New Jersey Department of Environmental Protection
Division of Water Monitoring and Standards
Bureau of Environmental Analysis, Restoration and Standards

Basis and Background for Criteria Derivation and Practical Quantitation Levels

Ground Water Quality Standards Rule Amendments N.J.A.C. 7:9C

New Jersey Department of Environmental Protection

December 2017

Basis and Background for Criteria Derivation and Practical Quantitation Levels for Proposed Amendments to the Ground Water Quality Standards Rules, N.J.A.C. 7:9C

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Introduction

The Ground Water Quality Standards rules, N.J.A.C. 7:9C, were previously amended on July 22, 2010 (see August 16, 2010 New Jersey Register) and readopted without change on March 4, 2014 (see April 7, 2014 New Jersey Register). The majority of the rules, including Appendix Table 1 "Specific Ground Water Quality Criteria - Class IIA and Practical Quantitation Levels", has remained unchanged since the readoption and recodification with amendments on November 7, 2005. Basis and Background documents supporting prior rulemaking are available on the Department's website at http://www.state.nj.us/dep/wms/bears/support_docs.htm#gwqs. This Basis and Background document is limited to amendments proposed on April 3, 2017 (see 45 NJR 596(a)) and adopted on December 14, 2018 (see the January 16, 2018 New Jersey Register). These amendments replace the prior interim specific ground water quality criteria, interim practical quantitation levels (PQLs), and interim specific ground water quality standards for 23 constituents with specific ground water quality criteria, PQLs, and ground water quality standards in Appendix Table 1 of the rules. The amendments also revise N.J.A.C. 7:9C-1.7(c)4 to allow, in the appropriate cases, use of alternative values and/or modified equations in the derivation of interim specific and specific ground water quality criteria as needed to reflect the best available science, using the sources set forth in the rule.

Background

Ground water quality standards are necessary to achieve the policy of the New Jersey Water Pollution Control Act (the Act), which is "to restore, enhance and maintain the chemical, physical, and biological integrity of [the State's] waters, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial and other uses of water" (N.J.S.A. 58:10A-2). Under the Ground Water Quality Standards rules (rules), N.J.A.C. 7:9C, the New Jersey Department of Environmental Protection (Department) designates ground water classifications throughout the State, assigns designated uses of the ground water within each classification, and establishes water quality criteria to support those designated uses.

The Department uses ground water quality standards to protect pristine aquifers, set standards for discharges to ground water under the New Jersey Pollutant Discharge Elimination System (NJPDES) program, establish standards for ground water remediation under the Site Remediation and Waste Management Program, and to implement other requirements and regulatory actions applicable to discharges that cause or may cause pollutants to enter the ground waters of the State, including nonpoint and diffuse sources regulated by the Department. Other relevant laws through which the ground water quality standards may be applied include, but are not limited to, the Spill Compensation and Control Act (N.J.S.A. 58:10-23.11 et seq.), the Brownfield and Contaminated Site Remediation Act (N.J.S.A. 58:10B-1 et seq.), the Site Remediation Reform Act (N.J.S.A. 58:10C-1 et seq.), the Solid Waste Management Act (N.J.S.A. 13:1E-1 et seq.), the

Industrial Site Recovery Act (N.J.S.A. 13:1K-6 et seq.), the Underground Storage of Hazardous Substances Act (N.J.S.A. 58:10A-21 et seq.), the Realty Improvement Sewerage and Facilities Act (N.J.S.A. 58:11-23 et seq.), and the Pesticide Control Act of 1971 (N.J.S.A. 13:1F-1 et seq.).

Ground water quality standards (or "constituent standards") are the maximum levels or concentrations of constituents allowed in each classification area, as established in N.J.A.C. 7:9C-1.7, 1.8 and 1.9(a) and (b). There are three major classes of ground water, as defined in N.J.A.C. 7:9C-1.5: "Class I Ground Water of Special Ecological Significance" (Class I), "Class II Ground Water for Potable Water Supply" (Class II), and "Class III Ground Water With Uses Other Than Potable Water Supply" (Class III). Each of these three classes of ground water contains subclasses based on the different primary and secondary designated uses of the ground water therein. In accordance with N.J.A.C. 7:9C-1.9(c), the ground water quality standard (constituent standard) for a particular constituent is the applicable ground water quality criterion established under N.J.A.C. 7:9C-1.7 based on the ground water classification and adjusted by the applicable antidegradation policy for that classification established under N.J.A.C. 7:9C-1.8 and any applicable criteria exceptions provided under N.J.A.C. 7:9C-1.9. These standards serve as the basis for the Department's regulation of ground water quality effects of past, present or future discharges to ground water or the land surface as authorized under N.J.A.C. 7:9C-1.1.

The ground water quality standard for each constituent in Class II-A ground water is based on the numeric ground water quality criterion derived from the most recent toxicological information available to ensure adequate protection of human health, and the practical quantitation level (PQL) selected or derived to reflect analytical constraints on measuring the constituent concentration in ground water. Ground water quality criteria for Class II-A ground water are the levels or concentrations of constituents that, when exceeded, will prohibit or significantly impair use as potable water (i.e., drinking water). There are three types of ground water quality criteria for constituents in Class II-A ground waters:

1. "Specific" ground water quality criteria are those listed for each constituent in Appendix Table 1 of the rules;

2. "Interim specific" ground water quality criteria are those established by the Department following procedures set forth in the rules, pending adoption via formal rulemaking of specific criteria for those constituents into Appendix Table 1 of the rules. Interim specific criteria are derived where sufficient information is available to determine the human health risk and derive an appropriate toxicity factor. This is done to assure that public health and the environment are protected in the most expeditious fashion once a concern is identified, usually in response to cleanup of a contaminated site.

3. "Interim generic" ground water quality criteria are those listed in Appendix Table 2 of the rules and applied to Synthetic Organic Chemicals (SOCs) without a specific or interim specific

ground water quality criterion, depending on the carcinogenicity and the number of SOCs present at a given site.

Since Class II-A ground water quality criteria are human health-based, they sometimes result in a concentration that is lower than the lowest concentration that is measurable using approved analytical methods. In these circumstances, the Department uses PQLs to determine compliance with the health-based criteria. A PQL is the lowest concentration of a constituent that can be reliably achieved among laboratories within specified limits of precision and accuracy during routine laboratory operating conditions. In accordance with N.J.A.C. 7:9C-1.9(c)3, the Department selects or derives PQLs that are as close to the health-based criterion as possible while achievable by the certified laboratory community. The ground water quality standard for each constituent in Class II-A ground water is the higher of the applicable ground water quality criterion and the PQL for that constituent.

Summary of Proposed Amendments to the Ground Water Quality Standards Rules, N.J.A.C. 7:9C

Prior to the current amendments, the existing specific ground water quality criteria, PQLs, and ground water quality standards for constituents in Class II-A ground waters (Appendix Table 1) were promulgated as part of the recodification and readoption of the rules with amendments in November 2005, except for barium and toluene, which were established via a Notice of Administrative Change in August 2007 pursuant to N.J.A.C. 7:9C-1.7(c)5. The existing interim generic ground water quality criteria (Appendix Table 2) were also promulgated as part of the November 2005 rule readoption. The interim specific ground water quality criteria, interim PQLs, and interim specific ground water quality standards were established between November 2005 and November 2015 pursuant to N.J.A.C. 7:9C-1.7(c) and 1.9(c) and posted to the Department's website (see http://www.state.nj.us/dep/wms/bears/gwqs.htm).

