices of the Congress, the International Commission on Radiological Protection (ICRP) was organized to deal initially with problems of X-ray protection and later with radioactivity protection. At that time "permissible" doses of X-rays were estimated primarily in terms of exposures which produced erythema, the amount of exposure which would produce a defined reddening of the skin. Obviously a critical problem in establishing criteria for radiation protection was one of developing useful standards and techniques of physical measurement. For this reason two of the organizations in this country with a major concern for X-ray protection, the American Roentgen Ray Society and the Radiology Society of North America, suggested that the National Bureau of Standards assume responsibility for organizing representative experts to deal with the problem. Accordingly, early in 1929, an Advisory Committee on X-ray and Radium Protection was organized to develop recommendations on the protection problem within the United States and to formulate United States points of view for presentation to the International Commission on Radiological Protection. The organization of the U.S. Advisory Committee included experts from both the medical and physical science fields.

As a result of the extensive developments immediately preceding and during World War II that added substantially to the importance of radiation protection problems, the Advisory Committee was reorganized in 1946 as the National Committee on Radiation Protection (and later, the National Committee on Radiation Protection and Measurements—NCRP). The revised Committee included representation from the various professional societies with an interest in the problem, government agencies with related interest and responsibilities, as well as individual experts. The continued sponsorship of the Committee by the National Bureau of

Standards was in accordance with its statutory responsibility to cooperate with other governmental agencies and with private organizations in the development of standard practices, incorporated in codes and specifications. In addition, the recommendations of the National Committee on Radiation Protection and Measurements have been published as handbooks by the National Bureau of Standards, again in accordance with its statutory authorizations.

The conclusions in the present handbooks are to be considered only as recommendations of a group of experts in the radiological protection field. They carry no legal implications demanding or requiring adoption. Inasmuch as the recommendations of the National Committee on Radiation Protection and Measurements impinge upon the areas of statutory responsibility of both the U.S. Public Health Service and the U.S. Atomic Energy Commission, it was considered important to determine that these agencies would not object to the publication of these recommendations by the National Bureau of Standards. Such assurances were obtained although these involve no commitment on the part of these agencies to adopt the recommendations of the National Committee on Radiation Protection and Measurements. Nor should the publication be construed as a recommendation by the National Bureau of Standards for adoption inasmuch as the important medical and biological factors involved in developing the recommendations are clearly outside of the Bureau's area of technical competence.

Since the publication in 1953 of the report of Subcommittee 2 of the National Committee on Radiation Protection on Permissible Internal Dose entitled "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water" (NBS Handbook 52) the study of the problem of internal irradiation has been continuous. The basic work for the preparation of this report has been handled to a major extent by Dr. K. Z. Morgan and by members of his staff at Oak Ridge. The same task has been carried out simultaneously for the corresponding committee of the International Commission on Radiological Protection of which Dr. Morgan is also Chairman.

Since 1953 new information relative to the problem of internal irradiation has been steadily increasing. Simultaneously there have been increasing demands for more information on radionuclides than was covered in the original edition of Handbook 52. In spite of the enormous amount of work which has been done by this subcommittee the problem of developing maximum permissible concentrations of radionuclides is still rendered difficult because of the relatively limited direct experience with the action of the radiation from radionuclides on human tissues. The contents of this Handbook are based on what is believed to be the best information available and it is to be expected that as our knowledge increases the numerical quantities presented in this report will be in a state of continuous modification.

The recommendations of this Handbook take into consideration the NCRP statement entitled "Maximum Permissible Radiation Exposures to Man," published as an addendum to Handbook 59 on April 15, 1958.

As noted above this study was carried out jointly by the ICRP and the NCRP, and the complete report is more extensive than the material contained in this Handbook. It was felt that for the sake of producing a handbook suitable for daily use, some of the more extensive treatment of the problem could be omitted, since it would be made available in the complete ICRP report published by Pergamon Press. A Table of Contents of the parts of the ICRP report not contained herein is given on page 22. In addition the ICRP committee has prepared a detailed bibliography containing hundreds of references relative to the problem. Since the demand for this bibliography will be somewhat limited it will be made available as a separate publication by Pergamon Press.

The National Committee on Radiation Protection and Measurements is governed by representatives of 17 participating organizations, including the National Bureau of Standards. Eighteen subcommittees have been established, each charged with the responsibility of preparing recommendations in its particular field. The reports of the subcommittees are approved by the Main Committee before publication.

The following parent organizations and individuals comprise the Main Committee:

H. L. Andrews, U.S. Public Health Service and Subcommittee Chairman.
E. C. Barnes, Amer. Indust. Hygiene Assoc.
C. M. Barnes, Amer. Veterinary Medical Assoc.
A. C. Blackman, Int. Assoc. of Govt. Labor Officials.
C. B. Braestrup, Radiol. Soc. of North Amer. and Subcommittee Chairman.
J. C. Bugher, Representative-at-large.
R. H. Chamberlain, Amer. College of Radiology.
W. D. Claus, U.S. Atomic Energy Commission.
C. L. Dunham, U.S. Atomic Energy Commission.
T. P. Eberhard, Amer. Radium Society and Subcommittee Chairman.

T. C. Evans, Amer. Roentgen Ray Society.
G. Failla, Representative-at-large.
J. W. Healy, Health Physics Soc. and Subcommittee Chairman.
P. C. Hodges, Amer. Medical Assoc.
M. Kleinfeld, Int. Assoc. Govt. Labor Officials.
H. W. Koch, Subcommittee Chairman.
W. Langham, Subcommittee Chairman.
R. M. Lechausse, Col., U.S. Air Force.
G. V. Leroy, Subcommittee Chairman.
W. B. Mann, Subcommittee Chairman.
W. A. McAdams, Atomic Indust. Forum and Subcommittee Chairman.
G. M. McDonnel, Lt. Col., U.S. Army.
G. W. Morgan, Subcommittee Chairman.
K. Z. Morgan, Health Physics Society and Subcommittee Chairman.
R. J. Nelsen, American Dental Assoc.
R. R. Newell, Amer. Roentgen Ray Society.
C. Powell, U.S. Public Health Service.
E. H. Quimby, Amer. Radium Society and Subcommittee Chairman.
J. A. Reynolds, Natl. Electrical Mfgr. Assoc.
H. H. Rossi, Subcommittee Chairman.
M. D. Schulz, Amer. College of Radiology.
L. S. Skaggs, Subcommittee Chairman.
J. H. Sterner, Amer. Indust. Hygiene Assoc.
R. S. Stone, Radiol. Soc. of North America.
L. S. Taylor, National Bureau of Standards.
E. D. Trout, Natl. Electrical Mfgr. Assoc.
Bernard F. Trum, Amer. Veterinary Medical Assoc.
Shields Warren, Representative-at-large.
E. G. Williams, Representative-at-large.
S. F. Williams, Capt., U.S. Navy.
H. O. Wyckoff, Subcommittee Chairman.

The following are the Subcommittees and their Chairmen:

Subcommittee 1.	Permissible Dose from External Sources. (Responsibility of the Executive Committee.)
Subcommittee 2.	Permissible Internal Dose, K. Z. Morgan.
Subcommittee 3.	X-rays up to Two Million Volts, T. P. Eberhard.
Subcommittee 4.	Heavy Particles (Neutrons, Protons, and Heavier), H. H. Rossi.
Subcommittee 5.	Electrons, Gamma Rays and X-rays Above Two Million Volts, H. W. Koch.
Subcommittee 6.	Handling of Radioactive Isotopes and Fission Products, J. W. Healy.
Subcommittee 7.	Monitoring Methods and Instruments, H. L. Andrews.
Subcommittee 8.	Waste Disposal and Decontamination. (This subcommittee has been inactivated.)
Subcommittee 9.	Protection Against Radiations from Ra, Co^{60} and Cs^{137} Encapsulated Sources, C. B. Braestrup.
Subcommittee 10.	Regulation of Radiation Exposure Dose, W. A. McAdams.
Subcommittee 11.	Incineration of Radioactive Waste, G. W. Morgan.
Subcommittee 12.	Electron Protection, L. S. Skaggs.
Subcommittee 13.	Safe Handling of Bodies Containing Radioactive Isotopes, E. H. Quimby.

Subcommittee 14. Permissible Exposure Doses Under Emergency Conditions, G. V. Leroy.
Subcommittee M–1. Standards and Measurement of Radioactivity for Radiological Use, W. B. Mann.
Subcommittee M–2. Standards and Measurement of Radiological Exposure Dose, H. O. Wyckoff.
Subcommittee M–3. Standards and Measurement of Absorbed Radiation Dose, H. O. Wyckoff.
Subcommittee M–4. Relative Biological Effectiveness, W. H. Langham.

The present Handbook was prepared by the Subcommittee on Permissible Internal Dose, with the following members:

K. Z. Morgan, Chairman	Oak Ridge National Laboratory
A. M. Brues	Argonne National Laboratory
P. Durbin	University of California
G. Failla	Columbia University
J. W. Healy	Hanford Works, Richland, Wash.
J. B. Hursh	University of Rochester
L. D. Marinelli	Argonne National Laboratory
W. S. Snyder	University of Tennessee
Shields Warren	New England Deaconness Hospital

In addition, many scientists of many countries have contributed, not only through their original research which is the basis of the report, but also by their generous aid in interpreting their results for use in this report. Finally, the technical work of collecting the data and interpreting it for conditions of occupational exposure as well as the writing of the text is largely the work of the Internal Dosimetry Section of the Oak Ridge National Laboratory headed by Dr. K. Z. Morgan. In particular, Mary Jane Cook has been responsible for the collection and presentation of the biological data, Mary Rose Ford has been responsible for the physical data used and for computation, James Muir and Janet Kohn have computed the tables for the gastrointestinal tract values and for the effective energies, respectively, and Dr. Walter S. Snyder has supervised the technical work and acted as secretary to the ICRP Committee II in preparing this report.

A. V. Astin, *Director.*

Contents

Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure

1. Introduction

The National Committee on Radiation Protection (NCRP) has a subcommittee on permissible internal dose whose function is to provide recommended values of maximum permissible body burden, q, of radionuclides and maximum permissible concentration, MPC, of these nuclides in air and in water (or food). These values are provided only for the more important radionuclides, and they *are applicable primarily to occupational exposure.* This subcommittee has recognized that such compilations are of limited usefulness unless periodically revised to incorporate the best available information and extended to include the values required by new developments and uses. It has worked closely with the Internal Dose Committee of the International Commission on Radiological Protection (ICRP) in collecting these data and in making revisions of the earlier publications of the NCRP (1953)[1] and by the ICRP (1955).[2] In fact, the respective subcommittees on Internal Dose of the NCRP and ICRP have the same chairman.

To avoid unnecessary duplication of publication, this report of the NCRP is an abridgment of the ICRP Internal Radiation report. It includes a statement of basic philosophy, explanations and tables of "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure."

The portions of the ICRP report giving the procedures for calculation and the associated tables are not included

[1] Report of National Committee on Radiation Protection, National Bureau of Standards Handbook 52 (1953), Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

[2] Recommendations of the International Commission on Radiological Protection (1955) British Journal of Radiology, Supplement 6 (Meeting of the International Congress of Radiology held in Copenhagen, Denmark, 1953).

in this report, and the reader should refer to the ICRP Internal Radiation report [5] for such information. A table of contents of those sections of the ICRP Internal Radiation report not included here is given at the end of this report.

In addition to revising and extending the earlier publications, the members of both committees hope that this publication will be a means of harmonizing and unifying the objectives and principles used by the NCRP and ICRP in arriving at their decisions.

The basic recommendations concerning permissible radiation exposure have been revised in recent years by the NCRP,[3] and similar revisions have been made by the ICRP.[4] An examination of the 1958 report of the ICRP reveals that the major changes of interest to Subcommittee 2 are the following:

(1) Instead of a weekly limit, a quarterly limit is recommended, thus giving greater flexibility for many operations.

(2) While the permissible quarterly rates for internal emitters are essentially comparable to former permissible rates, a limit on integrated dose is imposed in the case of exposure of the blood-forming organs and the gonads. The ICRP recommendations [4] also apply a limit on integrated dose to the lenses of the eyes, but the relevant data are so inadequate that the eyes are not considered as an organ of reference in either the 1953 or 1958 ICRP Internal Radiation reports.

(3) Recommendations are given for some nonoccupational groups and for the whole population.

A comparison of this publication with Handbook 52 (1953) will reveal that very extensive modifications have been required by new data and methods of estimating internal dose, and will indicate that the number of radionuclides listed in the earlier publication has been increased by about a factor of three. All biological and physical data used in the earlier publication have been reviewed and the permissible exposure values have been revised accordingly. Refinements in the calculations for the exposure of the gastrointestinal tract and for chains of radionuclides in the body have resulted in new values for many of the permissible limits. The "power function" model is discussed in the appendix of the ICRP Internal Radiation report [5] as an

[3] Report of National Committee on Radiation Protection, National Bureau of Standards Handbook 59. (Addendum, Jan. 8, 1957), Maximum permissible exposures to man. A preliminary statement of the National Committee on Radiation Protection and Measurement; (Addendum, Apr. 15, 1958), Maximum Permissible Radiation Exposures to Man. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

[4] Recommendations of the International Commission on Radiological Protection, Main Commission Report, Sept. 9, 1958; Pergamon Press, London, England, 1959.

[5] Recommendations of the ICRP, Report of the Committee on Permissible Dose for Internal Radiation—1958 revision; to be published, Pergamon Press, London, England.

alternative method of estimating the body burden for certain long-lived radionuclides. The data in table 1 were calculated using the "exponential or compartment" model for retention and elimination, but the MPC and body burden values listed in the tables were selected after careful consideration by the subcommittee of the values obtained by the use of both models. While it is clearly impossible to be completely abreast of the literature in such a rapidly developing field, this publication represents the most important findings through 1957 as well as those in a few early publications of 1958.

All MPC values are given for a 40-hr workweek as well as for continuous exposure; i.e., a 168-hr week. Previous editions of the permissible internal-dose publications listed values based on continuous exposure, partly because these same values were sometimes used, with an appropriate factor, to apply to cases of continuous nonoccupational exposure and also because of variations in the length of the workweek.

The MPC values based on a 40-hr workweek are included because they are directly applicable to the standard working conditions existing in this country.

The MPC values listed for continuous occupational exposure are convenient in obtaining permissible levels for special groups. The appropriate factors to be applied in obtaining permissible levels for these groups are discussed in the ICRP report.[4,5] Because the continuous exposure MPC values listed neglect several important considerations, particularly differences between children and adults, it should be emphasized that, even when corrected by the above factors, these can only be regarded as interim values for nonoccupational exposure. It is hoped that the term *continuous occupational exposure values* will emphasize the provisional nature of their use for other purposes.

Although the data on which the MPC values are based are very incomplete and in some cases uncertain, they embody the latest and best research of hundreds of scientists; and it is believed that these MPC values are the best now available. They should serve as a guide to indicate whether the operational procedures used in practice are adequate to insure that the dose delivered by internally-deposited radioactive material does not exceed the pertinent permissible limit set by NCRP.

For many radionuclides the radiation-exposure period may last for many months or even a lifetime, although the intake may have occurred in a relatively short time. When radioactive contaminants are deposited in the body, it is often difficult to make an accurate estimate of the total body burden or of its distribution in the body. In most cases, even when the fact is established that a person carries a large internal burden of a radionuclide, little can be done to hasten its elimination from the body. According to one theory, any dose of ionizing radiation, no matter how small, may produce some genetic or somatic damage; and thus, it is considered wise to avoid all unnecessary exposure to radionuclides. This has been pointed out, also, by several national and international[6] organizations. However, in the light of present knowledge, occupational exposure for the working life of an individual at the maximum permissible values recommended in this report is not expected to entail appreciable risk to the individual or to present a hazard more severe than those commonly accepted in other present day industries. The values given in this report are for occupational exposure and must be corrected by the application of appropriate factors for other uses; and, in all cases, the resultant tissue doses are intended to be in addition to those produced by the natural background and medical exposure.

2. Basic Standards of Maximum Permissible Radiation Exposure

The NCRP[3] has formulated the four following basic rules and recommendations concerning exposure to ionizing radiation:

Basic Rules

2.1. Accumulated Dose (Radiation Workers)

A. *External exposure to critical organs. Whole body, head and trunk, active blood-forming organs, eyes or gonads:* The Maximum Permissible Dose (MPD) to the most critical organs, accumulated at any age, shall not exceed 5 rems

[6] Medical Research Council, The hazards to man of nuclear and allied radiation (1956), Cmd. 9780, Her Majesty's Stationery Office, London, England.

National Academy of Science, Publication 452, Pathologic effects of atomic radiation, NAS-NRC, Washington, D.C., (1956); The biological effects of atomic radiation, Summary Reports NAS-NRC, Washington, D.C., (1956); The biological effects of atomic radiation, A report to the public, NAS-NRC, Washington, D.C., (1956); The biological effect of atomic radiation—Gonadal dose from the medical use of X-rays, (preliminary report of Section III by J. S. Laughlin and I. Pullman) NAS-NRC, Washington, D.C., (March 1957).

Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, Gen. Assembly Off. Records, Thirteenth Session Supplement No. 17 (A/3838), New York, 1958. Annex G, Mammalian somatic effects pp. 153–171. Report of the World Health Organization, Effects of Radiation on Human Heredity, WHO, Palais des Nations, Geneva (1957).

multiplied by the number of years beyond age 18, and the dose in any 13 consecutive weeks shall not exceed 3 rems.

Thus the accumulated MPD $=(N-18)\times 5$ rems where N is the age in years and is greater than 18.

COMMENT: This applies to radiation of sufficient penetrating power to affect a significant fraction of the critical tissue. (This will be enlarged upon in the revision of H59.)

B. *External exposure to other organs. Skin of whole body:* MPD $=10\ (N-18)$ rems, and the dose in any 13 consecutive weeks shall not exceed 6 rems.

COMMENT: This rule applies to radiation of low penetrating power. See figure 2, H59.[3]

Hands and forearms, feet and ankles: MPD $=75$ rems/year, and the dose in any 13 consecutive weeks shall not exceed 25 rems.

C. *Internal exposures.* The permissible levels from internal emitters will be consistent as far as possible with the age-proration and dose principles above. Control of the internal dose will be achieved by limiting the body burden of radioisotopes. This will generally be accomplished by control of the average concentration of radioactive materials in the air, water, or food taken into the body. Since it would be impractical to set different MPC values for air, water, and food for radiation workers as a function of age, the MPC values are selected in such a manner that they conform to the above-stated limits when applied to the most restrictive case; viz., they are set to be applicable to radiation workers of age 18. Thus, the values are conservative and are applicable to radiation workers of any age (assuming there is no occupational exposure to radiation permitted at age less than 18.)

The maximum permissible average concentrations of radionuclides in air and water are determined from biological data whenever such data are available, or are calculated on the basis of an averaged annual dose of 15 rems for most individual organs of the body, 30 rems when the critical organ is the thyroid or skin, and 5 rems when the gonads or the whole body is the critical organ. For bone-seekers the maximum permissible limit is based on the distribution of the deposit, the RBE,[7] and a comparison of the energy release in the bone with the energy release delivered by a maximum permissible body burden of 0.1 μg Ra^{226} plus daughters.

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[7] See discussion on p. 7.

2.2. Emergency Dose (Radiation Workers)

An accidental or emergency dose of 25 rems to the whole body or a major portion thereof, occurring only once in the lifetime of the person, need not be included in the determination of the radiation exposure status of that person (see p. 69, H59).[3]

2.3. Medical Dose (Radiation Workers)

Radiation exposures resulting from necessary medical and dental procedures need not be included in the determination of the radiation exposure status of the person concerned.

2.4. Dose to Persons In the Neighborhood of Controlled Areas

The radiation or radioactive material outside a controlled area, attributable to normal operations within the controlled area, shall be such that it is improbable that any individual will receive a dose of more than 0.5 rem in any 1 year from external radiation.

The maximum permissible average body burden of radionuclides in persons outside of the controlled area and attributable to the operations within the controlled area shall not exceed one-tenth of that for radiation workers.[5] This will generally entail control of the average concentrations in air or water at the point of intake, or of the rate of intake to the body in foodstuffs, to levels not exceeding one-tenth of the maximum permissible concentrations allowed in air, water, and foodstuffs for continuous occupational exposure. The body burden and concentrations of radionuclides may be averaged over periods up to 1 year.

The maximum permissible dose and the maximum permissible concentrations of radionuclides as recommended above are primarily for the purpose of keeping the average dose to the whole population as low as reasonably possible, and not because of the likelihood of specific injury to the individual.

2.5. Discussion

A minor difference will be noted between the above recommendation and those of the ICRP. The NCRP allows the skin only 6 rems in any 13-week period as compared with 8 rems allowed by the ICRP. The difference is unimportant, and the NCRP would probably have adopted the value of 8 rems had not its recommendations been published nearly a year earlier. The ICRP also uses a value of 8 rems in any 13 weeks as an upper limit for the dose to the

[5] Based on continuous occupational exposure for a 168-hr week.

thyroid; the NCRP has not specifically stated a 13-week limit for the thyroid. Any calculations in this report involving the skin or thyroid are based on the ICRP value of 8 rems in any 13 consecutive weeks.

The decision of the ICRP [9] (1956) to set the average external occupational exposure at 5 rems per year (corresponding to 0.1 rem per week) is not applied to internal dose calculations except in the cases of radionuclides that are distributed rather uniformly throughout the body or are concentrated in the gonads. The purpose of limiting the average weekly total body dose (0.1 rem) to 1/3 of the former maximum weekly dose (0.3 rem) was to lessen the possible incidence of certain types of somatic damage; e.g., radiation-induced leukemia and shortening of life span, which are considered to result primarily from total body exposure. Obviously, the reduction in the gonad dose was intended to lower the incidence of deleterious genetic mutations that could give rise to effects appearing in future generations.

Inasmuch as the restriction of integrated dose applies primarily to the total body and gonad dose, there is no basic change in the permissible RBE dose rate when individual organs [10] such as liver, spleen, bone, gastrointestinal (GI) tract, and kidney are the critical body organs for reasons given in ICRP report paragraph (14).[4] It should be noted that the limits recommended here are maximal. In practice, the average occupationally-exposed individual would receive a much lower dose.

Because the direct determination of the body burden or of the dose to an organ or to the total body is generally difficult, and because in most cases measures to decrease the body burden are rather ineffective and difficult to apply, the only practical procedure for general protection of occupational workers is to limit the concentration of the various radionuclides in the water, food, or air available for consumption. It is recommended, therefore, that:

(a) If there is no occupational external exposure, the concentration of a radionuclide or a mixture of radionuclides

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[9] Report on amendments to the recommendations of the International Commission on Radiological Protection (ICRP), Radiology **70**, 261–262 (1958).
Report on amendments during 1956 to the recommendations of the International Commission on Radiological Protection, Acta Radiologica **48**, 493–495 (1957); or British J. Radiology **31**, 93–94 (1958).
Meeting of the Main Commission and Committee Chairmen of the International Commission on Radiological Protection, held in New York City, March 3–5, 1958.

[10] All references for scientific data cited in this report are given in abbreviated form; they are listed in full in Bibliography for Biological Data, Pergamon Press, London, England. See Col-1, Fk-6, Fr-8, Ja-7, Ja-8, Swi-1, Swi-2, and Zr-1.

in air and in water which might be consumed by plant personnel during a 40-hour week be kept at levels not exceeding the appropriate MPC values given in this report. If there is occupational external exposure, the MPC values must be lowered to bring the total RBE doses within the limits prescribed by the basic rules. Thus, if D rem is the quarterly dose permitted to an organ by the basic rules and if external radiation delivers a dose of E rem per quarter, then the MPC based on this organ must be reduced by the factor (D–E)/D. The calculation of an acceptable level for the case of a mixture of radionuclides is discussed in section IV–8 of the ICRP Internal Radiation report.[5]

(b) Alternatively, over a period of 13 weeks, the concentrations of the various radionuclides present in air or in water may be allowed to vary, provided the total intake during any 13-week period does not exceed the total intake permitted by exposure at the constant levels indicated in subsection (a) above. (It should be realized that while this method is in accordance with the basic recommendations its use is cumbersome, expensive, and generally unreliable, because it requires accurate and continuous monitoring of work areas and the keeping of detailed exposure histories for each individual. Its use is, therefore, only justified in exceptional cases.)

The safest and simplest procedure to use in keeping within the basic limits given above is to maintain the level of contamination of the air, water, or food consumed by plant personnel in the controlled area at or below the indicated MPC values. These values are given for an exposure period of 40 hours per week and 168 hours per week. If a person's work assignments are such that he spends only 8 hours each week in the exposure area, the applicable MPC values are 5 times those listed for a 40-hour week in table 1. However, this requires considerable care to determine that he is effectively unexposed during the remainder of his working week. If he spends 48 hours each week in the exposure area, the applicable MPC values are five-sixths of those listed for a 40-hour work week in table 1.

Although the formula $5(N-18)$ permits an average yearly dose to the total body and the gonads of only 5 rems, the rules of the NCRP permit up to 3 rems during any interval (e.g., 1 minute, 1 day, 1 week, etc.) provided that not more than 3 rems are received in any 13 consecutive weeks. Thus an older person may receive up to 12 rems external exposure in a single year provided his dose does not exceed the limits prescribed by the formula $5(N-18)$. Although this flexibility is allowed in principle for internal exposures, in practice it is risky and usually impractical to increase the MPC values much beyond those determined for operation over an extended period. The permissible levels do, however, take into account the exposure period, and if the occupational exposures last for only 1 hour per week, the MPC values for a 40-hour week may be increased by a factor of 40. As an example, take the case of a specific situation where sufficient monitoring is available (i.e., external monitoring meters, body fluid analyses, air surveys, etc.) and where no exposure has been received for the prior 13-week period. If the restriction implied by the formula $5(N-18)$ is not exceeded, the person may work for 1 hour where the concentration in air of an isotope with the total body as the critical organ is roughly 1200 times the Maximum Permissible Concentration in air $(MPC)_a$ for a 40-hour week.[11]

In such a case no further exposure shall be permitted in the succeeding 13 weeks. This practice should be discouraged because of delays and inaccuracies in methods of estimating the body burden and dose to the organ from such an internally deposited radioactive material. However if such exposures to contaminated air are unavoidable, the dose may be reduced materially if appropriate and properly fitting respirators are worn.

While these revised MPC and body burden values presented here take into account many refinements previously neglected, there remain many serious uncertainties in the basic biological data on which the calculations are based and thus it is necessary again, as in the earlier handbooks, to urge that all exposures be kept to the minimum practically obtainable. While the data used for these estimates are believed to be the most reliable presently available, their use generally involves an extrapolation in time or in dosage level and they cannot be considered as definitive.

The Internal Dose Committees of the NCRP and of the ICRP are collecting available data on the long-range effects of low-level exposure to the population at large. These data include information on somatic damage to the exposed individual, genetic damage to his children, and ecological damage. It is hoped that this new table of values will be available for inclusion in the next revision of this publication.

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[11] $40 \times 13 \times 12/5 \cong 1200$, where 12 is the maximum, and 5 is the average yearly dose.

3. Maximum Permissible Values for Occupational Exposure to Radiation

3.1. Assumptions and Restrictions Applying to Maximum Permissible Exposure Values in Table 1

The values of q and MPC for an individual will depend upon many factors such as his age, physical condition, eating habits, and hygienic standards. They will depend also upon the physical and chemical properties of the radioactive material and the method of intake—by ingestion, by inhalation, through wounds, or by absorption through the skin. The paucity of data concerning the effect of most of these factors does not warrant detailed treatment. To keep the required work and the magnitude of this revision within reasonable limits and yet to meet the major needs of scientific and industrial users of radionuclides it has been necessary to limit severely the number of factors considered. Therefore, MPC values are listed only for relatively insoluble and for the more common soluble compounds, and these compounds are specified only by the extent of solubility rather than by specific chemical structure. The only methods of intake considered are ingestion and inhalation, except in a few cases—where immersion presents the greatest hazard criterion. All calculations are based on a "standard man" and thus do not provide for individual variations. The standard man is specified in tables VI through XI of the ICRP Internal Radiation report [5] and is a somewhat modified version of the standard man defined at the Chalk River Conference [12] (September 1949). This standard man is designed to represent a typical or average adult who is exposed occupationally.

Ideally, maximum permissible body burden, q, and maximum permissible concentration, MPC, should be based on studies of humans who have been exposed to and who have ingested a particular radionuclide under the working conditions and over an extended period of time approximating those which are typical of the average occupational exposure. However, human data are very scarce and only in the case of radium does one have an accumulation of human experience for as long as 50 years, which is the minimum for selecting values for chronic exposure to man. Studies using total and partial body counters have been made recently to

[12] Chalk River Conference on Permissible Dose. A conference of representatives from the United Kingdom, Canada, and the United States, meeting in Chalk River, Canada, September 29 and 30, 1949. RM-10 (1950).

determine the uptake, distribution and elimination of trace quantities of some radionuclides in the human body. In a few cases, certain radionuclides have been administered to humans therapeutically, and in some cases, accidents have occurred in which radionuclides have been taken into the body. The data from these cases of human exposure have been studied carefully, and, where possible, such data are substituted in this report for earlier data based on animal experiments. For the majority of radionuclides, human data are lacking, and in such cases data from animal experiments must be extrapolated to man. Sometimes even animal data are not available and estimates are made from comparison with elements having similar chemical behavior. Recent studies of trace and minor stable element distribution in the human body [13] have been particularly helpful in these revisions. It is assumed that the normal stable element distribution in the various body organs is typical of the distribution that would result from human exposure to radionuclides of these same elements and that the chemical form is similar. Likewise, a study of the metabolic balance between the trace and minor elements in the food, water, urine, and feces of man has yielded direct data for the MPC of radionuclides of these elements. Because of the many assumptions and approximations made in applying much of the data in this publication, *it is concluded that detailed refinements in the calculations generally are unwarranted.*

In table 1 are the recommended values of maximum permissible total body burden, q, and maximum permissible concentration in air, $(MPC)_a$, and in water, $(MPC)_w$, for about 240 radionuclides. The daily intake of water used in calculating $(MPC)_w$ includes the water content of food and thus consideration of the intake of a radionuclide in food is necessary only in case it concentrates in the food during processing or enters the food from other sources. In such cases the $(MPC)_w$ values of table 1 converted to microcuries per gram are applicable when corrected for daily intake, i.e., to take account of the total intake of radionuclides in the complete diet. This publication includes values for all the radionuclides listed in the previous publications of NCRP [1] (1953) and of ICRP [2] (1955) together with others for which a need has arisen and for which the necessary biological data are available. With few exceptions (e.g., certain daughter radionuclides and isomeric states) radionuclides with radio-

[13] See the section of the ICRP Internal Radiation report [5] titled "Bibliography for Biological Data," Ti-1 through Ti-7, Tie-1, Sti-1 through Sti-4, Kc-1, Kc-2, Rm-2, Kh-4, Gro-1, Led-1, Bg-1 through Bg-6.

active half-lives shorter than 1 hour are not considered in table 1. The following are the principal assumptions and factors which were used in the calculations.

(a) In all cases the values are listed both for soluble and for insoluble compounds (an exception is the case of some of the inert gases for which values are given only for the immersion of a person in the inert gas). The lowest values of $(MPC)_a$ and $(MPC)_w$ are given in boldface type both for the soluble and insoluble forms of the isotope. The organs on which these values are based are termed the critical organs and are also boldface in table 1.

(b) In all cases the values are computed for occupational exposure at the rate of 40 hours per week, 50 weeks per year for a continuous work period of 50 years, as well as for 50 years of continuous exposure, i.e., 168 hours per week.

(c) In all cases the calculated dose rate which determines the MPC takes into account the actual amounts of the radionuclide in the body or critical organ rather than assuming a state of equilibrium. The MPC values based on a critical organ are set by the requirement that the dose rate (rem per week) after 50 years of occupational exposure shall not exceed the values specified in section 2. During a 50-year exposure period, equilibrium is reached for the vast majority of the radionuclides because the effective half-life is short compared to this work period (i.e., the term $e^{-0.693t/T}$ in equations 7 and 8 of the ICRP Internal Radiation report [5] is approximately zero for $t=50\times365$ days). Exceptions to this rule are listed in table 2. Column 5 of table 2 gives the effective half-life, and column 6 gives the percent of equilibrium the body burden attains as a result of constant exposure to the MPC over a period of occupational exposure lasting 50 years. Most of the exceptions are in the 5-*f* type rare earth group of elements which are assigned a biological half-life of 200 years. The extreme case is represented by 10 of these radionuclides which reach only 16 percent of equilibrium in the body in 50 years of occupational exposure.

(d) In the case of a radionuclide which decays to form radioactive daughters, the calculation assumes that only the parent radionuclide enters the body, but the estimated dose rate includes all the energy released by the daughter elements formed in the body. There are two exceptional cases, Rn^{220} and Rn^{222}, where a state of equilibrium typical of that attained in ordinary air is assumed. These cases [5] are discussed in detail in the ICRP Internal Radiation report. In all other cases it is assumed that only the parent element enters the body. Because the various daughter elements generally have different effective half-lives the percent of equilibrium attained is generally not the same for all elements of a chain. Also, the effective energies, are not the same for different members of the chain so that the dose rate after 50 years' exposure will generally not be the same percentage of the dose rate resulting from an equilibrium body burden as the figure shown in table 2. Thus for radionuclides which decay to form radioactive daughters these percentages give only a rough indication of the percent of equilibrium dose rate attained at the end of 50 years.

(e) The assumptions and formulas are presented in terms of a compartment model, i.e., each organ is assigned a biological half-life and the radionuclide that accumulates in the organ is considered to be eliminated at a constant rate. In general, this is a drastic oversimplification of the situation since the organ retention usually requires several exponentials, or perhaps a power function, for its mathematical representation. Unfortunately, the biological information available generally does not yield detailed information on organ retention, particularly for the conditions and periods of exposure of interest here. In selecting MPC and body burden values, the subcommittee has considered both multiple exponential and power function models for retention when such information is available and the values finally selected are in some cases chosen between those calculated by these models. In view of the large measure of uncertainty in many of these cases, and in the interest of uniformity and economy of presentation the biological data in the tables are given in terms of a single compartment model for each organ considered with a biological half-life for each. The values of these are selected to produce in 50 years of exposure at a relatively constant level, the retention indicated by the more detailed model, and thus may not represent accurately the situation for short-term exposure. (A discussion of the power function model and a table of the necessary parameters for its use are given in the appendix of the ICRP Internal Radiation report.[5])

(f) If occupational exposure continues beyond 50 years, the dose rate will continue to rise in the case of the radionuclides listed in table 2 because they are not in a state of equilibrium under the assumed conditions of constant exposure level at the MPC, but for the radionuclides not listed in table 2 the maximum permissible dose rate would not be exceeded. However, since the period of occupational exposure probably will not greatly exceed 50 years, and since the maximum permissible body burden, q, would be reached only after 50 years of occupational exposure at the MPC values given in table 1, the average RBE dose rate over the working life of the individual will be well below the maximum permissible RBE dose rate even for the isotopes in table 2. While noteworthy, this observation does not alter the fact that the terminal RBE dose rates would be in violation of the criteria adopted in section 2, although the integrated RBE dose undoubtedly would be considerably less than that permitted for many radionuclides not listed in table 2. In the previous publications,[1 2] the calculations were based on a 70-year exposure. Although this change to an exposure period of 50 years has had very little effect on the MPC values (i.e., a maximum increase of 27 percent in the MPC values for some of the radionuclides in table 2), it is believed that this change should be made in the calculations because for most workers in controlled areas the working period extends from age 18 to age 65 or less.

(g) The average breathing rate 10^4 l per 8-hour work day; this is one-half the air breathed in 24 hours.

(h) The average rate of water consumption is 1100 ml per 8-hour work day; this is one-half the water consumed in 24 hours.

(i) The dose from inert gases with radiation of sufficient energy to penetrate the minimal epidermal layer (7mg/cm^2) results from external exposure to the surrounding cloud of radioactive gas rather than from the amount of gas in the body.

(j) With one exception, chemical toxicity is not considered in estimating the body burden or MPC values. However, in the case of uranium, the chemical toxicity has been considered and is the limiting criterion for the longer-lived nuclides of uranium.

3.2. Units of Ionizing Radiation Used in Table 1

In table 1 the units are the microcurie (μc) and microcurie per cubic centimeter (μc/cc) for maximum permissible quantities of the various radionuclides in the total body, q, and for the maximum permissible concentrations in air, $(MPC)_a$, and in water, $(MPC)_w$. One curie is a quantity of a radioactive nuclide in which the number of disintegrations per second is 3.700×10^{10}; the microcurie then, is 1 millionth of this amount. In accordance with long established usage in internal dose calculations, however, a curie of recently extracted uranium is considered to correspond to the sum of 3.7×10^{10} dis/sec from U^{238}, 3.7×10^{10} dis/sec from U^{234}, and 9×10^8 dis/sec from U^{235}. Also, a curie of recently extracted thorium is considered to correspond to the sum of 3.7×10^{10}

dis/sec from Th^{232} and 3.7×10^{10} dis/sec from Th^{228}. The rem is the unit of RBE dose of ionizing radiation in tissue. When a dose is expressed in rems it is superfluous to call it RBE dose. Therefore, the unqualified term "dose" is used in such cases. The rem corresponds to the dose in tissue which results in a biological effect equivalent to that produced per rad of X-radiation (of about 200 kv) having a linear energy transfer, LET, to water of 3.5 kev per micron, i.e., rem=RBE×rad. The rad corresponds to an energy absorption of ionizing radiation of 100 ergs per gram in any medium. In this case the energy absorption is in tissue. The relative biological effectiveness, RBE, in this report is taken as one for β, γ, X-radiation, and conversion electrons (for low energy β emitters, i.e., $E_m \leq 0.03$ Mev, the RBE=1.7), 10 for α-particles, and 20 for recoil nuclei. The reader is referred to the Handbook by the International Commission on Radiological Units for detailed information on units.[14]

3.3. Critical Body Organ

The values of body burden, q, in column 3 of table 1 are based on that amount of the radionuclide which is deposited in the total body and produces the maximum permissible RBE dose rate to the body organ listed in column 2. The concentration values in water (columns 4 and 6) and in air (columns 5 and 7) are in turn based on the intake by the standard man who accumulates this body burden as a consequence of occupational exposure for a period of 50 years. In most cases significantly different values of body burden result when effects on different organs are considered. The critical organ is determined by the following criteria: (1) the organ that accumulates the greatest concentration of the radioactive material; (2) the essentialness or indispensability of the organ to the well-being of the entire body; (3) the organ damaged by the entry of the radionuclide into the body; and (4) the radiosensitivity of the organ, e.g., the organ damaged by the lowest dose. Theoretically all of these considerations are taken into account through the use of the RBE factors, the basic standards, and the methods of calculation. Actually, except for a few radionuclides, case (1) above is the determining factor in choosing the critical body organ. For this revision, each radionuclide was studied individually. For some radionuclides as many as 12 reasonable choices of a critical organ were made with the corresponding permissible body burden and concentra-

[14] Report of the International Commission on Radiological Units and Measurements (ICRU) 1956, National Bureau of Standards Handbook 62 (1957). Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

tion values calculated for each organ, and these are listed in table 1. In the present state of our knowledge the organ giving the lowest MPC value seems the most likely choice as the critical organ; therefore such organs and such minimal values are printed in boldface type. For each isotope the MPC values are listed first for soluble materials and then for insoluble materials. The values for soluble materials are ranked with increasing magnitude of $(MPC)_w$ so that the first line in this group designates the critical organ determined primarily on the basis of having the lowest $(MPC)_w$. The values for insoluble materials are ranked according to the magnitude of $(MPC)_a$. The rankings based on $(MPC)_a$ and on $(MPC)_w$ may differ in some cases so the smallest MPC in each group is in boldface type to indicate it as a maximum permissible occupational exposure level for plant operation under the stated conditions. The MPC values for other organs (termed organs of reference in table 1) are given primarily as an aid in estimating MPC values for mixtures of radionuclides and thus by themselves are not permissible levels.

The total body is listed as an organ of reference for all nuclides except a few of the inert gases. Values for the total body are included primarily as an aid in computing MPC values for mixtures, and as a check on the oversimplified model used. As mentioned in (e) above, this one-compartment model is selected to represent the long-term retention in the critical organ and may not represent adequately the situation in other organs. For example, radium and strontium are long-term bone-seekers, but during the first day or two following ingestion appreciable amounts are present in the plasma and soft tissues. This amount may be negligible so far as the 50-year accumulation in the bone is concerned, but a check is necessary to determine that the amount present in the plasma and soft tissues does not increase the body burden in excess of the permissible limit. When present in a mixture, perhaps with other isotopes that concentrate primarily in the soft tissues, the dose delivered by this component of the total quantity should not be neglected. The MPC based on the retention of radionuclides in the total body also supplies a ready means of estimating the integrated dose, i.e., the dose to the body as a whole.

While the basic rules do not directly limit the integrated dose except in the case of whole body irradiation, knowledge of it is of considerable interest. Because the total body limit for constant-level exposure is based on an average of 5 rems per year (0.1 rem per week), the total body is sometimes the critical organ. Because the GI tract often receives a greater absorbed dose than any other body organ, and is frequently the critical organ for exposure to mixed fission products, it is, with few exceptions, included as an organ of reference for the soluble form of the radionuclides in table 1. MPC values are given also for the insoluble form of the radionuclides in which case the critical organs are the lungs or the GI tract.

3.4. Maximum Permissible Concentration of Unidentified Radionuclides (MPCU)

The identity of the radioactive contaminants in air, water, and food must be established before appropriate MPC values can be applied either for occupational exposure or for exposure to population outside of controlled areas. In many cases there is no question regarding the identity of a radionuclide because the operation involves only one radionuclide. Sometimes, however, preliminary surveys of radioactive contamination leave considerable uncertainty as to which radionuclides are the major contributors. When a laboratory is using a number of radionuclides, such as mixed fission products, an air sample may furnish only a few clues as to the identity of the radionuclide. By using the simplest of equipment and techniques, the level of air contamination may be established in a matter of minutes, but hours or even days may be required to conduct the radiochemical analyses necessary to identify the particular radionuclides that are present in the air. Fortunately, in such cases it is usually not necessary to go through a tedious, time-consuming and expensive radiochemical analysis. If it is known that certain of the more dangerous radionuclides could not be present (i.e., the concentration of the more dangerous radionuclides is small compared with the MPC values in table 1) the operation may be continued safely regardless of the radionuclide or mixture of radionuclides, provided the concentration does not exceed the values for MPC of unidentified radionuclides (MPCU) as listed in table 3 for water or in table 4 for air. These MPCU values are applicable to continuous occupational exposure (168 hours per week) and should be multiplied by 1/10 if they are to be applied as interim values outside, and in the neighborhood of, the controlled exposure area. It should be pointed out that the use of MPCU values may save an immense amount of effort and expense if they are applied properly to avoid unnecessary radionuclide analyses in areas where the air, water, and food contamination is usually less than the appropriate MPCU values. On the other hand, they can impose a needless penalty if improperly applied. For example, if initial measurements indicate a negligible amount of Ra^{226} and Ra^{228} in the drinking water of a small community near an atomic energy laboratory, and if it is determined by daily gross $\beta+\gamma$ sample counting that the activity does not exceed the $(\mathrm{MPCU})_w$ value, $(1/10\times 1\times 10^{-6}\ \mu c/cc = 1\times 10^{-7}\ \mu c/cc)$ it would seem foolish to carry out a daily radiochemical analysis of this water. If, on the other hand, the level ranged between 10^{-5} and $2\times 10^{-5}\ \mu c/cc$, it would be unwise to shut down the plant or to instigate an expensive modification of the operation without first identifying the radionuclides for it might be that the contamination in the water is from Na^{24} and P^{32}. In this case the appropriate $(\mathrm{MPC})_w$ value for application in the neighborhood of the plant is $1/10\times 2\times 10^{-3} = 2\times 10^{-4}$ and $1/10\times 2\times 10^{-4} = 2\times 10^{-5}$, respectively (see table 1).

3.5. Maximum Permissible Concentration of Known Mixtures of Radionuclides

Suppose a person is exposed to concentrations $\rho_{aA}, \rho_{aB}, \ldots \rho_{wA}, \rho_{wB} \ldots \mu c$ per cc of isotopes A, B, . . . in air and in water, respectively, and also to external sources of gamma and neutron radiations. Assume further that the external sources give doses R_γ^x, R_n^x to a given organ X for gamma and neutron radiation, respectively. If L^x rem is the average weekly dose permitted to organ X by the basic rules, then the total dose to organ X is

$$\left[\frac{\rho_{aA}}{(\mathrm{MPC})_{aA}^x}+\frac{\rho_{aB}}{(\mathrm{MPC})_{aB}^x}+\cdots+\frac{\rho_{wA}}{(\mathrm{MPC})_{wA}^x}+\frac{\rho_{wB}}{(\mathrm{MPC})_{wB}^x}+\cdots\right]L^x+R_\gamma^x+R_n^x. \quad (1)^{15}$$

This does not exceed L^x provided

$$\frac{\rho_{aA}}{(\mathrm{MPC})_{aA}^x}+\frac{\rho_{aB}}{(\mathrm{MPC})_{aB}^x}+\cdots+\frac{\rho_{wA}}{(\mathrm{MPC})_{wA}^x}+\frac{\rho_{wB}}{(\mathrm{MPC})_{wB}^x}+\cdots\frac{R_\gamma^x}{L^x}+\frac{R_n^x}{L^x}\leq 1 \quad (2)^{15}$$

[15] See equations 22 to 24 in ICRP Internal Radiation report.

and this provides a criterion for assessing whether or not the exposure is in excess of that permitted by the basic rules. If organ X is not listed as an organ of reference in table 1, and if an independent estimate of the corresponding MPC values is not available, the MPC based on total body may be used with the correction factor $L^x/0.1$, i.e., $L^x(\mathrm{MPC})_a^{TB}/0.1$ and $L^x(\mathrm{MPC})_w^{TB}/0.1$ may be substituted for $(\mathrm{MPC})_a^x$ and $(\mathrm{MPC})_w^x$ in such cases. In general it will be necessary to calculate the dose for all the organs for which the dose may reasonably be considered to be in excess of the prescribed limits. Often this may include the total body even though no one of the radionuclides irradiates a major portion of the body. Assuming that a major portion of the body is being irradiated at somewhat comparable rates, the calculation is essentially as before except that the MPC values based on total body are to be used. Thus, the criterion is

$$\frac{\rho_{aA}}{(\mathrm{MPC})_{aA}^{TB}}+\frac{\rho_{aB}}{(\mathrm{MPC})_{aB}^{TB}}+\cdots+\frac{\rho_{wA}}{(\mathrm{MPC})_{wA}^{TB}}+\frac{\rho_{wB}}{(\mathrm{MPC})_{wB}^{TB}}+\cdots+\frac{R_\gamma^{TB}}{0.1}\frac{R_n^{TB}}{0.1}\leq 1\cdot \qquad (3)^{15}$$

In effect this limits the average dose rate over the body to 0.1 rem per week. There may be some organs in which the dose rate exceeds 0.1 rem per week, but this is considered permissible so long as such organs do not constitute a major portion of the body. Of course, the criteria for these organs must also be considered, and the application of equation (2) will prevent any particular organ from exceeding the permissible limit set for that organ. However, it would seem too conservative and contrary to the intent of the basic rules to limit the dose to any portion of the body to a maximum rate of 0.1 rem per week merely because the entire body is receiving some dose, though it may be very small in most of the body and only be at the rate of 0.1 rem per week in a small portion. The values of $(\mathrm{MPC})^{TB}$ as given in table 1 and as applied in equation (3) were derived on the assumption that the total body dose of interest in this case is the gram-rem dose or the total weighted energy delivered to the total body.

(See Section IV–8 of ICRP Internal Radiation report.[5])

The application of these criteria may be illustrated by the following example: Suppose the mixture consists of Sr^{90}, Pu^{239}, Na^{24}, and that an external gamma source is also present, and that the measured intensities are those indicated in table 5. The concentrations have been chosen to illustrate the case of a mixture which is below the permissible limit for one of the criteria (bone), but is barely in excess of the limit determined by another of the criteria (total body).

Criterion (2) applied to bone gives

$$\frac{\rho_{aA}}{(\mathrm{MPC})^{z}_{aA}}+\frac{\rho_{wA}}{(\mathrm{MPC})^{z}_{wA}}+\frac{\rho_{aB}}{(\mathrm{MPC})^{z}_{aB}}+\frac{\rho_{wB}}{(\mathrm{MPC})^{z}_{wB}}$$

$$+\frac{0.1}{0.56}\left[\frac{\rho_{aC}}{(\mathrm{MPC})^{TB}_{aC}}+\frac{\rho_{wC}}{(\mathrm{MPC})^{TB}_{wC}}\right]+\frac{R^{z}_{\gamma}}{L^{z}}=0.06+0.038$$

$$+0.2+0.13+\frac{0.1}{0.56}(0.1+0.2)+\frac{0.065}{0.56}=0.60<1.$$

Thus, the average dose rate to the bone is about $0.60\times 0.56=0.34$ effective rem per week and is therefore within the limits set for bone.

Criterion (3) for total body gives

$$\frac{\rho_{aA}}{(\mathrm{MPC})^{TB}_{aA}}+\frac{\rho_{wA}}{(\mathrm{MPC})^{TB}_{wA}}+\frac{\rho_{aB}}{(\mathrm{MPC})^{TB}_{aB}}+\frac{\rho_{wB}}{(\mathrm{MPC})^{TB}_{wB}}$$

$$+\frac{\rho_{aC}}{(\mathrm{MPC})^{TB}_{aC}}+\frac{\rho_{wC}}{(\mathrm{MPC})^{TB}_{wC}}+\frac{R^{TB}_{\gamma}}{L^{TB}}=0.02+0.015+0.04$$

$$+0.013+0.1+0.2+0.65=1.038$$

and thus, the calculation indicates that the mixture is slightly, though not significantly, in excess of the permissible limit for total body.

If the gamma source is removed, the dose rate to the bone becomes $0.48\times 0.56=0.27$ rem per week while the dose rate to the total body is $0.39\times 0.1=0.039$ rem per week. These dose rates are 48 percent and 39 percent of the corresponding limits, and thus, the bone is now the critical organ. In this situation any or all of the concentrations could be increased by as much as a factor of 2 without exceeding the permissible limits.

3.6. Modifications Required for Other Applications

The MPC values listed in table 1 are primarily intended for occupational exposure. Nevertheless, they are frequently used for a variety of other purposes. In most cases the conditions of exposure will not strictly conform to the conditions assumed for the calculation of these values. Thus, great care and judgment should be used to insure that the departure from the conditions of occupational exposure assumed in table 1 are not so great as to completely invalidate the use of these values. In order to guard against the all-too frequent misuse of these values, some of the more common pitfalls that may often lead to large discrepancies will be mentioned.

A 50-year exposure period is assumed in deriving the MPC values in table 1, and the exposure level is assumed to be constant. Thus a transient situation (e.g., fallout shortly after a nuclear detonation or a major reactor accident where the level of activity is rapidly decreasing, and even the relative abundance of different radionuclides will be changing) presents a hazard widely different from the constant level 50-year occupational exposure which is assumed. The measure of difference is here so large that to attempt to correct it amounts to a new calculation.

The $(MPC)_w$ values listed in table 1 may, with caution, be applied to foods but to use the $(MPC)_w$ for the 168-hour week without correction for actual intake amounts to assuming that 2200 grams [16] of the individual's food, (i.e., substantially all his food) is contaminated at this level and that this situation will persist for 50 years, or until equilibrium is reached in the body. Obviously, a correction factor to take account of the food intake is needed, but to simply use the ratio of 2200 grams to the grams of intake of a particular food (e.g., butter) as correction factor amounts to assuming no other foods or beverages are contaminated. Again all the factors in the total situation must be considered and great judgment must be used in making such corrections.

Frequently the MPC values are used to obtain estimates of dose from large single intakes of a radionuclide. In many cases this is warranted but there may well be many cases where the distribution in the body following an acute exposure to the nuclide is markedly different from the distribution pattern reached following continuous, low-level exposure. For example, many nuclides concentrate in bone with a long biological half-life which leads to a large bone burden of the nuclide after many years of exposure. Then the bone is the critical organ although the fraction of the daily intake reaching the bone may be much smaller than that passing through the GI tract. For an acute single dose the GI tract may be the critical organ.

Many other factors may have a large effect in determining the proper value for a maximum permissible limit. The

[16] The average daily intake of water for the standard man.

relative abundance or scarcity in the diet of other nonradioactive nuclides with similar chemical properties, the wide range of physiological differences as well as differences in habits, age and sex, and the chemical form of the radionuclide or the size of the particle to which it is attached, may account for large changes in the value of the MPC in some cases. Many of these factors as well as others are being carefully studied at the present time, and we may expect that our knowledge of their influence on the permissible levels will be more precise. In the present state of our knowledge, the modification or adaptation of the values listed in table 1 for application to other situations than those specified by the exposure categories of the basic rules requires the careful consideration and mature judgment of competent experts in this field.

4. Additional Contents of ICRP Internal Radiation Report [5]

IV. Calculation of Maximum Permissible Exposure Values

1. Basis for Estimating Maximum Permissible Exposure Values.
2. Body Burden Based on Comparison with Radium.
3. Body Burden Based on a Permissible RBE Dose Rate to the Critical Organ.
4. Concentrations in Air and Water—Based on Exponential Model—Critical Organs Other than Gastrointestinal Tract.
5. Concentrations in Air and Water Based on RBE Dose Delivered to Various Segments of the GI Tract.
6. Maximum Permissible Concentration of Radionuclides of Noble Gases and Other Relatively Inert Gases.
7. Maximum Permissible Concentration of Unidentified Radionuclides. (Included in this report.)
8. Maximum Permissible Concentration of Known Mixtures of Radionuclides. (Included in this report.)
9. Modifications Required for Other Applications. (Included in this report.)

V. Factors Needed for Calculation of MPC Equations

1. Effective Energy.
2. Standard Man Data.
3. Other Biological and Physical Related Terms.

Appendix. Concentrations in Air and in Water Based on a Power Function Model

Tables of ICRP Internal Radiation Report

Tables I to IV	(1 to 5. Included in this report)
Table V	Effective Energies
Table V A	Effective Energies for Chains
Table VI	Element Distribution in Total Body of the Standard Man
Table VII	Elements in the Body Organs of the Standard Man
Table VIII	Organs of Standard Man—Mass and Effective Radius of Organs of the Adult Human Body
Table IX	Intake and Excretion of the Standard Man
Table X	Particulates in Respiratory Tract of the Standard Man
Table XI	Gastrointestinal Tract of the Standard Man
Table XII	Biological and Related Physical Constants

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_1H^3(H_2^3O)$ (β^-)	(Sol)	**Body Tissue**	10^3	**0.1**	**2×10^{-5}**	**0.03**	**5×10^{-6}**
		Total Body	2×10^3	0.2	**2×10^{-5}**	0.05	7×10^{-6}
(H_2^3)	(Immersion)	**Skin**			**2×10^{-3}**		**4×10^{-4}**
$_4Be^7$ (ϵ, γ)	(Sol)	**GI (LLI)***		**0.05**	10^{-5}	**0.02**	4×10^{-6}
		Total Body	600	6	**6×10^{-6}**	2	**2×10^{-6}**
		Kidney	800	9	8×10^{-6}	3	3×10^{-6}
		Liver	800	9	8×10^{-6}	3	3×10^{-6}
		Bone	2×10^3	20	2×10^{-5}	7	6×10^{-6}
		Spleen	4×10^3	50	4×10^{-5}	20	2×10^{-5}
	(Insol)	**Lung**			**10^{-6}**		**4×10^{-7}**
		GI (LLI)		**0.05**	9×10^{-6}	**0.02**	3×10^{-6}
$_6C^{14}(CO_2)$ (β^-)	(Sol)	**Fat**	300	**0.02**	**4×10^{-6}**	**8×10^{-3}**	**10^{-6}**
		Total Body	400	0.03	5×10^{-6}	0.01	2×10^{-6}
		Bone	400	0.04	6×10^{-6}	0.01	2×10^{-6}

	(Immersion)	**Total Body**			**5×10^{-5}**		**10^{-5}**
$_9F^{18}(\beta^+)$	(Sol)	**GI (SI)**		**0.02**	**5×10^{-6}**	**8×10^{-3}**	**2×10^{-6}**
		Bone and Teeth	20	0.2	3×10^{-5}	0.06	9×10^{-6}
		Total Body	20	0.3	4×10^{-5}	0.09	10^{-5}
	(Insol)	**GI (ULI)**		**0.01**	**3×10^{-6}**	**5×10^{-3}**	**9×10^{-7}**
		Lung			2×10^{-5}		6×10^{-6}
$_{11}Na^{22}(\beta^+, \gamma)$	(Sol)	**Total Body**	10	**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
		GI (LLI)		0.01	2×10^{-6}	3×10^{-3}	7×10^{-7}
	(Insol)	**Lung**			**9×10^{-9}**		**3×10^{-9}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{11}Na^{24}$ (β^-, γ)	(Sol)	**GI (SI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Total Body	7	0.01	2×10^{-6}	4×10^{-3}	6×10^{-7}
	(Insol)	**GI (LLI)**		8×10^{-4}	**10^{-7}**	3×10^{-4}	**5×10^{-8}**
		Lung			8×10^{-7}		3×10^{-7}
$_{14}Si^{31}$ (β^-, γ)	(Sol)	**GI (S)**		**0.03**	**6×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Lung	10	0.1	2×10^{-5}	0.05	7×10^{-6}
		Adrenal	30	0.3	4×10^{-5}	0.1	10^{-5}
		Total Body	30	0.3	4×10^{-5}	0.1	2×10^{-5}
		Testis	40	0.4	5×10^{-5}	0.1	2×10^{-5}
		Ovary	60	0.6	8×10^{-5}	0.2	3×10^{-5}
		Skin	100	1	2×10^{-4}	0.5	7×10^{-5}
	(Insol)	**GI (ULI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**3×10^{-7}**
		Lung			10^{-5}		4×10^{-6}

*The abbreviations GI, S, SI, ULI, and LLI refer to gastrointestinal tract, stomach, small intestines, upper large intestine, and lower large intestine, respectively.

**It will be noted that the MPC values for the 168-hour week are not always precisely the same multiples of the MPC for the 40-hour week. Part of this is caused by rounding off the calculated values to one digit, but in some instances it is due to technical differences discussed in the ICRP report. Because of the uncertainties present in much of the biological data and because of individual variations, the differences are not considered significant. The MPC values for the 40-hour week are to be considered as basic for occupational exposure, and the values for the 168-hour week are basic for continuous exposure as in the case of the population at large.

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{15}P^{32}$ (β^-)	(Sol)	**Bone**	6	**5×10^{-4}**	**7×10^{-8}**	2×10^{-4}	**2×10^{-8}**
		Total Body	30	3×10^{-3}	4×10^{-7}	9×10^{-4}	10^{-7}
		GI (LLI)		3×10^{-3}	6×10^{-7}	9×10^{-4}	2×10^{-7}
		Liver	50	5×10^{-3}	6×10^{-7}	2×10^{-3}	2×10^{-7}
		Brain	300	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
	(Insol)	**Lung**			**8×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{16}S^{35}$ (β^-)	(Sol)	**Testis**	90	**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**9×10^{-8}**
		Total Body	400	7×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Bone	800	0.02	2×10^{-6}	5×10^{-3}	8×10^{-7}
		Skin	3×10^{3}	0.07	10^{-5}	0.02	3×10^{-6}
		GI (LLI)		0.2	4×10^{-5}	0.05	10^{-5}
	(Insol)	**Lung**			**3×10^{-7}**		**9×10^{-8}**
		GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{17}Cl^{36}$ (β^-)	(Sol)	**Total Body**	80	**2×10^{-3}**	**4×10^{-7}**	**8×10^{-4}**	**10^{-7}**
		GI (LLI)		0.04	8×10^{-6}	0.01	3×10^{-6}
	(Insol)	**Lung**			**2×10^{-8}**		**8×10^{-9}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}

$_{17}Cl^{38}$ (β^-, γ)	(Sol)	GI (S)		0.01	3×10^{-6}	4×10^{-3}	9×10^{-7}
		Total Body	9	0.3	4×10^{-5}	0.1	2×10^{-5}
	(Insol)	GI (S)		0.01	2×10^{-6}	4×10^{-3}	7×10^{-7}
		Lung			10^{-5}		5×10^{-6}
$_{18}A^{37}$ (ϵ)	(Immersion)	Skin			6×10^{-3}		10^{-3}
$_{18}A^{41}$ (β^-, γ)	(Immersion)	Total Body			2×10^{-6}		4×10^{-7}
$_{19}K^{42}$ (β^-, γ)	(Sol)	GI (S)		9×10^{-3}	2×10^{-6}	3×10^{-3}	7×10^{-7}
		Total Body	10	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
		Brain	20	0.04	6×10^{-6}	0.01	2×10^{-6}
		Spleen	20	0.04	6×10^{-6}	0.01	2×10^{-6}
		Muscle	20	0.04	6×10^{-6}	0.02	2×10^{-6}
		Liver	50	0.08	10^{-5}	0.03	4×10^{-6}
	(Insol)	GI (LLI)		6×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
		Lung			9×10^{-7}		3×10^{-7}
$_{20}Ca^{45}$ (β^-)	(Sol)	Bone	30	3×10^{-4}	3×10^{-8}	9×10^{-5}	10^{-8}
		Total Body	200	2×10^{-3}	3×10^{-7}	7×10^{-4}	9×10^{-8}
		GI (LLI)		0.01	3×10^{-6}	4×10^{-3}	10^{-6}
	(Insol)	Lung			10^{-7}		4×10^{-8}
		GI (LLI)		5×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
$_{20}Ca^{47}$ (β^-, γ)	(Sol)	Bone	5	10^{-3}	2×10^{-7}	5×10^{-4}	6×10^{-8}
		GI (LLI)		2×10^{-3}	5×10^{-7}	8×10^{-4}	2×10^{-7}
		Total Body	10	4×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
	(Insol)	GI (LLI)		10^{-3}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Lung			2×10^{-7}		6×10^{-8}
$_{21}Sc^{46}$ (β^-, γ)	(Sol)	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}
		Liver	10	6	2×10^{-7}	2	8×10^{-8}
		Kidney	10	6	3×10^{-7}	2	9×10^{-8}
		Total Body	20	6	3×10^{-7}	2	10^{-7}
		Bone	60	20	10^{-6}	8	4×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations for radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ $\mu c/cc$	For 40 hour week (MPC)$_a$ $\mu c/cc$	For 168 hour week** (MPC)$_w$ $\mu c/cc$	For 168 hour week** (MPC)$_a$ $\mu c/cc$
	(Insol)	**Lung**			$\mathbf{2\times10^{-8}}$		$\mathbf{8\times10^{-9}}$
		GI (LLI)		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{4\times10^{-4}}$	7×10^{-8}
$_{21}Sc^{47}$ (β^-, γ)	(Sol)	**GI (LLI)**		$\mathbf{3\times10^{-3}}$	$\mathbf{6\times10^{-7}}$	$\mathbf{9\times10^{-4}}$	$\mathbf{2\times10^{-7}}$
		Liver	50	100	6×10^{-6}	50	2×10^{-6}
		Kidney	60	200	8×10^{-6}	60	3×10^{-6}
		Bone	60	200	8×10^{-6}	60	3×10^{-6}
		Total Body	80	200	10^{-5}	80	3×10^{-6}
	(Insol)	**GI (LLI)**		$\mathbf{3\times10^{-3}}$	$\mathbf{5\times10^{-7}}$	$\mathbf{9\times10^{-4}}$	$\mathbf{2\times10^{-7}}$
		Lung			10^{-6}		3×10^{-7}
$_{21}Sc^{48}$ (β^-, γ)	(Sol)	**GI (LLI)**		$\mathbf{8\times10^{-4}}$	$\mathbf{2\times10^{-7}}$	$\mathbf{3\times10^{-4}}$	$\mathbf{6\times10^{-8}}$
		Total Body	9	50	2×10^{-6}	20	7×10^{-7}
		Liver	9	50	2×10^{-6}	20	7×10^{-7}
		Kidney	10	80	3×10^{-6}	30	10^{-6}
		Bone	30	200	8×10^{-6}	60	3×10^{-6}
	(Insol)	**GI (LLI)**		$\mathbf{8\times10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{3\times10^{-4}}$	$\mathbf{5\times10^{-8}}$
		Lung			4×10^{-7}		10^{-7}

$_{23}V^{48}$ (β^+, ϵ, γ)	(Sol)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Kidney	8	0.03	3×10^{-7}	0.01	9×10^{-8}
		Total Body	10	0.04	4×10^{-7}	0.02	10^{-7}
		Spleen	20	0.06	5×10^{-7}	0.02	2×10^{-7}
		Liver	20	0.09	8×10^{-7}	0.03	3×10^{-7}
		Bone	60	0.2	2×10^{-6}	0.08	7×10^{-7}
	(Insol)	**Lung**			**6×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{24}Cr^{51}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**0.05**	**10^{-5}**	**0.02**	**4×10^{-6}**
		Total Body	800	0.6	**10^{-5}**	0.2	**4×10^{-6}**
		Lung	10^3	1	2×10^{-5}	0.4	8×10^{-6}
		Prostate	2×10^3	2	3×10^{-5}	0.5	10^{-5}
		Thyroid	4×10^3	3	6×10^{-5}	1	2×10^{-5}
		Kidney	8×10^3	6	10^{-4}	2	4×10^{-5}
	(Insol)	**Lung**			**2×10^{-6}**		**8×10^{-7}**
		GI (LLI)		**0.05**	8×10^{-6}	**0.02**	3×10^{-6}
$_{25}Mn^{52}$ (β^+, ϵ, γ)	(Sol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Pancreas	5	0.01	4×10^{-7}	4×10^{-3}	2×10^{-7}
		Liver	6	0.01	5×10^{-7}	4×10^{-3}	2×10^{-7}
		Total Body	9	0.02	8×10^{-7}	7×10^{-3}	3×10^{-7}
	(Insol)	**Lung**			**10^{-7}**		**5×10^{-8}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	**5×10^{-8}**
$_{25}Mn^{54}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	8×10^{-7}	**10^{-3}**	3×10^{-7}
		Liver	20	0.01	**4×10^{-7}**	4×10^{-3}	**10^{-7}**
		Total Body	40	0.02	8×10^{-7}	8×10^{-3}	3×10^{-7}
		Pancreas	50	0.02	9×10^{-7}	9×10^{-3}	3×10^{-7}
	(Insol)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{25}Mn^{56}$ (β^-, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Pancreas	2	0.2	6×10^{-6}	0.05	2×10^{-6}
		Liver	5	0.4	10^{-5}	0.1	5×10^{-6}
		Total Body	10	0.9	3×10^{-5}	0.3	10^{-5}
	(Insol)	**GI (LLI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{26}Fe^{55}$ (ϵ)	(Sol)	**Spleen**	10^3	**0.02**	**9×10^{-7}**	**8×10^{-3}**	**3×10^{-7}**
		Liver	2×10^3	0.04	2×10^{-6}	0.01	5×10^{-7}
		Total Body	3×10^3	0.06	2×10^{-6}	0.02	8×10^{-7}
		Lung	4×10^3	0.07	3×10^{-6}	0.03	9×10^{-7}
		GI (LLI)		0.08	2×10^{-5}	0.03	6×10^{-6}
		Bone	7×10^3	0.1	5×10^{-6}	0.04	2×10^{-6}
	(Insol)	**Lung**			**10^{-6}**		**3×10^{-7}**
		GI (LLI)		**0.07**	10^{-5}	**0.02**	4×10^{-6}
$_{26}Fe^{59}$ (β^-, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	4×10^{-7}	**6×10^{-4}**	10^{-7}
		Spleen	20	4×10^{-3}	**10^{-7}**	10^{-3}	**5×10^{-8}**
		Total Body	20	5×10^{-3}	2×10^{-7}	2×10^{-3}	7×10^{-8}
		Liver	30	6×10^{-3}	2×10^{-7}	2×10^{-3}	7×10^{-8}
		Lung	100	0.02	8×10^{-7}	7×10^{-3}	3×10^{-7}
		Bone	100	0.03	10^{-6}	0.01	4×10^{-7}

	(Insol)	**Lung**			**5×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**5×10^{-4}**	9×10^{-8}
$_{27}Co^{57}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		**0.02**	**3×10^{-6}**	**5×10^{-3}**	**10^{-6}**
		Total Body	200	0.07	6×10^{-6}	0.03	2×10^{-6}
		Pancreas	700	0.2	2×10^{-5}	0.08	7×10^{-6}
		Liver	10^3	0.4	2×10^{-5}	0.1	6×10^{-6}
		Spleen	2×10^3	0.7	6×10^{-5}	0.2	2×10^{-5}
		Kidney	3×10^3	0.9	8×10^{-5}	0.3	3×10^{-5}
	(Insol)	**Lung**			**2×10^{-7}**		**6×10^{-8}**
		GI (LLI)		**0.01**	2×10^{-6}	**4×10^{-3}**	7×10^{-7}
$_{27}Co^{58m}$ (β^+, ϵ, γ)	(Sol)	**GI (LLI)**		**0.08**	**2×10^{-5}**	**0.03**	**6×10^{-6}**
		Total Body	200	2	10^{-4}	0.6	5×10^{-5}
		Pancreas	800	6	5×10^{-4}	2	2×10^{-4}
		Liver	10^3	9	4×10^{-4}	3	10^{-4}
		Spleen	2×10^3	20	10^{-3}	5	4×10^{-4}
		Kidney	3×10^3	20	2×10^{-3}	8	6×10^{-4}
	(Insol)	**Lung**			**9×10^{-6}**		**3×10^{-6}**
		GI (LLI)		**0.06**	10^{-5}	**0.02**	4×10^{-6}
$_{27}Co^{58}$ (β^+, ϵ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Total Body	30	0.01	10^{-6}	4×10^{-3}	**3×10^{-7}**
		Pancreas	200	0.06	5×10^{-6}	0.02	2×10^{-6}
		Liver	200	0.08	4×10^{-6}	0.03	10^{-6}
		Spleen	400	0.1	10^{-5}	0.05	4×10^{-6}
		Kidney	600	0.2	2×10^{-5}	0.07	6×10^{-6}
	(Insol)	**Lung**			**5×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{27}Co^{60}$ (β^-, γ)	(Sol)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Total Body	10	4×10^{-3}	4×10^{-7}	10^{-3}	**10^{-7}**
		Pancreas	70	0.02	2×10^{-6}	7×10^{-3}	6×10^{-7}
		Liver	90	0.03	10^{-6}	9×10^{-3}	5×10^{-7}
		Spleen	200	0.05	4×10^{-6}	0.02	2×10^{-6}
		Kidney	200	0.07	6×10^{-6}	0.03	2×10^{-6}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hour week		For 168 hour week**	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
(Insol)	**Lung**			**9×10^{-9}**		**3×10^{-9}**
	GI (LLI)		**10^{-3}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
$_{28}Ni^{59}$ (ϵ) (Sol)	**Bone**	10^{3}	**6×10^{-3}**	**5×10^{-7}**	**2×10^{-3}**	**2×10^{-7}**
	Total Body	3×10^{3}	0.01	10^{-6}	4×10^{-3}	3×10^{-7}
	Liver	4×10^{3}	0.02	10^{-6}	6×10^{-3}	5×10^{-7}
	GI (LLI)		0.08	2×10^{-5}	0.03	6×10^{-6}
(Insol)	**Lung**			**8×10^{-7}**		**3×10^{-7}**
	GI (LLI)		**0.06**	10^{-5}	**0.02**	3×10^{-6}
$_{28}Ni^{63}$ (β^-) (Sol)	**Bone**	200	**8×10^{-4}**	**6×10^{-8}**	**3×10^{-4}**	**2×10^{-8}**
	Total Body	900	4×10^{-3}	4×10^{-7}	2×10^{-3}	10^{-7}
	Liver	10^{3}	6×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
	GI (LLI)		0.03	6×10^{-6}	0.01	2×10^{-6}
(Insol)	**Lung**			**3×10^{-7}**		**10^{-7}**
	GI (LLI)		**0.02**	4×10^{-6}	**7×10^{-3}**	10^{-6}
$_{28}Ni^{65}$ (β^-, γ) (Sol)	**GI (ULI)**		**4×10^{-3}**	**9×10^{-7}**	**10^{-3}**	**3×10^{-7}**
	Bone	4	0.1	10^{-5}	0.04	3×10^{-6}
	Total Body	10	0.4	3×10^{-5}	0.1	10^{-5}
	Liver	20	0.5	4×10^{-5}	0.2	10^{-5}

	(Insol)	**GI (ULI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{29}Cu^{64}$ (β^-, β^+, ϵ)	(Sol)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**3×10^{-3}**	**7×10^{-7}**
		Spleen	10	0.08	6×10^{-6}	0.03	2×10^{-6}
		Kidney	30	0.2	2×10^{-6}	0.07	5×10^{-6}
		Total Body	80	0.5	4×10^{-5}	0.2	10^{-5}
		Liver	100	0.6	5×10^{-5}	0.2	2×10^{-5}
		Heart	200	0.9	7×10^{-5}	0.3	3×10^{-5}
		Brain	600	4	3×10^{-4}	1	10^{-4}
	(Insol)	**GI (LLI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Lung			7×10^{-6}		3×10^{-6}
$_{30}Zn^{65}$ (β^+, ϵ, γ)	(Sol)	**Total Body**	60	**3×10^{-3}**	**10^{-7}**	**10^{-3}**	**4×10^{-8}**
		Prostate	70	**4×10^{-3}**	**10^{-7}**	**10^{-3}**	**4×10^{-8}**
		Liver	80	4×10^{-3}	**10^{-7}**	**10^{-3}**	5×10^{-8}
		Kidney	100	6×10^{-3}	2×10^{-7}	2×10^{-3}	7×10^{-8}
		GI (LLI)		6×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		Pancreas	200	7×10^{-3}	3×10^{-7}	3×10^{-3}	9×10^{-8}
		Muscle	200	0.01	4×10^{-7}	4×10^{-3}	10^{-7}
		Ovary	300	0.01	5×10^{-7}	4×10^{-3}	2×10^{-7}
		Testis	400	0.02	6×10^{-7}	6×10^{-3}	2×10^{-7}
		Bone	700	0.04	10^{-6}	0.01	4×10^{-7}
	(Insol)	**Lung**			**6×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{30}Zn^{69m}$ (γ, e^-, β^-)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	2×10^{-7}
		Prostate	0.7	0.01	**4×10^{-7}**	4×10^{-3}	**10^{-7}**
		Pancreas	5	0.07	3×10^{-6}	0.02	9×10^{-7}
		Liver	8	0.1	5×10^{-6}	0.05	2×10^{-6}
		Kidney	10	0.2	8×10^{-6}	0.07	3×10^{-6}
		Ovary	10	0.2	8×10^{-6}	0.07	3×10^{-6}
		Total Body	30	0.5	2×10^{-5}	0.2	6×10^{-6}
		Testis	30	0.5	2×10^{-5}	0.2	6×10^{-6}
		Bone	40	0.6	2×10^{-5}	0.2	7×10^{-6}
		Muscle	100	2	8×10^{-5}	0.7	3×10^{-5}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ μc/cc	For 40 hour week (MPC)$_a$ μc/cc	For 168 hour week** (MPC)$_w$ μc/cc	For 168 hour week** (MPC)$_a$ μc/cc
	(Insol)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung			2×10^{-6}		8×10^{-7}
$_{30}Zn^{69}(\beta^-)$	(Sol)	GI (S)		**0.05**	10^{-5}	**0.02**	4×10^{-6}
		Prostate	0.8	0.2	**7×10^{-6}**	0.07	**2×10^{-6}**
		Pancreas	5	1	5×10^{-5}	0.5	2×10^{-5}
		Liver	10	3	10^{-4}	1	4×10^{-5}
		Ovary	20	4	10^{-4}	1	5×10^{-5}
		Kidney	20	4	2×10^{-4}	2	5×10^{-5}
		Testis	30	9	3×10^{-4}	3	10^{-4}
		Bone	40	10	4×10^{-4}	3	10^{-4}
		Total Body	50	10	5×10^{-4}	5	2×10^{-4}
		Muscle	200	60	2×10^{-3}	20	7×10^{-4}
	(Insol)	**GI (S)**		**0.05**	**9×10^{-6}**	**0.02**	**3×10^{-6}**
		Lung			5×10^{-5}		2×10^{-5}
$_{31}Ga^{72}$ (β^-, γ)	(Sol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
		Liver	5	9	4×10^{-6}	3	10^{-6}
		Total Body	10	20	8×10^{-6}	6	3×10^{-6}
		Bone	10	20	10^{-5}	8	3×10^{-6}
		Spleen	10	20	10^{-5}	8	4×10^{-6}
		Kidney	10	20	10^{-5}	8	4×10^{-6}