On April 3, 2017, the Department published proposed amendments to replace all of the interim specific ground water quality criteria, interim PQLs, and interim specific ground water quality standards with specific ground water quality criteria, PQLs, and ground water quality standards in Appendix Table 1 of the rules. The Department also proposed to amend N.J.A.C. 7:9C-1.7(c)4 to allow, in the appropriate cases, use of alternative values and/or modified equations in the derivation of interim specific and specific ground water quality criteria as needed to reflect the best available science, using the sources set forth in the rule. The Department concurrently proposed adding one of these 23 constituents, perfluorononanoic acid (PFNA), to the List of Hazardous Substances at Appendix A of the Discharges of Petroleum and Other Hazardous Substances (DPHS) Rules, N.J.A.C. 7:1E. These amendments were adopted on December 14, 2017 and published in the January 16, 2018 New Jersey Register.

This Basis and Background document explains only the derivation of the specific ground water quality criteria, PQLs, and specific ground water quality standards for 23 constituents in Class II ground water that replaced the interim specific ground water quality criteria (ISGWQC), interim PQLs, and interim specific ground water quality standards (ISGWQS) for those constituents, including updated criteria or PQLs for four constituents. Other aspects of the proposed amendments are explained in detail in the summary of the rule proposal published in the New Jersey Register on April 3, 2017 and in the rule adoption published in the New Jersey Register on January 16, 2018. Unofficial versions of the rule proposal and the rule adoption are available on the Department's website at www.nj.gov/dep/rules.

Replacement or Update of Existing Interim Criteria, Interim PQLs, and Interim Standards with Specific Criteria, PQLs, and Standards

All ISGWQCs, interim PQLs, and ISGWQSs (for 23 constituents) were reevaluated by the Department to ensure that they reflect the best available science prior to promulgating these values as specific criteria, PQLs and specific ground water quality standards. The results of this reevaluation are summarized in Table A. Updated values are shown with large font and bold type. A more detailed explanation is provided in the Appendix of this document, which is comprised of individual fact sheets that explain the derivation of the specific ground water quality criterion (SGWQC), PQL, and specific ground water quality standard (SGWQS) for each of these 23 constituents.

Table A: Existing ISGWQC, Interim PQLs, and ISGWQS to be Replaced with SGWQC, PQLs, and SGWQS

Constituent	CASRN	Existing Interim Values (µg/L)			Proposed Values for Appendix Table 1 (µg/L)		
		ISGWQC	Interim PQL	ISGWQS	SGWQC	PQL	SGWQS
1,1,1-Trifluoroethane	420-46-2	5,000	60	5,000	5,000	60	5,000
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	76-13-1	20,000	0.3	20,000	20,000	0.3	20,000
1,1-Dichloro-1-fluoroethane	1717-00-6	500	30	500	500	30	500
1,4-Dioxane	123-91-1	0.4	0.1	0.4	0.4	0.1	0.4
1-Chloro-1,1-difluoroethane	75-68-3	100,000	500	100,000	100,000	500	100,000
2-(2-Methyl-4-chlorophenoxy) propionic acid (MCPP)	93-65-2	7	0.5	7	7	0.5	7

Constituent	CASRN	Existing Interim Values (µg/L)			Proposed Values for Appendix Table 1 (µg/L)		
		ISGWQC	Interim PQL	ISGWQS	SGWQC	PQL	SGWQS
Caprolactam	105-60-2	4,000	5,000	5,000	4,000	**60**	**4,000**
Cobalt	7440-48-4	100	0.5	100	100	0.5	100
Cresols (mixed isomers)	95-48-7 108-39-4 106-44-5	50	0.1	50	50	0.1	50
Dichlormid	37764-25-3	600	50	600	600	50	600
4,6-Dinitro-o-cresol	534-52-1	0.7	1	1	0.7	**0.03**	**0.7**
Diphenyl ether	101-84-8	100	10	100	100	10	100
2-Ethyl-1-hexanol	104-76-7	200	0.5	200	200	0.5	200
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.3	0.5	0.5	0.3	0.5	0.5
2-Hexanone	591-78-6	300	1	300	**40**	1	**40**
2-Methylnaphthalene	91-57-6	30	10	30	30	10	30
Metolachlor	51218-45-2	100	0.5	100	100	0.5	100
Perchlorate	14797-73-0	5	3	5	5	3	5
Perfluorononanoic acid (PFNA)	375-95-1	0.01	0.003	0.01	0.01	**0.005**	0.01
Strontium	7440-24-6	2,000	5	2,000	2,000	5	2,000
Tricresyl phosphate (mixed isomers)	1330-78-5 563-04-2 78-32-0	3	0.1	3	3	0.1	3
2,4,6-Trinitrotoluene (TNT)	118-96-7	1	0.3	1	1	0.3	1
Tri-ortho-cresyl phosphate	78-30-8	3	0.1	3	3	0.1	3

The Department determined that sufficient information was available to update the criterion or PQL for four constituents: caprolactam, 4,6-dinitro-o-cresol, 2-hexanone, and PFNA. As explained earlier, the ground water quality standard for each constituent is the higher of the applicable ground water quality criterion and the PQL. Updating the PQL or criterion for three of these four constituents also resulted in a change to the ground water quality standard, as explained below and shown in Table B:

- Caprolactam: The adopted SGWQC is 4,000 µg/L; which is the same as the ISGWQC 3,500 rounded to one significant figure pursuant to N.J.A.C. 7:9C-1.7(c)4iii. The adopted PQL for caprolactam is 60 micrograms per liter (62.5 micrograms per liter (µg/L) rounded to one significant figure pursuant to N.J.A.C. 7:9C-1.9(c)3i), which replaces the interim PQL of 5,000 µg/L. Since the criterion is the higher of the two values, **the adopted SGWQS is 4,000 µg/L**, which replaces the ISGWQS of 5,000 µg/L.

- 4,6-Dinitro-o-cresol: The adopted SGWQC is 0.7 µg/L, which is the same value as the ISGWQC. The adopted PQL for 4,6-dinitro-o-cresol is 0.03 µg/L, which replaces the interim PQL of 1 µg/L. Since the criterion is the higher of the two values, **the adopted SGWQS is 0.7 µg/L**, which replaces the ISGWQS of 1 µg/L.

- 2-Hexanone: The adopted SGWQC is 40 µg/L, which replaces the ISGWQC of 300 µg/L. The adopted PQL is 1 µg/L, which is the same as the interim PQL. Since the criterion is the higher of the two values, **the adopted SGWQS is 40 µg/L**, which replaces the ISGWQS of 300 µg/L.

- PFNA: The adopted SGWQC is 0.01 µg/L, which is the same value as the ISGWQC. The adopted PQL for PFNA is 0.005 µg/L, which replaces the interim PQL of 0.003 µg/L. Since the criterion is the higher of the two values, the adopted SGWQS is 0.01 µg/L, which is the same value as the ISGWQS.

Table B: Updates at a Glance

Constituent	Interim Values (µg/L)			Adopted Values for Appendix Table 1 (µg/L)		
	ISGWQC	Interim PQL	ISGWQS	SGWQC	PQL	SGWQS
Caprolactam	4,000	5,000	5,000	4,000	**60**	**4,000**
4,6-Dinitro-o-cresol	0.7	1	1	0.7	**0.03**	**0.7**
2-Hexanone	300	1	300	**40**	1	**40**
PFNA	0.01	0.003	0.01	0.01	**0.005**	0.01

Updated values are shown in Table B with large font and bold type. A more detailed explanation of the derivation of these updated criteria, PQLs and standards is provided in subsequent sections of this document and in the Appendix (see Appendix I, Appendix K, Appendix L, and Appendix T, respectively).