	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
		Lung			10^{-6}		4×10^{-7}
$_{32}Ge^{71}$ (ϵ)	(Sol)	**GI (LLI)**		**0.05**	**10^{-5}**	**0.02**	**4×10^{-6}**
		Kidney	100	10	5×10^{-5}	4	2×10^{-5}
		Liver	10^{3}	100	6×10^{-4}	50	2×10^{-4}
		Total Body	2×10^{3}	200	9×10^{-4}	70	3×10^{-4}
	(Insol)	**Lung**			**6×10^{-6}**		**2×10^{-6}**
		GI (LLI)		**0.05**	8×10^{-6}	**0.02**	3×10^{-6}
$_{33}As^{73}$ (ϵ, γ)	(Sol)	GI (LLI)		**0.01**	3×10^{-6}	**5×10^{-3}**	10^{-6}
		Total Body	300	0.2	**2×10^{-6}**	0.06	**7×10^{-7}**
		Kidney	600	0.3	4×10^{-6}	0.1	10^{-6}
		Liver	10^{3}	0.5	6×10^{-6}	0.2	2×10^{-6}
	(Insol)	**Lung**			**4×10^{-7}**		**10^{-7}**
		GI (LLI)		**0.01**	2×10^{-6}	**5×10^{-3}**	8×10^{-7}
$_{33}As^{74}$ (β^-, β^+, ϵ, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Total Body	40	0.07	8×10^{-7}	0.02	3×10^{-7}
		Kidney	80	0.1	2×10^{-6}	0.05	6×10^{-7}
		Liver	100	0.2	3×10^{-6}	0.08	10^{-6}
	(Insol)	Lung			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**5×10^{-4}**	9×10^{-8}
$_{33}As^{76}$ (β^-, γ)	(Sol)	**GI (LLI)**		**6×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Total Body	20	0.4	5×10^{-6}	0.1	2×10^{-6}
		Kidney	20	0.6	8×10^{-6}	0.2	3×10^{-6}
		Liver	40	1	10^{-5}	0.4	5×10^{-6}
	(Insol)	**GI (LLI)**		**6×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**3×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{33}As^{77}$ (β^-, γ)	(Sol)	**GI (LLI)**		2×10^{-3}	**5×10^{-7}**	**8×10^{-4}**	2×10^{-7}
		Total Body	80	2	2×10^{-5}	0.5	7×10^{-6}
		Kidney	100	2	2×10^{-5}	0.7	8×10^{-6}
		Liver	200	4	5×10^{-5}	1	2×10^{-5}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
	(Insol)	**GI (LLI)**		2×10^{-3}	4×10^{-7}	8×10^{-4}	10^{-7}
		Lung			2×10^{-6}		6×10^{-7}
$_{34}Se^{75}$ (ϵ, γ)	(Sol)	**Kidney**	90	9×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Total Body	100	0.01	10^{-6}	3×10^{-3}	5×10^{-7}
		Liver	100	0.01	2×10^{-6}	4×10^{-3}	5×10^{-7}
		Spleen	200	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
		GI (LLI)		0.07	2×10^{-5}	0.03	6×10^{-6}
	(Insol)	**Lung**			10^{-7}		4×10^{-8}
		GI (LLI)		8×10^{-3}	10^{-6}	3×10^{-3}	5×10^{-7}
$_{35}Br^{82}$ (β^-, γ)	(Sol)	**Total Body**	10	8×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		GI (SI)		8×10^{-3}	2×10^{-6}	3×10^{-3}	6×10^{-7}
	(Insol)	**GI (LLI)**		10^{-3}	2×10^{-7}	4×10^{-4}	6×10^{-8}
		Lung			6×10^{-7}		2×10^{-7}
$_{36}Kr^{85}m$ (β^-, γ)	(Immersion)	**Total Body**			6×10^{-6}		10^{-6}
$_{36}Kr^{85}$ (β^-)	(Immersion)	**Total Body**			10^{-5}		3×10^{-6}
$_{36}Kr^{87}$ (β^-, γ)	(Immersion)	**Total Body**			10^{-6}		2×10^{-7}

$_{37}Rb^{86}$ (β^-, γ)	(Sol)	**Total Body**	30	**2×10^{-3}**	**3×10^{-7}**	**7×10^{-4}**	**10^{-7}**
		Pancreas	30	**2×10^{-3}**	**3×10^{-7}**	**7×10^{-4}**	**10^{-7}**
		Liver	40	3×10^{-3}	4×10^{-7}	10^{-3}	**10^{-7}**
		Spleen	50	3×10^{-3}	5×10^{-7}	10^{-3}	2×10^{-7}
		Muscle	70	5×10^{-3}	7×10^{-7}	2×10^{-3}	2×10^{-7}
		GI (LLI)		0.01	3×10^{-6}	5×10^{-3}	10^{-6}
	(Insol)	**Lung**			**7×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{37}Rb^{87}$ (β^-)	(Sol)	**Pancreas**	200	**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Total Body	200	4×10^{-3}	6×10^{-7}	2×10^{-3}	**2×10^{-7}**
		Liver	200	5×10^{-3}	7×10^{-7}	2×10^{-3}	**2×10^{-7}**
		Muscle	400	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		Spleen	400	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		GI (LLI)		0.1	2×10^{-5}	0.03	8×10^{-6}
	(Insol)	**Lung**			**7×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{38}Sr^{85m}$ (ϵ, γ)	(Sol)	**GI (SI)**		**0.2**	**4×10^{-5}**	**0.07**	**10^{-5}**
		Total Body	50	3	2×10^{-4}	1	8×10^{-5}
		Bone	70	5	4×10^{-4}	2	10^{-4}
	(Insol)	**GI (SI)**		**0.2**	**3×10^{-5}**	**0.07**	**10^{-5}**
		Lung			9×10^{-5}		3×10^{-5}
$_{38}Sr^{85}$ (ϵ, γ)	(Sol)	**Total Body**	60	**3×10^{-3}**	**2×10^{-7}**	**10^{-3}**	**8×10^{-8}**
		Bone	70	4×10^{-3}	4×10^{-7}	2×10^{-3}	10^{-7}
		GI (LLI)		7×10^{-3}	2×10^{-6}	2×10^{-3}	5×10^{-7}
	(Insol)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	**3×10^{-7}**
$_{38}Sr^{89}$ (β^-)	(Sol)	**Bone**	4	**3×10^{-4}**	**3×10^{-8}**	**10^{-4}**	**10^{-8}**
		GI (LLI)		10^{-3}	3×10^{-7}	4×10^{-4}	9×10^{-8}
		Total Body	40	2×10^{-3}	2×10^{-7}	7×10^{-4}	6×10^{-8}
	(Insol)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations for radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{38}Sr^{90}$ (β^-)	(Sol)	**Bone**	2	**4×10^{-6}**	**3×10^{-10}**	**10^{-6}**	**10^{-10}**
		Total Body	20	10^{-5}	9×10^{-10}	4×10^{-6}	3×10^{-10}
		GI (LLI)	----------	10^{-3}	3×10^{-7}	5×10^{-4}	10^{-7}
	(Insol)	**Lung**	----------	----------	**5×10^{-9}**	----------	**2×10^{-9}**
		GI (LLI)	----------	**10^{-3}**	2×10^{-7}	**4×10^{-4}**	6×10^{-8}
$_{38}Sr^{91}$ (β^-, γ)	(Sol)	**GI (LLI)**	----------	**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**2×10^{-7}**
		Bone	3	0.02	2×10^{-6}	7×10^{-3}	5×10^{-7}
		Total Body	9	0.07	6×10^{-6}	0.02	2×10^{-6}
	(Insol)	**GI (LLI)**	----------	**10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**9×10^{-8}**
		Lung	----------	----------	10^{-6}	----------	4×10^{-7}
$_{38}Sr^{92}$ (β^-, γ)	(Sol)	**GI (ULI)**	----------	**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**2×10^{-7}**
		Bone	2	0.05	4×10^{-6}	0.02	2×10^{-6}
		Total Body	8	0.2	2×10^{-5}	0.07	6×10^{-6}
	(Insol)	**GI (ULI)**	----------	**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung	----------	----------	3×10^{-6}	----------	10^{-6}
$_{39}Y^{90}$ (β^-)	(Sol)	**GI (LLI)**	----------	**6×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Bone	3	10	5×10^{-7}	4	2×10^{-7}
		Total Body	20	80	3×10^{-6}	30	10^{-6}

	(Insol)	GI (LLI)		6×10^{-4}	10^{-7}	2×10^{-4}	3×10^{-8}
		Lung			3×10^{-7}		10^{-7}
$_{39}Y^{91m}$ (β^-, γ)	(Sol)	GI (SI)		0.1	2×10^{-5}	0.03	8×10^{-6}
		Bone	5	10^{3}	6×10^{-5}	400	2×10^{-5}
		Total Body	20	6×10^{3}	2×10^{-4}	2×10^{3}	8×10^{-5}
	(Insol)	GI (SI)		0.1	2×10^{-5}	0.03	6×10^{-6}
		Lung			4×10^{-5}		10^{-5}
$_{39}Y^{91}$ (β^-, γ)	(Sol)	GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Bone	5	0.8	4×10^{-8}	0.3	10^{-8}
		Total Body	30	5	2×10^{-7}	2	8×10^{-8}
	(Insol)	Lung			3×10^{-8}		10^{-8}
		GI (LLI)		8×10^{-4}	10^{-7}	3×10^{-4}	5×10^{-8}
$_{39}Y^{92}$ (β^-, γ)	(Sol)	GI (ULI)		2×10^{-3}	4×10^{-7}	6×10^{-4}	10^{-7}
		Bone	2	100	6×10^{-6}	40	2×10^{-6}
		Total Body	10	800	3×10^{-5}	300	10^{-5}
	(Insol)	GI (ULI)		2×10^{-3}	3×10^{-7}	6×10^{-4}	10^{-7}
		Lung			3×10^{-6}		10^{-6}
$_{39}Y^{93}$ (β^-, γ, e^-)	(Sol)	GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Bone	2	50	2×10^{-6}	20	7×10^{-7}
		Total Body	10	250	10^{-5}	90	4×10^{-6}
	(Insol)	GI (LLI)		8×10^{-4}	10^{-7}	3×10^{-4}	5×10^{-8}
		Lung			10^{-6}		4×10^{-7}
$_{40}Zr^{93}$ (β^-, γ, e^-)	(Sol)	GI (LLI)		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
		Bone	100	3	10^{-7}	0.9	4×10^{-8}
		Kidney	300	6	3×10^{-7}	2	9×10^{-8}
		Spleen	500	10	4×10^{-7}	3	10^{-7}
		Total Body	900	20	8×10^{-7}	6	3×10^{-7}
		Liver	10^{3}	30	10^{-6}	9	4×10^{-7}
	(Insol)	Lung			3×10^{-7}		10^{-7}
		GI (LLI)		0.02	4×10^{-6}	8×10^{-3}	10^{-6}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{40}Zr^{95}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**2×10^{-3}**	4×10^{-7}	**6×10^{-4}**	10^{-7}
		Total Body	20	3	**10^{-7}**	1	**4×10^{-8}**
		Bone	30	4	2×10^{-7}	2	6×10^{-8}
		Kidney	30	4	2×10^{-7}	2	6×10^{-8}
		Liver	40	6	3×10^{-7}	2	9×10^{-8}
		Spleen	40	7	3×10^{-7}	2	10^{-7}
	(Insol)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}
$_{40}Zr^{97}$ (β^-, γ)	(Sol)	**GI (LLI)**		**5×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Bone	5	60	3×10^{-6}	20	10^{-6}
		Kidney	8	100	5×10^{-6}	40	2×10^{-6}
		Total Body	9	100	5×10^{-6}	40	2×10^{-6}
		Liver	10	200	7×10^{-6}	60	3×10^{-6}
		Spleen	10	200	8×10^{-6}	60	3×10^{-6}
	(Insol)	**GI (LLI)**		**5×10^{-4}**	**9×10^{-8}**	**2×10^{-4}**	**3×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}

$_{41}Nb^{93m}$ (γ, e^-)	(Sol)	**GI (LLI)**		**0.01**	3×10^{-6}	**4×10^{-3}**	9×10^{-7}
		Bone	200	3	**10^{-7}**	1	**4×10^{-8}**
		Kidney	300	5	2×10^{-7}	2	7×10^{-8}
		Spleen	400	5	2×10^{-7}	2	8×10^{-8}
		Liver	400	6	3×10^{-7}	2	9×10^{-8}
		Total Body	500	8	3×10^{-7}	3	10^{-7}
	(Insol)	**Lung**			**2×10^{-7}**		**5×10^{-8}**
		GI (LLI)		**0.01**	2×10^{-6}	**4×10^{-3}**	7×10^{-7}
$_{41}Nb^{95}$ (β^-, γ)	(Sol)	**GI (LLI)**		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	**2×10^{-7}**
		Total Body	40	10	**5×10^{-7}**	4	**2×10^{-7}**
		Liver	60	20	7×10^{-7}	6	3×10^{-7}
		Kidney	60	20	8×10^{-7}	6	3×10^{-7}
		Bone	80	20	9×10^{-7}	7	3×10^{-7}
		Spleen	80	20	10^{-6}	7	3×10^{-7}
	(Insol)	**Lung**			**10^{-7}**		**3×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**10^{-3}**	2×10^{-7}
$_{41}Nb^{97}$ (β^-, γ)	(Sol)	**GI (ULI)**		**0.03**	**6×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Bone	10	2×10^{3}	9×10^{-5}	700	3×10^{-5}
		Kidney	20	4×10^{3}	2×10^{-4}	10^{3}	6×10^{-5}
		Total Body	20	4×10^{3}	2×10^{-4}	10^{3}	6×10^{-5}
		Liver	30	4×10^{3}	2×10^{-4}	2×10^{3}	7×10^{-5}
		Spleen	30	5×10^{3}	2×10^{-4}	2×10^{3}	7×10^{-5}
	(Insol)	**GI (ULI)**		**0.03**	**5×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Lung			2×10^{-5}		7×10^{-6}
$_{42}Mo^{99}$ (β^-, γ)	(Sol)	**Kidney**	8	**5×10^{-3}**	**7×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		GI (LLI)		7×10^{-3}	2×10^{-6}	**2×10^{-3}**	5×10^{-7}
		Liver	20	0.01	2×10^{-6}	5×10^{-3}	6×10^{-7}
		Total Body	40	0.02	3×10^{-6}	8×10^{-3}	10^{-6}
	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**7×10^{-8}**
		Lung			5×10^{-7}		2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ $\mu c/cc$	For 40 hour week (MPC)$_a$ $\mu c/cc$	For 168 hour week** (MPC)$_w$ $\mu c/cc$	For 168 hour week** (MPC)$_a$ $\mu c/cc$
$_{43}Tc^{96m}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		**0.4**	**8×10^{-5}**	**0.1**	**3×10^{-5}**
		Kidney	60	3	4×10^{-4}	1	10^{-4}
		Total Body	70	4	4×10^{-4}	1	10^{-4}
		Liver	800	40	4×10^{-3}	14	10^{-3}
		Lung	2×10^{3}	130	0.01	40	5×10^{-3}
		Bone	10^{4}	700	0.08	200	0.03
		Skin	2×10^{4}	800	0.09	300	0.03
	(Insol)	**Lung**			**3×10^{-5}**		**10^{-5}**
		GI (LLI)		**0.3**	5×10^{-5}	**0.1**	2×10^{-5}
$_{43}Tc^{96}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Kidney	10	0.03	3×10^{-6}	0.01	10^{-6}
		Total Body	10	0.03	4×10^{-6}	0.01	10^{-6}
		Liver	200	0.4	4×10^{-5}	0.1	10^{-5}
		Lung	500	1	10^{-4}	0.4	4×10^{-5}
		Bone	2×10^{3}	4	5×10^{-4}	1	2×10^{-4}
		Skin	10^{4}	20	3×10^{-3}	9	9×10^{-4}
	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
		Lung			3×10^{-7}		9×10^{-8}

$_{43}Tc^{97m}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		**0.01**	$\mathbf{2\times10^{-6}}$	$\mathbf{4\times10^{-3}}$	$\mathbf{8\times10^{-7}}$
		Kidney	20	0.03	4×10^{-6}	0.01	10^{-6}
		Total Body	200	0.4	4×10^{-5}	0.1	2×10^{-5}
		Liver	200	0.4	5×10^{-5}	0.1	2×10^{-5}
		Skin	500	1	10^{-4}	0.3	4×10^{-5}
		Bone	700	1	10^{-4}	0.5	5×10^{-5}
		Lung	2×10^{3}	4	4×10^{-4}	1	2×10^{-4}
	(Insol)	**Lung**			$\mathbf{2\times10^{-7}}$		$\mathbf{5\times10^{-8}}$
		GI (LLI)		$\mathbf{5\times10^{-3}}$	9×10^{-7}	$\mathbf{2\times10^{-3}}$	3×10^{-7}
$_{43}Tc^{97}$ (ϵ)	(Sol)	**GI (LLI)**		**0.05**	$\mathbf{10^{-5}}$	**0.02**	4×10^{-6}
		Kidney	60	0.1	$\mathbf{10^{-5}}$	0.04	$\mathbf{4\times10^{-6}}$
		Liver	800	2	2×10^{-4}	0.5	6×10^{-5}
		Total Body	10^{3}	2	2×10^{-4}	0.6	7×10^{-5}
		Bone	6×10^{3}	10	10^{-3}	4	4×10^{-4}
		Lung	9×10^{3}	20	2×10^{-3}	6	7×10^{-4}
		Skin	3×10^{4}	60	6×10^{-3}	20	2×10^{-3}
	(Insol)	**Lung**			$\mathbf{3\times10^{-7}}$		$\mathbf{10^{-7}}$
		GI (LLI)		**0.02**	4×10^{-6}	$\mathbf{8\times10^{-3}}$	10^{-6}
$_{43}Tc^{99m}$ (β^-, γ)	(Sol)	**GI (ULI)**		**0.2**	$\mathbf{4\times10^{-5}}$	**0.06**	$\mathbf{10^{-5}}$
		Total Body	200	2	2×10^{-4}	0.8	9×10^{-5}
		Kidney	800	7	8×10^{-4}	3	3×10^{-4}
		Liver	10^{4}	100	0.01	30	4×10^{-3}
		Lung	2×10^{4}	200	0.02	70	8×10^{-3}
		Bone	10^{5}	10^{3}	0.1	400	0.04
		Skin	10^{5}	10^{3}	0.1	400	0.04
	(Insol)	**GI (ULI)**		**0.08**	$\mathbf{10^{-5}}$	**0.03**	$\mathbf{5\times10^{-6}}$
		Lung			8×10^{-5}		3×10^{-5}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ $\mu c/cc$	For 40 hour week (MPC)$_a$ $\mu c/cc$	For 168 hour week** (MPC)$_w$ $\mu c/cc$	For 168 hour week** (MPC)$_a$ $\mu c/cc$
$_{43}Tc^{99}$ (β^-)	(Sol)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**3×10^{-3}**	**7×10^{-7}**
		Kidney	10	0.02	3×10^{-6}	8×10^{-3}	9×10^{-7}
		Liver	200	0.3	4×10^{-5}	0.1	10^{-5}
		Total Body	200	0.4	4×10^{-5}	0.1	10^{-5}
		Skin	400	0.7	7×10^{-5}	0.2	3×10^{-5}
		Bone	500	0.9	9×10^{-5}	0.3	3×10^{-5}
		Lung	2×10^{3}	4	4×10^{-4}	1	10^{-4}
	(Insol)	**Lung**			**6×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**5×10^{-3}**	8×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{44}Ru^{97}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**8×10^{-7}**
		Kidney	30	0.4	5×10^{-6}	0.1	10^{-6}
		Total Body	100	2	3×10^{-5}	0.7	9×10^{-6}
		Bone	900	10	2×10^{-4}	5	6×10^{-5}
	(Insol)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**3×10^{-3}**	**6×10^{-7}**
		Lung			**2×10^{-6}**		7×10^{-7}
$_{44}Ru^{103}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**5×10^{-7}**	**8×10^{-4}**	**2×10^{-7}**
		Kidney	20	0.08	10^{-6}	0.03	3×10^{-7}
		Total Body	50	0.2	3×10^{-6}	0.08	9×10^{-7}
		Bone	100	0.6	7×10^{-6}	0.2	2×10^{-6}

	(Insol)	**Lung**			**8×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**2×10^{-3}**	4×10^{-7}	**8×10^{-4}**	10^{-7}
$_{44}Ru^{105}$ (β^-, γ, e^-)	(Sol)	**GI (ULI)**		**3×10^{-3}**	**7×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Kidney	2	0.3	3×10^{-6}	0.09	10^{-6}
		Total Body	20	3	4×10^{-5}	0.9	10^{-5}
		Bone	40	6	8×10^{-5}	2	3×10^{-5}
	(Insol)	**GI (ULI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{44}Ru^{106}$ (β^-, γ)	(Sol)	**GI (LLI)**		**4×10^{-4}**	**8×10^{-8}**	**10^{-4}**	**3×10^{-8}**
		Kidney	3	0.01	10^{-7}	4×10^{-3}	5×10^{-8}
		Bone	10	0.04	5×10^{-7}	0.01	2×10^{-7}
		Total Body	10	0.06	7×10^{-7}	0.02	3×10^{-7}
	(Insol)	**Lung**			**6×10^{-9}**		**2×10^{-9}**
		GI (LLI)		**3×10^{-4}**	6×10^{-8}	**10^{-4}**	2×10^{-8}
$_{45}Rh^{103m}$ (γ, e^-)	(Sol)	**GI (S)**		**0.4**	**8×10^{-5}**	**0.1**	**3×10^{-5}**
		Kidney	200	20	10^{-3}	7	4×10^{-4}
		Spleen	200	30	2×10^{-3}	10	6×10^{-4}
		Total Body	400	40	3×10^{-3}	20	10^{-3}
		Liver	700	80	5×10^{-3}	30	2×10^{-3}
		Bone	10^3	100	9×10^{-3}	50	3×10^{-3}
	(Insol)	**GI (S)**		**0.3**	**6×10^{-5}**	**0.1**	**2×10^{-5}**
		Lung			3×10^{-4}		10^{-4}
$_{45}Rh^{105}$ (β^-, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	200	8×10^{-3}	5×10^{-5}	3×10^{-3}	2×10^{-5}
		Kidney	40	0.1	9×10^{-6}	0.05	3×10^{-6}
		Spleen	60	0.2	10^{-5}	0.07	5×10^{-6}
		Total Body	100	0.4	2×10^{-5}	0.1	7×10^{-6}
		Liver	200	0.6	4×10^{-5}	0.2	10^{-5}
	(Insol)	**GI (LLI)**		**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			2×10^{-6}		8×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations for radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hour week		For 168 hour week**	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{46}Pd^{103}$ (ϵ, γ, e^-) (Sol)	**GI (LLI)**		**0.01**	2×10^{-6}	**3×10^{-3}**	8×10^{-7}
	Kidney	20	0.02	**10^{-6}**	7×10^{-3}	**5×10^{-7}**
	Spleen	100	0.1	8×10^{-6}	0.04	3×10^{-6}
	Liver	100	0.1	8×10^{-6}	0.04	3×10^{-6}
	Total Body	300	0.4	2×10^{-5}	0.1	8×10^{-6}
(Insol)	**Lung**			**7×10^{-7}**		**3×10^{-7}**
	GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{46}Pd^{109}$ (β^-, γ, e^-) (Sol)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
	Kidney	7	0.06	4×10^{-6}	0.02	10^{-6}
	Spleen	30	0.3	2×10^{-5}	0.09	5×10^{-6}
	Liver	40	0.3	2×10^{-5}	0.1	7×10^{-6}
	Total Body	50	0.4	3×10^{-5}	0.1	9×10^{-6}
(Insol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**10^{-7}**
	Lung			3×10^{-6}		10^{-6}
$_{47}Ag^{105}$ (ϵ, γ) (Sol)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
	Total Body	30	0.6	3×10^{-6}	0.2	10^{-6}
	Kidney	30	0.7	3×10^{-6}	0.2	10^{-6}
	Liver	70	1	6×10^{-6}	0.5	2×10^{-6}
	Bone	200	4	2×10^{-5}	1	6×10^{-6}

	(Insol)	**Lung**			**8×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**10^{-3}**	2×10^{-7}
$_{47}Ag^{110m}(\beta^-, \gamma)$	(Sol)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Kidney	10	0.2	8×10^{-7}	0.06	3×10^{-7}
		Total Body	10	0.2	9×10^{-7}	0.07	3×10^{-7}
		Liver	20	0.4	2×10^{-6}	0.1	5×10^{-7}
		Bone	40	0.7	3×10^{-6}	0.2	10^{-6}
	(Insol)	**Lung**			**10^{-8}**		**3×10^{-9}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{47}Ag^{111}(\beta^-, \gamma)$	(Sol)	**GI (LLI)**		**10^{-3}**	**3×10^{-7}**	**4×10^{-4}**	**10^{-7}**
		Kidney	20	0.7	3×10^{-6}	0.2	10^{-6}
		Total Body	50	1	6×10^{-6}	0.5	2×10^{-6}
		Bone	60	2	8×10^{-6}	0.6	3×10^{-6}
		Liver	80	2	10^{-5}	0.8	3×10^{-6}
	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
		Lung			3×10^{-7}		9×10^{-8}
$_{48}Cd^{109}(\epsilon, \gamma, e^-)$	(Sol)	**GI (CLLI)**		**5×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Liver	20	0.05	**5×10^{-8}**	0.02	**2×10^{-8}**
		Kidney	20	0.05	**6×10^{-8}**	0.02	**2×10^{-8}**
		Total Body	200	0.5	5×10^{-7}	0.2	2×10^{-7}
	(Insol)	**Lung**			**7×10^{-8}**		**3×10^{-8}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{48}Cd^{115m}(\beta^-, \gamma, e^-)$	(Sol)	**GI (LLI)**		**7×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
		Liver	3	0.03	**4×10^{-8}**	0.01	**10^{-8}**
		Kidney	4	0.04	**4×10^{-8}**	0.01	2×10^{-8}
		Total Body	30	0.4	4×10^{-7}	0.1	10^{-7}
	(Insol)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**3×10^{-4}**	4×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{48}Cd^{115}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**8×10^{-8}**
		Liver	3	0.6	6×10^{-7}	0.2	2×10^{-7}
		Kidney	5	0.8	8×10^{-7}	0.3	3×10^{-7}
		Total Body	30	5	5×10^{-6}	2	2×10^{-6}
	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}
$_{49}In^{113m}$ (γ, e^-)	(Sol)	**GI (ULI)**		**0.04**	**8×10^{-6}**	**0.01**	**3×10^{-6}**
		Kidney	30	200	2×10^{-4}	70	6×10^{-5}
		Spleen	30	200	2×10^{-4}	70	6×10^{-5}
		Liver	50	300	3×10^{-4}	100	9×10^{-5}
		Total Body	70	400	4×10^{-4}	200	10^{-4}
		Bone	90	600	5×10^{-4}	200	2×10^{-4}
		Skin	100	900	8×10^{-4}	300	3×10^{-4}
		Thyroid	500	3×10^{3}	3×10^{-3}	10^{3}	10^{-3}
	(Insol)	**GI (ULI)**		**0.04**	**7×10^{-6}**	**0.01**	**2×10^{-6}**
		Lung			5×10^{-5}		2×10^{-5}

$_{49}In^{114m}$ (β^-, ϵ, γ, e^-)	(Sol)	**GI (LLI)**	------	**5×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Kidney	6	0.1	**10^{-7}**	0.04	**4×10^{-8}**
		Spleen	7	0.1	**10^{-7}**	0.04	**4×10^{-8}**
		Liver	10	0.2	2×10^{-7}	0.07	6×10^{-8}
		Bone	10	0.3	2×10^{-7}	0.09	8×10^{-8}
		Skin	20	0.4	3×10^{-7}	0.1	10^{-7}
		Total Body	20	0.4	4×10^{-7}	0.1	10^{-7}
		Thyroid	50	0.9	8×10^{-7}	0.3	3×10^{-7}
	(Insol)	**Lung**	------	------	**2×10^{-8}**	------	**7×10^{-9}**
		GI (LLI)	------	**5×10^{-4}**	8×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{49}In^{115m}$ (β_-, γ, e^-)	(Sol)	**GI (ULI)**	------	**0.01**	**2×10^{-6}**	**4×10^{-3}**	**8×10^{-7}**
		Kidney	30	80	7×10^{-5}	30	2×10^{-5}
		Spleen	30	80	7×10^{-5}	30	2×10^{-5}
		Liver	50	100	10^{-4}	40	4×10^{-5}
		Total Body	80	200	2×10^{-4}	60	6×10^{-5}
		Thyroid	80	200	2×10^{-4}	70	6×10^{-5}
		Bone	90	200	2×10^{-4}	70	6×10^{-5}
		Skin	100	300	3×10^{-4}	100	10^{-4}
	(Insol)	**GI (ULI)**	------	**0.01**	**2×10^{-6}**	**4×10^{-3}**	**6×10^{-7}**
		Lung	------	------	2×10^{-5}	------	6×10^{-6}
$_{49}In^{115}$ (β^-)	(Sol)	**GI (LLI)**	------	**3×10^{-3}**	6×10^{-7}	**9×10^{-4}**	2×10^{-7}
		Kidney	30	0.3	**2×10^{-7}**	0.1	**9×10^{-8}**
		Spleen	40	0.4	3×10^{-7}	0.1	10^{-7}
		Liver	50	0.5	4×10^{-7}	0.1	10^{-7}
		Bone	60	0.6	5×10^{-7}	0.2	2×10^{-7}
		Skin	80	0.8	7×10^{-7}	0.3	2×10^{-7}
		Total Body	100	1	10^{-6}	0.4	3×10^{-7}
		Thyroid	3×10^{3}	30	2×10^{-5}	9	8×10^{-6}
	(Insol)	**Lung**	------	------	**3×10^{-8}**	------	**10^{-8}**
		GI (LLI)	------	**3×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week $(MPC)_w$ $\mu c/cc$	For 40 hour week $(MPC)_a$ $\mu c/cc$	For 168 hour week** $(MPC)_w$ $\mu c/cc$	For 168 hour week** $(MPC)_a$ $\mu c/cc$
${}_{50}Sn^{113}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		$\mathbf{2\times10^{-3}}$	5×10^{-7}	$\mathbf{9\times10^{-4}}$	2×10^{-7}
		Bone	30	0.02	$\mathbf{4\times10^{-7}}$	6×10^{-3}	$\mathbf{10^{-7}}$
		Total Body	60	0.04	8×10^{-7}	0.01	3×10^{-7}
		Prostate	70	0.04	9×10^{-7}	0.02	3×10^{-7}
		Liver	400	0.3	5×10^{-6}	0.09	2×10^{-6}
		Thyroid	10^3	0.9	2×10^{-5}	0.3	6×10^{-6}
	(Insol)	**Lung**			$\mathbf{5\times10^{-8}}$		$\mathbf{2\times10^{-8}}$
		GI (LLI)		$\mathbf{2\times10^{-3}}$	4×10^{-7}	$\mathbf{8\times10^{-4}}$	10^{-7}
${}_{50}Sn^{125}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		$\mathbf{5\times10^{-4}}$	$\mathbf{10^{-7}}$	$\mathbf{2\times10^{-4}}$	$\mathbf{4\times10^{-8}}$
		Bone	7	0.02	3×10^{-7}	6×10^{-3}	10^{-7}
		Prostate	10	0.03	6×10^{-7}	9×10^{-3}	2×10^{-7}
		Total Body	20	0.05	10^{-6}	0.02	4×10^{-7}
		Liver	100	0.3	7×10^{-6}	0.1	2×10^{-6}
		Thyroid	300	0.8	2×10^{-5}	0.3	5×10^{-6}
	(Insol)	**Lung**			$\mathbf{8\times10^{-8}}$		$\mathbf{3\times10^{-8}}$
		GI (LLI)		$\mathbf{5\times10^{-4}}$	9×10^{-8}	$\mathbf{2\times10^{-4}}$	$\mathbf{3\times10^{-8}}$
${}_{51}Sb^{122}$ (β^-, γ)	(Sol)	**GI (LLI)**		$\mathbf{8\times10^{-4}}$	$\mathbf{2\times10^{-7}}$	$\mathbf{3\times10^{-4}}$	$\mathbf{6\times10^{-8}}$
		Total Body	20	0.3	4×10^{-6}	0.1	10^{-6}
		Lung	40	0.5	6×10^{-6}	0.2	2×10^{-6}
		Bone	40	0.5	6×10^{-6}	0.2	2×10^{-6}
		Liver	10^3	10	2×10^{-4}	4	5×10^{-5}
		Thyroid	3×10^3	40	4×10^{-4}	10	2×10^{-4}

	(Insol)	**GI (LLI)**		**8×10^{-4}**	**10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			4×10^{-7}		10^{-7}
$_{51}Sb^{124}$ (β^-, γ)	(Sol)	**GI (LLI)**		**7×10^{-4}**	**2×10^{-7}**	**2×10^{-4}**	**5×10^{-8}**
		Total Body	10	0.02	**2×10^{-7}**	6×10^{-3}	7×10^{-8}
		Lung	20	0.02	3×10^{-7}	8×10^{-3}	10^{-7}
		Bone	30	0.04	5×10^{-7}	0.01	2×10^{-7}
		Liver	800	1	10^{-5}	0.4	4×10^{-6}
		Thyroid	10^4	20	2×10^{-4}	6	7×10^{-5}
	(Insol)	**Lung**			**2×10^{-8}**		**7×10^{-9}**
		GI (LLI)		**7×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{51}Sb^{125}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	**2×10^{-7}**
		Lung	40	0.04	**5×10^{-7}**	0.01	**2×10^{-7}**
		Total Body	60	0.05	6×10^{-7}	0.02	**2×10^{-7}**
		Bone	70	0.06	8×10^{-7}	0.02	**2×10^{-7}**
		Liver	3×10^3	3	3×10^{-5}	0.9	10^{-5}
		Thyroid	7×10^4	60	7×10^{-4}	20	2×10^{-4}
	(Insol)	**Lung**			**3×10^{-8}**		**9×10^{-9}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**10^{-3}**	2×10^{-7}
$_{52}Te^{125m}$ (γ, e^-)	(Sol)	**Kidney**	29	**5×10^{-3}**	**4×10^{-7}**	**2×10^{-3}**	**10^{-7}**
		GI (LLI)		**5×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Testis	20	6×10^{-3}	5×10^{-7}	**2×10^{-3}**	2×10^{-7}
		Spleen	50	0.02	10^{-6}	6×10^{-3}	4×10^{-7}
		Liver	100	0.04	3×10^{-6}	0.01	9×10^{-7}
		Total Body	100	0.04	3×10^{-6}	0.01	10^{-6}
		Bone	100	0.04	3×10^{-6}	0.02	10^{-6}
		Thyroid	500	0.2	10^{-5}	0.05	4×10^{-6}
	(Insol)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hour week		For 168 hour week**	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{52}Te^{127m}$ (β^-, γ, e^-) (Sol)	**Kidney**	7	**2×10^{-3}**	**10^{-7}**	**6×10^{-4}**	**5×10^{-8}**
	Testis	7	**2×10^{-3}**	**10^{-7}**	7×10^{-4}	**5×10^{-8}**
	GI (LLI)		**2×10^{-3}**	5×10^{-7}	8×10^{-4}	2×10^{-7}
	Spleen	20	6×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
	Bone	50	0.01	9×10^{-7}	4×10^{-3}	3×10^{-7}
	Liver	50	0.01	10^{-6}	5×10^{-3}	4×10^{-7}
	Total Body	60	0.02	10^{-6}	6×10^{-3}	4×10^{-7}
	Thyroid	200	0.05	4×10^{-6}	0.02	10^{-6}
(Insol)	**Lung**			**4×10^{-8}**		**10^{-8}**
	GI (LLI)		**2×10^{-3}**	3×10^{-7}	**5×10^{-4}**	9×10^{-8}
$_{52}Te^{127}$ (β^-) (Sol)	**GI (LLI)**		**8×10^{-3}**	**2×10^{-6}**	**3×10^{-3}**	**6×10^{-7}**
	Kidney	20	0.1	10^{-5}	0.05	4×10^{-6}
	Testis	20	0.2	10^{-5}	0.05	4×10^{-6}
	Spleen	50	0.5	4×10^{-5}	0.2	10^{-5}
	Total Body	80	0.8	6×10^{-5}	0.3	2×10^{-5}
	Bone	100	1	7×10^{-5}	0.3	2×10^{-5}
	Liver	100	1	9×10^{-5}	0.4	3×10^{-5}
	Thyroid	100	1	10^{-4}	0.5	4×10^{-5}
(Insol)	**GI (LLI)**		**5×10^{-3}**	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
	Lung			8×10^{-6}		3×10^{-6}

$_{52}Te^{129m}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**	-----------	**10^{-3}**	2×10^{-7}	**3×10^{-4}**	7×10^{-8}
		Kidney	3	**10^{-3}**	**8×10^{-8}**	4×10^{-4}	**3×10^{-8}**
		Testis	3	**10^{-3}**	9×10^{-8}	4×10^{-4}	**3×10^{-8}**
		Spleen	10	4×10^{-3}	3×10^{-7}	10^{-3}	9×10^{-8}
		Total Body	20	6×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
		Liver	20	8×10^{-3}	6×10^{-7}	3×10^{-3}	2×10^{-7}
		Bone	20	9×10^{-3}	6×10^{-7}	3×10^{-3}	2×10^{-7}
		Thyroid	70	0.03	2×10^{-6}	8×10^{-3}	6×10^{-7}
	(Insol)	**Lung**	-----------	-----------	**3×10^{-8}**	-----------	**10^{-8}**
		GI (LLI)	-----------	**6×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
$_{52}Te^{129}$ (β^-, γ, e^-)	(Sol)	**GI (S)**	-----------	**0.02**	**5×10^{-6}**	**8×10^{-3}**	**2×10^{-6}**
		Kidney	5	0.4	3×10^{-5}	0.1	10^{-5}
		Testis	6	0.4	3×10^{-5}	0.2	10^{-5}
		Spleen	20	1	10^{-4}	0.5	3×10^{-5}
		Total Body	20	2	10^{-4}	0.5	4×10^{-5}
		Liver	40	3	2×10^{-4}	1	7×10^{-5}
		Bone	40	3	2×10^{-4}	1	8×10^{-5}
		Thyroid	60	4	3×10^{-4}	1	10^{-4}
	(Insol)	**GI (ULI)**	-----------	**0.02**	**4×10^{-6}**	**8×10^{-3}**	**10^{-6}**
		Lung	-----------	-----------	2×10^{-5}	-----------	7×10^{-6}
$_{52}Te^{131m}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**	-----------	**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Kidney	4	0.01	10^{-6}	5×10^{-3}	3×10^{-7}
		Total Body	10	0.04	3×10^{-6}	0.01	10^{-6}
		Spleen	20	0.05	4×10^{-6}	0.02	10^{-6}
		Liver	30	0.09	7×10^{-6}	0.03	2×10^{-6}
		Bone	50	0.1	10^{-5}	0.05	4×10^{-6}
		Thyroid	50	0.2	10^{-5}	0.06	4×10^{-6}
	(Insol)	**GI (LLI)**	-----------	**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**6×10^{-8}**
		Lung	-----------	-----------	6×10^{-7}	-----------	2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{52}Te^{132}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Kidney	3	5×10^{-3}	4×10^{-7}	2×10^{-3}	10^{-7}
		Testis	5	7×10^{-3}	5×10^{-7}	2×10^{-3}	2×10^{-7}
		Total Body	10	0.02	10^{-6}	5×10^{-3}	4×10^{-7}
		Spleen	10	0.02	10^{-6}	6×10^{-3}	4×10^{-7}
		Liver	20	0.03	2×10^{-6}	0. 01	8×10^{-7}
		Bone	30	0.05	4×10^{-6}	0. 02	10^{-6}
		Thyroid	50	0.07	5×10^{-6}	0. 02	10^{-6}
	(Insol)	**GI (LLI)**		**6×10^{-4}**	**10^{-7}**	**2×10^{-4}**	**4×10^{-8}**
		Lung			2×10^{-7}		7×10^{-8}
$_{53}I^{126}$ (β^-, ϵ, γ)	(Sol)	**Thyroid**	1	**5×10^{-5}**	**8×10^{-9}**	**2×10^{-5}**	**3×10^{-9}**
		Total Body	90	6×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		GI (LLI)		0.05	10^{-5}	0. 02	4×10^{-6}
	(Insol)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**3×10^{-3}**	5×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{53}I^{129}$ (β^-, γ, e^-)	(Sol)	**Thyroid**	3	**10^{-5}**	**2×10^{-9}**	**4×10^{-6}**	**6×10^{-10}**
		Total Body	200	2×10^{-3}	2×10^{-7}	5×10^{-4}	7×10^{-8}
		GI (LLI)		0.1	3×10^{-5}	0. 04	9×10^{-6}
	(Insol)	**Lung**			**7×10^{-8}**		**2×10^{-8}**
		GI (LLI)		**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}

				Occupational		Public	
				water	Air	water	Air
$_{53}I^{131}$ (β^-, γ, e^-)	(Sol)	Thyroid	0.7	6×10^{-5}	9×10^{-9}	2×10^{-5}	3×10^{-9}
		Total Body	50	5×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
		GI (LLI)		0.03	7×10^{-6}	0.01	2×10^{-6}
	(Insol)	GI (LLI)		2×10^{-3}	3×10^{-7}	6×10^{-4}	10^{-7}
		Lung			3×10^{-7}		10^{-7}
$_{53}I^{132}$ (β^-, γ, e^-)	(Sol)	Thyroid	0.3	2×10^{-3}	2×10^{-7}	6×10^{-4}	8×10^{-8}
		GI (SI)		0.01	3×10^{-6}	4×10^{-3}	9×10^{-7}
		Total Body	10	0.1	2×10^{-5}	0.04	6×10^{-6}
	(Insol)	GI (ULI)		5×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		Lung			7×10^{-6}		2×10^{-6}
$_{53}I^{133}$ (β^-, γ, e^-)	(Sol)	Thyroid	0.3	2×10^{-4}	3×10^{-8}	7×10^{-5}	10^{-8}
		GI (SI)		0.02	4×10^{-6}	6×10^{-3}	10^{-6}
		Total Body	20	0.02	4×10^{-6}	9×10^{-3}	10^{-6}
	(Insol)	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	7×10^{-8}
		Lung			10^{-6}		4×10^{-7}
$_{53}I^{134}$ (β^-, γ)	(Sol)	Thyroid	0.2	4×10^{-3}	5×10^{-7}	10^{-3}	2×10^{-7}
		GI (S)		0.02	4×10^{-6}	6×10^{-3}	10^{-6}
		Total Body	10	0.3	5×10^{-5}	0.1	2×10^{-5}
	(Insol)	GI (S)		0.02	3×10^{-6}	6×10^{-3}	10^{-6}
		Lung			2×10^{-5}		7×10^{-6}
$_{53}I^{135}$ (β^-, γ, e^-)	(Sol)	Thyroid	0.3	7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
		GI (SI)		0.01	3×10^{-6}	5×10^{-3}	10^{-6}
		Total Body	20	0.05	7×10^{-6}	0.02	3×10^{-6}
	(Insol)	GI (LLI)		2×10^{-3}	4×10^{-7}	7×10^{-4}	10^{-7}
		Lung			3×10^{-6}		10^{-6}
$_{54}Xe^{131m}$ (γ, e^-)	(Immersion)	Total Body			2×10^{-5}		4×10^{-6}
$_{54}Xe^{133}$ (γ, e^-)	(Immersion)	Total Body			10^{-5}		3×10^{-6}
$_{54}Xe^{135}$ (β^-, γ)	(Immersion)	Total Body			4×10^{-6}		10^{-6}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hour week		For 168 hour week**	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{55}Cs^{131}$ (ϵ) (Sol)	**Total Body**	700	**0.07**	**10^{-5}**	**0.02**	**4×10^{-6}**
	Liver	800	0.09	**10^{-5}**	0.03	**4×10^{-6}**
	Spleen	10^3	0.1	2×10^{-5}	0.04	6×10^{-6}
	Kidney	10^3	0.1	2×10^{-5}	0.05	7×10^{-6}
	Muscle	2×10^3	0.2	3×10^{-5}	0.07	10^{-5}
	GI (SI)	----------	0.5	10^{-4}	0.2	4×10^{-5}
	Bone	8×10^3	0.9	10^{-4}	0.3	4×10^{-5}
	Lung	10^4	1	2×10^{-4}	0.4	5×10^{-5}
(Insol)	**Lung**	----------	----------	**3×10^{-6}**	----------	**10^{-6}**
	GI (LLI)	----------	**0.03**	5×10^{-6}	**9×10^{-3}**	2×10^{-6}
$_{55}Cs^{134m}$ (β^-, γ, e^-) (Sol)	**GI (S)**	----------	**0.2**	**4×10^{-5}**	**0.06**	**10^{-5}**
	Total Body	100	0.7	10^{-4}	0.3	4×10^{-5}
	Liver	100	1	10^{-4}	0.3	5×10^{-5}
	Spleen	200	1	2×10^{-4}	0.5	7×10^{-5}
	Kidney	200	2	2×10^{-4}	0.6	8×10^{-5}
	Muscle	200	2	2×10^{-4}	0.6	9×10^{-5}
	Bone	600	4	6×10^{-4}	1	2×10^{-4}
	Lung	2×10^3	10	2×10^{-3}	4	6×10^{-4}
(Insol)	**GI (ULI)**	----------	**0.03**	**6×10^{-6}**	**0.01**	**2×10^{-6}**
	Lung	----------	----------	3×10^{-5}	----------	10^{-5}

$_{55}Cs^{134}$ (β^-, γ)	(Sol)	**Total Body**	20	**3×10^{-4}**	**4×10^{-8}**	**9×10^{-5}**	**10^{-8}**
		Liver	30	4×10^{-4}	6×10^{-8}	10^{-4}	2×10^{-8}
		Muscle	30	4×10^{-4}	6×10^{-8}	2×10^{-4}	2×10^{-8}
		Spleen	40	6×10^{-4}	9×10^{-8}	2×10^{-4}	3×10^{-8}
		Kidney	90	10^{-3}	2×10^{-7}	4×10^{-4}	6×10^{-8}
		Bone	200	2×10^{-3}	3×10^{-7}	7×10^{-4}	10^{-7}
		Lung	300	4×10^{-3}	5×10^{-7}	10^{-3}	2×10^{-7}
		GI (SI)	----	0.01	3×10^{-6}	5×10^{-3}	10^{-6}
	(Insol)	**Lung**	----	----	**10^{-8}**	----	**4×10^{-9}**
		GI (LLI)	----	**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}
$_{55}Cs^{135}$ (β^-)	(Sol)	**Liver**	200	**3×10^{-3}**	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Spleen	300	4×10^{-3}	**5×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Total Body	300	4×10^{-3}	6×10^{-7}	**10^{-3}**	**2×10^{-7}**
		Bone	400	6×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
		Muscle	500	6×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		Kidney	600	9×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Lung	2×10^{3}	0.03	4×10^{-6}	0.01	10^{-6}
		GI (LLI)	----	0.1	3×10^{-5}	0.05	10^{-5}
	(Insol)	**GI (LLI)**	----	**7×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Lung	----	----	**9×10^{-8}**	----	**3×10^{-8}**
$_{55}Cs^{136}$ (β^-, γ)	(Sol)	**Total Body**	30	**2×10^{-3}**	**4×10^{-7}**	**9×10^{-4}**	**10^{-7}**
		Liver	60	5×10^{-3}	7×10^{-7}	2×10^{-3}	2×10^{-7}
		Spleen	80	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		Muscle	90	8×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		Kidney	100	8×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
		GI (SI)	----	0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
		Bone	400	0.03	4×10^{-6}	0.01	2×10^{-6}
		Lung	800	0.06	9×10^{-6}	0.02	3×10^{-6}
	(Insol)	**Lung**	----	----	**2×10^{-7}**	----	**6×10^{-8}**
		GI (LLI)	----	**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week $(MPC)_w$ $\mu c/cc$	For 40 hour week $(MPC)_a$ $\mu c/cc$	For 168 hour week** $(MPC)_w$ $\mu c/cc$	For 168 hour week** $(MPC)_a$ $\mu c/cc$
$_{55}Cs^{137}$ (β^-, γ, e^-)	(Sol)	**Total Body**	30	4×10^{-4}	6×10^{-8}	2×10^{-4}	2×10^{-8}
		Liver	40	5×10^{-4}	8×10^{-8}	2×10^{-4}	3×10^{-8}
		Spleen	50	6×10^{-4}	9×10^{-8}	2×10^{-4}	3×10^{-8}
		Muscle	50	7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
		Bone	100	10^{-3}	2×10^{-7}	5×10^{-4}	7×10^{-8}
		Kidney	100	10^{-3}	2×10^{-7}	5×10^{-4}	8×10^{-8}
		Lung	300	5×10^{-3}	6×10^{-7}	2×10^{-3}	2×10^{-7}
		GI (SI)		0.02	5×10^{-6}	8×10^{-3}	2×10^{-6}
	(Insol)	**Lung**			10^{-8}		5×10^{-9}
		GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}
$_{56}Ba^{131}$ (ϵ, γ)	(Sol)	**GI (LLI)**		5×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
		Total Body	50	0.1	2×10^{-6}	0.03	7×10^{-7}
		Bone	80	0.1	3×10^{-6}	0.05	10^{-6}
		Liver	10^{4}	20	4×10^{-4}	7	10^{-4}
		Muscle	2×10^{4}	40	7×10^{-4}	10	2×10^{-4}
		Lung	2×10^{4}	40	7×10^{-4}	10	2×10^{-4}
		Spleen	3×10^{4}	60	10^{-3}	20	4×10^{-4}
		Kidney	4×10^{4}	70	10^{-3}	20	5×10^{-4}
	(Insol)	**Lung**			4×10^{-7}		10^{-7}
		GI (LLI)		5×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}

$_{56}Ba^{140}$ (β^-, γ)	(Sol)	GI (LLI)	----------	8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Bone	4	6×10^{-3}	10^{-7}	2×10^{-3}	4×10^{-8}
		Total Body	9	0.01	3×10^{-7}	5×10^{-3}	10^{-7}
		Liver	10^3	2	5×10^{-5}	0.9	2×10^{-5}
		Lung	3×10^3	4	9×10^{-5}	2	3×10^{-5}
		Muscle	3×10^3	5	10^{-4}	2	4×10^{-5}
		Spleen	4×10^3	6	10^{-4}	2	4×10^{-5}
		Kidney	4×10^3	8	2×10^{-4}	3	5×10^{-5}
	(Insol)	Lung	----------	----------	4×10^{-8}	----------	10^{-8}
		GI (LLI)	----------	7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
$_{57}La^{140}$ (β^-, γ)	(Sol)	GI (LLI)	----------	7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
		Liver	9	50	2×10^{-6}	20	7×10^{-7}
		Bone	10	60	2×10^{-6}	20	8×10^{-7}
		Total Body	10	60	2×10^{-6}	20	9×10^{-7}
	(Insol)	GI (LLI)	----------	7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
		Lung	----------	----------	4×10^{-7}	----------	10^{-7}
$_{58}Ce^{141}$ (β^-, γ)	(Sol)	GI (LLI)	----------	3×10^{-3}	6×10^{-7}	9×10^{-4}	2×10^{-7}
		Liver	30	10	4×10^{-7}	3	2×10^{-7}
		Bone	40	10	6×10^{-7}	5	2×10^{-7}
		Kidney	70	20	9×10^{-7}	7	3×10^{-7}
		Total Body	90	30	10^{-6}	10	4×10^{-7}
	(Insol)	Lung	----------	----------	2×10^{-7}	----------	5×10^{-8}
		GI (LLI)	----------	3×10^{-3}	5×10^{-7}	9×10^{-4}	2×10^{-7}
$_{58}Ce^{143}$ (β^-, γ)	(Sol)	GI (LLI)	----------	10^{-3}	3×10^{-7}	4×10^{-4}	9×10^{-8}
		Liver	7	50	2×10^{-6}	20	7×10^{-7}
		Bone	10	70	3×10^{-6}	20	10^{-6}
		Kidney	20	100	5×10^{-6}	40	2×10^{-6}
		Total Body	20	100	6×10^{-6}	50	2×10^{-6}
	(Insol)	GI (LLI)	----------	10^{-3}	2×10^{-7}	4×10^{-4}	7×10^{-8}
		Lung	----------	----------	6×10^{-7}	----------	2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations for radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{58}Ce^{144}$ (α, β^-, γ)	(Sol)	**GI (LLI)**	----------	**3×10^{-4}**	8×10^{-8}	**10^{-4}**	3×10^{-8}
		Bone	5	0.2	**10^{-8}**	0.08	**3×10^{-9}**
		Liver	6	0.3	**10^{-8}**	0.1	4×10^{-9}
		Kidney	10	0.5	2×10^{-8}	0.2	7×10^{-9}
		Total Body	20	0.7	3×10^{-8}	0.3	10^{-8}
	(Insol)	**Lung**	----------	----------	**6×10^{-9}**	----------	**2×10^{-9}**
		GI (LLI)	----------	**3×10^{-4}**	6×10^{-8}	**10^{-4}**	2×10^{-8}
$_{59}Pr^{142}$ (β^-, γ)	(Sol)	**GI (LLI)**	----------	**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**7×10^{-8}**
		Bone	7	80	4×10^{-6}	30	10^{-6}
		Liver	9	100	4×10^{-6}	40	2×10^{-6}
		Kidney	20	200	8×10^{-6}	60	3×10^{-6}
		Total Body	20	300	10^{-5}	90	4×10^{-6}
	(Insol)	**GI (LLI)**	----------	**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung	----------	----------	10^{-6}	----------	4×10^{-7}
$_{59}Pr^{143}$ (β^-)	(Sol)	**GI (LLI)**	----------	**10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Bone	20	10	5×10^{-7}	4	2×10^{-7}
		Liver	20	20	7×10^{-7}	5	2×10^{-7}
		Kidney	40	30	10^{-6}	9	4×10^{-7}
		Total Body	60	40	2×10^{-6}	10	6×10^{-7}

	(Insol)	Lung			2×10^{-7}		6×10^{-8}
		GI (LLI)		10^{-3}	3×10^{-7}	5×10^{-4}	9×10^{-8}
$_{60}Nd^{144}$ (α)	(Sol)	Bone	0.1	2×10^{-3}	8×10^{-11}	7×10^{-4}	3×10^{-11}
		GI (LLI)		2×10^{-3}	5×10^{-7}	8×10^{-4}	2×10^{-7}
		Kidney	0.3	4×10^{-3}	2×10^{-10}	10^{-3}	5×10^{-11}
		Liver	0.7	0.01	4×10^{-10}	3×10^{-3}	2×10^{-10}
		Total Body	1	0.01	6×10^{-10}	5×10^{-3}	2×10^{-10}
	(Insol)	Lung			3×10^{-10}		10^{-10}
		GI (LLI)		2×10^{-3}	4×10^{-7}	8×10^{-4}	10^{-7}
$_{60}Nd^{147}$ (α, β^-, γ)	(Sol)	GI (LLI)		2×10^{-3}	4×10^{-7}	6×10^{-4}	10^{-7}
		Liver	10	8	4×10^{-7}	3	10^{-7}
		Kidney	20	10	6×10^{-7}	5	2×10^{-7}
		Bone	20	20	8×10^{-7}	6	3×10^{-7}
		Total Body	50	40	2×10^{-6}	10	6×10^{-7}
	(Insol)	Lung			2×10^{-7}		8×10^{-8}
		GI (LLI)		2×10^{-3}	3×10^{-7}	6×10^{-4}	10^{-7}
$_{60}Nd^{149}$(β^-, γ)	Sol)	GI (LLI)		8×10^{-3}	2×10^{-6}	3×10^{-3}	6×10^{-7}
		Liver	3	300	10^{-5}	100	5×10^{-6}
		Kidney	5	600	3×10^{-5}	200	9×10^{-6}
		Bone	7	700	3×10^{-5}	300	10^{-5}
		Total Body	20	2×10^{3}	9×10^{-5}	700	3×10^{-5}
	(Insol)	GI (ULI)		8×10^{-3}	10^{-6}	3×10^{-3}	5×10^{-7}
		Lung			9×10^{-6}		3×10^{-6}
$_{61}Pm^{147}$(α, β^-)	(Sol)	GI (LLI)		6×10^{-3}	10^{-6}	2×10^{-3}	5×10^{-7}
		Bone	60	1	6×10^{-8}	0.5	2×10^{-8}
		Kidney	200	4	2×10^{-7}	2	7×10^{-8}
		Total Body	300	7	3×10^{-7}	2	10^{-7}
		Liver	300	8	4×10^{-7}	3	10^{-7}
	(Insol)	Lung			10^{-7}		3×10^{-8}
		GI (LLI)		6×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{61}Pm^{149}(\beta^-, \gamma)$	(Sol)	**GI (LLI)**	----------	**10^{-3}**	**3×10^{-7}**	**4×10^{-4}**	**10^{-7}**
		Bone	20	70	3×10^{-6}	20	10^{-6}
		Kidney	30	100	6×10^{-6}	40	2×10^{-6}
		Total Body	40	200	7×10^{-6}	50	2×10^{-6}
		Liver	50	200	10^{-5}	80	3×10^{-6}
	(Insol)	**GI (LLI)**	----------	**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	**8×10^{-8}**
		Lung	----------	----------	7×10^{-7}	----------	3×10^{-7}
$_{62}Sm^{147}(\alpha)$	(Sol)	**Bone**	0.1	**2×10^{-3}**	**7×10^{-11}**	**6×10^{-4}**	**2×10^{-11}**
		GI (LLI)	----------	**2×10^{-3}**	4×10^{-7}	7×10^{-4}	2×10^{-7}
		Kidney	0.6	8×10^{-3}	4×10^{-10}	3×10^{-3}	10^{-10}
		Liver	0.6	9×10^{-3}	4×10^{-10}	3×10^{-3}	10^{-10}
		Total Body	0.9	0.01	5×10^{-10}	4×10^{-3}	2×10^{-10}
	(Insol)	**Lung**	----------	----------	**3×10^{-10}**	----------	**9×10^{-11}**
		GI (LLI)	----------	**2×10^{-3}**	4×10^{-7}	**7×10^{-4}**	10^{-7}
$_{62}Sm^{151}(\beta^-, \gamma)$	(Sol)	**GI (LLI)**	----------	**0.01**	2×10^{-6}	**4×10^{-3}**	8×10^{-7}
		Bone	100	2	**6×10^{-8}**	0.5	**2×10^{-8}**
		Kidney	300	4	2×10^{-7}	2	6×10^{-8}
		Liver	300	5	2×10^{-7}	2	7×10^{-8}
		Total Body	500	7	3×10^{-7}	2	10^{-7}

	(Insol)	**Lung**			**10^{-7}**		**5×10^{-8}**
		GI (LLI)		**0.01**	2×10^{-6}	**4×10^{-3}**	7×10^{-7}
$_{62}Sm^{153}$ (β^-, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**5×10^{-7}**	**8×10^{-4}**	**2×10^{-7}**
		Liver	20	70	3×10^{-6}	30	10^{-6}
		Bone	30	100	6×10^{-6}	50	2×10^{-6}
		Kidney	50	200	10^{-5}	80	4×10^{-6}
		Total Body	70	300	10^{-5}	100	5×10^{-6}
	(Insol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**8×10^{-4}**	**10^{-7}**
		Lung			10^{-6}		5×10^{-7}
$_{63}Eu^{152}$ (9.2 hr) (β^-, ϵ, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Liver	8	200	9×10^{-6}	70	3×10^{-6}
		Bone	10	300	10^{-5}	90	4×10^{-6}
		Kidney	10	300	10^{-5}	100	5×10^{-6}
		Total Body	20	500	2×10^{-5}	200	8×10^{-6}
	(Insol)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung			3×10^{-6}		9×10^{-7}
$_{63}Eu^{152}$(13 yr)(β^-, ϵ, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	5×10^{-7}	**8×10^{-4}**	2×10^{-7}
		Kidney	20	0.3	**10^{-8}**	0.09	**4×10^{-9}**
		Total Body	30	0.5	2×10^{-8}	0.2	7×10^{-9}
		Bone	30	0.6	3×10^{-8}	0.2	8×10^{-9}
		Liver	80	1.0	6×10^{-8}	0.4	2×10^{-8}
	(Insol)	**Lung**			**2×10^{-8}**		**6×10^{-9}**
		GI (LLI)		**2×10^{-3}**	4×10^{-7}	**8×10^{-4}**	10^{-7}
$_{63}Eu^{154}$(β^-, ϵ, γ)	(Sol)	**GI (LLI)**		**6×10^{-4}**	10^{-7}	**2×10^{-4}**	5×10^{-8}
		Kidney	5	0.09	**4×10^{-9}**	0.03	**10^{-9}**
		Bone	5	0.09	**4×10^{-9}**	0.03	**10^{-9}**
		Total Body	20	0.2	10^{-8}	0.08	4×10^{-9}
		Liver	30	0.5	2×10^{-8}	0.2	7×10^{-9}
	(Insol)	**Lung**			**7×10^{-9}**		**2×10^{-9}**
		GI (LLI)		**6×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{63}Eu^{155}(\beta^-, \gamma)$	(Sol)	**GI (LLI)**	----------	**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
		Kidney	70	2	**9×10^{-8}**	0.7	**3×10^{-8}**
		Bone	80	2	10^{-7}	0.8	**3×10^{-8}**
		Total Body	100	4	2×10^{-7}	1	5×10^{-8}
		Liver	200	5	2×10^{-7}	2	8×10^{-8}
	(Insol)	**Lung**	----------	----------	**7×10^{-8}**	----------	**3×10^{-8}**
		GI (LLI)	----------	**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
$_{64}Gd^{153}(\epsilon, \gamma, e^-)$	(Sol)	**GI (LLI)**	----------	**6×10^{-3}**	10^{-6}	**2×10^{-3}**	5×10^{-7}
		Bone	90	5	**2×10^{-7}**	2	**8×10^{-8}**
		Total Body	100	7	3×10^{-7}	2	10^{-7}
		Liver	100	7	3×10^{-7}	2	10^{-7}
	(Insol)	**Lung**	----------	----------	**9×10^{-8}**	----------	**3×10^{-8}**
		GI (LLI)	----------	**6×10^{-3}**	10^{-6}	**2×10^{-3}**	4×10^{-7}
$_{64}Gd^{159}(\beta^-, \gamma)$	(Sol)	**GI (LLI)**	----------	**2×10^{-3}**	**5×10^{-7}**	**8×10^{-4}**	**2×10^{-7}**
		Bone	20	200	9×10^{-6}	70	3×10^{-6}
		Liver	40	400	2×10^{-5}	200	7×10^{-6}
		Total Body	50	700	3×10^{-5}	200	10^{-5}
	(Insol)	**GI (LLI)**	----------	2×10^{-3}	**4×10^{-7}**	**8×10^{-4}**	**10^{-7}**
		Lung	----------	----------	3×10^{-6}	----------	10^{-6}

$_{65}Tb^{160}$ (β^-, γ)	(Sol)	GI (LLI)		10^{-3}	3×10^{-7}	4×10^{-4}	10^{-7}
		Bone	20	2	10^{-7}	0.8	3×10^{-8}
		Kidney	20	3	10^{-7}	1	4×10^{-8}
		Total Body	20	3	10^{-7}	1	5×10^{-8}
	(Insol)	Lung			3×10^{-8}		10^{-8}
		GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}
$_{66}Dy^{165}$ (β^-, γ)	(Sol)	GI (LLI)		0.01	3×10^{-6}	4×10^{-3}	9×10^{-7}
		Bone	10	10^{3}	5×10^{-5}	400	2×10^{-5}
		Total Body	40	4×10^{3}	2×10^{-4}	10^{3}	6×10^{-5}
		Liver	60	6×10^{3}	3×10^{-4}	2×10^{3}	9×10^{-5}
	(Insol)	GI (ULI)		0.01	2×10^{-6}	4×10^{-3}	7×10^{-7}
		Lung			2×10^{-5}		6×10^{-6}
$_{66}Dy^{166}$ (β^-, γ, e^-)	(Sol)	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}
		Bone	5	10	6×10^{-7}	4	2×10^{-7}
		Total Body	30	70	3×10^{-6}	20	10^{-6}
		Liver	30	80	4×10^{-6}	30	10^{-6}
	(Insol)	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	7×10^{-8}
		Lung			3×10^{-7}		10^{-7}
$_{67}Ho^{166}$ (β^-, γ, e^-)	(Sol)	GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
		Bone	5	40	2×10^{-6}	10	6×10^{-7}
		Kidney	20	200	7×10^{-6}	50	2×10^{-6}
		Total Body	30	200	10^{-6}	80	4×10^{-7}
		Liver	40	300	10^{-5}	100	4×10^{-6}
	(Insol)	GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Lung			10^{-6}		3×10^{-7}
$_{68}Er^{169}$ (β^-, γ)	(Sol)	GI (LLI)		3×10^{-3}	6×10^{-7}	9×10^{-4}	2×10^{-7}
		Bone	30	30	10^{-6}	10	5×10^{-7}
		Total Body	50	50	2×10^{-6}	20	8×10^{-7}
		Kidney	70	60	3×10^{-6}	20	10^{-6}
		Liver	200	200	9×10^{-6}	70	3×10^{-6}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
	(Insol)	**Lung**			**4×10^{-7}**		**10^{-7}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**9×10^{-4}**	2×10^{-7}
$_{68}Er^{171}$ (β^-, γ, e^-)	(Sol)	**GI (ULI)**		**3×10^{-3}**	**7×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Bone	9	300	10^{-5}	90	4×10^{-6}
		Kidney	30	800	4×10^{-5}	300	10^{-5}
		Total Body	30	900	4×10^{-5}	300	10^{-5}
	(Insol)	**GI (ULI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{69}Tm^{170}$ (β^-, ϵ, γ, e^-)	(Sol)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**5×10^{-4}**	10^{-7}
		Bone	9	0.8	**4×10^{-8}**	0.3	**10^{-8}**
		Kidney	30	4	2×10^{-7}	1	6×10^{-8}
		Total Body	60	5	2×10^{-7}	2	7×10^{-8}
	(Insol)	**Lung**			**3×10^{-8}**		**10^{-8}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**5×10^{-4}**	8×10^{-8}
$_{69}Tm^{171}$ (β^-)	(Sol)	**GI (LLI)**		**0.01**	3×10^{-6}	**5×10^{-3}**	10^{-6}
		Bone	90	3	**10^{-7}**	0.9	**4×10^{-8}**
		Kidney	700	20	8×10^{-7}	6	3×10^{-7}
		Total Body	700	20	8×10^{-7}	6	3×10^{-7}

	(Insol)	Lung			2×10^{-7}		8×10^{-8}
		GI (LLI)		0.01	3×10^{-6}	5×10^{-3}	9×10^{-7}
$_{70}Yb^{175}$ (β^-, γ)	(Sol)	GI (LLI)		3×10^{-3}	7×10^{-7}	10^{-3}	2×10^{-7}
		Bone	30	60	3×10^{-6}	20	9×10^{-7}
		Kidney	30	80	3×10^{-6}	30	10^{-6}
		Total Body	100	300	10^{-5}	100	4×10^{-6}
	(Insol)	GI (LLI)		3×10^{-3}	6×10^{-7}	10^{-3}	2×10^{-7}
		Lung			10^{-6}		4×10^{-7}
$_{71}Lu^{177}$ (β^-, γ)	(Sol)	GI (LLI)		3×10^{-3}	6×10^{-7}	10^{-3}	2×10^{-7}
		Bone	20	30	10^{-6}	10	4×10^{-7}
		Total Body	100	200	7×10^{-6}	60	2×10^{-6}
		Kidney	200	200	10^{-5}	80	3×10^{-6}
	(Insol)	GI (LLI)		3×10^{-3}	5×10^{-7}	10^{-3}	2×10^{-7}
		Lung			7×10^{-7}		2×10^{-7}
$_{72}Hf^{181}$ (β^-, γ)	(Sol)	GI (LLI)		2×10^{-3}	4×10^{-7}	7×10^{-4}	2×10^{-7}
		Spleen	4	0.9	4×10^{-8}	0.3	10^{-8}
		Liver	10	2	10^{-7}	0.8	4×10^{-8}
		Total Body	40	9	4×10^{-7}	3	10^{-7}
		Kidney	50	10	5×10^{-7}	4	2×10^{-7}
		Bone	100	20	9×10^{-7}	7	3×10^{-7}
	(Insol)	Lung			7×10^{-8}		3×10^{-8}
		GI (LLI)		2×10^{-3}	4×10^{-7}	7×10^{-4}	10^{-7}
$_{73}Ta^{182}$ (β^-, γ)	(Sol)	GI (LLI)		10^{-3}	3×10^{-7}	4×10^{-4}	9×10^{-8}
		Liver	7	0.9	4×10^{-8}	0.3	10^{-8}
		Kidney	20	2	8×10^{-8}	0.7	3×10^{-8}
		Total Body	20	2	9×10^{-8}	0.7	3×10^{-8}
		Spleen	30	4	10^{-7}	1	5×10^{-8}
		Bone	50	6	3×10^{-7}	2	9×10^{-8}
	(Insol)	Lung			2×10^{-8}		7×10^{-9}
		GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	7×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{74}W^{181}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**8×10^{-7}**
		Liver	70	0.6	2×10^{-5}	0.2	8×10^{-6}
		Total Body	100	0.9	3×10^{-5}	0.3	10^{-5}
		Bone	200	2	7×10^{-5}	0.7	2×10^{-5}
	(Insol)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**0.01**	2×10^{-6}	**3×10^{-3}**	6×10^{-7}
$_{74}W^{185}$ (β^-)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	30	0.3	10^{-5}	0.09	3×10^{-6}
		Liver	40	0.4	2×10^{-5}	0.1	5×10^{-6}
		Total Body	100	1	5×10^{-5}	0.5	2×10^{-5}
	(Insol)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{74}W^{187}$ (β^-, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**7×10^{-4}**	**2×10^{-7}**
		Total Body	30	0.5	2×10^{-5}	0.2	7×10^{-6}
		Liver	30	0.6	2×10^{-5}	0.2	8×10^{-6}
		Bone	60	1	4×10^{-5}	0.4	10^{-5}
	(Insol)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Lung			2×10^{-6}		6×10^{-7}

$_{75}Re^{183}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**0.02**	4×10^{-6}	**6×10^{-3}**	10^{-6}
		Total Body	80	**0.02**	**3×10^{-6}**	8×10^{-3}	**9×10^{-7}**
		Thyroid	300	0.09	10^{-5}	0.03	3×10^{-6}
		Liver	800	0.2	3×10^{-5}	0.08	8×10^{-6}
		Skin	4×10^{3}	1	10^{-4}	0.4	4×10^{-5}
		Bone	2×10^{4}	6	6×10^{-4}	2	2×10^{-4}
	(Insol)	**Lung**			**2×10^{-7}**		**5×10^{-8}**
		GI (LLI)		**8×10^{-3}**	10^{-6}	**3×10^{-3}**	5×10^{-7}
$_{75}Re^{186}$ (β^-, γ)	(Sol)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**9×10^{-4}**	**2×10^{-7}**
		Thyroid	20	0.01	2×10^{-6}	5×10^{-3}	5×10^{-7}
		Skin	30	0.02	2×10^{-6}	7×10^{-3}	8×10^{-7}
		Total Body	50	0.04	4×10^{-6}	0.01	10^{-6}
		Liver	300	0.2	3×10^{-5}	0.08	9×10^{-6}
		Bone	800	0.6	7×10^{-5}	0.2	2×10^{-5}
	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
		Lung			5×10^{-7}		2×10^{-7}
$_{75}Re^{187}$ (β^-)	(Sol)	**GI (LLI)**		**0.07**	2×10^{-5}	**0.03**	6×10^{-6}
		Skin	300	0.08	**9×10^{-6}**	**0.03**	**3×10^{-6}**
		Thyroid	900	0.2	3×10^{-5}	0.08	9×10^{-6}
		Total Body	**2×10^{3}**	0.4	5×10^{-5}	0.2	2×10^{-5}
		Liver	6×10^{3}	2	2×10^{-4}	0.5	6×10^{-5}
		Bone	4×10^{4}	9	10^{-3}	3	4×10^{-4}
	(Insol)	**Lung**			**5×10^{-7}**		**2×10^{-7}**
		GI (LLI)		**0.04**	7×10^{-6}	**0.02**	2×10^{-6}
$_{75}Re^{188}$ (β^-, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Thyroid	7	0.02	2×10^{-6}	7×10^{-3}	7×10^{-7}
		Skin	20	0.05	5×10^{-6}	0.02	2×10^{-6}
		Total Body	20	0.06	7×10^{-6}	0.02	2×10^{-6}
		Liver	200	0.5	5×10^{-5}	0.2	2×10^{-5}
		Bone	300	0.9	10^{-4}	0.3	3×10^{-5}
	(Insol)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**6×10^{-8}**
		Lung			10^{-6}		4×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations for radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{76}Os^{185}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		$\mathbf{2\times10^{-3}}$	$\mathbf{5\times10^{-7}}$	$\mathbf{7\times10^{-4}}$	$\mathbf{2\times10^{-7}}$
		Kidney	8	0.04	10^{-6}	0.01	5×10^{-7}
		Total Body	40	0.2	6×10^{-6}	0.06	2×10^{-6}
		Liver	50	0.2	8×10^{-6}	0.08	3×10^{-6}
	(Insol)	**Lung**			$\mathbf{5\times10^{-8}}$		$\mathbf{2\times10^{-8}}$
		GI (LLI)		$\mathbf{2\times10^{-3}}$	3×10^{-7}	$\mathbf{7\times10^{-4}}$	10^{-7}
$_{76}Os^{191m}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**0.07**	$\mathbf{2\times10^{-5}}$	**0.03**	$\mathbf{6\times10^{-6}}$
		Kidney	100	2	8×10^{-5}	0.8	3×10^{-5}
		Total Body	300	7	2×10^{-4}	2	8×10^{-5}
		Liver	600	10	5×10^{-4}	4	2×10^{-4}
	(Insol)	**Lung**			$\mathbf{9\times10^{-6}}$		$\mathbf{3\times10^{-6}}$
		GI (LLI)		**0.07**	10^{-5}	**0.02**	4×10^{-6}
$_{76}Os^{191}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		$\mathbf{5\times10^{-3}}$	$\mathbf{10^{-6}}$	$\mathbf{2\times10^{-3}}$	$\mathbf{4\times10^{-7}}$
		Kidney	20	0.1	4×10^{-6}	0.04	10^{-6}
		Total Body	100	0.6	4×10^{-5}	0.2	8×10^{-6}
		Liver	100	0.7	3×10^{-5}	0.2	9×10^{-6}
	(Insol)	**Lung**			$\mathbf{4\times10^{-7}}$		$\mathbf{10^{-7}}$
		GI (LLI)		$\mathbf{5\times10^{-3}}$	8×10^{-7}	$\mathbf{2\times10^{-3}}$	3×10^{-7}