Updated/Replaced Ground Water Quality Criteria

The Department establishes interim specific and specific ground water quality criteria for Class II ground water constituents in two ways:

1. Where a maximum contaminant level (MCL) for a constituent is promulgated in the Department's Safe Drinking Water Act rules (N.J.A.C. 7:10), the health-based level used to establish the MCL is used as the specific ground water criterion for that constituent; and

2. Where an MCL has not been promulgated, the Department develops a ground water quality criterion based on the weight of evidence available regarding the constituent's carcinogenicity, toxicity, public welfare or organoleptic effects, as appropriate for the protection of human health based on exposure to potable water through the ingestion pathway.

The rules describe the equations, data sources, default values and conventions used by the Department when developing interim specific and specific ground water quality criteria for Class II constituents not covered by a promulgated MCL. A "default value" is a scientifically-established general value used in risk assessment when contaminant-specific information is not available. Figures 1 and 2 below show the equations and default values established at N.J.A.C. 7:9C-1.7(c)4i and ii for deriving specific and interim specific ground water quality criteria for Class II-A constituents.

Figure 1: Equations and Default Values for Deriving Criteria for Carcinogenic Constituents

$$\text{Criterion } (\mu g/L) = \frac{\text{Upper Bound Lifetime Excess Cancer Risk} \times \text{Average Adult Weight} \times \text{Conversion Factor}}{\text{Carcinogenic Slope Factor} \times \text{Assumed Daily Water Consumption}}$$

Where the default values are:

Average Adult Weight	= 70 kg
Assumed Daily Water Consumption	= two liters per day
Upper Bound Lifetime Excess Cancer Risk	= 1×10^{-6}
Conversion Factor	= 1,000 μg/mg
Carcinogenic Slope Factor	= value from the United States Environmental Protection Agency (USEPA) Integrated Risk Information System (IRIS) data base, http://www.epa.gov/iris/, incorporated herein by reference, as $(mg/kg/day)^{-1}$

Figure 2: Equations and Default Values for Deriving Criteria for Non-carcinogens or Carcinogens Without a Slope Factor

$$\text{Criterion } (\mu g/L) = \frac{\text{Reference Dose} \times \text{Average Adult Weight} \times \text{Conversion Factor} \times \text{Relative Source Contribution}}{\text{Assumed Daily Water Consumption} \times \text{Uncertainty Factor}}$$

Where the default values are:

Average Adult Weight	= 70 kg
Relative Source Contribution	= 20 Percent
Assumed Daily Water Consumption	= two liters per day
Conversion Factor	= 1,000 μg/mg
Reference Dose	= value from the USEPA IRIS data base, http://www.epa.gov/iris/, incorporated herein by reference, as (mg/kg/day)
Uncertainty Factor	= 10 for carcinogens for which no carcinogenic slope factor is applicable; 1 for non-carcinogens

As stated in the summary of the proposed amendments adopted in 2005 (see 36 N.J.R. 4374(b)) and now codified under the adopted amendments to N.J.A.C. 7:9C-1.7(c)4, the Department may, as appropriate, use alternative values or modified equations in the derivation of interim specific and specific ground water quality criteria to ensure that criteria reflect the best available science and adequately protect human health, using the sources set forth in the rule. Any ground water quality criteria that were derived using alternative values or modified equations are noted in Table C and explained further in the Appendix, which is comprised of individual fact sheets explaining the derivation/update of each ground water quality criterion, PQL, and ground water quality standards addressed by the adopted amendments.

As shown earlier in Table A, all (23) interim specific ground water quality criteria updated and/or replaced with specific ground water quality criteria and added to Appendix Table 1 of the rules were reevaluated by the Department to ensure that they reflect the best available science. The ground water quality criterion for **2-hexanone** was the only one updated based on this reevaluation, resulting in a change in the ground water quality criterion from 300 µg/L to 40 µg/L. More detailed information explaining the derivation of this updated ground water quality criterion is provided in Appendix I.

Table C: Factors Used to Derive Ground Water Quality Criteria

Constituent	CASRN	RfD (mg/kg/day)	Slope Factor $(mg/kg/day)^{-1}$	Carcinogenicity	RSC (%)	Criterion (µg/L)
1,1,1-Trifluoroethane	420-46-2	0.7 *	NA	Non-carcinogen	20	5,000
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	76-13-1	3*	NA	Non-carcinogen	20	20,000
1,1-Dichloro-1-fluoroethane	1717-00-6	0.07*	NA	Non-carcinogen	20	500
1,4-Dioxane	123-91-1	NA	0.1	Likely to be carcinogenic to humans	NA	0.4
1-Chloro-1,1-difluoroethane	75-68-3	14*	NA	Non-carcinogen	20	100,000
2-(2-Methyl-4-chlorophenoxy) propionic acid (MCPP)	93-65-2	0.001	NA	Non-carcinogen	20	7
2,4,6-Trinitrotoluene (TNT)	118-96-7	1.7×10^{-4}	0.03	Possible Human Carcinogen	20	1
2-Ethyl-1-hexanol	104-76-7	0.0357*	NA	Non-carcinogen	20	200
2-Hexanone	591-78-6	0.005	NA	Non-carcinogen	20	40
2-Methylnaphthalene	91-57-6	0.004	NA	Non-carcinogen	20	30
4,6-Dinitro-o-cresol	534-52-1	1×10^{-4}	NA	Non-carcinogen	20	0.7
Caprolactam	105-60-2	0.5	NA	Non-carcinogen	20	4,000
Cobalt	7440-48-4	0.02*	NA	Non-carcinogen	20	100
Cresols (mixed isomers)	95-48-7 108-39-4 106-44-5	7.3×10^{-3}*	NA	Suggestive evidence of carcinogenic potential	20	50
Dichlormid	37764-25-3	0.02*	NA	Non-carcinogen	80	600
Diphenyl ether	101-84-8	0.02*	NA	Non-carcinogen	20	100
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.003	0.11	Possible Human Carcinogen	20	0.3

Constituent	CASRN	RfD (mg/kg/day)	Slope Factor $(mg/kg/day)^{-1}$	Carcinogenicity	RSC (%)	Criterion (µg/L)
Metolachlor	51218-45-2	0.015	None available	Possible Human Carcinogen	20	100
Perchlorate	14797-73-0	7×10^{-4}	NA	Non-carcinogen	20	5
Perfluorononanoic acid (PFNA)	375-95-1	7.4×10^{-4} *	NA	Non-carcinogen	50	0.01
Strontium	7440-24-6	0.3	NA	Non-carcinogen	20	2,000
Tricresyl phosphate (mixed isomers)	1330-78-5 563-04-2 78-32-0	4×10^{-4}*	NA	Non-carcinogen	20	3
Tri-ortho-cresyl phosphate	78-30-8	4×10^{-4} *	NA	Non-carcinogen	20	3

Table C Notes:

CASRN = Chemical Abstracts Service Registry Number is a unique numerical identifier assigned to every chemical substance described in the open scientific literature.

Reference Dose (RfD) was based on data retrieved from USEPA IRIS through July 31, 2016 except where noted with an asterisk **(*).** Details on using an alternative RfD are available per constituent in the Appendix.