$_{76}Os^{193}$ (β^-)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**4×10^{-7}**	**6×10^{-4}**	**10^{-7}**
		Kidney	10	0.1	4×10^{-6}	0.04	2×10^{-6}
		Total Body	50	0.6	2×10^{-5}	0.2	7×10^{-6}
		Liver	70	0.9	3×10^{-5}	0.3	10^{-5}
	(Insol)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**9×10^{-8}**
		Lung			10^{-6}		5×10^{-7}
$_{77}Ir^{190}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**6×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Liver	40	0.04	2×10^{-6}	0.02	5×10^{-7}
		Kidney	40	0.04	2×10^{-6}	0.02	6×10^{-7}
		Spleen	40	0.05	2×10^{-6}	0.02	6×10^{-7}
		Total Body	50	0.06	2×10^{-6}	0.02	8×10^{-7}
	(Insol)	**Lung**			**4×10^{-7}**		**10^{-7}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{77}Ir^{192}$ (β^-, γ)	(Sol)	**GI (LLI)**		**10^{-3}**	3×10^{-7}	**4×10^{-4}**	9×10^{-8}
		Kidney	6	4×10^{-3}	**10^{-7}**	10^{-3}	**4×10^{-8}**
		Spleen	7	4×10^{-3}	**10^{-7}**	10^{-3}	5×10^{-8}
		Liver	8	5×10^{-3}	2×10^{-7}	2×10^{-3}	6×10^{-8}
		Total Body	20	0.01	4×10^{-7}	4×10^{-3}	10^{-7}
	(Insol)	**Lung**			**3×10^{-8}**		**9×10^{-9}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	6×10^{-8}
$_{77}Ir^{194}$ (β^-)	(Sol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**3×10^{-4}**	**8×10^{-8}**
		Kidney	7	0.08	3×10^{-6}	0.03	10^{-6}
		Liver	8	0.09	3×10^{-6}	0.03	10^{-6}
		Spleen	8	0.09	4×10^{-6}	0.03	10^{-6}
		Total Body	20	0.3	10^{-5}	0.1	4×10^{-6}
	(Insol)	**GI (LLI)**		**9×10^{-4}**	**2×10^{-7}**	**3×10^{-4}**	**5×10^{-8}**
		Lung			10^{-6}		4×10^{-7}
$_{78}Pt^{191}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Kidney	10	0.04	10^{-6}	0.01	5×10^{-7}
		Total Body	30	0.1	4×10^{-6}	0.03	10^{-6}
		Liver	30	0.1	4×10^{-6}	0.04	2×10^{-6}
		Spleen	70	0.2	8×10^{-6}	0.08	3×10^{-6}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ $\mu c/cc$	For 40 hour week (MPC)$_a$ $\mu c/cc$	For 168 hour week** (MPC)$_w$ $\mu c/cc$	For 168 hour week** (MPC)$_a$ $\mu c/cc$
	(Insol)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			8×10^{-7}		3×10^{-7}
$_{78}Pt^{193m}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**0.03**	**7×10^{-6}**	**0.01**	**2×10^{-6}**
		Kidney	100	0.3	10^{-5}	0.1	4×10^{-6}
		Total Body	300	0.8	3×10^{-5}	0.3	10^{-5}
		Liver	300	1	4×10^{-5}	0.3	10^{-5}
		Spleen	600	2	7×10^{-5}	0.7	2×10^{-5}
	(Insol)	**GI (LLI)**		**0.03**	**5×10^{-6}**	**0.01**	**2×10^{-6}**
		Lung			7×10^{-6}		**2×10^{-6}**
$_{78}Pt^{193}$ (ϵ)	(Sol)	**Kidney**	70	**0.03**	**10^{-6}**	**9×10^{-3}**	**4×10^{-7}**
		GI (LLI)		0.05	10^{-5}	0.02	4×10^{-6}
		Spleen	500	0.2	6×10^{-6}	0.06	2×10^{-6}
		Total Body	500	0.2	6×10^{-6}	0.06	2×10^{-6}
		Liver	600	0.2	9×10^{-6}	0.09	3×10^{-6}
	(Insol)	**Lung**			**3×10^{-7}**		**10^{-7}**
		GI (LLI)		**0.05**	8×10^{-6}	**0.02**	3×10^{-6}

$_{78}Pt^{197m}$ (β^-, γ, e^-)	(Sol)	**GI (ULI)**		**0.03**	**6×10^{-6}**	**0.01**	**2×10^{-6}**
		Kidney	5	0.8	3×10^{-5}	0.3	10^{-5}
		Liver	20	3	10^{-4}	1	4×10^{-5}
		Spleen	30	5	2×10^{-4}	2	7×10^{-5}
		Total Body	40	6	2×10^{-4}	2	7×10^{-5}
	(Insol)	**GI (ULI)**		**0.03**	**5×10^{-6}**	**9×10^{-3}**	**2×10^{-6}**
		Lung			2×10^{-5}		8×10^{-6}
$_{78}Pt^{197}$ (β^-, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Kidney	10	0.1	5×10^{-6}	0.05	2×10^{-6}
		Liver	40	0.6	2×10^{-5}	0.2	7×10^{-6}
		Spleen	70	0.8	3×10^{-5}	0.3	10^{-5}
		Total Body	80	1	4×10^{-5}	0.3	10^{-5}
	(Insol)	**GI (LLI)**		**3×10^{-3}**	**6×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{79}Au^{196}$ (β^-, γ, e^-)	(Sol)	**GI (LLI)**		**5×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Total Body	40	0.07	3×10^{-6}	0.03	9×10^{-7}
		Kidney	50	0.09	4×10^{-6}	0.03	10^{-6}
		Spleen	200	0.3	10^{-5}	0.1	4×10^{-6}
		Liver	200	0.3	10^{-5}	0.1	4×10^{-6}
	(Insol)	**Lung**			**6×10^{-7}**		**2×10^{-7}**
		GI (LLI)		**4×10^{-3}**	8×10^{-7}	**10^{-3}**	3×10^{-7}
$_{79}Au^{198}$ (β^-, γ)	(Sol)	**GI (LLI)**		**2×10^{-3}**	**3×10^{-7}**	**5×10^{-4}**	**10^{-7}**
		Kidney	20	0.07	3×10^{-6}	0.02	9×10^{-7}
		Total Body	30	0.1	4×10^{-6}	0.04	2×10^{-6}
		Spleen	60	0.2	8×10^{-6}	0.07	3×10^{-6}
		Liver	80	0.3	10^{-5}	0.1	4×10^{-6}
	(Insol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**5×10^{-4}**	**8×10^{-8}**
		Lung			6×10^{-7}		2×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ $\mu c/cc$	For 40 hour week (MPC)$_a$ $\mu c/cc$	For 168 hour week** (MPC)$_w$ $\mu c/cc$	For 168 hour week** (MPC)$_a$ $\mu c/cc$
$_{79}Au^{199}$ (β^-, γ) (Sol)	**GI (LLI)**		5×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
	Kidney	70	0.2	8×10^{-6}	0.07	3×10^{-6}
	Total Body	100	0.3	10^{-5}	0.1	4×10^{-6}
	Spleen	200	0.6	2×10^{-5}	0.2	8×10^{-6}
	Liver	300	0.8	3×10^{-5}	0.3	10^{-5}
(Insol)	**GI (LLI)**		4×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
	Lung			2×10^{-6}		6×10^{-7}
$_{80}Hg^{197m}$ (ϵ, γ, e^-) (Sol)	**Kidney**	4	6×10^{-3}	7×10^{-7}	2×10^{-3}	3×10^{-7}
	GI (LLI)		0.02	4×10^{-6}	7×10^{-3}	10^{-6}
	Spleen	40	0.05	7×10^{-6}	0.02	2×10^{-6}
	Liver	50	0.07	9×10^{-6}	0.02	3×10^{-6}
	Total Body	70	0.09	10^{-5}	0.03	4×10^{-6}
(Insol)	**GI (LLI)**		5×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
	Lung			4×10^{-6}		10^{-6}
$_{80}Hg^{197}$ (ϵ, γ, e^-) (Sol)	**Kidney**	20	9×10^{-3}	10^{-6}	3×10^{-3}	4×10^{-7}
	GI (LLI)		0.06	10^{-5}	0.02	4×10^{-6}
	Spleen	200	0.08	10^{-5}	0.03	4×10^{-6}
	Liver	200	0.1	10^{-5}	0.03	4×10^{-6}
	Total Body	200	0.1	2×10^{-5}	0.04	5×10^{-6}

	(Insol)	**GI (LLI)**		**0.01**	**3×10^{-6}**	**5×10^{-3}**	**9×10^{-7}**
		Lung			5×10^{-6}		2×10^{-6}
$_{80}Hg^{203}$ (β^-, γ, e^-)	(Sol)	**Kidney**	4	**5×10^{-4}**	**7×10^{-8}**	**2×10^{-4}**	**2×10^{-8}**
		Spleen	40	6×10^{-3}	8×10^{-7}	2×10^{-3}	3×10^{-7}
		Liver	40	7×10^{-3}	9×10^{-7}	2×10^{-3}	3×10^{-7}
		Total Body	80	0.01	2×10^{-6}	4×10^{-3}	5×10^{-7}
		GI (LLI)		0.01	3×10^{-6}	4×10^{-3}	10^{-6}
	(Insol)	**Lung**			**10^{-7}**		**4×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{81}Tl^{200}$ (ϵ, γ)	(Sol)	**GI (LLI)**		**0.01**	**3×10^{-6}**	**4×10^{-3}**	**9×10^{-7}**
		Kidney	40	0.08	8×10^{-6}	0.03	3×10^{-6}
		Total Body	50	0.1	10^{-5}	0.04	4×10^{-6}
		Muscle	100	0.3	3×10^{-5}	0.09	9×10^{-6}
		Liver	200	0.4	5×10^{-5}	0.2	2×10^{-5}
		Lung	800	2	2×10^{-4}	0.6	6×10^{-5}
		Bone	10^3	2	2×10^{-4}	0.8	9×10^{-5}
	(Insol)	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{81}Tl^{201}$ (ϵ, γ, e^-)	(Sol)	**GI (LLI)**		**9×10^{-3}**	**2×10^{-6}**	**3×10^{-3}**	**7×10^{-7}**
		Kidney	40	0.04	5×10^{-6}	0.02	2×10^{-6}
		Total Body	100	0.1	10^{-5}	0.04	4×10^{-6}
		Muscle	300	0.3	3×10^{-5}	0.1	10^{-5}
		Liver	300	0.3	3×10^{-5}	0.1	10^{-5}
		Bone	400	0.4	5×10^{-5}	0.2	2×10^{-5}
		Lung	10^3	1	10^{-4}	0.4	4×10^{-5}
	(Insol)	**GI (LLI)**		5×10^{-3}	**9×10^{-7}**	**2×10^{-3}**	**3×10^{-7}**
		Lung			2×10^{-6}		7×10^{-7}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations for radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hour week		For 168 hour week**	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{81}Tl^{202}$ (ϵ, γ, e^-) (Sol)	**GI (LLI)**	----------	**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
	Kidney	20	0.01	10^{-6}	3×10^{-3}	4×10^{-7}
	Total Body	50	0.03	3×10^{-6}	0.01	10^{-6}
	Muscle	100	0.07	7×10^{-6}	0.02	2×10^{-6}
	Liver	100	0.08	8×10^{-6}	0.03	3×10^{-6}
	Bone	200	0.1	10^{-5}	0.03	4×10^{-6}
	Lung	400	0.3	3×10^{-5}	0.09	9×10^{-6}
(Insol)	**Lung**	----------	----------	**2×10^{-7}**	----------	**8×10^{-8}**
	GI (LLI)	----------	**2×10^{-3}**	4×10^{-7}	**7×10^{-4}**	10^{-7}
$_{81}Tl^{204}$ (β^-) (Sol)	**GI (LLI)**	----------	**3×10^{-3}**	7×10^{-7}	**10^{-3}**	**2×10^{-7}**
	Kidney	10	6×10^{-3}	**6×10^{-7}**	2×10^{-3}	**2×10^{-7}**
	Total Body	80	0.03	3×10^{-6}	0.01	10^{-6}
	Bone	100	0.04	5×10^{-6}	0.02	2×10^{-6}
	Liver	100	0.06	6×10^{-6}	0.02	2×10^{-6}
	Muscle	200	0.07	7×10^{-6}	0.02	3×10^{-6}
	Lung	500	0.2	2×10^{-5}	0.07	7×10^{-6}
(Insol)	**Lung**	----------	----------	**3×10^{-8}**	----------	**9×10^{-9}**
	GI (LLI)	----------	**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}

$_{82}Pb^{203}(\epsilon, \gamma)$	(Sol)	**GI (LLI)**		**0.01**	**3×10^{-6}**	**4×10^{-3}**	**9×10^{-7}**
		Kidney	30	0.1	4×10^{-6}	0.05	10^{-6}
		Total Body	90	0.5	10^{-5}	0.2	5×10^{-6}
		Liver	200	1	3×10^{-5}	0.3	10^{-5}
		Bone	400	2	7×10^{-5}	0.8	2×10^{-5}
	(Insol)	**GI (LLI)**		**0.01**	**2×10^{-6}**	**4×10^{-3}**	**6×10^{-7}**
		Lung			4×10^{-6}		10^{-6}
$_{82}Pb^{210}(\alpha, \beta^-, \gamma)$	(Sol)	**Kidney**	0.4	**4×10^{-6}**	**10^{-10}**	**10^{-6}**	**4×10^{-11}**
		Total Body	4	**4×10^{-6}**	10^{-9}	**10^{-6}**	4×10^{-10}
		Bone	0.7	6×10^{-6}	2×10^{-10}	2×10^{-6}	7×10^{-11}
		Liver	1	10^{-5}	4×10^{-10}	5×10^{-6}	10^{-10}
		GI (LLI)		6×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
	(Insol)	**Lung**			**2×10^{-10}**		**8×10^{-11}**
		GI (LLI)		**5×10^{-3}**	9×10^{-7}	**2×10^{-3}**	3×10^{-7}
$_{82}Pb^{212}(\alpha, \beta^-, \gamma, e^-)$	(Sol)	**Kidney**	0.02	**6×10^{-4}**	**2×10^{-8}**	**2×10^{-4}**	**6×10^{-9}**
		GI (LLI)		**6×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
		Bone	0.1	2×10^{-3}	7×10^{-8}	8×10^{-4}	3×10^{-8}
		Liver	0.2	6×10^{-3}	2×10^{-7}	2×10^{-3}	6×10^{-8}
		Total body	0.2	6×10^{-3}	2×10^{-7}	2×10^{-3}	6×10^{-8}
	(Insol)	**Lung**			**2×10^{-8}**		**7×10^{-9}**
		GI (LLI)		**5×10^{-4}**	9×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{83}Bi^{206}(\epsilon, \gamma)$	(Sol)	**GI (LLI)**		**10^{-3}**	**2×10^{-7}**	**4×10^{-4}**	8×10^{-8}
		Kidney	1	0.04	**2×10^{-7}**	0.02	**6×10^{-8}**
		Liver	7	0.2	10^{-6}	0.08	4×10^{-7}
		Total Body	10	0.4	2×10^{-6}	0.1	5×10^{-7}
		Spleen	20	0.5	2×10^{-6}	0.2	8×10^{-7}
		Bone	300	10	4×10^{-5}	3	10^{-5}
	(Inso.)	**Lung**			**10^{-7}**		**5×10^{-8}**
		GI (LLI)		**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week**	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(PMPC)_a$ $\mu c/cc$
$_{83}Bi^{207}$ (ϵ, γ)	(Sol)	**GI (LLI)**	----------	**2×10^{-3}**	4×10^{-7}	**6×10^{-4}**	10^{-7}
		Kidney	2	0.04	**2×10^{-7}**	0.02	**6×10^{-8}**
		Liver	7	0.1	6×10^{-7}	0.05	2×10^{-7}
		Spleen	20	0.4	2×10^{-6}	0.1	5×10^{-7}
		Total Body	20	0.4	2×10^{-6}	0.1	5×10^{-7}
		Bone	300	6	2×10^{-5}	2	8×10^{-6}
	(Insol)	**Lung**	----------	----------	**10^{-8}**	----------	**5×10^{-9}**
		GI (LLI)	----------	**2×10^{-3}**	3×10^{-7}	**6×10^{-4}**	10^{-7}
$_{83}Bi^{210}$ (α, β^-)	(Sol)	**GI (LLI)**	----------	**10^{-3}**	3×10^{-7}	**4×10^{-4}**	9×10^{-8}
		Kidney	0.04	2×10^{-3}	**6×10^{-9}**	5×10^{-4}	**2×10^{-9}**
		Liver	0.5	0.02	8×10^{-8}	6×10^{-3}	3×10^{-8}
		Spleen	0.6	0.02	10^{-7}	8×10^{-3}	3×10^{-8}
		Total Body	20	0.07	3×10^{-7}	0.03	10^{-7}
		Bone	6	0.2	10^{-6}	0.08	3×10^{-7}
	(Insol)	**Lung**	----------	----------	**6×10^{-9}**	----------	**2×10^{-9}**
		GI (LLI)	----------	**10^{-3}**	2×10^{-7}	**4×10^{-4}**	7×10^{-8}

$_{83}Bi^{212}(\alpha, \beta^-, \gamma)$	(Sol)	**GI (S)**		**0.01**	2×10^{-6}	$\mathbf{4\times10^{-3}}$	8×10^{-7}
		Kidney	0.01	0.02	$\mathbf{10^{-7}}$	8×10^{-3}	$\mathbf{3\times10^{-8}}$
		Liver	0.1	0.3	10^{-6}	0.09	4×10^{-7}
		Spleen	0.2	0.4	10^{-6}	0.1	5×10^{-7}
		Total Body	0.2	0.5	2×10^{-6}	0.2	8×10^{-7}
		Bone	0.9	2	8×10^{-6}	0.7	3×10^{-6}
	(Insol)	**Lung**			$\mathbf{2\times10^{-7}}$		$\mathbf{7\times10^{-8}}$
		GI (S)		**0.01**	2×10^{-6}	$\mathbf{4\times10^{-3}}$	6×10^{-7}
$_{84}Po^{210}(\alpha)$	(Sol)	**Spleen**	0.03	$\mathbf{2\times10^{-5}}$	$\mathbf{5\times10^{-10}}$	$\mathbf{7\times10^{-6}}$	$\mathbf{2\times10^{-10}}$
		Kidney	0.04	$\mathbf{2\times10^{-5}}$	$\mathbf{5\times10^{-10}}$	8×10^{-6}	$\mathbf{2\times10^{-10}}$
		Liver	0.1	7×10^{-5}	2×10^{-9}	3×10^{-5}	6×10^{-10}
		Total Body	0.4	2×10^{-4}	5×10^{-9}	8×10^{-5}	2×10^{-9}
		Bone	0.5	3×10^{-4}	7×10^{-9}	10^{-4}	2×10^{-9}
		GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
	(Insol)	**Lung**			$\mathbf{2\times10^{-10}}$		$\mathbf{7\times10^{-11}}$
		GI (LLI)		$\mathbf{8\times10^{-4}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	5×10^{-8}
$_{85}At^{211}(\alpha, \epsilon, \gamma)$	(Sol)	**Thyroid**	0.02	$\mathbf{5\times10^{-5}}$	$\mathbf{7\times10^{-9}}$	$\mathbf{2\times10^{-5}}$	$\mathbf{2\times10^{-9}}$
		Ovary	0.02	$\mathbf{5\times10^{-5}}$	$\mathbf{7\times10^{-9}}$	$\mathbf{2\times10^{-5}}$	3×10^{-9}
		Spleen	0.06	2×10^{-4}	3×10^{-8}	6×10^{-5}	9×10^{-9}
		Total Body	0.3	8×10^{-4}	10^{-7}	3×10^{-4}	4×10^{-8}
		GI (S)		0.02	4×10^{-6}	7×10^{-3}	2×10^{-6}
	(Insol)	**Lung**			$\mathbf{3\times10^{-8}}$		$\mathbf{10^{-8}}$
		GI (ULI)		$\mathbf{2\times10^{-3}}$	4×10^{-7}	$\mathbf{7\times10^{-4}}$	10^{-7}
$_{86}Rn^{220}$†$(\alpha, \beta^-, \gamma, e^-)$		**Lung**			$\mathbf{3\times10^{-7}}$		$\mathbf{10^{-7}}$
$_{86}Rn^{222}$†(α, β, γ)		**Lung**			$\mathbf{3\times10^{-8}}$		$\mathbf{10^{-8}}$

†The daughter isotopes of Rn^{220} and Rn^{222} are assumed present to the extent they occur in unfiltered air. For all other isotopes the daughter elements are not considered as part of the intake and if present must be considered on the basis of the rules for mixtures.

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week, $(MPC)_w$ $\mu c/cc$	Maximum permissible concentrations: For 40 hour week, $(MPC)_a$ $\mu c/cc$	Maximum permissible concentrations: For 168 hour week**, $(MPC)_w$ $\mu c/cc$	Maximum permissible concentrations: For 168 hour week**, $(MPC)_a$ $\mu c/cc$
$_{88}Ra^{223}$ (α, β^-, γ)	(Sol)	**Bone**	0.05	2×10^{-5}	2×10^{-9}	7×10^{-6}	6×10^{-10}
		Total Body	0.07	4×10^{-5}	3×10^{-9}	10^{-5}	10^{-9}
		GI (LLI)		2×10^{-4}	4×10^{-8}	6×10^{-5}	10^{-8}
	(Insol)	**Lung**			2×10^{-10}		8×10^{-11}
		GI (LLI)		10^{-4}	2×10^{-8}	4×10^{-5}	7×10^{-9}
$_{88}Ra^{224}$ (α, β^-, γ, e^-)	(Sol)	**Bone**	0.06	7×10^{-5}	5×10^{-9}	2×10^{-5}	2×10^{-9}
		Total Body	0.07	9×10^{-5}	8×10^{-9}	3×10^{-5}	3×10^{-9}
		GI (LLI)		2×10^{-4}	5×10^{-8}	7×10^{-5}	2×10^{-8}
	(Insol)	**Lung**			7×10^{-10}		2×10^{-10}
		GI (LLI)		2×10^{-4}	3×10^{-8}	5×10^{-5}	9×10^{-9}
$_{88}Ra^{226}$ (α, β^-, γ)	(Sol)	**Bone**	0.1	4×10^{-7}	3×10^{-11}	10^{-7}	10^{-11}
		Total Body	0.2	6×10^{-7}	5×10^{-11}	2×10^{-7}	2×10^{-11}
		GI (LLI)		10^{-3}	3×10^{-7}	5×10^{-4}	10^{-7}
	(Insol)	**GI (LLI)**		9×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
$_{88}Ra^{228}$ (α, β^-, γ, e^-)	(Sol)	**Bone**	0.06	8×10^{-7}	7×10^{-11}	3×10^{-7}	2×10^{-11}
		Total Body	0.09	10^{-6}	9×10^{-11}	4×10^{-7}	3×10^{-11}
		GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}

	(Insol)	Lung			4×10^{-11}		10^{-11}
		GI (LLI)		7×10^{-4}	10^{-7}	3×10^{-4}	4×10^{-8}
$_{89}Ac^{227}$ (α, β^-, γ)	(Sol)	Bone	0.03	6×10^{-5}	2×10^{-12}	2×10^{-5}	8×10^{-13}
		Total Body	0.1	2×10^{-4}	7×10^{-12}	6×10^{-5}	3×10^{-12}
		Liver	0.2	2×10^{-4}	10^{-11}	8×10^{-5}	3×10^{-12}
		Kidney	0.4	7×10^{-4}	3×10^{-11}	2×10^{-4}	9×10^{-12}
		GI (LLI)		9×10^{-3}	2×10^{-6}	3×10^{-3}	7×10^{-7}
	(Insol)	Lung			3×10^{-11}		9×10^{-12}
		GI (LLI)		9×10^{-3}	2×10^{-6}	3×10^{-3}	5×10^{-7}
$_{89}Ac^{228}$ (α, β^-, γ, e^-)	(Sol)	GI (ULI)		3×10^{-3}	6×10^{-7}	9×10^{-4}	2×10^{-7}
		Bone	0.04	2	9×10^{-8}	0.5	3×10^{-8}
		Liver	0.05	2	8×10^{-8}	0.6	3×10^{-8}
		Total Body	0.09	3	10^{-7}	1	5×10^{-8}
		Kidney	0.5	20	6×10^{-7}	6	2×10^{-7}
	(Insol)	Lung			2×10^{-8}		6×10^{-9}
		GI (ULI)		3×10^{-3}	4×10^{-7}	9×10^{-4}	2×10^{-7}
$_{90}Th^{227}$ (α, β^-, γ)	(Sol)	GI (LLI)		5×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
		Bone	0.02	8×10^{-3}	3×10^{-10}	3×10^{-3}	10^{-10}
		Kidney	0.08	0.04	2×10^{-9}	0.01	6×10^{-10}
		Total Body	0.1	0.05	2×10^{-9}	0.02	7×10^{-10}
		Liver	0.5	0.2	10^{-8}	0.08	4×10^{-9}
	(Insol)	Lung			2×10^{-10}		6×10^{-11}
		GI (LLI)		5×10^{-4}	9×10^{-8}	2×10^{-4}	3×10^{-8}
$_{90}Th^{228}$ (α, β^-, γ, e^-)	(Sol)	Bone	0.02	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		GI (LLI)		4×10^{-4}	8×10^{-8}	10^{-4}	3×10^{-8}
		Kidney	0.09	10^{-3}	5×10^{-11}	4×10^{-4}	2×10^{-11}
		Total Body	0.09	10^{-3}	5×10^{-11}	4×10^{-4}	2×10^{-11}
		Liver	0.5	7×10^{-3}	3×10^{-10}	2×10^{-3}	10^{-10}
	(Insol)	Lung			6×10^{-12}		2×10^{-12}
		GI (LLI)		4×10^{-4}	7×10^{-8}	10^{-4}	2×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week $(MPC)_w$ $\mu c/cc$	For 40 hour week $(MPC)_a$ $\mu c/cc$	For 168 hour week** $(MPC)_w$ $\mu c/cc$	For 168 hour week** $(MPC)_a$ $\mu c/cc$
$_{90}Th^{230}$ (α, γ) (Sol)	**Bone**	0.05	**5×10^{-5}**	**2×10^{-12}**	**2×10^{-5}**	**8×10^{-13}**
	Kidney	0.3	10^{-4}	4×10^{-12}	3×10^{-5}	2×10^{-12}
	Total Body	0.4	3×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
	Liver	0.6	5×10^{-4}	2×10^{-11}	2×10^{-4}	7×10^{-12}
	GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
(Insol)	**Lung**			**10^{-11})**		**3×10^{-12}**
	GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
$_{90}Th^{231}$ $(\alpha, \beta^-, \gamma)$ (Sol)	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**5×10^{-7}**
	Bone	30	200	10^{-5}	80	4×10^{-6}
	Kidney	40	300	10^{-5}	100	5×10^{-6}
	Total Body	100	900	4×10^{-5}	300	10^{-5}
	Liver	300	2×10^{3}	10^{-4}	800	3×10^{-5}
(Insol)	**GI (LLI)**		**7×10^{-3}**	**10^{-6}**	**2×10^{-3}**	**4×10^{-7}**
	Lung			6×10^{-6}		2×10^{-6}
$_{90}Th^{232}$ $(\alpha, \beta^-, \gamma, e^-)$ (Sol)	**Bone**	0.04	**5×10^{-5}**	**(2×10^{-12})**	**2×10^{-5}**	**(7×10^{-13})‡**
	Kidney	0.3	10^{-4}	(5×10^{-12})	4×10^{-5}	(2×10^{-12})
	Total Body	0.3	3×10^{-4}	(10^{-11})	9×10^{-5}	(4×10^{-12})
	Liver	0.7	6×10^{-4}	3×10^{-11}	2×10^{-4}	(9×10^{-12})
	GI (LLI)		10^{-3}	2×10^{-7}	4×10^{-4}	8×10^{-8}

	(Insol)	Lung	—	—	10^{-11}	—	4×10^{-12}
		GI (LLI)	—	10^{-3}	2×10^{-7}	4×10^{-4}	7×10^{-8}
$_{90}Th^{234}$ (β^-, γ)	(Sol)	GI (LLI)	—	5×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
		Bone	4	1	6×10^{-8}	0.5	2×10^{-8}
		Kidney	6	2	9×10^{-8}	0.7	3×10^{-8}
		Total Body	20	8	4×10^{-7}	3	10^{-7}
		Liver	30	10	5×10^{-7}	4	2×10^{-7}
	(Insol)	Lung	—	—	3×10^{-8}	—	10^{-8}
		GI (LLI)	—	5×10^{-4}	9×10^{-8}	2×10^{-4}	3×10^{-8}
$_{90}$Th–Nat $(\alpha, \beta^-, \gamma, e^-)$	(Sol)	Bone	0.01	3×10^{-5}	(2×10^{-12})	10^{-5}	(6×10^{-13})‡
		Kidney	0.07	10^{-4}	(4×10^{-12})	4×10^{-5}	(2×10^{-12})
		Total Body	0.07	2×10^{-4}	(9×10^{-12})	7×10^{-5}	(3×10^{-12})
		GI (LLI)	—	3×10^{-4}	6×10^{-8}	10^{-4}	2×10^{-8}
		Liver	0.3	5×10^{-4}	(2×10^{-11})	2×10^{-4}	(8×10^{-12})
	(Insol)	Lung	—	—	(4×10^{-12})	—	(10^{-12})
		GI (LLI)	—	3×10^{-4}	5×10^{-8}	10^{-4}	2×10^{-8}
$_{91}Pa^{230}$ $(\alpha, \beta^-, \smile, \gamma)$	(Sol)	GI (LLI)	—	7×10^{-3}	2×10^{-6}	2×10^{-3}	5×10^{-7}
		Bone	0.07	0.04	2×10^{-9}	0.01	6×10^{-10}
		Kidney	0.2	0.1	5×10^{-9}	0.04	2×10^{-9}
		Total Body	0.3	0.2	8×10^{-9}	0.06	3×10^{-9}
	(Insol)	Lung	—	—	8×10^{-10}	—	3×10^{-10}
		GI (LLI)	—	7×10^{-3}	10^{-6}	2×10^{-3}	4×10^{-7}
$_{91}Pa^{231}$ $(\alpha, \beta^-, \gamma)$	(Sol)	Bone	0.02	3×10^{-5}	10^{-12}	9×10^{-6}	4×10^{-13}
		Kidney	0.06	7×10^{-5}	3×10^{-12}	2×10^{-5}	10^{-12}
		Total Body	0.1	10^{-4}	5×10^{-12}	4×10^{-5}	2×10^{-12}
		Liver	0.3	4×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)	—	8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(Insol)	Lung	—	—	10^{-10}	—	4×10^{-11}
		GI (LLI)	—	8×10^{-4}	10^{-7}	2×10^{-4}	5×10^{-8}

‡Provisional values for Th^{232} and Th-nat. Although calculations and animal experiments suggest that Th-nat is perhaps as hazardous as Pu and indicate the values listed above, industrial experience to date has suggested that the hazard of Th-nat is not much greater than that of U-nat. The NCRP has recognized that a certain period of time may be required for adjustment of operations to comply with new recommendations. Therefore, pending further investigation the values $(MPC)_a=3\times10^{-11}$ μc/cc for the 40-hour week and $(MPC)_a=10^{-11}$ μc/cc for continuous occupational exposure (168 hr/wk) are recommended as permissible levels. These values are essentially those that have been generally used in this country (Federal Register 1957). However, the values given in Table 1 are listed to indicate the possibility that further evidence may require lower values and to urge especially that exposure levels of Th-nat be kept as low as is operationally possible. The exception indicated here applies only to the $(MPC)_a$ values for Th-nat and Th^{232}.

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations: For 40 hour week (MPC)$_w$ $\mu c/cc$	For 40 hour week (MPC)$_a$ $\mu c/cc$	For 168 hour week (MPC)$_w$ $\mu c/cc$	For 168 hour week (MPC)$_a$ $\mu c/cc$
$_{91}Pa^{233}$ (β^-, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	8×10^{-7}	**10^{-3}**	3×10^{-7}
		Kidney	40	10	**6×10^{-7}**	5	**2×10^{-7}**
		Bone	60	20	9×10^{-7}	7	3×10^{-7}
		Total Body	60	20	9×10^{-7}	7	3×10^{-7}
		Liver	200	50	2×10^{-6}	20	8×10^{-7}
	(Insol)	**Lung**			**2×10^{-7}**		**6×10^{-8}**
		GI (LLI)		**3×10^{-3}**	6×10^{-7}	**10^{-3}**	2×10^{-7}
$_{92}U^{230}$ (α, β^-, γ)	(Sol)	**GI (LLI)**		**10^{-4}**	3×10^{-8}	**5×10^{-5}**	10^{-8}
		Kidney	0.01	7×10^{-3}	**3×10^{-10}**	2×10^{-3}	10^{-10}
		Total Body	0.06	0.03	10^{-9}	0.01	5×10^{-10}
		Bone	7×10^{-3}	0.04	2×10^{-9}	0.02	6×10^{-10}
	(Insol)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**10^{-4}**	2×10^{-8}	**5×10^{-5}**	8×10^{-9}
$_{92}U^{232}$ (α, β^-, γ, e^-)	(Sol)	**GI (LLI)**		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	6×10^{-8}
		Bone	0.01	2×10^{-3}	**10^{-10}**	8×10^{-4}	**3×10^{-11}**
		Total Body	0.07	6×10^{-3}	3×10^{-10}	2×10^{-3}	10^{-10}
		Kidney	0.04	0.01	6×10^{-10}	4×10^{-3}	2×10^{-10}
	(Insol)	**Lung**			**3×10^{-11}**		**9×10^{-12}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}

$_{92}U^{233}$ (α, γ)	(Sol)	**GI (LLI)**		$\mathbf{9\times10^{-4}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	7×10^{-8}
		Bone	0.05	0.01	$\mathbf{5\times10^{-10}}$	4×10^{-3}	$\mathbf{2\times10^{-10}}$
		Kidney	0.08	0.03	10^{-9}	0.01	4×10^{-10}
		Total Body	0.4	0.04	2×10^{-9}	0.01	5×10^{-10}
	(Insol)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4\times10^{-11}}$
		GI (LLI)		$\mathbf{9\times10^{-4}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	6×10^{-8}
$_{92}U^{234}$ (α, γ)	(Sol)	**GI (LLI)**		$\mathbf{9\times10^{-4}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	7×10^{-8}
		Bone	0.05	0.01	$\mathbf{6\times10^{-10}}$	4×10^{-3}	$\mathbf{2\times10^{-10}}$
		Kidney	0.08	0.03	10^{-9}	0.01	4×10^{-10}
		Total Body	0.4	0.04	2×10^{-9}	0.01	6×10^{-10}
	(Insol)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4\times10^{-11}}$
		GI (LLI)		$\mathbf{9\times10^{-4}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	6×10^{-8}
$_{92}U^{235}$ (α, β^-, γ)	(Sol)	**GI (LLI)**		$\mathbf{8\times10^{-4}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	6×10^{-8}
		Kidney	0.03	0.01	$\mathbf{5\times10^{-10}}$	4×10^{-3}	$\mathbf{2\times10^{-10}}$
		Bone	0.06	0.01	6×10^{-10}	5×10^{-3}	$\mathbf{2\times10^{-10}}$
		Total Body	0.4	0.04	2×10^{-9}	0.01	6×10^{-10}
	(Insol)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4\times10^{-11}}$
		GI (LLI)		$\mathbf{8\times10^{-4}}$	10^{-7}	$\mathbf{3\times10^{-4}}$	5×10^{-8}
$_{92}U^{236}$ (α, γ)	(Sol)	**GI (LLI)**		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	7×10^{-8}
		Bone	0.06	0.01	$\mathbf{6\times10^{-10}}$	5×10^{-3}	$\mathbf{2\times10^{-10}}$
		Kidney	0.08	0.03	10^{-9}	0.01	4×10^{-10}
		Total Body	0.4	0.04	2×10^{-9}	0.01	6×10^{-10}
	(Insol)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{4\times10^{-11}}$
		GI (LLI)		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{3\times10^{-4}}$	6×10^{-8}
$_{92}U^{238}$ (α, γ, e^-)	(Sol)	**GI (LLI)**		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{4\times10^{-4}}$	8×10^{-8}
		Kidney	5×10^{-3}	2×10^{-3}	$\mathbf{7\times10^{-11}}$	6×10^{-4}	$\mathbf{3\times10^{-11}}$
		Bone	0.06	0.01	6×10^{-10}	5×10^{-3}	2×10^{-10}
		Total Body	0.5	0.04	2×10^{-9}	0.01	6×10^{-10}
	(Insol)	**Lung**			$\mathbf{10^{-10}}$		$\mathbf{5\times10^{-11}}$
		GI (LLI)		$\mathbf{10^{-3}}$	2×10^{-7}	$\mathbf{4\times10^{-4}}$	6×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body q (μc)	Maximum permissible concentrations: For 40 hour week		For 168 hour week	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(PMPC)_a$ $\mu c/cc$
$_{92}$U-Nat (α, β^-, γ, e^-)	(Sol)	**GI (LLI)**		**5×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}
		Kidney	5×10^{-3}	2×10^{-3}	**7×10^{-11}**	6×10^{-4}	**3×10^{-11}**
		Bone	0.03	6×10^{-3}	3×10^{-10}	2×10^{-3}	10^{-10}
		Total Body	0.2	0.02	8×10^{-10}	7×10^{-3}	3×10^{-10}
	(Insol)	**Lung**			**6×10^{-11}**		**2×10^{-11}**
		GI (LLI)		**5×10^{-4}**	8×10^{-8}	**2×10^{-4}**	3×10^{-8}
$_{92}$Np^{237} (α, β^-, γ)	(Sol)	**Bone**	0.06	**9×10^{-5}**	**4×10^{-12}**	**3×10^{-5}**	**10^{-12}**
		Kidney	0.1	2×10^{-4}	7×10^{-12}	6×10^{-5}	2×10^{-12}
		Total Body	0.5	4×10^{-4}	2×10^{-11}	10^{-4}	6×10^{-12}
		Liver	0.5	6×10^{-4}	2×10^{-11}	2×10^{-4}	8×10^{-12}
		GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
	(Insol)	**Lung**			**10^{-10}**		**4×10^{-11}**
		GI (LLI)		**9×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{93}$Np^{239} (α, β^-, γ)	(Sol)	**GI (LLI)**		**4×10^{-3}**	**8×10^{-7}**	**10^{-3}**	**3×10^{-7}**
		Bone	30	100	4×10^{-6}	30	2×10^{-6}
		Kidney	40	200	7×10^{-6}	50	2×10^{-6}
		Total Body	70	300	10^{-5}	90	4×10^{-6}
		Liver	100	500	2×10^{-5}	200	8×10^{-6}