Slope factor was selected from IRIS to develop a criterion that corresponds with the upper bound lifetime excess cancer risk of 10-6. For contaminants classified as possible or suggestive carcinogens for which a slope factor was not available from IRIS, the risk assessment was based on non-carcinogenic effects using the RfD with an additional uncertainty factor of 10 to protect from possible carcinogenic effects. Details on using an alternative slope factor and/or uncertainty factor are available per constituent in the Appendix.

NA=Not Applicable

A **Relative Source Contribution** (RSC) factor other than the default value of 20% RSC for drinking water was used when information was available to develop a chemical-specific RSC higher than 20%. Details on using an alternative RSC are available per constituent in the Appendix.

Updated/Replaced Practical Quantitation Levels (PQLs)

The PQL and the method detection limit (MDL) are performance measures used to estimate the limits of performance of analytical chemistry methods for measuring contaminants. The MDL is defined as "the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero" (40 CFR Part 136 Appendix B). The U.S. Environmental Protection Agency (USEPA) recommends that the MDL be multiplied by a factor of five or ten to account for the variability and uncertainty that can occur at the MDL. In accordance with N.J.A.C. 7:9c-1.9(c)3ii(1), the Department uses a value of five as the median upper boundary of the inter-laboratory MDL distribution from the New Jersey certified laboratory community and multiplies the MDL by five to derive the PQL. Establishing the PQL at a level that is five times the MDL provides a reliable quantitation level that most laboratories can be expected to meet during day-to-day operations. The Department establishes PQLs for Class II ground water constituents in two ways:

1. PQLs derived from Method Detection Limit (MDL) data from the New Jersey Department of Health and Senior Services Laboratory (DHSS) multiplied by 5; or

2. PQLs derived from laboratory performance data that has been evaluated by the Department using the method of Sanders, Lippincott and Eaton (See Sanders, P. et al., "Determining Quantitation Levels for Regulatory Purposes." J. Amer. Water Works Assoc., 1996, March pp. 104-114).

In accordance with N.J.A.C. 7:9C-1.9(c)3, the first option is preferred unless it is not available (e.g., insufficient MDL data) or is not based on the more sensitive analytical method. As shown earlier in Table A, all (23) existing interim PQLs proposed to be updated or replaced with specific PQLs and added to Appendix Table 1 of the rules were reevaluated by the Department to ensure that they reflect the best available science. The PQLs for **4,6-dinitro-o-cresol, caprolactam, and PFNA** were the only ones that were updated based on this reevaluation. The PQL for 4,6-dinitro-o-cresol changed from 1 µg/L to 0.03 µg/L. The PQL for caprolactam changed from 5,000 µg/L to 60 µg/L (rounded from 62.5). The PQL for PFNA changed from 0.003 to 0.005 µg/L. These changes were all due to improved laboratory methods. More detailed information explaining the derivation of the replaced/updated ground water quality criteria is provided in the Appendix of this document (see Appendix K, Appendix L, and Appendix T, respectively), which is comprised of individual fact sheets explaining the derivation/update of each ground water quality criterion, PQL, and ground water quality standard addressed by this proposal.

Updated Ground Water Quality Standards

As shown earlier in Table A, all 23 ISGWQS were updated and/or replaced with SGWQS and added to Appendix Table 1 of the rules. N.J.A.C. 7:9C-1.9(c) establishes that, for constituents in Class II ground waters, the ground water quality standard (i.e., the constituent standard) is the higher of the applicable PQL and the ground water quality criterion. Based on the reevaluation of the ground water quality criteria and PQLs explained earlier, the ground water quality standards for **2-hexanone**, **caprolactam**, and **4,6-dinitro-o-cresol** were the only ones updated. The ground water quality standard for caprolactam changed from 5,000 µg/L to 4,000 µg/L (rounded from 3500); the ground water quality standard for 4,6-dinitro-o-cresol changed from 1 µg/L to 0.7 µg/L; and the ground water quality standard for 2-hexanone changed from 300 µg/L to 40 µg/L. (While the PQL for PFNA was updated, this did not require a change to the ground water quality standard, which remains 0.01 µg/L.) More detailed information explaining the derivation of these updated ground water quality standards is provided in Appendix I, K, and Appendix L, respectively.

Rounding Issues

Conventions for determining significant figures and rounding are often applied to environmental standards to establish the degree of confidence in the accuracy of a given number. The conventions established in the existing rules are designed to reflect the limitations of the scientific equipment and methods available to collect and analyze data used to derive and implement the ground water quality standards. The existing rules require that all human health-based Class II criteria and PQLs be rounded to one significant figure using standard methods (see N.J.A.C. 7:9C-1.7(c)4iii and 1.9(c)3i).

Rounding of ground water quality criteria and PQLs follows the general scientific practice of dropping digits that are not significant. If the digit 6, 7, 8, or 9 is dropped, the preceding digit is increased by one; if the digit 0, 1, 2, 3, or 4 is dropped, the preceding digit remains the same. If the digit 5 is dropped, then the preceding digit is rounded to the nearest even number (APHA, 1998; USEPA, 2000). For example, 2.5 would become 2, and 3.5 would become 4. (See Section II and III of the "Basis and Background for Criteria Derivation and Practical Quantitation Levels, Ground Water Quality Standards Rule Recodification and Readoption with Amendments, N.J.A.C 7:9C, NJDEP, September 2004" at http://www.state.nj.us/dep/wms/bears/docs/gwqsbb.pdf.)

In re-evaluating the ISGWQC and interim PQLs, the Department determined that these rounding conventions were not always applied correctly in deriving SGWQC and PQLs. The adopted amendments include the following updates to the Class II ground water quality criteria and PQLs necessary to be consistent with these conventions.

Updates and Amendments Based on Rounding

In addition to the updated criteria, PQLs and standards explained earlier, the adopted amendments also correct previous rounding errors made in deriving the criterion or PQL for two additional constituents: **perchlorate and strontium**. Appendix Table 1 includes the SGWQC, PQL and SGWQS for each constituent in Class II ground waters for which constituent standards have been promulgated. Pursuant to N.J.A.C. 7:9C-1.7(c)4iii, all ISGWQC and SGWQC are rounded to one significant figure. For strontium, the ISGWQS was rounded to two significant figures (1,500 µg/L rounded to 2,000 µg/L) but the ISGWQC was not. The adopted amendments show both the SGWQC and the SGWQS for strontium as 2,000 µg/L (the rounded value). The applicable ground water quality standard continues to be 2,000 µg/L (the higher of the specific criterion of 2,000 µg/L and the PQL of 5 µg/L). Similarly, the interim PQL for perchlorate was established as 2.7 µg/L. Pursuant to N.J.A.C. 7:9C-1.9(c)3i, PQLs are also rounded to one significant figure. The adopted amendments show the PQL for PQL for perchlorate as 3 µg/L (the rounded value). The applicable ground water quality standard for perchlorate continues to be 5 µg/L (the higher of the specific criterion of 5 µg/L and the PQL of 3 µg/L).

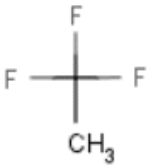
Index of Appendices

Appendix A: 1,1,1-Trifluoroethane

Ground Water Quality Standard for
1,1,1-Trifluoroethane (HFC-143a)
CASRN 420-46-2

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 5,000 µg/L and a practical quantitation level (PQL) of 60 µg/L for 1,1,1-trifluoroethane (also known as "HFC-143a"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 1,1,1-trifluoroethane is 5,000 µg/L**.

1,1,1-Trifluoroethane (HFC-143a)
Molecular Formula:
$C_2H_3F_3$
Molecular Structure:



Background: 1,1,1-Trifluoroethane is mainly used in stationary air conditioning systems and commercial refrigeration (OECD, 2010).

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on 1,1,1-trifluoroethane indicates that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, 1,1,1-trifluoroethane was considered a non-carcinogen in the development of a human health-based ground water quality criterion. No criteria or standards developed by other government agencies for 1,1,1-trifluoroethane in drinking water, ground water, surface water, or soil were located. The No Observed Adverse Effect Level (NOAEL) of 40,000 ppm from the subchronic rat inhalation study (Brock et al., 1996) was selected as the basis for the Reference Dose. The inhalation NOAEL can be converted to an oral NOAEL by multiplying by the default daily inhalation volume 20 m^3/day (USEPA, 2009), and body weight, 70 kg, and adjusting for the fact that exposure occurred for 5 of 7 days per week, 6 of 24 hours per day, as follows:

NOAEL[1] = 40,000 ppm = 137,000 mg/m^3

$$\text{Oral NOAEL} = \frac{137{,}000\ \text{mg/m}^3 \times 20\ \text{m}^3\text{/day} \times 6\ \text{hrs}/24\ \text{hrs} \times 5/7\ \text{days per week}}{70\ \text{kg}}$$

Oral NOAEL = 7,000 mg/kg/day

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Interindividual variability in sensitivity in the human population
10: Subchronic-to-chronic extrapolation
10: Database insufficiency, to account for lack of two-generation reproductive study, and for insufficient data to evaluate the potential for decreased body weight from chronic exposure

Total Uncertainty Factor = 10,000

$$\text{RfD} = \text{Oral NOAEL}/\ UF_{total} = \frac{7{,}000\ \text{mg/kg/day}}{10{,}000} = 0.7\ \text{mg/kg/day}$$

Therefore, the RfD used to derive the ground water quality criterion for 1,1,1-trifluoroethane is 0.7 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 1,1,1-trifluoroethane was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.7 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion (µg/L)} = \frac{0.7\ \text{mg/kg/day} \times 70\ \text{kg} \times 1{,}000\ \text{µg/mg} \times 0.2}{2\ \text{L/day}} = 4{,}900\ \text{µg/L}$$

Where:
0.7 mg/kg/day = Reference Dose (RfD)
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 5,000 µg/L

[1] This conversion is based on the following equation: Y mg/m^3 = (X ppm)(molecular weight)/24.45 at 25 °C and 1 atmosphere.

Therefore, the specific ground water quality criterion for 1,1,1-trifluoroethane is 5,000 µg/L.

Derivation of PQL: 1,1,1-Trifluoroethane was listed along with other hydrochlorofluorocarbons as a parameter in a published USEPA method "624, Purgeable organic compounds in Water by Purge and Trap Capillary-Column GC/MS" by a Department-certified laboratory for a client. Sufficient performance data was obtained from the laboratory to generate a PQL using the supplied data performed on a ground water matrix sample batch. The reported method detection limit (MDL) was 11 ppb. Pursuant to N.J.A.C. 7:9c-1.9(c)3, the PQL for 1,1,1-trifluoroethane was derived by multiplying the MDL by 5, rounded to one significant figure, and expressed in µg/L, as shown below:

PQL = 11 ppb x 5 = 55 ppb

PQL rounded to one significant figure = 60 ppb = 60 µg/L

Therefore, the PQL for 1,1,1-trifluoroethane is 60 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 5,000 µg/L and a PQL of 60 µg/L for 1,1,1-trifluoroethane. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for 1,1,1-trifluoroethane is 5,000 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for 1,1,1-Trifluoroethane CASRN# 420-46-2*. October 2015. NJDEP.http://www.state.nj.us/dep/wms/bears/docs/111%20trifluoroehane%20final%20draft%20for%20posting.pdf.
- *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*, NJDEP. 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- R. Lee Lippincott, Ph.D., NJDEP, May 1, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1,1,1,trifluoroethane-pql.pdf.
- *Interim Specific Groundwater Criterion Support Document for 1,1,1-Trifluoroethane (HCFC-143a)*, Gloria Post, Ph.D., DABT. NJDEP, April 22, 2012. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1,1,1,trifluoroethane.pdf.

References:

AFEAS. 2009. Alternative Fluorocarbons Environmental Acceptability Study (AFEAS). Annual fluorocarbon production reported. http://www.afeas.org/.

Brock, W.J., Trochimowicz, H.J., Millischer, R.J., Farr, C., and Rusch, G.M. 1996. Acute, subchronic, and developmental toxicity and genotoxicity of 1,1,1-trifluoroethane (HFC-143a). Fd Chem. Toxic. 31:200-209.

Cracknell, S. 1992. Forane 143a: acute inhalation toxicity study in the rat. Unpublished report 91/ATH007/1159. Life Science Research, Eye, Suffolk, England, UK. Atochem, Paris la Defense, France. (Cited in OECD, 2010).

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Longstaff, E., Robinson, M., Bradbrook, C., Styles, J.A., and Purchase, I.F.H.1984. Genotoxicity and carcinogenicity of fluorocarbons: assessment by short-term in vitro tests and chronic exposure in rats. Toxicology and Applied Pharmacology 71:15-31.

OECD. 2010. Organisation for Economic Co-operation and Development. 1,1,1- Trifluoroethane. CAS No. 420-46-2. Screening information data sets (sids) initial assessment report for 30th SIDS Initial Assessment Meeting (SIAM). http://webnet.oecd.org.

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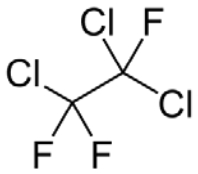
Appendix B: 1,1,2-Trichloro-1,2,2-trifluoroethane

Ground Water Quality Standard for
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
CASRN 76-13-1

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 20,000 µg/L and a practical quantitation level (PQL) of 0.3 µg/L for 1,1,2-trichloro-1,2,2-trifluoroethane (also known as "CFC 113" or "Freon 113"). The basis for this criterion and PQL are discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard for 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113) is 20,000 µg/L.**

1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
Molecular Formula:
$C_2Cl_2F_3$
Molecular Structure**:**



Background: Freon 113 was one of the most commonly used chlorofluorocarbons (CFCs). It was used as a refrigerant in air conditioners and refrigerators and was also formerly used as a solvent to clean electronics, especially phones, before being phased out of production.

Reference Dose (RfD): There are no recent mutagenicity studies or cancer bioassays; however, earlier mutagenicity studies provide no evidence of a mutagenic or carcinogenic potential (Longstaff, 1988). Therefore, 1,1,2-trichloro-1,2,2-trifluoroethane was considered a non-carcinogen in the development of the human health-based ground water quality criterion. The U.S. Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) database shows an RfD for 1,1,2-trichloro-1,2,2-trifluoroethane of 30 mg/kg/day, which was developed based on a source document published in 1983 that was last reviewed by USEPA in 1987 based on an occupational exposure study (Imbus and Adkins, 1972). This study examined workers who were exposed to Freon 113 for five days/week for up to 4 ½ years. The USEPA used this study, in which exposure appears to have occurred exclusively or nearly exclusively through