	(Insol)	**GI (LLI)**		**4×10^{-3}**	**7×10^{-7}**	**10^{-3}**	**2×10^{-7}**
		Lung			2×10^{-6}		7×10^{-7}
$_{94}Pu^{238}$ (α, γ)	(Sol)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**7×10^{-13}**
		Liver	0.2	6×10^{-4}	8×10^{-12}	2×10^{-4}	3×10^{-12}
		Kidney	0.3	8×10^{-4}	10^{-11}	3×10^{-4}	4×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total Body	0.3	10^{-3}	10^{-11}	4×10^{-4}	5×10^{-12}
	(Insol)	**Lung**			**3×10^{-11}**		**10^{-11}**
		GI (LLI)		**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{94}Pu^{239}$ (α, γ)	(Sol)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**6×10^{-13}**
		Liver	0.4	5×10^{-4}	7×10^{-12}	2×10^{-4}	2×10^{-12}
		Kidney	0.5	7×10^{-4}	9×10^{-12}	2×10^{-4}	3×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total Body	0.4	10^{-3}	10^{-11}	3×10^{-4}	5×10^{-12}
	(Insol)	**Lung**			**4×10^{-11}**		**10^{-11}**
		GI (LLI)		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{94}Pu^{240}$(α, γ)	(Sol)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**5×10^{-5}**	**6×10^{-13}**
		Liver	0.4	5×10^{-4}	7×10^{-12}	2×10^{-4}	2×10^{-12}
		Kidney	0.5	7×10^{-4}	9×10^{-12}	2×10^{-4}	3×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total Body	0.4	10^{-3}	10^{-11}	3×10^{-4}	5×10^{-12}
	(Insol)	**Lung**			**4×10^{-11}**		**10^{-11}**
		GI (LLI)		**8×10^{-4}**	2×10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{94}Pu^{241}$(α, β^-, γ)	(Sol)	**Bone**	0.9	**7×10^{-3}**	**9×10^{-11}**	**2×10^{-3}**	**3×10^{-11}**
		Kidney	5	0.04	5×10^{-10}	0.01	2×10^{-10}
		GI (LLI)		0.04	8×10^{-6}	0.01	3×10^{-6}
		Total Body	9	0.06	8×10^{-10}	0.02	3×10^{-10}
		Liver	10	0.07	10^{-9}	0.03	3×10^{-10}
	(Insol)	**Lung**			**4×10^{-8}**		**10^{-8}**
		GI (LLI)		**0.04**	7×10^{-6}	**0.01**	2×10^{-6}

TABLE 1. *Maximum peamissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay	Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
			For 40 hour week		For 168 hour week	
			$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{94}Pu^{242}(\alpha)$ (Sol)	**Bone**	0.05	10^{-4}	2×10^{-12}	5×10^{-5}	6×10^{-13}
	Liver	0.4	6×10^{-4}	7×10^{-12}	2×10^{-4}	3×10^{-12}
	Kidney	0.5	7×10^{-4}	10^{-11}	3×10^{-4}	3×10^{-12}
	GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	7×10^{-8}
	Total Body	0.4	10^{-3}	10^{-11}	4×10^{-4}	5×10^{-12}
(Insol)	**Lung**			4×10^{-11}		10^{-11}
	GI (LLI)		9×10^{-4}	2×10^{-7}	3×10^{-4}	5×10^{-8}
$_{95}Am^{241}$ (α, γ) (Sol)	**Kidney**	0.1	10^{-4}	6×10^{-12}	4×10^{-5}	2×10^{-12}
	Bone	0.05	10^{-4}	6×10^{-12}	5×10^{-5}	2×10^{-12}
	Liver	0.4	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
	Total Body	0.3	4×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
	GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
(Insol)	**Lung**			10^{-10}		4×10^{-11}
	GI (LLI)		8×10^{-4}	10^{-7}	2×10^{-4}	5×10^{-8}
$_{95}Am^{243}$ $(\alpha, \beta^-, \gamma)$ (Sol)	**Bone**	0.05	10^{-4}	6×10^{-12}	4×10^{-5}	2×10^{-12}
	Kidney	0.1	10^{-4}	6×10^{-12}	5×10^{-5}	2×10^{-12}
	Liver	0.4	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
	Total Body	0.4	4×10^{-4}	2×10^{-11}	10^{-4}	5×10^{-12}
	GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}

	(Insol)	Lung			10^{-10}		4×10^{-11}
		GI (LLI)		8×10^{-4}	10^{-7}	3×10^{-4}	5×10^{-8}
$_{96}Cm^{242}$ (α, γ)	(Sol)	GI (LLI)		7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
		Liver	0.05	3×10^{-3}	10^{-10}	9×10^{-4}	4×10^{-11}
		Bone	0.09	5×10^{-3}	2×10^{-10}	2×10^{-3}	8×10^{-11}
		Kidney	0.2	9×10^{-3}	4×10^{-10}	3×10^{-3}	10^{-10}
		Total Body	0.2	0.01	6×10^{-10}	5×10^{-3}	2×10^{-10}
	(Insol)	Lung			2×10^{-10}		6×10^{-11}
		GI (LLI)		7×10^{-4}	10^{-7}	3×10^{-4}	4×10^{-8}
$_{96}Cm^{243}$ (α, γ)	(Sol)	Bone	0.09	10^{-4}	6×10^{-12}	5×10^{-5}	2×10^{-12}
		Liver	0.2	2×10^{-4}	10^{-11}	8×10^{-5}	3×10^{-12}
		Kidney	0.2	3×10^{-4}	10^{-11}	10^{-4}	4×10^{-12}
		Total Body	0.3	5×10^{-4}	2×10^{-11}	2×10^{-4}	7×10^{-12}
		GI (LLI)		7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
	(Insol)	Lung			10^{-10}		3×10^{-11}
		GI (LLI)		7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}
$_{96}Cm^{244}$ (α, γ)	(Sol)	Bone	0.1	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Liver	0.2	3×10^{-4}	10^{-11}	9×10^{-5}	4×10^{-12}
		Kidney	0.2	4×10^{-4}	2×10^{-11}	10^{-4}	6×10^{-12}
		Total Body	0.3	6×10^{-4}	3×10^{-11}	2×10^{-4}	9×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(Insol)	Lung			10^{-10}		3×10^{-11}
		GI (LLI)		8×10^{-4}	10^{-7}	3×10^{-4}	5×10^{-8}
$_{96}Cm^{245}$ (α, β^-, γ)	(Sol)	Bone	0.04	10^{-4}	5×10^{-12}	4×10^{-5}	2×10^{-12}
		Liver	0.5	2×10^{-4}	8×10^{-12}	7×10^{-5}	3×10^{-12}
		Kidney	0.2	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Total Body	0.4	3×10^{-4}	10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)		8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(Insol)	Lung			10^{-10}		4×10^{-11}
		GI (LLI)		8×10^{-4}	10^{-7}	3×10^{-4}	5×10^{-8}

TABLE 1. *Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure*—Continued

Radionuclide and type of decay		Organ of reference (critical organ in boldface)	Maximum permissible burden in total body $q(\mu c)$	Maximum permissible concentrations			
				For 40 hour week		For 168 hour week	
				$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$	$(MPC)_w$ $\mu c/cc$	$(MPC)_a$ $\mu c/cc$
$_{96}Cm^{246}$ (α)	(Sol)	**Bone**	0.05	**10^{-4}**	**5×10^{-12}**	**4×10^{-5}**	**2×10^{-12}**
		Liver	0.5	2×10^{-4}	8×10^{-12}	7×10^{-5}	3×10^{-12}
		Kidney	0.2	2×10^{-4}	9×10^{-12}	7×10^{-5}	3×10^{-12}
		Total Body	0.4	3×10^{-4}	10^{-11}	10^{-4}	5×10^{-12}
		GI (LLI)	----------	8×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
	(Insol)	**Lung**	----------	----------	**10^{-10}**	----------	**4×10^{-11}**
		GI (LLI)	----------	**8×10^{-4}**	10^{-7}	**3×10^{-4}**	5×10^{-8}
$_{97}Bk^{249}$ (α, β^-, γ)	(Sol)	**GI (LLI)**	----------	**0.02**	4×10^{-6}	**6×10^{-3}**	10^{-6}
		Bone	0.7	0.07	**9×10^{-10}**	0.02	**3×10^{-10}**
		Total Body	5	0.5	7×10^{-9}	0.2	2×10^{-9}
	(Insol)	**Lung**	----------	----------	**10^{-7}**	----------	**4×10^{-8}**
		GI (LLI)	----------	**0.02**	3×10^{-6}	**6×10^{-3}**	10^{-6}
$_{98}Cf^{249}$ (α, γ)	(Sol)	**Bone**	0.04	**10^{-4}**	**2×10^{-12}**	**4×10^{-5}**	**5×10^{-13}**
		GI (LLI)	----------	7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
		Total Body	0.3	9×10^{-4}	10^{-11}	3×10^{-4}	4×10^{-12}
	(Insol)	**Lung**	----------	----------	**10^{-10}**	----------	**3×10^{-11}**
		GI (LLI)	----------	**7×10^{-4}**	10^{-7}	**2×10^{-4}**	4×10^{-8}

$_{98}Cf^{250}(\alpha)$	(Sol)	**Bone**	0.04	4×10^{-4}	5×10^{-12}	10^{-4}	2×10^{-12}
		GI (LLI)		7×10^{-4}	2×10^{-7}	3×10^{-4}	6×10^{-8}
		Total Body	0.3	3×10^{-3}	4×10^{-11}	10^{-3}	10^{-11}
	(Insol)	**Lung**			10^{-10}		3×10^{-11}
		GI (LLI)		7×10^{-4}	10^{-7}	3×10^{-4}	4×10^{-8}
$_{98}Cf^{252}(\alpha, \gamma)$	(Sol)	**GI (LLI)**		7×10^{-4}	2×10^{-7}	2×10^{-4}	5×10^{-8}
		Bone	0.04	2×10^{-3}	2×10^{-11}	6×10^{-4}	7×10^{-12}
		Total Body	0.3	0.01	2×10^{-10}	4×10^{-3}	5×10^{-11}
	(Insol)	**Lung**			10^{-10}		4×10^{-11}
		GI (LLI)		7×10^{-4}	10^{-7}	2×10^{-4}	4×10^{-8}

In keeping with its previous practice [3] when recommending changes in MPD levels, the NCRP suggests that a 5-year transition period be allowed during which the new values in Table 1 may be put into effect.

TABLE 2.—*Radionuclides which do not reach equilibrium in the body within 50 years*

Z	Radionuclide	Radioactive half-life T_r (yr)	Biological half-life T_b (yr)	Effective half-life T (yr)	Percent equil. reached in 50 yr
38	Sr^{90}	28	50	18	86
88	Ra^{226}	1622	45	44	56
89	Ac^{227}	21. 8	200	20	83
90	Th^{230}	8.0×10^4	200	200	16
90	Th^{232}	1.39×10^{10}	200	200	16
91	Pa^{231}	3.4×10^4	200	200	16
93	Np^{237}	2.20×10^6	200	200	16
94	Pu^{238}	89. 6	200	62	43
94	Pu^{239}	2.44×10^4	200	200	16
94	Pu^{240}	6.6×10^3	200	190	16
94	Pu^{241}	13. 2	200	12	94
94	Pu^{242}	3.8×10^5	200	200	16
95	Am^{241}	462	200	140	22
95	Am^{243}	8×10^3	200	200	16
96	Cm^{243}	35	200	30	69
96	Cm^{244}	18. 4	200	17	87
96	Cm^{245}	2×10^4	200	200	16
96	Cm^{246}	6.6×10^3	200	190	16
98	Cf^{249}	4.7×10^2	200	140	22
98	Cf^{250}	10	200	10	97

TABLE 3. *Provisional maximum permissible concentration of unidentified radionuclides in water* $(MPCU)_w$

Values that are applicable for occupational exposure (168 hr/wk) to any radionuclide or mixture of radionuclides

Limitations	μc/cc of water**
If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226} Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present* the continuous exposure level $(MPC)_w$, is not less than	3×10^{-5}
If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present* the continuous exposure level $(MPC)_w$, is not less than	2×10^{-5}
If Sr^{90}, Pb^{210}, Ra^{226}, and Ra^{228} are not present* the continuous exposure level $(MPC)_w$, is not less than	6×10^{-6}
If Ra^{226} and Ra^{228} are not present* the continuous exposure level $(MPC)_w$, is not less than	10^{-6}
In all cases the continuous occupational level $(MPC)_w$, is not less than	10^{-7}

*In this case "not present" implies the concentration of the radionuclide in water is small compared with the MPC value in table 1.
**Use 1/10 of these values for interim application in the neighborhood of an atomic energy plant.

TABLE 4. *Provisional maximum permissible concentration of unidentified radionuclides in air* $(MPCU)_a$

Values that are applicable for occupational exposure (168 hr/wk) to any radionuclide or mixture of radionuclides

Limitations	μc/cc of air**
If there are no α-emitters and if β-emitters Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present* the continuous exposure level, $(MPC)_a$, is not less than	10^{-9}
If there are no α-emitters and if β-emitters Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present* the continuous exposure level, $(MPC)_a$, is not less than	10^{-10}
If there are no α-emitters and if β-emitter Ac^{227} is not present* the continuous exposure level, $(MPC)_a$, is not less than	10^{-11}
If Ac^{227}, Th^{230}, Pa^{231}, Th^{232}, Th-nat, Pu^{238}, Pu^{239}, Pu^{240}, Pu^{242}, and Cf^{249} are not present* the continuous exposure level, $(MPC)_a$, is not less than	10^{-12}
If Pa^{231}, Th-nat, Pu^{239}, Pu^{240}, Pu^{242}, and Cf^{249} are not present* the continuous exposure level, $(MPC)_a$, is not less than	7×10^{-13}
In all cases the continuous occupational level, $(MPC)_a$, is not less than	4×10^{-13}

*In this case "not present" implies the concentration of the radionuclide in air is small compared with the MPC value in table 1.
**Use 1/10 of these values for interim application in the neighborhood of an atomic energy plant.

TABLE 5. *Calculation of MPC of a mixture of radionuclides*

Sample of concurrent exposure to several radionuclides (in soluble form) and an external source of radiation

Source of exposure	Body organ exposed	In air*	In water*
Sr^{90}	Bone	$\frac{\rho_{aA}}{(MPC)^{x}_{aA}}=\frac{1.8\times10^{-11}\mu c/cc}{3\times10^{-10}\mu c/cc}$	$\frac{\rho_{wA}}{(MPC)^{x}_{wA}}=\frac{1.5\times10^{-7}\mu c/cc}{4\times10^{-6}\mu c/cc}$
	Total body	$\frac{\rho_{aA}}{(MPC)^{TB}_{aA}}=\frac{1.8\times10^{-11}\mu c/cc}{9\times10^{-10}\mu c/cc}$	$\frac{\rho_{wA}}{(MPC)^{TB}_{wA}}=\frac{1.5\times10^{-7}\mu c/cc}{1\times10^{-5}\mu c/cc}$
Pu^{239}	Bone	$\frac{\rho_{aB}}{(MPC)^{x}_{aB}}=\frac{4\times10^{-13}\mu c/cc}{2\times10^{-12}\mu c/cc}$	$\frac{\rho_{wB}}{(MPC)^{x}_{wB}}=\frac{1.3\times10^{-5}\mu c/cc}{1\times10^{-4}\mu c/cc}$
	Total body	$\frac{\rho_{aB}}{(MPC)^{TB}_{aB}}=\frac{4\times10^{-13}\mu c/cc}{1\times10^{-11}\mu c/cc}$	$\frac{\rho_{wB}}{(MPC)^{TB}_{wB}}=\frac{1.3\times10^{-5}\mu c/cc}{1\times10^{-3}\mu c/cc}$
Na^{24}	Total body	$\frac{\rho_{aC}}{(MPC)^{TB}_{aC}}=\frac{2\times10^{-7}\mu c/cc}{2\times10^{-6}\mu c/cc}$	$\frac{\rho_{wC}}{(MPC)^{TB}_{wC}}=\frac{2\times10^{-3}\mu c/cc}{1\times10^{-2}\mu c/cc}$
γ**	Bone	$\frac{R^{x}_{\gamma}}{L^{x}}=\frac{0.065\text{ rem/week}}{0.56\text{ rem/week}}$	
	Total body	$\frac{R^{TB}_{\gamma}}{L^{TB}}=\frac{0.065\text{ rem/week}}{0.1\text{ rem/week}}$	

* The ratios given for Sr^{90}, Pu^{239}, and Na^{24} are the ($\mu c/cc$ present in air)/$(MPC)^{x}_{aA}$ where $(MPC)^{x}_{aA}$ is the $(MPC)_a$ for element A(Sr^{90}) and organ x (bone), etc.

** The ratio given for γ is the (actual RBE dose rate)/(maximum permissible RBE dose rate).

Submitted for the National Committee on Radiation Protection.

Lauriston S. Taylor, *Chairman*.

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United States
Environmental
Protection Agency

Implementation Guidance for Radionuclides

Appendix I

Comparison of Derived Values of Beta and Photon Emitters

Derived Concentrations (pCi/L) of Beta and Photon Emitters in Drinking Water Yielding a Dose of 4 mrem/y to the Total Body or to Any Critical Organ as Defined in NBS Handbook 69

Nuclide	pCi/L	Nuclide	pCi/L	Nuclide	pCi/L	Nuclide	pCi/L
H-3	20,000	Sr-85 m	20,000	Sb-124	60	Er-169	300
Be-7	6,000	Sr-85	900	Sb-125	300	Er-171	300
C-14	2,000	Sr-89	20	Te-125m	600	Tm-170	100
F-18	2,000	Sr-90	8	Te-127	900	Tm-171	1,000
Na-22	400	Sr-91	200	Te-127m	200	Yb-175	300
Na-24	600	Sr-92	200	Te-129	2,000	Lu-177	300
Si-31	3,000	Y-90	60	Te-129m	90	Hf-181	200
P-32	30	Y-91	90	Te-131m	200	Ta-182	100
S-35 inorg	500	Y-91m	9,000	Te-132	90	W-181	1,000
Cl-36	700	Y-92	200	I-126	3	W-185	300
Cl-38	1,000	Y-93	90	I-129	1	W-187	200
K-42	900	Zr-93	2,000	I-131	3	Re-186	300
Ca-45	10	Zr-95	200	I-132	90	Re-187	9,000
Ca-47	80	Zr-97	60	I-133	10	Re-188	200
Sc-46	100	Nb-93m	1,000	I-134	100	Os-185	200
Sc-47	300	Nb-95	300	I-135	30	Os-191	600
Sc-48	80	Nb-97	3,000	Cs-131	20,000	Os-191m	9,000
V-48	90	Mo-99	600	Cs-134	80	Os-193	200
Cr-51	6,000	Tc-96	300	Cs-134m	20,000	Ir-190	600
Mn-52	90	Tc-96m	30,000	Cs-135	900	Ir-192	100
Mn-54	300	Tc-97	6,000	Cs-136	800	Ir-194	90
Mn-56	300	Tc-97m	1,000	Cs-137	200	Pt-191	300
Fe-55	2,000	Tc-99	900	Ba-131	600	Pt-193	3,000
Fe-59	200	Tc-99m	20,000	Ba-140	90	Pt-193m	3,000
Co-57	1,000	Ru-97	1,000	La-140	60	Pt-197	300
Co-58	300	Ru-103	200	Ce-141	300	Pt-197m	3,000
Co-58m	9000	Ru-105	200	Ce-143	100	Au-196	600
Co-60	100	Ru-106	30	Ce-144	30	Au-198	100
Ni-59	300	Rh-103m	30,000	Pr-142	90	Au-199	600
Ni-63	50	Rh-105	300	Pr-143	100	Hg-197	900
Ni-65	300	Pd-103	900	Nd-147	200	Hg-197m	600
Cu-64	900	Pd-109	300	Nd-149	900	Hg-203	60
Zn-65	300	Ag-105	300	Pm-147	600	Tl-200	1,000
Zn-69	6,000	Ag-110m	90	Pm-149	100	Tl-201	900
Zn-69m	200	Ag-111	100	Sm-151	1,000	Tl-202	300
Ga-72	100	Cd-109	600	Sm-153	200	Tl-204	300
Ge-71	6,000	Cd-115	90	Eu-152	200	Pb-203	1,000
As-73	1,000	Cd-115m	90	Eu-154	60	Bi-206	100
As-74	100	In-113m	3,000	Eu-155	600	Bi-207	200
As-76	60	In-114m	60	Gd-153	600	Pa-230	600
As-77	200	In-115	300	Gd-159	200	Pa-233	300

Nuclide	pCi/L	Nuclide	pCi/L	Nuclide	pCi/L	Nuclide	pCi/L
Se-75	900	In-115m	1,000	Tb-160	100	Np-239	300
Br-82	100	Sn-113	300	Dy-165	1,000	Pu-241	300
Rb-86	600	Sn-125	60	Dy-166	100	Bk-249	2,000
Rb-87	300	Sb-122	90	Ho-166	90		

ATTACHMENT A.4. Examples of Calculations Allowed in Radiological Monitoring Activities.

Example 1. Calculating the Running Annual Average (RAA):

1st Qtr. (16 pCi/L) +2nd Qtr. (12 pCi/L) + 3rd Qtr. (13 pCi/L) + 4th Qtr. (16 pCi/L)
= (16 + 12 + 13 + 16)/4 = 14.25 pCi/L → 14 pC/L
Note: If a quarterly result is missing, divide by 3. If a sample measures at < method detection limit (DL), zero is used in calculating the RAA.

Example 2. Determining the PMCL for beta particle and photon radioactivity:

A waterworks near a nuclear power facility collects a sample for beta emitters with the following speciated results.

	X	Y	X/Y	4(X/Y)
Beta Emitters	Lab Analysis (pCi/L)	From Tables (pCi/ 4 mrem)*	Calculate Fraction	Calculate Total (mrem)
Cs-134	5,023	20,000	0.25115	
Cs-137	30	200	0.150	
Sr-90	4	8	0.5	
I-131	2	3	0.67	
		Sum of the Fractions	1.57115 ≈ 1.6	1.6 x 4=6.4 ≈6 (> 4 mrem PMCL)

*For more information, see Attachments A.3.

Example 3. Substituting Gross alpha for Radium-226:

Measured Gross alpha is < DL
Use ½ DL for gross alpha (i.e., 3 pCi/L/2 = 1.5 pC/L) to substitute for Ra-226.
Measured Ra-228 = 2 pCi/L.
Combined (Ra-226 + Ra-228) = 1.5 pCi/L + 2 pCi/L = 3.5 pCi/L
(PMCL=5 pCi/L)
Monitoring frequency: > ½ DL ≤ PMCL → Sample every 3 years

Example 4. Analyze for uranium since gross alpha >15 pCi/L:

Measured gross alpha = 24 pCi/L
Measured uranium = 22 µg/L (mass basis)
Converting to activity basis = 22 µg/L * 0.67 pCi/µg = 14.74 ≈ 15 pCi/L
Gross alpha activity (excludes radon & uranium) = 24 pCi/L – 15 pCi/L = 9 pCi/L (PMCL=15 pCi/L)
Monitoring frequency: > ½ DL ≤ PMCL → Sample every 3 years

,

ATTACHMENT B.1.a. Waterworks Owner Notification - Designation of Sources as Vulnerable to Beta Particle and Photon Emitter Radioactivity
INSTRUCTIONS: Complete/select items shown with (*italics*), and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

As part of our review process of the impact to waterworks from man-made radionuclides referenced in the *Waterworks Regulations*, we have determined that your waterworks is vulnerable to man-made beta particle and photon emitter radioactivity. This designation is based in part on *(insert details of the situation, such as proximity of waterworks to nuclear material handling facility/using a contaminated source, etc.*) within (*insert #*) [ft/miles] of the (*describe waterworks source*).

The *Waterworks Regulations* require owners of community waterworks designated as vulnerable to sample for beta particle and photon radioactivity. Entry point samples must be collected quarterly for beta emitters, and annually for tritium and strontium–90, within one quarter after notification. Therefore, you must begin sampling no later than (*insert #*) quarter of (*year*) with the results reported to us. We may reduce your monitoring frequency after one year of sampling is completed (i.e., four quarters of gross beta sampling) depending on the sample results.

Samples must be collected in an approved manner and analyzed by a laboratory approved by the Division of Consolidated Laboratory Services (DCLS) for the specific radionuclides to be tested. Not all laboratories listed under the general category of radionuclides on the DCLS approved list of drinking water labs have the capability or certification to perform all tests required by this designation. Please confirm that the laboratory you are considering has capability and certification to perform the required drinking water analyses before initiating your sampling program.

If you have any questions or concerns regarding your responsibilities for the waterworks monitoring as described above, please contact me at (*phone #*) or email (*email address*).

Sincerely,

(*Name*)
(Name) Field Office

ABC/xyz

cc: VDH, ODW – Central Office

ATTACHMENT B.1.b. Waterworks Owner Notification - Designation of Sources as Contaminated By Beta Particle and Photon Emitter Radioactivity
INSTRUCTIONS: Complete/select items shown with (*italics*), and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

As part of our review process of the impact to waterworks from man-made radionuclides referenced in the *Waterworks Regulations*, we have determined that your waterworks is contaminated by man-made beta particle and photon emitter radioactivity. This designation is based in part on *(insert details of the situation, such as proximity of waterworks to nuclear material handling facility/using a contaminated source, etc.*) within (*insert #*) [ft/miles] of the (*describe waterworks source*).

The *Waterworks Regulations* require owners of community waterworks designated as contaminated to sample for beta particle and photon radioactivity. Entry point samples must be collected quarterly for beta emitters and iodine-131, and annually for tritium and strontium–90 within one quarter after notification. Therefore, you must begin sampling no later than (*insert #*) quarter of (*year*) with the results reported to us. We may reduce your monitoring frequency after one year of sampling is completed (i.e., four quarters of gross beta sampling) depending on the sample results.

Samples must be collected in an approved manner and analyzed by a laboratory approved by the Division of Consolidated Laboratory Services (DCLS) for the specific radionuclides to be tested. Not all laboratories listed under the general category of radionuclides on the DCLS approved list of drinking water labs have the capability or certification to perform all tests required by this designation. Please confirm that the laboratory you are considering has capability and certification to perform the required drinking water analyses before initiating your sampling program.

If you have any questions or concerns regarding your responsibilities for the waterworks monitoring as described above, please contact me at (*phone #*) or email (*email address*).

Sincerely,

(*Name*)
(Name) Field Office

ABC/xyz
cc: VDH, ODW – Central Office

ATTACHMENT B.2. Waterworks Owner Notification – Designation of Sources Not Vulnerable To/Contaminated By Beta Particle and Photon Emitter Radioactivity
INSTRUCTIONS: Complete/select items shown with (*italics*), and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

As part of our review process for source water vulnerability to man-made radionuclides referenced in the *Waterworks Regulations*, we have determined that your waterworks is (select either: *not vulnerable to* or *not contaminated by*) man-made beta particle and photon emitter radioactivity. This determination is based in part on existing radiological results and the location of the nuclear material handling facilities within the Commonwealth of Virginia. Therefore, you are not required to monitor your entry point(s) for man-made beta particle and photon radioactivity at this time.

If you have any questions or concerns regarding this matter, please contact me at (*phone #*) or email (*email address*).

Sincerely,

(*Name*)
(*Name*) Field Office

ABC/xyz

cc: VDH, ODW – Central Office

Instructions and General Information

Completing the Monitoring Waiver Application Form

Introduction

The Safe Drinking Water Act requires that all community and nontransient noncommunity (NTNC) waterworks have their drinking water tested for the Phase II/V contaminants, in accordance with a Standardized Monitoring Framework consisting of a compliance cycle of 9 years made up of three consecutive 3-year compliance periods. This framework initially started in 1993 (1^{st} cycle: 1993-1998; 2^{nd} cycle: 2002-2010; 3^{rd} cycle: 2011-2019; 4^{th} cycle: 2020-2028; and so on repeating every 9 years.)

For each 3-year compliance period, all community and NTNC waterworks are required to monitor for the regulated Synthetic Organic Chemical (SOC) contaminants listed in Table 1, or the waterworks may apply for one or more SOC monitoring waivers. The Federal Regulations allow the State Health Commissioner (Commissioner), by his/her own volition or by waiver application evaluation, to grant waivers, contaminant by contaminant, for SOCs. In addition to SOC waivers, the Commissioner may grant a waiver for one inorganic chemical (IOC) - cyanide. Cyanide monitoring may be waived after the initial monitoring requirements have been completed with no detection.

The Commissioner will determine if these contaminant(s) will be waived by contaminant group, regional, or statewide grants. Waterworks that are not granted waivers must comply with the minimum sampling requirements defined in the 12VAC5-590-370, *Waterworks Regulations*. The Commissioner will grant waivers for a maximum of 3 or 9 years, depending on the contaminant and waterworks' specific conditions. Generally, waivers are renewable, but an application must be filed with the ODW prior to the waivers expiring. The Commissioner may rescind any waiver at his/her discretion, and waivers will not be granted by the Commissioner to any waterworks that knowingly falsifies information.

Definitions

"Source Water Assessment Area" is described as the watershed area as follows:

Zone 1 - This is an assessment area where contamination events are considered to have the highest risk to impact drinking water supplies under VDH Source Water Assessment Program (SWAP). Typically, Zone 1 represents a 5-mile radius upstream from a surface water intake, and a 1,000-ft radius from a groundwater source.

Zone 2 - This is an assessment area beyond Zone 1 where contamination events are considered to possibly exist and may still have an impact on drinking water supplies under the VDH SWAP. Zone 2 represents the watershed area beyond Zone 1 for a surface water intake, and the area between Zone 1 and a 1-mile radius from a groundwater source.

"Entry point" is defined as the initial location of water entering the distribution system which is representative of each source after treatment. Waterworks may have one or more entry points, and the SOC monitoring must occur at these entry points. All waiver applications must address each entry point to the waterworks.

Statewide Waivers

The United States Environmental Protection Agency (USEPA) allows States to propose statewide waivers based on geographic vulnerability assessments. The Commissioner has determined that statewide waivers are appropriate for the following chemicals: Dioxin, Endothall, Asbestos, and Glyphosate. Waivers have already been granted for these contaminants to all community and NTNC waterworks.

Contaminant-Specific Waivers

The USEPA allows States to grant contaminant-specific waivers for chemicals listed in Table 1, based on use and susceptibility determination. The Commissioner may grant waivers for three SOCs: dibromochloropropane, ethylene dibromide, and diquat. However, waterworks that are in sandy soil areas of the Tidewater region, where diquat is used, will not be granted a waiver.

In addition to SOC waivers, the Commissioner may grant a waiver for one IOC - cyanide. Cyanide monitoring may be waived after the initial monitoring requirements have been completed with no detection, with the condition that at least one cyanide sample must be taken while the waiver is effective. Waivers for cyanide are granted based on a compliance cycle of 9 years. Before considering granting a cyanide waiver, field staff should determine the vulnerability of the waterworks (i.e., a vulnerability assessment) and evaluate any prior analytical results. Issues to consider: Is chlorination utilized at the treatment process? Are the following industries in the assessment/evaluation area: (i) electroplating, (ii) steel processing, (iii) plastics, (iv) synthetic fibers, and (v) fertilizer.

A waterworks may apply for other use waivers if it can be determined that the regulated contaminant(s) were not used, manufactured, stored, transported, or disposed of in the source water assessment area. Should any contaminant(s) exist in the source water assessment area, a monitoring waiver may or may not be granted, depending on proximity to the source and other factors.

A waterworks may apply for a susceptibility waiver if the waterworks owner provides the following information for review and evaluation:

- Previous monitoring data, including well developmental samples. If a contaminant has been detected in previous monitoring, the waterworks is normally not eligible for a waiver. However, for a "no detect" of a contaminant, a waiver will typically be granted.
- Contaminant persistence and transport. As an example, a contaminant such as polychlorinated biphenyls (PCBs), which is a "Semivolatile" SOC listed in Table 1, persists in the environment, but is generally not mobile. In such situations, it is unlikely that a waiver will be granted for the contaminant.
- Aquifer properties and geological setting. A shallow, unconfined aquifer is more susceptible to contamination than a deep, confined aquifer. If a waterworks source is located in a karst area, the waterworks is not normally eligible for a waiver. A groundwater well under the direct influence of surface water (GUDI) is considered susceptible to contamination, and would not normally be eligible for a susceptible waiver.
- Well construction. Wells that do not comply with the *Waterworks Regulations* regarding construction would not be eligible for a susceptibility waiver.

Attachment A.1 Instructions & General Information for the Completion of the Waiver Application Form by Waterworks Owners.

Completing the Waiver Application Form

Complete the enclosed waiver application form for all SOC and cyanide monitoring waivers. The following tables have been provided to assist you:

- **Table 1. List of the Regulated SOC (Synthetic Organic Chemical) Contaminants** that may be waived.
- **Table 2. Common Names for Synthetic Organic Chemicals** helps to identify between the common/commercial name (i.e., "Trade" name) and the "scientific" name of a chemical product, such as a pesticide.
- **Table 3. Source Water Assessment Typical Contaminants Compendium** describes various land use activities and the types of chemical contaminants that might potentially exist or be associated with these land use activities

You may choose to use information by others. For example, ODW has developed a Source Water Assessment (SWA) information tool that can generate outputs (e.g., maps and GIS data showing land use, potential contaminant sources, etc.) specific to your waterworks. This information can be made available to you upon request through your District Engineer.

Return the completed waiver application to the appropriate ODW Field Office on or before the stated deadline in the transmittal letter. Failure to submit a waiver application will result in the waterworks having to collect the appropriate SOC and/or cyanide samples in accordance with the *Waterworks Regulations*.

If you have questions or need technical assistance, contact your District Engineer at the appropriate ODW Field Office.

Table 1. List of the Regulated SOC (Synthetic Organic Chemical) Contaminants

Volatile Fumigants 1. Ethylene dibromide 2. Dibromochloropropane **Carbamates** 3. Carbofuran 4. Oxamyl (vydate) **Chlorinated Acid Herbicides** 5. Pentachlorophenol[0] 6. 2,4-D 7. Dalapon 8. 2,4,5-TP 9. Dinoseb 10. Picloram	**Semivolatiles** 11. Polychlorinated biphenyls 12. Toxaphene 13. Alachlor 14. Atrazine 15. Benzo [a] pyrene 16. Chlordane 17. Di(2-ethylhexy)adipate 18. Di(2-ethylhexy)phthalate 19. Endrin 20. Heptachlor 21. Heptachlor epoxide 22. Hexachlorobenzene 23. Hexachlorocyclopentadiene 24. Lindane 25. Methoxychlor 26. Simazine	27. Diquat 28. Endothall 29. Glyphosate 30. 2,3,7,8-TCDD (Dioxin)

Table 2. Common Names for Synthetic Organic Chemicals

Chemical	Common Commercial Names	Origin and Use
Alachlor	Alanex; Alanox; Alatox; Alochlor; Alochlore; Chimiclor; CP 50144; Lasagrin; Lassagrin; Lasso; Lazo; Metachlor; Methachlor; and Pillarzo; Agrinate; Pillarmate	Alachlor was widely used as a pre-emergence herbicide to control annual grasses and broadleaf weeds in soybean, sorghum, cotton, vegetables, forage crops, beans, beets, cabbage, ornamentals, teas, potatoes, sugarcane, sunflowers, tobacco, peanuts, maize, groundnuts, lima beans, oilseed rape, brassicas, radish, soya bean, oil radish, and corn.
Aldicarb Sulfone	Aldoxycarb; ENT 4.9; ENT A13-29261; Standak; Sulfocarb; and UC-21865.	Aldicarb Sulfane is a breakdown product of aldicarb.
Aldicarb Sulfoxide	Temik Sulfoxide.	Aldicarb Sulfoxide is a breakdown product of aldicarb.
Aldicarb	Aldecarb; Carbamyl; Carbanolate; ENT 27,093; NCI-C08640; OMS 771; Sulfone aldoxycarb; Temic; Temik; and UC 21149.	Aldicarb was used as a pesticide to control insects, mites and nematodes on ornamentals, sugar beet, fodder beet, strawberries, potatoes, onions, hops, vine nurseries, tree nurseries, groundnuts, soya beans, citrus fruit, bananas, coffee, sorghum, pecans, cotton, and sweet potatoes.
Aldrin	Aldocit; Aldrec; Aldrex; Aldrine; Aldrite; Aldrix; Aldron; Aldrosol; Algran; HHDN; Kortofin; Ocudene; Seedrin; Seedrin; Soilgrin; Tatuzinho; and Tipula.	Aldrin is an insecticide used to control soil-dwelling pests.
Atrazine	A 361; Aatrex; Actinite; Akticon; Aktikon; Aktinit; Argezin; Atazinax; Atranex; Atrasine; Atrataf-, Atratol A; Atrazin; Atrex; Atred; Candex; Cekuzina-T; Chromozin; Crisatrina; Crisazine; Cyazin; Fenamin; Fenamine; Fenatrol; G 30027; Geigy 30,027; Gesaprim; Gesoprim; Griffex; Hungazin; Inakor; Oleogesaprim; Pitezin; Primatol; Primaze; Radazin; Radizine; Strazine; Triazine A 1294; Vectal; Weedex A; Wonuk; Farmco Atrazine; Fiffex 4L; G30027; Gesaprim; Malermais; Zeaphos; Zeazin; Zeazine; and Caswell No. 063.	Atrazine was widely used as a herbicide for control of broadleaf and grassy weeds in corn, sorghum, sugarcane, pineapple, citrus fruits, bananas, rangeland, macadamia orchards, turf grass sod, conifer reforestation, Christmas tree plantation, asparagus, forestry, grasslands, grass crops, roses, African oil palm, and coffee.
Benzo(a)pyrene	BaP; 3,4-Benz(a)pyrene	Benzo(a)pyrene is found in exhaust from motor vehicles and other gasoline and diesel engines, emission from coal-, oil-, and wood-burning stoves and furnaces, cigarette smoke; general soot and smoke of industrial, municipal, and domestic origin, and cooked foods, especially charcoal-broiled; in incinerators, coke ovens, and asphalt processing and use.
Butachlor	Aimehlor; Lambast; Mach-Mach; and Weedout.	Butachlor is an herbicide used to control most annual grasses and certain broadleaf weeds.
Carbaryl	Arilat; Arilate; Arylam; Atoxan; Befcema	Carbaryl is used as an insecticide for corn, alfalfa, livestock, poultry,

Chemical	Common Commercial Names	Origin and Use
	NMCSO; Bug Master; Carbamine; Carbaril; Cekubaryl; Crunch; Denapon; Devicarb; Dicarbam; Germain's; Hexavin; Karbaspray; Karbatox; Menaphtam; Monsur; Murvin; Panam; Pomex; Savit; Sedit F; Seffein; Septene; Sevin; Pellents; Tercyl; and Tricarnam.	gardens, lawns, mangoes, bananas, strawberries, nuts, vines, olives, okra, curcurbits, sorghum, lucerne, potatoes, ornamentals, and forestry.
Carbofuran	Bay 70143; Brifur; Carbofuran; Chinufur; Crisfuran; Curateff; Curaterr; D1221; ENT 27164; FMC 10242; Furacarb; Furadan; Furodan; Kenofuran; Niagara 10242; OMS 964; Pillarfuran; and Yaltox.	Carbofuran was used as an insecticide, nematocide, and miticide to control insects, mites, and nematodes in corn, alfalfa weevil, aphids, lygus bugs, foliage feeding insects in tobacco, thrips in peanuts and cotton, rice water weevil, wireworms, sugarcane borer in sugarcane, greenbug in sorghum, Colorado potato beetle, leafhoppers, flea beetles in potatoes, mexican bean beetle in soybeans, foliar feeding insects, phylloxera in grapes, grasshoppers, stem weevils, and sunflower beetles.
Chlordane	Aspon-chlordane; Belt; CD 68; Chlor Kil; Chlordan; Chlordano; Chlorindan; Chlortox; Corodane; Cortilan-Neu; Dowchlor; ENT 25,552-X; ENT 9,932; Gold Crest C-100; HCS 3260; Intox; Kilex Lindane; Kypchlor; NCI-C00099; Niran; Octa-Klor; Octa-Klor; Octachlor; Oktaterr; Ortho-Klor; Pentiklor; Prentos; Synklor; Tat Chlor; Termi-Ded; Topiclor; Toxichlor; Velsicol 1068; and Intox 8.	Chlordane was used as a fumigant, an acaricide, and an insecticide to control underground termites, grubs, ants, webworms, armyworms, cutworms, fire ants, chiggers and leafhoppers in homes, gardens, ornamentals, deciduous fruits, nuts, corn, citrus, vegetables, lawns, turf, ditch banks, and roadsides.
Dibromochloropropane (1,2-dibromo-3-chloropropane)	BBC 12; DBCP; Fumagon; Fumazone; NCI-C00500; Nemabrom; Nemaftune; Nemagone; Nemanax; Nemapaz; Nemaset; Nematocide; and Nemawn.	Dibromochloropropane was used as a pesticide to control nematodes on cucumbers, summer squash, cabbage, cauliflower, carrots, snap beans, okra, aster, shasta, daisy, ornamental turf (lawns), bermuda grass, centipede grass, St. Augustine grass, zoysia gram, ardisia, azalea, camellia, forsythia, gardenia, hibiscus, roses and arborvitae. Dibromochloropropane's use was discontinued in 1979.
2,4-D	2,4-dichlorophenoxyacetic acid; A-4D; Acme LV 4; Acme Amine 4; Acme LV 6; Agent White; Agricorn D; Agrotect; Agroxone; AGSCO 400; Amoxone; AquaKleen; B-Selektonon; Barrage; Bladex-B; Brush Killer 64; Butyl Ester 4; Chipco Turf Herbicide D; Chloroxone; Croprider; Dicofur; Dinoxol; DMA 4; Dormon; 2,4-Dichloro-phenoxyacetic	2,4-D is an herbicide commonly used on wheat, sorghum, corn barley, rangeland, pasture, and by homeowners to control canada thistle, ragweed, annual mustards, lambs quarters, dandelions and other broadleaf plants in the lawn. If you have used a dandelion killer on your lawn, you have probably used 2,4-D.