inhalation[2] of Freon 113, to derive an ingestion RfD by assuming that ingested Freon 113 would be absorbed twice as efficiently as inhaled Freon 113. This assumption was based on data showing significant concentrations of Freon 113 in exhaled breath (Woollen et al., 1990). This study did not examine effects that are typically examined in animal studies, including pathology and histopathology, organ weight, weight loss/gain, cancer incidence, reproductive, or developmental effects. The freestanding No Observed Adverse Effect Level (NOAEL) from the Imbus and Adkins (1972) study was 699 ppm - the mean level of exposure measured in the workplace of the exposed subjects - which is equivalent to 5,358 mg/m^3. This inhalation exposure was converted to an equivalent ingestion exposure by adjusting the 5,358 mg/m^3 air concentration to account for exposure during 5 days per week, and by assuming a 70-kg body weight and a 10 m^3 daily occupational inhalation volume, and by assuming that 100% of ingested Freon 113 would be absorbed versus 50% of inhaled Freon 113 (i.e., 0.5 inhalation vs. ingestion absorption factor). This gives an Oral NOAEL of 273 mg/kg. USEPA applied an uncertainty factor adjustment of 10 to account for inter-individual variability in sensitivity in the human population, which resulted in a value of 27.3 mg/kg/day that was rounded to one significant figure to give an RfD of 30 mg/kg/day. The Department applied an additional uncertainty factor of 10 to account for uncertainty from the small population used in the source study, lack of any data that address reproductive or developmental endpoints, and the lack of a useable ingestion-specific study.

Therefore, the RfD used to derive the ground water quality criterion for 1,1,2-trichloro-1,2,2-trifluoroethane is 3 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 1,1,2-trichloro-1,2,2-trifluoroethane was derived pursuant to the formula for non-carcinogens established at N.J.A.C. 7:9C-1.7(c)4, using a derived RfD of 3 mg/kg/day that incorporates a total uncertainty factor of 100 (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{3\ \text{mg/kg/day} \times 70\ \text{kg} \times 1{,}000\ \mu\text{g/mg} \times 0.2}{2\ \text{L/day}} = 21{,}000\ \mu\text{g/L}$$

Where:
3 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 20,000 µg/L

[2] Because of its volatility, nearly all toxicological investigations of Freon 113 focused on the inhalation route of exposure.

Derivation of PQL: 1,1,2-Trichloro-1,2,2-trifluoroethane appears as a listed parameter in National Environmental Methods Index (NEMI) with a method detection limit (MDL) of 0.06 ppb using USEPA method "6200B, Volatile organic compounds in Water by Purge and Trap Capillary-Column GC/MS". Pursuant to N.J.A.C. 7:9c-1.9(c)3, the PQL for 1,1,2-trichloro, 1,2,2-trifluoroethane was derived by multiplying the MDL by five, and expressed in µg/L, as shown below:

PQL = 0.06 ppb x 5 = 0.3 ppb = 0.3 µg/L

Therefore, the PQL for 1,1,2-trichloro-1,2,2-trifluoroethane is 0.3 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 20,000 µg/L and a PQL of 0.3 µg/L for 1,1,2-trichloro-1,2,2-trifluoroethane. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for 1,1,2-trichloro-1,2,2-trifluoroethane is 20,000 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for Freon 113 CASRN# 76-13-1*. October 2015. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/freon%20113%20final%20draft.pdf.
- *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*, NJDEP. 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)*. R. Lee Lippincott, Ph.D. NJDEP. March 13, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1-1-2-trichloro-pql.pdf.
- *Development of Interim Specific Ground Water Quality Criterion for Freon 113*, Alan Stern, D.Ph., D.A.B.T, NJDEP, May 4, 2010. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1-1-2-trichloro.pdf.

References:

Egeland, G.M., T.F. Bloom, T.M. Schnorr, R.W. Hornung, A.J. Suruda and K.K. Wille. 1992. Fluorocarbon 113 exposure and cardiac dysrhythmias among aerospace workers. Am J Ind Med. 22:851-7.

Imbus, H.R. and C. Adkins. 1972. Physical examinations of workers exposed to trichlorotrifluoroethane. Arch Environ Health. 24:257-61 (1972).

Kaufman, J.D., M.A. Silverstein and R. Moure-Eraso. 1994. Atrial fibrillation and sudden death related to occupational solvent exposure. Am J Ind Med.25:731-5.

Kawakami, T., T. Takano and R. Araki. 1990. Enhanced arrhythmogenicity of Freon 113 by hypoxia in the perfused rat heart. Toxicol Ind Health. 6:493-8.

Longstaff, E. 1988. Carcinogenic and mutagenic potential of several fluorocarbons. Ann N Y Acad Sci. 534:283-98.

McKnight, J.E. and J.L. McGraw, Jr. 1983. Ultrastructural study of the effects of trichlorotrifluoroethane on the liver of hairless mice. J Submicrosc Cytol. 15:447-51 (1983).

Michaelson, J.B. and D.J. Huntsman. 1963. Oral toxicity study of 1,2,2-Trichloro-1,1,2-trifluoroethane. J Med Chem. 7:378-9.

Neghab, M., S. Qu, C.L. Bai, J. Caples and N.H. Stacey. 1997. Raised concentration of serum bile acids following occupational exposure to halogenated solvents, 1,1,2-Trichloro-1,2,2-trifluoroethane and trichloroethylene. Int Arch Occup Environ Health. 70:187-94.

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

USEPA. 2002. A review of the Reference Dose and Reference Concentration processes. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, EPA/630/P-02/002F. http://www.epa.gov/osa/review-reference-dose-and-reference-concentration-processes.

USEPA. 1987. Integrated Risk Information System (IRIS) Chemical Assessment Summary: 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113); CASRN 76-13-1 IRIS. https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0123_summary.pdf, accessed August 29, 2016.

Voge, V.M. 1996. Secondary arterial hypertension linked to Freon exposure. South Med J. 89:516-8.

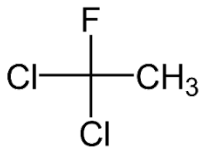
Woollen, B.H., E.A. Guest, W. Howe, J.R. Marsh, H.K. Wilson, T.R. Auton and P.G. Blain PG. 1990. Human inhalation pharmacokinetics of 1,1,2-Trichloro-1,2,2-trifluoroethane (FC113). Int Arch Occup Environ Health. 62:73-8.

Appendix C: 1,1-Dichloro-1-fluoroethane

Ground Water Quality Standard for
1,1-Dichloro-1-fluoroethane (HCFC-141b)
CASRN 1717-00-6

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 500 µg/L and a practical quantitation level (PQL) of 30 µg/L for 1,1-dichloro-1-fluoroethane (also known as "HCFC-141b"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 1,1-dichloro-1-fluoroethane is 500 µg/L**.

1,1-Dichloro-1-fluoroethane (HCFC-141b)
Molecular Formula:
$C_2H_3Cl_2F$
Molecular Structure:



Background: 1,1-Dichloro-1-fluoroethane was developed as a substitute for CFC-11, a fully halogenated chlorofluorocarbon, mainly for use as a blowing agent for polyurethane and polyisocyanurate insulating foams and as a solvent in electronic and other precision cleaning applications. It is no longer permitted to be used as a blowing agent. It is produced and used as a substitute for fully halogenated chlorofluorocarbons with comparable physical properties since it has less unfavorable environmental properties (ECETOC, 1994; OECD, 2001).