Chemical	Common Commercial Names	Origin and Use
	acid; Fernesta; Ferxone; Green Cross Weed-No-More 80; Hedonal; Ipaner; Lawn-Keep; Macondray; Malerbane; Malerbane Cereali; Mota Maskros; Moxon; Netagrone; Permamine D; Pielik; Planotox; Plantgard; Red Devil Dry Weed Killer; Scott's 4XD; Silvaprop; Tributon; Verton; Weedone; Weed Rhap; Weed-Ag-Bar; Weed-B-Gone; Weedar; Weedatul; Weedez Wonder Bar; and Weedtrine-11.	
Dalapon	Alatex; Basfapon; Basinex; Crisapon; Dalacide; Dalapon-NA; Dawpon-RAE; Ded-Weed; Devipon; Dowpon; DPA; Gramevin; Kenapon; Liropon; Propon; Proprop; Radapon; Revenge; Unipon S-1315; S-95; 2,2-DPA; and 2,2-dichloro-proprionic acid	Dalapon is used as an herbicide to control grasses in crops, drainage ditches, along railroads and in industrial areas.
Di(2-ethylhexyl)adipate	Adipol, Bisoflex, Effomoll, Kodiflex, Monoplex, Plastomoll, Sicol, Truflex, Vestinol, Wickenol, Witamol, Ergoplast, Kemester, Reomol, Rucoflex, and Staflex	Di(2-ethylhexyl)adipate is released in fly ash from municipal waste incineration, wastewater effluent from sewage treatment plants and chemical manufacturing plants, Since Di(2-ethylhexyl)adipates are known to leach from plumbing made of PVC plastic, they have been recognized as a potential drinking water contaminant. If released to soil or water, Di(2-ethylhexyl)adipate is expected to be broken down by microbes. It will adhere to sediments in water bodies and will not leach through soil to ground water.
Di(2-ethylhexyl)phthalate	BEHP; Bisoflex 81; DAF 68; DEHP; Dioctyl phthalate; Ergoplast; Eviplast; Fleximel; Flexol; Good-rite GP264; Hatcol; Hercoflex 260; Kodaflex; Mollan; Nuoplaz; Palatinol; Pittsburgh PX-138; Platinol AH; Octoil; RC Plasticizer; Reomol; Sicol; Staflex; Truflex; Vestinol; Vinicizer;	Disposal of polyvinyl chloride and other di(2-ethylhexyl)phthalate containing materials by incineration, landfill, etc., will result in the release of di(2-ethylhexyl)phthalate into the environment.
Dibromochloropropane	BBC 12; DBCP; Fumagon; Fumazone; Nemabrom; Nemafum; Nemafon; Nemanax; Nemapaz; Nemaset; Nemazon; Gro-Tone Nematode; and Durham Nematocide.	Dibromochloropropane was released into the environment from fumigants and nematocide uses.
Dicamba	Banvel; Brush Buster; Compound B; Dianat; MDBA; Mediben; Metambane; and Velsicol.	Dicamba is a post-emergence herbicide commonly used on corn oats, wheat, for lawn care, and right-of-ways. Dicamba controls weeds in crops lands and non-crop areas and to control brush and vines in non-cropland, pastures and rangeland areas.

Chemical	Common Commercial Names	Origin and Use
Dieldrin	Alvit; Dieldrex; Dieldrite; Dielmoth; HEOD; Octalox; Quintox; Red Shield; Termitox; and Illoxol.	Dieldrin is an insecticide used for soil insects, termites, and several other pests.
Dinoseb	Aatox; Basanite; Butaphene; BNP-20; Caldon; Chemox; Chemsect; Desicoil; Dibutox; Dinitrall; Dinitro; Dinitrobutyl-phenol; Dow Selective Weed Killer; DNBP; Dynamyte; Dytop; Elgetol; Gebutox; Hel-Fire; Hivertox; Kiloseb; Knox-Weed; Ladob; Laseb; Nitropone C; Premerge; Sinox General; Subitex; Unicrop DNBP; and Vertac Dinitro Weed Killer.	Dinoseb is used as an insecticide, ovicide, desiccant, and dormant fruit spray.
Diquat	Aquacide; Deiquat; Dextrone; Reglone; sand Weed-trine-D.	Diquat is commonly used on potatoes and for aquatic plant control.
Dioxin (2,3,7,8-TCDD)	Dioxin and Tetradioxin	Dioxin is one of the most toxic and environmentally stable tricyclic aromatic compounds of its structural class. Due to its very low water solubility, most of the dioxin occurring in water will adhere to sediments and suspended silts. Similarly, it tends to adhere to soil if released to land, and is not likely to reach ground water.
Endothall	Accelerate; Aquathol; Des-i-cate; Endothall Turf Herbicide (ETH); Endothall Weed Killer; Herbicide 273; Herbon Pennout; Hydout; Hydrothol; and Niagrathal.	Endothall is used as a defoliant, desiccant, and as an herbicide for terrestrial and aquatic weeds.
Endrin	Compound 269; EN 57; Endrex; Endricol; Hexadrin; Mendrin; Nendrin; and Oktanex.	Endrin is an insecticide used to control army cutworm, pale western cutworm, pine vole, meadow vole, and grasshoppers on cotton, maize, grains, rice, ornamentals, cereals, sugarcane, and apple orchards.
Ethylene Dibromide	Aadibroom; Bromofume; Celmide; Dowfume; E-D-Bee; EDB; EDB-85; ENT 15,349; Glycol dibromide; Iscobrome D; KopFume; NCIC00522; Nefis; Nephis; Pestmaster; Sanhyuum; Soilbrom; Soilfume; and Unifume.	Ethylene Dibromide was used as a fumigant, an insecticide, a nematicide, and a solvent for agricultural settings but it is no longer used to control nematodes, to fumigate grains and fruits, to dissolve resins, gums, and waxes, and as a scavenger for lead in gasoline. EPA banned the use of Ethylene Dibromide in 1983.
Glyphosate	Glialka; Glifonox; Glycel; Glycine; Muster; Rodeo; Rondo; Round-up; Sonic; Spasor; Sting; and Tumbleweed.	Glyphosate is an herbicide used in field crops, right-of-ways, and homeowners use for control of grasses, broadleaf weeds and woody brush.
Heptachlor and Heptachlor Epoxide	Aahepta; Agroceres; Basaklor; Drinox; H-34; Eptacloro; Gold Crest H-60; GPKH; Hepta; Heptachloor; Heptachlorane; Heptachlore; Heptagran; Heptagranox; Heptamak;	Heptachlor was used as an insecticide for control of termite, cotton boll weevil, white grubs, root weevils and wireworms on certain field crops, citrus crops, foliar treatment, seed treatment, vegetables, sugar beets, and pineapples.

Chemical	Common Commercial Names	Origin and Use
	Heptarnul; Heptamul; Heptasol; Heptox; Rhodiachlor; Soleptax; Termide; and Velsicol.	
Hexachlorobenzene	Anticarie; Amatin; Bunt-cure; Bunt-no-more; Ceku C.B.; Co-op hexa; Granox; HCB; Hexa CB; Julin's carbon chloride; No Bunt; Phenyl perchloryl; Perchlorobenzene; Sanocide; Snieciotox; Smut-go; and Voronit C.	Hexachlorobenzene is used as a fungicide for seed protection.
Hexachlorocyclopentadiene	Hex and Hexachloropentadiene	Hexachlorocyclopentadiene is not a persistent environmental contaminant. If released to soil, it is likely to adhere to soil where it will be degraded by microbes. In water it evaporates quickly and is attacked by sunlight and other reactive chemicals.
3-Hydroxycarbofuran	Carbofuran-3-hydroxy;	3-Hydroxycarbofuran is a metabolite of the insecticide carbofuran, a fumigant used on rice and alfalfa.
Lindane	Agronexit; Etan 3G; Exagamma; Forlin; Gamaphex; Gamma BHC; Gamma-Hexachlorocyclohexane; Gamma-Mean 400; Gamma-Mean L.O.; Gammex; Gammaphex; HCH; Hi Lin; Inexit; Isotox; Kwell; Lacco Lin-0-Mulsion; Lacco; Lin-O-Sol; Lindagam; Lindagranox; Lindaterra; Lovigram; Necit; Novigam; and Silvanol.	Lindane was used as a insecticide for corn, wheat, ornamental, pastures, forage crops, forestry, timber protection, livestock, and for soil and seed treatment and viticulture.
Methomyl	Metomil; Mesomile; Acinate, Agrinate, DuPont 1179, Flytek, Kipsin, Lannate, Lanox, Memilene, Methavin, Methomex, Nudrin, NuBait, Pillarmate; and SD 14999	Methomyl is a broad-spectrum insecticide that is used to kill insect pests. It is registered for commercial/professional use under certain conditions on sites including field, vegetable, and orchard crops; turf (sod farms only); livestock quarters; commercial premises; and refuse containers. Products containing 1% Methomyl are available to the general public for retail sale, but more potent formulations are classified as restricted-use pesticides.
Methoxychlor	Chemform; Dimethoxy-DDT; DMDT; Double-M EC; Flo Pro Mc; Higalmetox; Maralate; Methoxcide; Methoxo; Methoxy-DDT; Methoxo; Methoxcide; Metox; and Moxie.	Methoxychlor is used as an insecticide on sweet corn, snap beans, apples, and is effective against mosquito larvae and house-flies.
Metolachlor	Bicep; COA; Dual; Humextra; Metelilachlor; Metolachlore; Pennant; Primagram; and Primextra.	Metolachlor is a selective herbicide used for pre-emergence and preplant incorporated weed control in corn soybean, potatoes, maize, sorghum, cotton, sugar beet, fodder. beet, groundnuts, safflowers, sunflowers, woody ornamentals, sunflowers and flax.
Metribuzin	Bay; Bayer; Lexone; Sencor; Sencoral;	Metribuzin is an herbicide used to control grassy and broadleaf weeds in

Chemical	Common Commercial Names	Origin and Use
	Sencorex; and Sengoral.	soybeans and potatoes.
Oxamyl	DPX 4010; Dioxamyl; Dupont 1410; Oxamil; Thioxamyl; and Vydate.	Oxamyl is used as an insecticide, acaricide and nematocide on field crops, vegetables, apples, other fruits, ornamentals, and mint.
Pentachlorophenol	Antimicrobial; Block Penta; Chlon; Dowicide EC-7; Dura Treet 11; Forpen-50; Fungifen; GLAZD Penta; Grundier Arbezol; Lauxtol; Liroprern; Ontrack WE Herbicide; Osmose WPC; PCP; Penchlorol; Penta; Penta Ready;Penta WR; Pentacon; Penwar; Permasan; Priltox; Santobrite; Santophen; Sinituho; Watershed WP; Weed and Brush Killer; Weedone; and Woodtreat.	Pentachlorophenol is a wood preservative commonly used for treating fence posts and in other applications where wood is expected to come in contact with the soil to protect against fungal decay and termite attack. In addition, pentachlorophenol is used as an herbicide, antimicrobial agent, disinfectant, mollusicide, slimicide, algaecide, and defoliant.
Picloram	Agent White; Arndon; Borolin; Grazon; K-Pin; Pinene; and Tordon.	Picloram is used as an herbicide for control of broadleaf and woody plants in range lands, pastures, and in rights-of-way for powerlines and highways.
Polychlorinated Biphenyls (PCBs)	Aroclor; Dykanol; Chlorextol; Chlorinated diphenyl; Clophen; Fenclor; Inerteen; Kanechlor; Monter; Noflamol; PCB; Pyralene; Santotherm; Sovol; and Therminol.	Polychlorinated Biphenyls current releases are due mainly to the cycling of this persistent contaminant from soil to air to soil. PCBs are released from landfills, incineration of municipal refuse and sewage sludge, and improper (or illegal) disposal of PCB materials, such as waste transformer fluid, to open areas.
Propachlor	Ramrod; Bexton; and CP 31393.	Propachlor is a preemergence herbicide on corn (all types), soybeans (seed only), grain sorghum (milo), green peas, pumpkins, cotton, and flax. In corn, it can also be applied as an early postemergence control. Sorghum is the largest use site for propachlor, accounting for most uses of the wettable powder formulation. Corn is the second largest use site for propachlor, accounting for most uses of the granular formulation.
Simazine	Aktinit; Aquazine; Batazina; Bitemol; CAT; CDT; Cekusina; CET; Geigy; Gerbazin; Gerbex; Gesatop; Herbazin; Herbex; Hungazin; Premazine; Primatol S; Princep; Printop; Radocon; Simadex; Tafazine; Totazina; and Zeapur.	Simazine is an herbicide used as a selective pre-emergence herbicide for control of most annual grasses and broadleaf weeds in corn, apples, and various other crops and in certain ornamental and tree nursery stock, such as Christmas trees and in turf grass soil production. It is also used to inhibit the growth of algae in aquariums, fish ponds and fountains.
Toxaphene	Agricide Maggot Killer; Alltex; Alltox; Anatox; Attac; Argo-Chem Brand Torbidan 28; Camphechlor; Camphochlor; Camphophene Huileux; Chem-Phene; Chlorinated Camphene; Cotton-Tox; Crestoxo; Compound 3956; Dr. Roger's Toxene; Estonox; Fasco-Terpene; Geniphene; Gy-phene; Hercules; Kamfochlor; M5055; Melipax; Motox;	Toxaphene is used as an insecticide for cranberries, strawberries, apples, pears, quinces, nectarines, peaches, bananas, pineapple, eggplant, peppers, pimentos, tomatoes, broccoli, brussel sprouts, cabbage, cauliflower, collards, kale, kohlrabi, spinach, lettuce, parsnips, rutabagas, beans, cowpeas, okra, barley, oats, rye, celery, cotton, peas, soybeans, peanut, corn, wheat, rice, alfalfa, sorghum, fruits, nuts, ornamentals, forage, turf, cattle, sheep, goats, swine, and horses.

Chemical	Common Commercial Names	Origin and Use
	Octachlorocamphene; PCC; Penphene; Phenacide; Phenatox; Polychlorocamthene; Poxyphen; Rigo Toxaphene; Royal Brand Bean Tox; Security Tox-Sol-6; Security Tox-MP cotton spray; Strobane T-90; Strobane-T; Toxadust; Tox"; Toxaphen; Toxon 63; and Vertac 90%.	
2,4,5-Trichlorophenoxypropionic Acid (2,4,5-TP)	2-(2,4,5-trichlorophenoxy)proprionic acid; Amchern; Amchem 2,4,5 TP; Aqua-Vex; Color-Set; Ded-Weed; Double Strength; Fenoprop; Fenormone; Fruitone T; Garlon; Kuron; Kurosal; Miller Nu Set; O-X-D; Propon; Silvex; Silvi-Rhap; Sta-Fast; and Weed-B-Gone.	2,4,5-Trichlorophenoxypropionic Acid is used as an herbicide for weed and brush control on floodways, canals, reservoirs, streams, pasture, rangeland, lawns, turf, and aquatic use.

Table 3. Source Water Assessment - Typical Contaminants Compendium

Land Use or Activity	Typical Contaminants[1,2,3]	Potential Contaminant Types
COMMERCIAL / INDUSTRIAL		
Auction lots	Livestock sewage wastes; nitrates; phosphates; coliform and noncoliform bacteria; giardia, viruses; total dissolved solids	Inorganics
Automotive Body shops/repair shops Car washes Gas stations	Waste oils; solvents; acids; paints; automotive wastes[4]; miscellaneous cutting oils Soaps; detergents, waxes; miscellaneous chemicals oils; solvents; gasoline, diesel, miscellaneous wastes, lead	Inorganics, SOCs, VOCs
Boat Services/repair/refinishing	Diesel fuels; oil; septage from boat waste disposal area; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes[4]	Inorganics, SOCs, VOCs
Cement / concrete plants	Diesel fuels; solvents; oils; miscellaneous wastes	Inorganics, SOCs, VOCs
Dry cleaners	Solvents (perchloroethylene, petroleum solvents, Freon); spotting chemicals (trichloroethane, methyl chloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)	VOCs
Electrical/electronic manufacturing	Cyanides; metal sludges; caustic (chromic acid); solvents; oils; alkalis; acids; paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene; trichloroethane; acetone; methanol; toluene; PCBs	Inorganics, SOCs, VOCs
Food processing / Animal Slaughtering	Nitrates; salts; phosphorus; miscellaneous food wastes; chlorine; ammonia; ethylene glycol	Inorganics, Microbial, VOCs, SOCs
Funeral homes and Mortuaries	External corporeal wash water, internal body fluids, as well as residual arterial embalming chemicals (formaldehyde, phenol, and methanol	Inorganics, Microbial, SOCs, VOCs
Furniture repair/manufacturing	Paints; solvents; degreasing and solvent recovery sludges; lacquers; sealants	Inorganics, SOCs, VOCs
Hardware/lumber/parts stores	Hazardous chemical products in inventories; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote; paints; thinners; lacquers; varnishes	Inorganics, SOCs, VOCs
Home manufacturing	Solvents; paints; glues and other adhesives; waste insulation; lacquers; tars; sealants; epoxy wastes; miscellaneous chemical wastes	Inorganics, SOCs, VOCs
Hospitals/Research laboratories	X-ray developers and fixers[8]; infectious wastes; radiological biological wastes, disinfectants; asbestos; beryllium; solvents; infectious materials; drugs; disinfectants; (quaternary ammonia, hexachlorophene, peroxides, chlorhexidine, bleach); and miscellaneous chemical wastes.	Inorganics, Microbial, RADs, SOCs, VOCs

Junk/scrap/salvage yards	Automotive wastes[4]; PCB contaminated wastes; any wastes from businesses[6] and households[7]; oils; lead	Inorganics, SOCs, VOCs
Machine shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mold-release agents	Inorganics, SOCs, VOCs
Medical/vet offices	X-ray developers and fixers[8]; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; variable miscellaneous chemicals	Inorganics, Microbial, RADs, SOCs, VOCs
Metal plating/finishing/ fabricating	Sodium and hydrogen cyanide; metallic salts; hydrochloric acid; sulfuric acid; chromic acid; boric acid; paint wastes; heavy metals; plating wastes; oils; solvents	Inorganics, SOCs, VOCs
Military installations	Wide variety of hazardous and nonhazardous wastes depending on the nature of the facility and operation[9]; diesel fuels; jet fuels; solvents; paints; waste oils; heavy metals; radioactive wastes	Inorganics, RADs, SOCs, VOCs
Office buildings/complexes	Building wastes[6]; lawn and garden maintenance chemicals[5]; gasoline; motor oil	Inorganics, SOCs, VOCs
Parking lots/malls	Hydrocarbons; heavy metals; building wastes[6]	Inorganics, SOCs, VOCs
Pharmaceutical	TSS, oil & grease, fecal coliform, volatile organic compounds, nonconventional pollutants.	Microbial, SOCs, VOCs
Photo processing, print shop	Ethanol, isopropanol, ethylene glycol, xylene, toluene, cyclohexanone, petroleum products, volatile organic compounds, lead, chromium, silver, cadmium, and barium,	Inorganics, SOCs, VOCs
Textiles	Scouring alkali waste, oils, surfactants, lubricants, dye, bleaching (hydrogen peroxide, sodium hypochlorite, sodium chlorite, sulfur dioxide), caustic soda, salts	Inorganics, SOCs
Wood preserving/treating	Wood preservatives; creosote, pentachlorophenol, arsenic, dioxin.	Dioxin, Inorganics, SOCs
Wood/pulp/paper processing and mills	Metals; acids; minerals; sulfides; other hazardous and nonhazardous chemicals[9]; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide; treated wood residue (copper quinolate, mercury, sodium azide); tanner gas; paint sludges; solvents; creosote; coating and gluing wastes, dioxin.	Dioxin, Inorganics, SOCs
Chemical Processing / Storage		
Above/Below ground storage tanks	Heating oil; diesel fuel; gasoline; other chemicals	Inorganics, SOCs, VOCs
Chemical/petroleum processing/storage	Hazardous chemicals; solvents; hydrocarbons; heavy metals; asphalt	Inorganics, SOCs, VOCs
Coal Gasification Facility	Gas loss, leaching of residual products found in ash residue in the spent gasification cavity (calcium, sodium, sulfate, bicarbonate, metals), condensed liquids (BTEX, phenolic compounds, Polycyclic aromatic hydrocarbons (PAHs) and heterocyclic compounds.	Inorganics, SOCs, VOCs
Pesticide / Herbicide / Fertilizer Manufacture / Distribution / Storage	Wide variety of hazardous and nonhazardous wastes depending on the nature of the facility.	Inorganics, SOCs, VOCs
Plastics/synthetics producers	Solvents; oils; miscellaneous organic and inorganics (phenols, resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfactant; glycols; phenols; formaldehyde; peroxides; etc.	Inorganics, SOCs, VOCs

Disposal		
Solid Waste Collection / Transfer Site	Wide variety of contaminants depending on the historical use. Anthropogenic waste (toxic metals, hydrocarbons, chlorinated hydrocarbons, surfactant-derived compounds, phthalates, pharmaceutical chemicals. Biological waste (ammonia, dissolved organic carbon, aliphatic compounds, phenols, derivates of abietic acid)	Inorganics, Microbial, SOCs, VOCs
Hazardous Waste Recovery Facility / Waste Transfer / Storage / Disposal and Superfund Sites	Wide variety of contaminants depending on historical use.	Inorganics, Microbial, RADs, SOCs, VOCs
Resource Extraction		
Shale Gas extraction / Coalbed methane extractions / Tight sands hydraulic fracturing	Total dissolved solids, fracturing fluid additives: acids, biocides, gel agents, clay stabilizers, corrosion inhibitors, pH adjusting agents, scale inhibitors, surfactants; metals, naturally occurring radioactive materials.	Inorganics, RADs, SOCs, VOCs
Mines/gravel pits	Mine spills or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulfides; metals; acids; minerals sulfides; other hazardous and nonhazardous chemicals[9]	Inorganics, RADs, VOCs
NON-INDUSTRIAL		
Golf courses	Fertilizers [12]; herbicides[11]; pesticides for controlling mosquitoes, ticks, ants, gypsy moths, and other pests [5]	Inorganics, SOCs, VOCs
Transportation		
Airports (maintenance/fueling areas)	Jet fuels; deicers; diesel fuel; chlorinated solvents; automotive wastes;[4] heating oil; building wastes[6]	VOCs
Barge and Vessel Traffic	Fuel, miscellaneous wastes; oil; variable transported materials	Inorganics, Microbial, RADs, SOCs, VOCs
Boat ramps and marinas	Gasoline, diesel, miscellaneous wastes, lead, waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes[4]; deicing products; variable transported materials	Inorganics, SOCs, VOCs
Fleet / trucking / bus terminals	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes[4]	Inorganics, SOCs, VOCs
Primary Roadways / Truck Terminals	Gasoline, diesel, miscellaneous wastes, lead, waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes[4]; deicing products; variable transported materials	Inorganics, Microbial, RADs, SOCs, VOCs
Railroad tracks / yards / maintenance / fueling areas	Diesel fuel; herbicides for rights-of-way [11]; creosote from preserving wood ties; solvents; paints; waste oils	Inorganics, Microbial, RADs, SOCs, VOCs
Agriculture		
Crop and Fodder Production/ Specialty Crop Production/Nursery	Pesticides, herbicides, fertilizers, nitrates.	Inorganics, SOCs, VOCs
Pasture (Grazing)/Confined Animal Feeding Operations/Aquaculture	Nutrients: nitrogen, ammonia, and phosphorus; organic matter; pathogens; parasites, bacteria, and viruses; solid matter; pesticides and hormones; antibiotics, metals	Inorganics, Microbial
Land Disposal		

Cemetery	Microbiological contaminants including *Staphylococcus spp.*, *Bacillus spp.*, *Enterobacteriaceae spp.*, fecal streptococci, *Clostridium spp.*, *Helicobacter pylori*, enteroviruses, rotavirus, calicivirus; arsenic, mercury, formaldehyde, copper, lead, zinc.	Inorganics, Microbial, SOCs
Injection wells/drywells/sumps	Stormwater runoff; spilled liquids; used oils; antifreeze; gasoline; solvents; other petroleum products; pesticides[11]; and a wide variety	Inorganics, Microbial, RADs, SOCs, VOCs
Landfills/dumps (active and closed)	Leachate; organic and inorganic chemical contaminants; waste from households[7] and businesses[6]; nitrates; oils; metals; solvents; sludge	Inorganics, Microbial, SOCs, VOCs
Septic systems	Nitrates; septage; Cryptosporidium; Giardia; coliform[10] and noncoliform bacteria; viruses; drain cleaners; solvents; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides;[5,13] paints; paint thinner; swimming pool chemicals;[14] septic tank/cesspool cleaner chemicals[15]; elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate; other household hazardous wastes[7]	Inorganics, Microbial
Utilities		
Urban stormwater management infrastructure	TSS, pesticides and fertilizers, animal waste, metals, oil and grease/hydrocarbons, bacteria and viruses, nitrogen and phosphorus ,	Inorganics, Microbial, SOCs, VOCs
Utility stations/maintenance areas	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way	Dioxin, SOCs
Wastewater treatment facilities	Municipal wastewater; sludge[16]; treatment chemicals[17]; nitrates; heavy metals; coliform[10] and noncoliform bacteria; nonhazardous wastes[16]	Inorganics, Microbial, SOCs, VOCs

NOTES

[1] This table lists the most common wastes, but not all potential wastes. For example, it is not possible to list all potential contaminants contained in stormwater runoff or from military installations.

[2] In general, water contamination stems from the misuse and improper disposal of liquid and solid wastes; the illegal dumping or abandonment of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or the improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial drinking water wells and liquid and solid waste disposal facilities. Contaminants also can stem from atmospheric pollutants, such as airborne sulfur and nitrogen compounds, which are created by smoke, flue dust, aerosols, and automobile emissions, fall as acid rain, and percolate through the soil. When the contaminants list in this table are used and managed properly, environmental contamination is not likely to occur.

[3] Contaminants can reach water bodies from activities occurring on the land surface, such as industrial waste storage; from sources below the land surface but above the water table, such as septic systems; from structures beneath the water table, such as wells; or from contaminated recharge water.

[4] Automobile wastes can include gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils.

[5] Common pesticides used for lawn and garden maintenance (i.e., weed killers, and mite, grub, and aphid controls) include such chemicals as 2,4-D; chlorpyrifos; diazinon; benomyl; captan; dicofol; and methoxychlor.

[6] Common wastes from public and commercial buildings include automotive wastes; and residues from cleaning products that may contain chemicals such a xylenols, glycol esters, isopropanol, 1,1,1-trichloroethane, sulfonates, chlorinated phenols, and cresols.

[7] Household hazardous wastes are common household products which contain a wide variety of toxic or hazardous.

[8] X-ray developers and fixers may contain reclaimable silver, glutaraldehyde, hydroquinone, potassium bromide, sodium sulfite, sodium carbonate, thiosulfates, and potassium alum.

[9] The Resource Conservation and Recovery Act (RCRA) defines a hazardous waste as a solid waste that may cause an increase in mortality or serious illness or pose a substantial threat to human health and the environment when improperly treated, stored, transported, disposed of, or otherwise managed. A waste is hazardous if it exhibits characteristics of ignitability, corrosivity, reactivity, and/or toxicity. Not covered by RCRA regulations are domestic sewage; irrigation waters or industrial discharges allowed by the Clean Water Act; certain nuclear and mining wastes; household wastes; agricultural wastes (excluding some pesticides); and small quantity hazardous wastes (i.e., less than 220 pounds per month) generated by businesses.

[10] Coliform bacteria can indicate the presence of pathogenic (disease-causing) microorganisms that may be transmitted in human feces. Diseases such as typhoid fever, hepatitis, diarrhea, and dysentery can result from sewage contamination of drinking water supplies.

[11] Pesticides include herbicides, insecticides, rodenticides, fungicides and avicides. EPA has registered approximately 50,000 different pesticide products for use in the United States. Many are highly toxic and quite mobile in the subsurface. An EPA survey found that the most common pesticides found in drinking water wells were DCPA (dacthal) and atrazine, which EPA classifies as moderately toxic (class 3) and slightly toxic (class 4) materials, respectively

[12] The EPA National Pesticides Survey found that the use of fertilizers correlates to nitrate contamination of groundwater supplies.

[13] Common household pesticides for controlling pests such as ants, termites, bees, wasps, flies, cockroaches, silverfish, mites, ticks, fleas, worm, rates, and mice can contain active ingredients include naphthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons, arsenic, strychnine, kerosene, nitrosamines, and dioxin.

[14] Swimming pool chemicals can contain free and combined chlorine; bromine; iodine; mercury-based, copper-based, and quaternary algaecides; cyanuric acid; calcium or sodium hypochlorite; muriatic acid; sodium carbonate.

[15] Septic tank/cesspool cleaners include synthetic organic chemicals such as 1,1,1 trichloroethane, tetrachloroethylene, carbon tetrachloride, and methylene chloride.

[16] Municipal wastewater treatment sludge can contain organic matter, nitrates; inorganic salts, heavy metals; coliform and noncoliform bacteria; and viruses.

[17] Municipal wastewater treatment chemicals include calcium oxide; alum; activated alum, carbon, and silica; polymers; ion exchange resins; sodium hydroxide; chlorine; ozone; and corrosion inhibitors.

Application for Monitoring Waivers

Compliance Period: 2020-2022 (SOC Waivers)
Compliance Cycle: 2020-2028 (Cyanide Waiver)

To apply for monitoring waivers, the waterworks owner must complete all the information requested on this form for each entry point. **Use a separate form for each entry point.** Providing false information will result in a denial of waivers. This application is for the following waivers:

Name of Waterworks	PWSID #
Printed Name of Applicant	Title
Street Address of Waterworks	(Area Code) Telephone Number
City or Town; State; Zip Code	County/City
WATERWORKS CLASSIFICATION (check one): ☐ Community ☐ Non-transient Non-community	TYPE OF SOURCE (check one): ☐ Groundwater (including springs) ☐ Surface water (including GUDIs)
ENTRY POINT:	
SOURCE NAME*:	

* List additional sources that are associated with this entry point. Note: The Source Name and Entry Point designation **must agree** with those previously established by the ODW field office.

Monitoring Waivers Requested [Check all that apply]	
☐ SOC – Volatile Fumigants	☐ SOC – Semi-Volatiles
☐ SOC – Carbamates	☐ SOC – Diquat
☐ SOC – Chlorinated Acid herbicides	☐ Cyanide*

**Cyanide waivers will be considered based on a vulnerability assessment and prior results of the waterworks.*

Please mark what best describes the **soil in the assessment area** **[**1,000-feet radius (Zone 1) for Groundwater Source or 5-mile radius upstream of a Surface Water Source intake]:
☐ Sandy soil underlain by unconsolidated formations ☐ Topsoil rich in humus ☐ Topsoil with heavy clay ☐ Other soils (please describe):

Observed Land Use/Activity - Check [√] all that apply	
☐ Residential	☐ Undeveloped
☐ Livestock	☐ Abandoned Wells
☐ Crop Land	☐ Agricultural Chemical Storage
☐ Industrial	☐ Caves/Sinkholes
☐ Pesticide/Herbicide Manufacturer	☐ Electroplating/Metal Finishing/Steel Processing
☐ Petroleum Storage Tank Farm	☐ Furniture/Boat Refinish
☐ Wood Preservative Manufacturer	☐ Golf Course/Nursery
☐ Hazardous Waste Recovery Facility	☐ Industrial Waste Site
☐ Airport	☐ Laboratories
☐ Landfill	☐ Machine Shop
☐ Gasoline Station/Service Centers	☐ Mining Waste Sites
☐ Plastics Manufacturer	☐ Oil & Gas Production
☐ Coal Gasification Facility	☐ Photo Processor
☐ Dry Cleaning Establishment	☐ Underground Injection Wells
☐ Hazardous Material Transfer, Storage, or Disposal	☐ Underground Storage Tanks
☐ Synthetic Fabrics	☐ Fertilizer Industry/Manufacture
☐ Superfund Site	☐ Other (describe)
☐ Pipeline/Power line Right of Way	

Observed Use or Storage of these Chemicals - Check [√] all that apply	
☐ Alachlor	☐ Hexachlorobenzene
☐ Aldrin	☐ Hexachlorocyclopentadiene
☐ Atrazine	☐ Lindane
☐ Benzo(a)pyrene	☐ Methomyl
☐ Butachlor	☐ Methoxychlor
☐ Carbaryl	☐ Metolachlor
☐ Carbofuran	☐ Metribuzin
☐ Chlordane	☐ Oxamyl (Vydate)
☐ Dibromochloropropane	☐ Pentachlorophenol
☐ Dalapon	☐ Picloram
☐ Dicamba	☐ Polychlorinated biphenyls (PCBs)
☐ Dinoseb	☐ Propachlor
☐ Dieldrin	☐ Simazine
☐ Diquat	☐ Toxaphene
☐ Di(2-ethylhexyl)adipate	☐ 2,4-D
☐ Di(2-ethylhexyl)phthalate	☐ 2,4,5-TP
☐ Ethylene dibromide	☐ 3-Hydroxycarbofuran
☐ Endrin	☐ Cyanide
☐ Hepachlor	☐ Hepachlor epoxide

Have changes to land use/activity taken place [Check all that apply]	
Within a 1000-feet radius of the groundwater source (Zone 1)?	☐ Yes ☐ No ☐ Don't Know
Within a 1-mile radius of the groundwater source (Zone 2)?	☐ Yes ☐ No ☐ Don't Know
Within a 5-mile radius upstream of the surface water intake?	☐ Yes ☐ No ☐ Don't Know

Responsible Party:	
Signature	Title
Date:	

For VDH Use Only

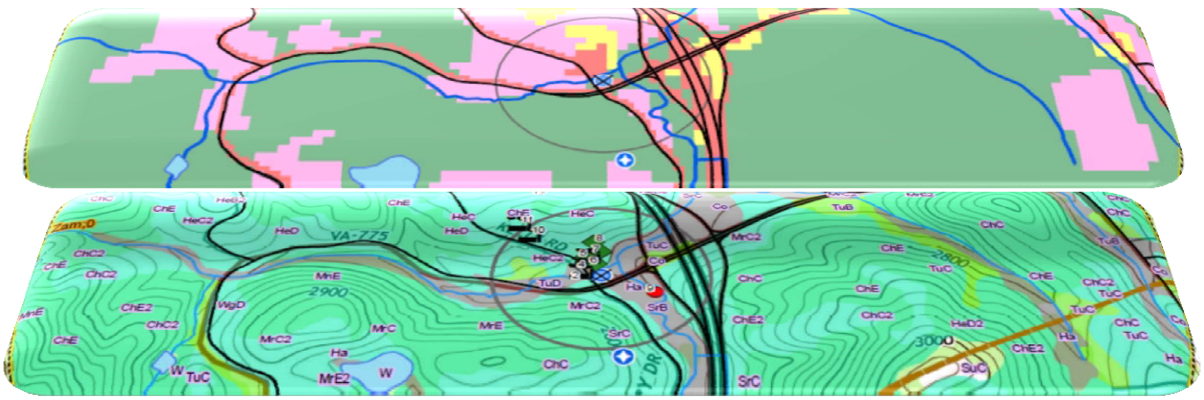
Evaluator's Name:	Evaluation Date:
Any land use/activity changes in the source water assessment area?	☐ Yes ☐ No
Any other related risks or concerns from the Source Water Assessment reports?	☐ Yes ☐ No
Sanitary Survey or other evaluations indicate a potential for SOC contamination?	☐ Yes ☐ No
Does the waterworks utilize chlorination in the treatment process?	☐ Yes ☐ No
Are any modifications to current waiver status warranted?	☐ Yes ☐ No
If "yes" for any above, explain:	
Has nitrate ever exceeded the MCL?	☐ Yes ☐ No
If yes", what is the suspected source of nitrate?	
Has Diquat ever been detected in this source/entry point or in any neighboring sources?	☐ Yes ☐ No
Have any samples from the source/entry point detected the following: **Benzene, ethylbenzene, toluene, xylene,** or **1,2-dichloroethane** *(If "yes, circle the ones that were detected)* If yes, have any samples for ethylene dibromide (EDB) been collected?	☐ Yes ☐ No ☐ Yes ☐ No
For existing sources after 1993 and for new sources, were three rounds of cyanide monitoring completed for the entry point with all results showing no detection?	☐ Yes ☐ No

Waiver Recommendations

Place an "S" for Susceptibility or a "U" for Use depending on the type of waiver granted or denied in the appropriate column.