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on 1,1-dichloro-1-fluoroethane indicates that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, 1,1-dichloro-1-fluoroethane was considered a noncarcinogen in the development of a human health-based ground water quality criterion. Because no oral subchronic, chronic, developmental, or reproductive studies are available for 1,1-dichloro-1-fluoroethane, the Department derived an RfD based on systemic effects from an inhalation study (Rusch et al., 1995). The endpoint used as the basis for the RfD was the inhalation Lowest Observed Adverse Effect Level (LOAEL) of 2,000 ppm (9,700 mg/m^3) for decreased body weight in F_1 rat pups from a two-generation study (Rusch et al., 1995). The inhalation LOAEL was converted to an oral LOAEL

by applying default values for daily inhalation volume (20 m^3/day) (USEPA, 2009), default body weight (70 kg), and adjusting for exposure of 6 hours per day, as follows:

LOAEL = 2,000 ppm = 9,700 mg/m^3

$$\text{Oral LOAEL} = \frac{9{,}700\ mg/m^3 \times 20\ m^3/day \times 6\ hrs/24\ hrs}{70\ kg}$$

Oral LOAEL = 693 mg/kg/day

Based on the weight of evidence from a number of studies (see References), the Department concluded that the appropriate carcinogenicity descriptor for 1,1-dichloro-1-fluoroethane is "Suggestive Evidence of Carcinogenic Potential." The Department has adopted a risk assessment approach for chemicals with Suggestive Evidence of Carcinogenic Potential (see NJDWQI, 2009). Under this approach, the risk assessment is based on a slope factor at the 10^{-6} upper bound lifetime excess cancer risk level if the data support development of a slope factor, or an RfD for non-cancer effects with an additional uncertainty factor of 10 to protect against potential carcinogenic effects if the data do not support development of a slope factor. The Department used the alternative approach for risk assessment based on an RfD that includes an additional uncertainty factor of 10 to protect for possible carcinogenic effects. (Note: An uncertainty factor for less-than-lifetime exposure is not used for developmental endpoints, since they result from exposure over a short time period.)

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Interindividual variability in sensitivity in the human population
10: LOAEL-to-NOAEL extrapolation
10: Possible carcinogenicity for suggestive carcinogens

Total Uncertainty Factor = 10,000

$$\text{RfD} = \text{Oral LOAEL}/UF_{total} = \frac{693\ mg/kg/day}{10{,}000} = 0.07\ mg/kg/day$$

Therefore, the RfD used to derive the ground water quality criterion for 1,1-dichloro-1-fluoroethane is 0.07 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 1,1-dichloro-1-fluoroethane was derived pursuant to the formula established at N.J.A.C. 7:9C-

1.7(c)4, an RfD of 0.07 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure:

$$\text{Criterion} = \frac{0.07\ \text{mg/kg/day} \times 70\ \text{kg} \times 1{,}000\ \mu\text{g/mg} \times 0.2}{2\ \text{L/day}} = 490\ \mu\text{g/L}$$

Where:
0.07 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 500 µg/L

Therefore, the specific ground water quality criterion for 1,1-dichloro-1-fluoroethane is 500 µg/L.

Derivation of PQL: 1,1-dichloro-1-fluoroethane was listed along with other hydrochlorofluorocarbons as a parameter in a published USEPA method "624, Purgeable organic compounds in Water by Purge and Trap Capillary Column GC/MS" by a Department-certified laboratory for a client. Sufficient performance data was obtained from the laboratory to generate a PQL using the supplied data performed on a ground water matrix sample batch. The reported method detection limit (MDL) was 6.4 ppb. Pursuant to N.J.A.C. 7:9c-1.9(c)3, the PQL for 1,1-dichloro-1-fluoroethane was derived by multiplying the MDL by 5, rounded to one significant figure, and expressed in µg/L, as shown below:

PQL = 6.4 ppb x 5 = 32 ppb

PQL rounded to one significant figure = 30 ppb = 30 µg/L

Therefore, the PQL for 1,1-dichloro-1-fluoroethane is 30 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 500 µg/L and a PQL of 30 µg/L for 1,1-dichloro-1-fluoroethane. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for 1,1-dichloro-1-fluoroethane is 500 µg/L.**

Technical Support Documents:

- *Ground Water Quality Standard for 1,1-Dichloro-1-Fluoroethane CASRN# 1717-00-6.* October 2015. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/1,1-dichloro-1-fluoroethane_fact_sheet.pdf.
- *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*. NJDEP. 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for 1,1-Dichloro-1-Fluoroethane*, R. Lee Lippincott, Ph.D., NJDEP, May 1, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1,1,-dichloro-1,fluoroethane-pql.pdf.
- *Interim Specific Groundwater Criterion Support Document 1,1-Dichloro-1-fluoroethane (HCFC141b)*, Gloria Post, Ph.D., NJDEP, April 17, 2012. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1,1,-dichloro-1,fluoroethane.pdf.

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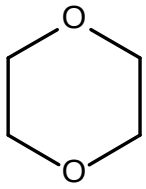
Appendix D: 1,4-Dioxane

Ground Water Quality Standard for
1,4-Dioxane
CASRN 123-91-1

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 0.4 µg/L and a practical quantitation level (PQL) of 0.1 µg/L for 1,4-dioxane (also known as "1,4-diethylene dioxide"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 1,4-dioxane is 0.4 µg/L.**

1,4-Dioxane (1,4-diethylene dioxide)
Molecular Formula:
$C_4H_8O_2$
Molecular Structure:



Background: 1,4-Dioxane is used as a solvent and a laboratory reagent. It is also found as a trace contaminant in the manufacture of cosmetics.

Derivation of Ground Water Quality Criterion: 1,4-Dioxane had been previously evaluated by the U.S. Environmental Protection Agency (USEPA) in 1988 and was classified as a Group B2 Probable Human Carcinogen. USEPA's Integrated Risk Information System (IRIS) database assessment for 1,4-dioxane was updated on August 11, 2010 and again in September 2013 (see chronology in USEPA, 2013a), and is supported by a Toxicological Review document (USEPA, 2013b). The updated IRIS assessment classifies 1,4-dioxane as likely to be carcinogenic to humans and provides an updated slope factor of 0.1 $(mg/kg/day)^{-1}$. This current slope factor is based on liver tumors in a study of female mice (Kano et al., 2009) which provides a more sensitive endpoint for carcinogenicity than the previously used studies. For chemicals classified as likely to be carcinogenic to humans, the Cancer Slope Factor is used to develop a ground water quality criterion at the 10^{-6} upper bound lifetime excess cancer risk level.

The specific ground water quality criterion for 1,4-dioxane was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for carcinogens, a Cancer Slope Factor of 0.1 $(mg/kg/day)^{-1}$ as explained above, standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{10^{-6} \times 70\ kg \times 1{,}000\ \mu g/mg}{(0.1\ mg/kg/day)^{-1} \times 2\ L/day} = 0.35\ \mu g/L$$

Where:
10^{-6} = Upper Bound Lifetime Excess Cancer Risk
0.1 $(mg/kg/day)^{-1}$ = Cancer Slope Factor
70 kg = average adult weight
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 0.4 µg/L

Therefore, the specific ground water quality criterion for 1,4-dioxane is 0.4 µg/L.

Derivation of PQL: 1,4-dioxane appears as a listed parameter in the National Environmental Methods Index (NEMI) for published USEPA Method 522 entitled *Determination of 1,4-Dioxane in Drinking Water by Solid Phase Extraction (SPE) and Gas Chromatography/Mass Spectrometry (GC/MS) with Selected Ion Monitoring (SIM)*. The published method detection limit (MDL) for water ranges from 0.020 ppb to 0.026 ppb depending on the absorbent cartridge used to isolate this compound. The Department selected the higher end of this range as the MDL for 1,4-dioxane. Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL for 1,4-dioxane was derived by multiplying the method detection limit (MDL) by five, rounded to one significant figure, and expressed in µg/L.