Contaminant / Group	Granted	Denied
Volatile Fumigants		
Carbamates		
Chlorinated Acid Herbicides		
Semi-Volatiles		
Diquat		
Cyanide		

Comments: Years of three rounds of cyanide sampling: ________, ________, and ________.



VDH SWAP User Guide:
SOC Monitoring Waiver Evaluations

Version 1.0
April 27, 2016

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
www.vdh.virginia.gov

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

Contents

Figures

1. PURPOSE

This document provides general guidance to use VDH SWAP in support of SOC monitoring waiver evaluations.

2. DEFINITIONS

The following table defines the most commonly used terms and acronyms.

Term/Acronym	Definition/Description
AM	Action Memo
GIS	Geographic Information Systems
Layer	A collection of features sharing the same schema
ODW	Office of Drinking Water; an office within VDH
PSC	Potential Source(s) of Contamination
SOC	Synthetic Organic Chemicals
SWA	Source Water Assessment
SWA Outputs	Documents produced with VDH SWAP GIS Tool (i.e., maps, tables)
SWAP	Source Water Assessment Program
VDH	Virginia Department of Health
Zone 1	Assessment area where contamination events are considered to have the highest risk to impact a drinking water supplies under VDH SWAP. Typically, Zone 1 represents 5 mile radius from an intake into its watershed delineation, and 1,000 feet radius from a groundwater source.
Zone 2	Assessment area beyond Zone 1 where contamination events may still have an impact on drinking water supplies under VDH SWAP. Zone 2 represents the watershed area beyond Zone 1 of an intake, and the area between Zone 1 and 1 mile radius from a groundwater source.

3. PROCEDURES

The following sections describe how to use relevant SWA Outputs associated with SOC monitoring waiver determinations. The main location to access SWAP information is \\odwsrv1\odwshare\15-SWAP-Processing.

3.1. Processing SWA Outputs requests from Waterworks

Waterworks owners have the right to request copies of the SWA Outputs for their system(s). Processing waterworks requests for SWA Outputs is accomplished as follows:

1. Open SWAP Tracking Log
   \\odwsrv1\odwshare\15-SWAP-Processing\SWAP_TrackingLog.xlsx
2. Fill a request following instructions from the log.
   ***Note**: Make sure to provide owner's email and/or mailing address in Column P.*

Central Office will then deliver the information to the waterworks and update the log.

3.2. Searching for SWA Outputs

SWA Outputs for active sources should be available at \\odwsrv1\odwshare\15-SWAP-Processing\08-SWA_Outputs.

Each SWA Output is compressed into a .zip file. These files follow a three-part naming convention, where each part is segregated by underscores.
(i.e., PWSID_WATERWORKS NAME_SOURCE ID.zip)

Files may be searched by any of the three parts from the naming convention. **Searching by PWSID is recommended** to quickly find all sources associated with a system.

Figure 1 (right) depicts how entering PWSID 1035581 in the search bar returns associated files.

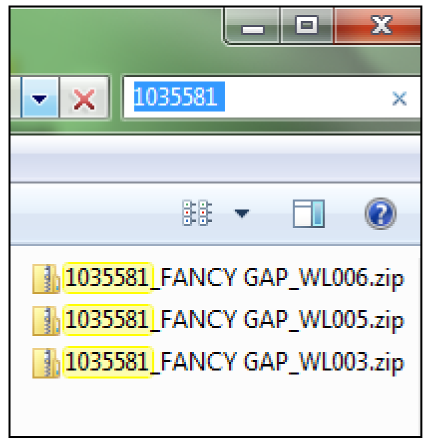


Figure 1: SWA Outputs search results

NOTE: If SWA Outputs for a known active source are unavailable, contact the Special Projects Engineer.

3.3. Relevant SWA Outputs

Figure 2 (right) illustrates the content of a SWA Outputs .zip. Highlighted items may support approval/denial of SOC monitoring waiver applications.

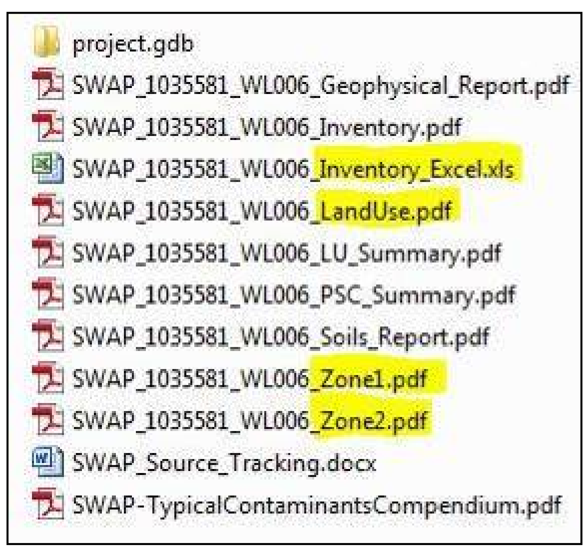


Figure 2: SWA Outputs .zip content

4. Using SWA Outputs

4.1.1. Getting Started

To maximize the utility of .pdf files, particularly of maps, **make sure Navigation Pane Buttons are active in Adobe Acrobat**. If it is active, you should be able to see the icons depicted in **Figure 3** (right) on the top left of your Adobe Acrobat window.

NOTE: The button (icon) pointed by the arrow on Figure 3 will only be available for files that contain layers, such as the maps. It allows users to turn layers on/off to facilitate finding the information of interest.

If Navigation Pane Buttons are not visible:

1. Right click inside the Adobe Acrobat window
2. Select "Show Navigation Pane Buttons" (at bottom of pop-up menu)

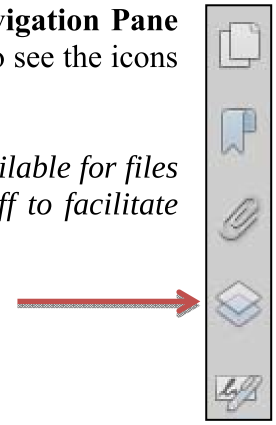


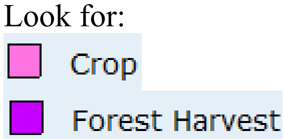
Figure 3: Navigation Pane Buttons

4.1.2. Land Use Map

The land use map illustrates generalized activities that may be taking place or have taken place in different areas of Virginia. *Crop* (pink) and *Forest Harvest* (magenta) land use activity may represent risk of contamination from regulated SOCs.

The following procedure describes how to find if these layers are within assessment area Zone 1 or 2 of a drinking water source:

1. Open **…_LandUse.pdf**
2. Look for:

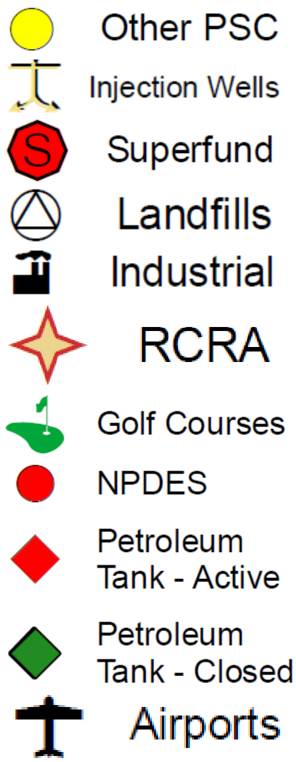


4.1.3. Zone 1 & 2 Maps

The Zone 1 & 2 maps illustrate the approximate location of known PSC that may threaten drinking water sources. PSC such as *Other PSC* (VDH Staff/Contractor collected information), *Injection Wells, Superfund, Landfills, Industrial, RCRA, Golf Courses, NPDES, Petroleum Tank – Active/Close* and *Airports* may represent risk of contamination from regulated SOCs. These PSC are labeled with numbers, starting at "1" for the closest point to the drinking water source and so on. This labeling practice is intended to help associate PSC location with additional details provided in the PSC Inventory files (discussed in **Section 4.1.4** below).

The following procedure describes how to find if these layers are within assessment area Zone 1 or 2 of a drinking water source:

1. Open **…_Zone1.pdf** or **…_Zone2.pdf**
2. Look for:



4.1.4. PSC Inventory

The PSC Inventory files provide additional information about known PSC depicted in Zone 1 & 2 maps (discussed in **Section 4.1.3** above.) There are two type of Inventory files: .pdf and .xls. **Using …_Inventory.xls is recommended** because it may provide information on up to 14 fields vs. 7 on **…_Inventory.pdf**. For example, **…_Inventory.xls** may offer facility hyperlinks to EPA's website (when available).

Attachment B.1. Waiver Application Transmittal Letter
INSTRUCTIONS: Complete/select items with *(italics)*, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, shown bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

Synthetic Organic Chemical (SOC) monitoring waivers granted for the 2017-2019 compliance period and the cyanide monitoring waiver(s) granted for the 2011-2019 compliance cycle will expire on December 31, 2019. Pursuant to 12VAC5-590-373 C 2 e and 12VAC5-590-373 D 2 c of the *Waterworks Regulations*, respectively, please complete the enclosed waiver application form for each source water entry point and submit to this office for evaluation on or before **September 30, 2019**. Failure to submit this form will result in monitoring requirements at your waterworks for the following SOC and cyanide contaminant categories:

- Volatile Fumigants;
- Carbamates;
- Chlorinated Acid Herbicides;
- Semivolatiles; Diquat; and
- Cyanide

The State Health Commissioner has extended statewide waivers for dioxin (2,3,7,8-TCDD), endothall, glyphosate, and asbestos. These waivers will continue to be in effect during the 2020-2022 compliance period. Cyanide waivers will be considered based on a vulnerability assessment of the waterworks and three rounds of monitoring with results showing no detection.

Information specific to your waterworks from Virginia's source water assessment program (e.g., land use maps and potential sources of contamination data) can be made available to you upon request. Please contact me at (*phone #*) or email (*email address*) for this information, or if you have any questions.

Sincerely,

(*Name)*
District Engineer/Inspector
(Name) Field Office

ABC/xyz

Enclosure: *Waiver Instructions & Application Form*

cc: *Insert LHD information*

Attachment B.2. SOC and Cyanide Waivers Denied/Granted
INSTRUCTIONS: Complete/select items shown with (*italics*), and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address
City/County, State Zip

Dear *Waterworks Owner*:

The Virginia Department of Health Office of Drinking Water has evaluated your Synthetic Organic Chemical (SOC) and cyanide monitoring waiver application received on *(date)* pursuant to 12VAC5-590-373 C 2 e and 12VAC5-590-373 D 2 c of the *Waterworks Regulations*, respectively. Based on the information provided in your application and the Department's understanding of prevailing conditions affecting water quality at your waterworks, the Department has approved or denied your monitoring waiver request for the SOC and cyanide contaminant categories (and associated Entry Point) indicated in the table(s) below.

Entry Point: (*name of entry point; repeat table style/format for multiple entry points*)				
Contaminant Groups	Effective Date	Expiration Date	Granted	Denied
Volatile Fumigants	January 1, 2020	December 31, 2022		
Carbamates	January 1, 2020	December 31, 2022		
Chlorinated Acid Herbicides	January 1, 2020	December 31, 2022		
Semi-Volatiles	January 1, 2020	December 31, 2022		
Diquat	January 1, 2020	December 31, 2022		
Cyanide*	January 1, 2020	December 31, 2028		

***** One cyanide sample is required from the entry point while the waiver is in effect. Your next cyanide sample for this entry point is scheduled for *(insert applicable date).*

Use the following paragraph for all denied waivers:
[You must collect *(number)* *(quarterly or annual)* sample(s) from each entry point for which a SOC and cyanide contaminant category monitoring waiver request was denied. As provided by Rule 2A:2 of the Supreme Court of Virginia, you have thirty days from the date of this letter within which to appeal this decision by filing a notice of appeal in accordance with the Rules of the Supreme Court of Virginia with the State Health Commissioner. In the event that this decision was served to you by mail, three days are added to that period.]

Your approved monitoring waiver requests will expire on December 31, 2022 for the SOC waivers and December 31, 2028 for cyanide waivers. You should reapply for SOC and cyanide monitoring waivers no

Attachment B.2. SOC and Cyanide Waivers Denied/Granted
INSTRUCTIONS: Complete/select items shown with (*italics*), and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins.

later than **September 30, 2022 and September 30, 2028, respectively**. You will be notified prior to the next compliance period of the required submittals.

If you have any questions concerning this matter, please contact (*name*), District Engineer, at (*phone #*) or email (*email address*).

Sincerely,

Engineering Field Director
Field office name

ABC/xyz

cc: *Insert LHD information*

Sampling Manual Chapter 13, Attachment A.1. Notification of LT2 Source Water Monitoring Requirements
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1” top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

This letter serves to notify you of your upcoming sampling requirements as part of the U.S. Environmental Protection Agency (EPA) Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule). You are required to establish a Source Water Monitoring Plan to conduct an initial and a second round of source water monitoring for each plant that treats a surface water or groundwater under the direct influence of a surface water source. Your waterworks shall begin the LT2 *(insert Round 1 or Round 2 as applicable)* sampling requirements by *(select as appropriate: insert date typically <6 months after issuance/re-issuance of the Operation Permit for the initial round for new waterworks and new sources to existing waterworks; for Round 2, insert date not to exceed 6 years after the initial round is completed with bin determination)*.

(Option 1- ≥10,000 population)
Your waterworks serves at least 10,000 people, and shall therefore sample the source water for *Cryptosporidium*, *E.coli*, and turbidity at least monthly for 24 months.

(Option 2- <10,000 population)
Your waterworks serves fewer than 10,000 people, and shall therefore sample the source water for *E.coli* at least once every 2 weeks for 12 months. Alternatively, you shall sample for *Cryptosporidium* at least twice per month for 12 months or at least monthly for 24 months. If you elect to monitor for *Cryptosporidium*, you must notify us no later than *(insert date)*. Your waterworks can elect to use either of these monitoring options. However, your waterworks must sample for *Cryptosporidium* if either of the following conditions are determined following the results of *E. coli* monitoring:

1. For waterworks using lake/reservoir sources, the annual mean *E. coli* concentration is greater than 10 *E. coli*/100 mL.
2. For waterworks using free-flowing stream sources, the annual mean *E. coli* concentration is greater than 50 *E. coli*/100 mL.

Please submit a Source Water Monitoring Plan that includes your waterworks' LT2 sampling schedule and description of sample location(s) to the *(insert field office name)* no later than 3 months prior to your first sampling date. At the latest, ODW shall receive this information by (*insert date*). ODW will review the proposed schedule and provide your waterworks with a written approval letter no later than 30 days prior to the scheduled start of monitoring.

Source Water Monitoring Plans should be developed following EPA's 1996 Source Water Monitoring Guidance Manual for Public Water Systems. It is available at http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_swmonitoringguidance.pdf. In addition, consider the following sampling location guidelines when completing your Source Water Monitoring Plan:

Sampling Manual Chapter 13, Attachment A.1. Notification of LT2 Source Water Monitoring Requirements
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

1) Each water plant must monitor separately, except where multiple plants draw water from the same influent pipeline or intake. In such case a representative sample for all of the plants may be used.
2) Samples are to be collected prior to any chemical treatment, unless ODW makes a specific determination that:
   a) Sampling prior to chemical treatment is not feasible; and
   b) Chemical treatment will not have any adverse impact on analysis of the sample.
3) If a waterworks practices recycle of the filter backwash, all samples must be collected prior to the point of any filter backwash water addition.
4) Plants with multiple water sources which include multiple surface water sources and blended surface water and ground water sources must use the following criteria:
   a) The use of multiple sources during monitoring must be consistent with routine operational practice.
   b) Must use a sample tap where the sources are combined prior to treatment, if available.
   c) If a combined sample tap is not available then samples must be collected at each source intake on the same day and must either:
      i) Composite the samples into one sample prior to analysis. (This composite must be flow weighted based on the proportion of the source in the total plant flow at the time the sample was collected.), or
      ii) Analyze each sample and calculate a weighted average of the analysis results for each sampling date. The weighted average must be calculated by multiplying the analysis result for each source by the fraction the source contributed to total plant flow at the time the sample was collected and then summing these values.

You must submit your *(insert Round 1 or Round 2)* samples for the LT2 Rule to analytical laboratories certified by the Virginia Division of Consolidated Laboratory Services (DLCS) for *Cryptosporidium* and *E. coli*. You can go to the DCLS website www.dgs.state.va.us/DivisionofConsolidatedLaboratoryServices and click on Drinking Water and Tuning Fork Certification on the right column menu for a current list of certified laboratories. DCLS does not analyze drinking water for *Cryptosporidium*. Laboratories performing *Cryptosporidium* analyses must use EPA Method 1622, EPA Method 1623, or EPA Method 1623.1 (ODW's preferred method). Laboratories performing *E. coli* analyses must use an *E. coli* enumeration method (presence/absence is not acceptable). Turbidity measurements may be taken by the waterworks.

We look forward to working with you to ensure that your waterworks achieves compliance with these sampling requirements of the LT2 Rule. If you have any questions or would like to meet to discuss this requirement, please do not hesitate to contact me at *(phone)* or *(email)*.

Sincerely,

(Name), District Engineer
Name of field office

ABC:xyz
ec/enc: *(electronic copy, if applicable)*
cc: *Name*, (*Health Director/Environmental Health Manager*), *Name of LHD*
VDH, ODW-Central Office

Sampling Manual Chapter 13 Attachment A.2. Approval Letter for Source Water Monitoring Plan
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have received your proposed Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule) Source Water Monitoring Plan for (*insert Round 1 or Round 2*), dated *(insert date)*. Your proposed monitoring schedule and sampling location(s) have been found by the Virginia Department of Health to meet the requirements of the *Waterworks Regulations.*

(Option for waterworks with filtered systems serving ≥10,000 people)

Please remember that all samples must be collected per the approved schedule (no more than 2 days before or 2 days after the scheduled date). Samples must be analyzed by a laboratory which has been certified by DCLS for *Cryptosporidium* using EPA Method 1622, EPA Method 1623, or EPA Method 1623.1 (ODW's preferred method) and *E. coli* using an enumeration method (presence/absence is not acceptable). The laboratory(s) shall report the results directly to our Central Office in Richmond no later than the tenth day of the month following the month in which the sample was collected (e.g., a January sample must be reported no later than February 10^{th}).

Please request the analytical laboratory to email your *Cryptosporidium* and turbidity analysis report to **labadmin@vdh.virginia.gov** with the subject line of their email as "*Cryptosporidium* Results for VApwsid#." Analytical laboratories should submit *E.coli* results using our standard template for electronic data submittals (see www.vdh.virginia.gov/ODW/ InformationforLaboratories.htm). As the owner, you should request that the laboratory provide you with a copy of the analytical results for your records. Additionally, it is important that you record your turbidity results from the LT 2 sampling events on the laboratory chain-of-custody form for the *Cryptosporidium* sample submittal.

(Option for waterworks with filtered systems serving <10,000 people doing E. coli monitoring)

Please remember that all samples must be collected per the approved schedule (no more than 2 days before or 2 days after the scheduled date), and must be analyzed by a laboratory which has been certified by DCLS for *E. coli* (enumeration). The laboratory will report the results directly to our Central Office in Richmond no later than the tenth day of the month following the month in which the sample was collected (e.g., a January sample must be reported no later than February 10^{th}). Analytical laboratories should submit *E.coli* results using our standard template for electronic data submittals (see www.vdh.virginia.gov/ODW/ InformationforLaboratories.htm). As the owner, you should request that the laboratory provide you with a copy of the analytical results for your records.

Sampling Manual Chapter 13 Attachment A.2. Approval Letter for Source Water Monitoring Plan
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1” top, bottom, and side margins

(Option for waterworks with filtered systems serving <10,000 people doing Cryptosporidium monitoring)

Please remember that all samples must be collected per the approved schedule (no more than 2 days before or 2 days after the scheduled date), and must be analyzed by a laboratory which has been certified by DCLS for *Cryptosporidium* using EPA Method 1622, EPA Method 1623, or EPA Method 1623.1 (ODW's preferred method). The laboratory will report the results directly to our Central Office in Richmond no later than the tenth day of the month following the month in which the sample was collected (e.g., a January sample must be reported no later than February 10th). Please request the analytical laboratory to email your *Cryptosporidium* and turbidity analysis report to labadmin@vdh.virginia.gov with the subject line of their email as "*Cryptosporidium* Results for VApwsid#."

As the owner, you should request that the laboratory provide you with a copy of the analytical results for your records. If you have any questions or concerns, please do not hesitate to contact *(insert name)*, District Engineer, of this office at *(insert phone number)* or *(insert email)*.

Sincerely,

(Name), Engineering Field Director
Name of field office

ABC:xyz

ec/enc: *(electronic copy, if applicable)*

cc: *Name, (Health Director/Environmental Health Manager), Name of LHD*

Sampling Manual Chapter 13, Attachment A.3 Approval of Bin Classification
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have received the LT2 Bin Classification Statement for your waterworks, submitted in accordance with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule).

(Option 1 - use for all source water monitoring with BIN 1 determination)

The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for *(insert Round 1 or Round 2 as applicable)* source water samples from your waterworks is *(insert number)* oocysts per Liter. According to Table 401.2 of the Virginia *Waterworks Regulations*, your waterworks is hereby classified as Bin 1. This means that no additional treatment is required of your waterworks with respect to *Cryptosporidium*. (*Choose one as appropriate:* The Virginia Department of Health will advise you in the future concerning the second round of required source water monitoring (Round 2) and of any other reporting requirements. *OR* This completes the required source water monitoring under the LT2 Rule.)

(Option 2 - use for Round 1 monitoring with >BIN 1 determination)

The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the Round 1 source water samples from your waterworks is *(insert number)* oocysts per Liter. According to Table 401.2 of the Virginia *Waterworks Regulations*, your waterworks is hereby classified as Bin *(insert number)*. This means that your waterworks will need to provide an additional *(insert number)* logs of removal/inactivation for *Cryptosporidium*, in order to achieve a total removal and inactivation of *(insert number)* logs. Please contact this office to schedule a meeting to discuss your plans and schedule for implementing the additional *Cryptosporidium* removal/inactivation requirement.

(*Option 3 - use for Round 2 if remaining with >BIN 1 determination.)*

The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the Round 2 source water samples from your waterworks is *(insert number)* oocysts per Liter. According to Table 401.2 of the Virginia *Waterworks Regulations*, your waterworks is hereby classified as Bin *(insert number)*. Under the Round 1 source water monitoring, your waterworks was classified as Bin *(insert number)*. This means that no additional treatment is required of your waterworks with respect to *Cryptosporidium*. This completes the required source water monitoring under the LT2 Rule.

(Option 4 - used if increasing BIN Number)

The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the Round 2 source water samples from your waterworks is *(insert number)* oocysts per Liter. According to Table 401.2 of the Virginia *Waterworks Regulations*, your waterworks is hereby classified as Bin *(insert number)*. Under Round 1 source water monitoring, your waterworks was classified as Bin *(insert number)*. This means that your waterworks will need to provide an additional *(insert number)* logs of removal/inactivation for *Cryptosporidium*, in order to achieve a total removal and inactivation of *(insert* *number)* logs. Please contact this office to schedule a meeting to discuss your plans and schedule for implementing the additional *Cryptosporidium* removal/inactivation requirement.

A copy of the approved Bin Classification Statement is enclosed for your files and information.

If you have any questions regarding this matter, please do not hesitate to contact *(insert name)*, District Engineer, of this office at *(insert phone number)* or *(insert email)*.

Sincerely,

Name, Engineering Field Director
Name of field office

ABC/xyz

Enclosure: Bin Classification Statement
ec/enc: *(electronic copy, if applicable)*
cc: *Name, (Health Director/Environmental Health Manager), Name of LHD*

Sampling Manual Chapter 13, Attachment A.4. Cryptosporidium Sampling Data Results and Bin Recommendation

INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have received *Cryptosporidium* data from your waterworks, collected for the (*insert Round 1 or Round 2*) source water monitoring under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule). This letter is to advise that the Virginia Department of Health has reviewed the data, and has calculated the *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration, as required by the rule.

(Option 1 - Round 1)

The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the source water samples from your waterworks is *(insert number)* oocysts per Liter. According to the LT2 Rule bin classification table in 12VAC5-590 420 B 3 c (1) (b), your waterworks is classified as Bin *(insert number)*.

(Option 2 - If Round 2 is same as Round 1)

Under Round 1 of the source water monitoring, your waterworks was classified as Bin *(insert number).* The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the Round 2 source water samples from your waterworks is *(insert number)* oocysts per Liter. According to the LT2 Rule bin classification table in 12VAC5-590 420 B 3 c, your waterworks shall retain the Bin *(insert number)* classification.

(Option 3 - If Round 2 is higher than Round 1)

Under Round 1 of the source water monitoring, your waterworks was classified as Bin *(insert number)*. The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the Round 2 source water samples from your waterworks is *(insert number)* oocysts per Liter. According to the LT2 Rule bin classification table in 12VAC5-590 420 B 3 c, your waterworks will increase to the Bin *(insert number)* classification.

(*Option 4 - If Round 2 is lower than Round 1*)

Under Round 1 of the source water monitoring, your waterworks was classified as Bin *(insert number)*. The *(mean Cryptosporidium / highest annual mean Cryptosporidium)* concentration for the Round 2 source water samples from your waterworks is *(insert number)* oocysts per Liter. According to the LT2 Rule bin classification table in 12VAC5-590 420 B 3 c, this means that your waterworks would be classified as Bin *(insert new bin number)*. However, the Round 2 bin classification may not be lower than the initial Round 1 bin classification. Thus, your waterworks will retain the Round 1 Bin *(insert number)* classification.

Sampling Manual Chapter 13, Attachment A.4. Cryptosporidium Sampling Data Results and Bin Recommendation
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

If you are in agreement with our findings, please complete the enclosed LT2 Bin Classification Statement, and return it to this office by *(insert deadline)*. A copy of the bin calculation worksheet, listing the *Cryptosporidium* results for your waterworks, is attached to the Bin Classification Statement, for your files and information. If you have any objections to the proposed classification, please respond as soon as possible, providing additional information and justification for an alternate classification, so that we may begin discussions concerning your alternate classification.

If you have any questions regarding this matter, please do not hesitate to contact me at *(phone number)* or *(email).*

Sincerely,

(Name), District Engineer
Name of field office

ABC:xyz

Enclosures: Owner's Bin Classification Statement and Bin Calculation Worksheet

ec/enc: *(electronic copy, if applicable)*
cc: *Name, (Health Director/Environmental Health Manager), Name of LHD*
VDH, ODW-Central Office

Sampling Manual Chapter 13, Attachment A.5. *E.coli* Sampling Data Results and Bin Recommendation for either Round 1 or Round 2 [Revised August 19, 2018]
INSTRUCTIONS: Complete/select items shown with italics, and convert to regular font. Print 1st page on VDH letterhead. Pages are 1" top, bottom, and side margins

SUBJECT: *County/City*
Waterworks: *Waterworks Name*
PWSID No: *PWSID*

Date

Waterworks Owner
Address 1
Address 2
City, State, Zip

Dear *Waterworks Owner:*

We have received *E. coli* data from your waterworks, collected during source water monitoring under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule). This letter is to advise that the Virginia Department of Health has reviewed the data, and has calculated the mean annual *E. coli* concentration, as required by the rule.

The water source of your waterworks is a (*choose correct source type: lake or reservoir/free flowing stream/GUDI*). Per 12VAC5-590-420 B 3 a, a waterworks with your source type has a trigger level of *(insert number)* *E. coli* per 100 mL.

(Option 1)

The mean annual concentration of the Round *(1 or 2)* source water samples from your waterworks is *(insert number)* *E. coli* per 100 mL. This means that your waterworks has not exceeded the trigger level. According to the LT2 Rule bin classification table in 12VAC5-590 420 B 3 c (1) (b), your waterworks is hereby classified as Bin 1. This means that no additional treatment is required of your waterworks with respect to *Cryptosporidium*. *(If this is Round 1, use:) [VDH will advise you in the future concerning the second round (Round 2) of required source water monitoring and of any other reporting requirements.]*

(Option 2)

The mean annual concentration of the Round *(1 or 2)* source water samples from your waterworks is *(insert number)* *E. coli* per 100 mL. This means that your waterworks has exceeded the trigger level. According to 12VAC5-590-420 B 3 a (c), your waterworks must now proceed to *Cryptosporidium* monitoring. You will need to develop a monitoring plan for *Cryptosporidium*, and submit that schedule to VDH for approval within the next 60 days. Please contact this office for guidance in developing this monitoring plan.

If you have any questions regarding this matter, please do not hesitate to contact *(insert name)*, District Engineer, of this office at *(insert phone number)* or *(email)*.

Sincerely,

(Name)
Engineering Field Director

ABC:xyz

ec/enc: *(electronic copy, if applicable)*
cc: *Name, (Health Director/Environmental Health Manager), Name of LHD*
VDH ODW-Central Office

Sampling Manual Chapter 13, Attachment A.6. LT2 Bin Classification Statement
INSTRUCTIONS: Fill out top section of form for the waterworks; Field Director to complete bottom section of the form

LT2 BIN CLASSIFICATION STATEMENT

Waterworks Name: ______________________________________ PWSID No.: ________________

I have reviewed the attached spreadsheet containing *Cryptosporidium* data collected from the ___________ waterworks, and the bin classification based on that data. I accept the classification based on the results of the monitoring.

☐ Round 1 Source Water Monitoring ☐ Round 2 Source Water Monitoring

Cryptosporidium concentration	Bin Classification
Cryptosporidium < 0.075 oocysts per Liter	1
0.075 oocysts per Liter ≤ *Cryptosporidium* < 1.0 oocysts per Liter	2
1.0 oocysts per Liter ≤ *Cryptosporidium* < 3.0 oocysts per Liter	3
Cryptosporidium ≥ 3.0 oocysts per Liter	4

Cryptosporidium concentration: ____ Bin Classification: ____

Owner Signature: ____ Date: __________________

Printed Name: ____

Title: ____

Attachment: *Cryptosporidium* data – Bin calculation worksheet

For ODW use only:

After reviewing the above Owner's Statement and the data in the attached spreadsheet, this is to advise that this Bin Classification is:

☐ Approved ☐ Disapproved

By ____ ___________________

Engineering Field Director Date

Sampling Manual Chapter 13, Attachment A.6. LT2 Bin Classification Statement

INSTRUCTIONS: Fill out top section of form for the waterworks; Field Director to complete bottom section of the form

Review Sheet: LT2 Source Water Monitoring Plan

City / County ______________________________

Waterworks ______________________________

PWSID # ______________ Plant ______________

Is waterworks part of a CDS ☐ Yes ☐ No

Reviewed By: ______________________________

Total time spent: ______________________________

	Date
SWM Plan Received	
Review Started	
Modifications Requested	
Revisions Received	
Approved	

I. GENERAL		
Population served	__________ Persons	
Is system on this schedule because of being part of a CDS?	☐ Yes ☐ No	
Required date for plan submission	Date due __________	
Plan received by due date	☐ Yes ☐ No	
II. MONITORING REQUIREMENTS		**COMMENT**
No. of months of monitoring required	☐ 24 ☐ 12	
Sufficient number of months scheduled	☐ Yes ☐ No	
At least one sample per month provided (every two weeks for Schedule 4 doing *E. coli)*	☐ Yes ☐ No	
Monitor for: Cryptosporidium *E. coli* Turbidity	 ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No	
Actual sample dates specified	☐ Yes ☐ No	
Plan addresses monitoring windows	☐ Yes ☐ No	
III. ANALYTICAL REQUIREMENTS		**COMMENT**
Cryptosporidium		
DCLS-approved labs	☐ Yes ☐ No	__________
Method identified	☐ Yes ☐ No	☐ 1622 ☐ 1623 ☐ 1623.1
Filtered on-site	☐ Yes ☐ No	Type:
Full sample shipped	☐ Yes ☐ No	
Plan addresses matrix spike samples	☐ Yes ☐ No	
Sampling procedures discussed	☐ Yes ☐ No	
E. coli		
Lab identified	☐ Yes ☐ No	
Exact analytical method identified	☐ Yes ☐ No	
Lab certified for *E. coli* enumeration?	☐ Yes ☐ No	

Turbidity		
On-site measurement? If no, lab identified	☐ Yes ☐ No ☐ Yes ☐ No	
On-site equipment/Method identified	☐ Yes ☐ No	
IV. SAMPLING LOCATION(S)		**COMMENT**
Does plant have more than one source	☐ Yes ☐ No	
If yes, are flows combined at a point prior to sample collections	☐ Yes ☐ No	
If no, how will plant sample	☐ Flow-weighted composite samples ☐ Flow-weighted averaged results	
Discuss sample location(s)		
Schematic(s) of sample location(s) provided	☐ Yes ☐ No	
Schematic show appropriate sample locations	☐ Yes ☐ No	
Will plant monitor prior to the addition of any chemicals	☐ Yes ☐ No	
Will plant monitor prior to the addition of filter backwash water recycle	☐ Yes ☐ No	
If answer to either of last two questions is “No”, discuss:		

General comments & discussion:

DETERMINATION:

Source Water Monitoring Plan ☐ **IS** ☐ **IS NOT** acceptable.

Review Completion Date: ________________ By: __________________________________

Review Checklist - LT2 Source Water Monitoring
***Cryptosporidium* Results**

City/County: ________________________ Waterworks Name: ________________________

PWSID #: ________________________ Water Plant Name: ________________________

System Population: _________________ Date of Data Submission: ____________________

Reviewed By: _____________________ Date Review Started: _______________________

I. GENERAL		
Date Source Water Monitoring (SWM) Plan approved		
Samples collected in accordance with approved SWM plan		
Within "5 day window"?	☐ Yes ☐ No	
At approved sample locations?	☐ Yes ☐ No	
Using laboratory identified in SWM plan?	☐ Yes ☐ No	
If "No", identify laboratory?	____________________________	
Is new lab on DCLS' list of approved labs?	☐ Yes ☐ No ☐ NA	
Has new lab submitted "certification letter" about analytical work?	☐ Yes ☐ No ☐ NA	
Was approved SWM plan revised?	☐ Yes ☐ No (if so, discuss below)	
II. REVIEW OF RESULTS		**COMMENT**
Results submitted in a timely fashion	☐ Yes ☐ No	
Results reported appropriately (i.e., "oocysts)	☐ Yes ☐ No	
Appropriate number of matrix spiked (MS) samples collected and reported?	☐ Yes ☐ No	

(see attached pages for check of individual results)

General comments & discussion:

DETERMINATION:

Cryptosporidium data ☐ **IS** ☐ **IS NOT** acceptable.

Date Review Completed: ____________________

Reviewed By: ___________________________

Source Water Monitoring *Cryptosporidium* Data Quality Control Checklist

Required Elements	**Sample ID:**			
	Collection Date:			
Sample Type	field or matrix spike			
Samples arrive between 1°-10°C but < 20 °C	°C			
Samples analyzed within holding time limit (96 hours from collection)	hours			
Sample volume filtered (L)	Liters			
Was 100% of filtered volume examined? *	Yes or No			
Number of oocysts counted	Number			
Results (oocysts per Liter) – three decimal places	Number			
If less than 100% examined				
Volume of resuspended concentrate	Liters			
Volume of resuspended concentrate processed via IMS	Liters			
If less than 10 L filtered or less than 100% examined				
Number of filters used *	Number			
Packed pellet volume *	mL			
For matrix spike samples				
Sample volume spiked	Liters			
Estimated number of oocysts spiked	Number			
Sample meets all requirements?	Yes or No			

*Volume analyzed for all field samples must be at least 10 L, 2 mL of packed pellet, or as much volume as could be filtered by 2 filters

NOTE: Make copies of this page, in order to complete for each sample submitted. If sample is NOT acceptable, contact waterworks **immediately** to advise of quality assurance/quality control concern, and to discuss possible resolution of the concern.

Review Checklist - LT2 Source Water Monitoring for Waterworks < 10,000 population Worksheet for *E. coli* results	
City/County: ____________________________	Waterworks Name:_______________________
PWSID #: ______________________	Water Plant Name: _______________________
System Population: ______________	Date of Data Submission: __________________
Evaluated By: ______________________	Date: _____________________

Monitoring Requirement:	**Met?**
Requirement: Sample at least every two weeks for 12 months	☐ Yes ☐ No
(If not met, discuss on next page)	

Sample No.	**Month**	**Year**	**Result (*E. coli*/100 mL)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			

Name of Laboratory: ____

Certified by DCLS for *E. coli* enumeration. Lab Certification #: ____________________

(Continued)

Sampling Manual Chapter 13, Attachment B.3. Review Sheet for LT2 Source Water Monitoring - *E.coli*

Results: Average of all results: _____ *E. coli* per 100 mL

Water Source for Plant: ________________________________

Water Source Type and "Trigger Levels":

☐ Lake/Reservoir: 10 *E. coli*/100 mL

☐ Stream/River: 50 *E. coli*/100 mL

☐ GUDI: _____ *E. coli*/100 mL

Do results exceed "Trigger Levels"? ☐ Yes ☐ No

If "No": Plant is classified as "Bin 1"

If "Yes": Plant must perform Source Water Monitoring for *Cryptosporidium* in order to determine bin classification

Monitoring Performance (discussion):
The LT2 Rule requires filtered systems serving < 10,000 to sample for *E. coli* every two weeks for 12 months, or proceed to *Cryptosporidium* monitoring. If the waterworks did not collect the full number of required samples, discuss what will be done to resolve the issue.