PQL = 0.026 ppb x 5 = 0.13 ppb

PQL rounded to one significant figure = 0.1 ppb = 0.1 µg/L

Therefore, the PQL for 1,4-dioxane is 0.1 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 0.4 µg/L and a PQL of 0.1 µg/L (ppb) for 1,4-dioxane. Pursuant to N.J.A.C. 7:9C-1.9(c), since the criterion is higher than the PQL, **the ground water quality standard for 1,4-dioxane is 0.4 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for 1,4-Dioxane CASRN# 123-91-1.* October 2015. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/1,4%20dioxane%20final%20draft%20for%20posting2.pdf.

- *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*, NJDEP. 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for 1,4-Dioxane*. R. Lee Lippincott, Ph.D. NJDEP. October 8, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1,4-dioxane-pql.pdf.
- *Recommendation of revised interim specific ground water criterion for 1,4-dioxane*. Dr. Gloria Post. NJDEP. October 29, 2010. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1,4-dioxane.pdf.

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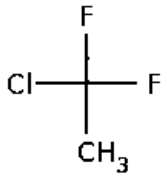
Appendix E: 1-Chloro-1,1-difluoroethane

Ground Water Quality Standard for
1-Chloro-1,1-difluoroethane ((HCFC142b)
CASRN 75-68-3

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 100,000 µg/L and a practical quantitation level (PQL) of 500 µg/L for 1-chloro-1,1-difluoroethane (also known as "HCFC142b". The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 1-chloro-1,1-difluoroethane is 100,000 µg/L**.

1-Chloro-1,1-difluoroethane (HCFC142b)
Molecular Formula:
$C_2H_3ClF_2$
Molecular Structure:



Background: 1-Chloro-1,1-difluoroethane is used primarily as a refrigerant.

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on 1-chloro-1,1-difluoroethane indicates that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, 1-chloro-1,1-difluoroethane was considered a noncarcinogen in the development of a human health-based ground water quality criterion. Because no oral data are available, the endpoint used as the basis for the RfD was the inhalation No Observed Adverse Effect Level (NOAEL) of 20,000 ppm (82,620 mg/m^3) from a two-year (chronic) rat inhalation study (Seckar et al., 1986). The inhalation NOAEL was converted to an oral NOAEL by applying default values for daily inhalation volume (20 m^3/day) (USEPA, 1989) and default body weight (70 kg) and adjusting for exposure of 6 hours per day, five days per week, as follows:

NOAEL = 20,000 ppm = 82,620 mg/m^3

$$\text{Oral NOAEL} = \frac{82{,}620\ \text{mg/m}^3 \times 20\ \text{m}^3\text{/day} \times 6\ \text{hrs}/24\ \text{hrs} \times 5/7\ \text{days per week}}{70\ \text{kg}}$$

Oral NOAEL = 4,215 mg/kg/day

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Intraspecies variability to protect sensitive subpopulations
3: Database insufficiency, to account for the lack of a two-generation reproductive study

Total Uncertainty Factor = 300

$$RfD = \text{Oral NOAEL}/ UF_{total} = \frac{4{,}215 \text{ mg/kg/day}}{300} = 14 \text{ mg/kg/day}$$

Therefore, the RfD used to derive the ground water quality criterion for 1-chloro-1,1-difuoroethane is 14 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 1-chloro-1,1-difuoroethane was derived pursuant to the formula established at N.J.A.C. 7:9C-1.7(c)4 for non-carcinogens, an RfD of 14 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{14 \text{mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 98{,}000 \text{ µg/L}$$

Where:
14 mg/kg/day = the derived RfD
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure= 100,000 µg/L

Therefore, the specific ground water quality criterion for 1-chloro-1,1-difuoroethane is 100,000 µg/L.

Derivation of PQL: 1-Chloro-1,1-difluoroethane is listed along with other hydrochlorofluorocarbons in a published USEPA method "624, Purgeable organic compounds in Water by Purge and Trap Capillary-Column GC/MS" by a Department-certified laboratory for a client. Sufficient performance information was obtained from the laboratory to generate a PQL

using the supplied data performed on a ground water matrix sample batch. The reported method detection limit (MDL) is 100 ppb. Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL for 1-chloro-1,1-difluoroethane was derived by multiplying the MDL by five, and expressed in µg/L, as shown below:

PQL = 100 ppb x 5 = 500 ppb = 500 µg/L

Therefore, the PQL for 1-chloro-1,1-difluoroethane is 500 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 100,000 µg/L and a PQL of 500 µg/L for 1-chloro-1,1-difluoroethane. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for 1-chloro-1,1-difluoroethane is 100,000 µg/L.**

Technical Support Documents:

- *Ground Water Quality Standard for 1-Chloro-1,1-Difluoroethane CASRN# 75-68-3.* October 2015. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/1-chloro-11diflouroethane%20hcfc-142b%20fact%20sheet%20draft%20final%20for%20posting.pdf.
- *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*. NJDEP. 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Describing Process for Development of an Analytical Practical Quantitation Level (PQL) for 1-Chloro-1,1-difluoroethane*. R. Lee Lippincott, Ph.D. NJDEP. May 1, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1-chloro-1,1-difluoroethane-pql.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for 1-Chloro-1,1-Difluoroethane (HCFC-142b)*. Gloria Post, Ph.D. D.A.B.T. NJDEP. April 26, 2012. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/1-chloro-1,1-difluoroethane.pdf.

References:

ERM. Interim Criterion Support Document for HCFC-142b. Submitted to NJDEP on January 5, 2012.

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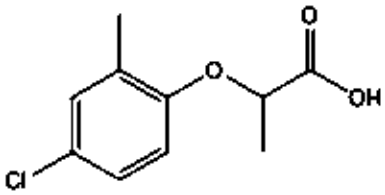
USEPA. 2011. Regional Screening Level Table. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/pdf/master_sl_table_run_NOV2011.pdf.

Appendix F: 2-(2-Methyl-4-chlorophenoxy)propionic acid (MCPP)

Ground Water Quality Standard for
2-(2-Methyl-4-chlorophenoxy)propionic acid (MCPP)
CASRN 93-65-2

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 7 µg/L and a practical quantitation level (PQL) of 0.5 µg/L for 2-(2-methyl-4-chlorophenoxy)propionic acid (also known as "MCPP"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 2-(2-methyl-4-chlorophenoxy)propionic acid is 7 µg/L**.

2-(2-Methyl-4-chlorophenoxy)propionic acid
(MCPP)
Molecular Formula:
$C_{10}H_{11}ClO_3$
Molecular Structure:



Background: None available

Reference Dose (RfD): The U.S. Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) database does not provide an evaluation of carcinogenicity in its assessment of 2-(2-methyl-4-chlorophenoxy)propionic acid; therefore, it was considered a non-carcinogen in the development of a human health-based ground water quality criterion. IRIS shows an oral RfD of 0.001 mg/kg/day for 2-(2-methyl-4-chlorophenoxy)propionic acid, which was derived by USEPA in 1989 based on a No Observed Effect Level (NOEL) of 3 mg/kg/day and a total uncertainty factor of 3,000. The Department concurred with the USEPA-derived RfD).

Therefore, the RfD used to derive the ground water quality criterion is 0.001 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 2-(2-methyl-4-chlorophenoxy)propionic acid was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.001 mg/kg/day (as explained above), and standard

default assumptions, as shown below:

$$\text{Criterion} = \frac{0.001 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 7 \text{ µg/L}$$

Where:
0.001 mg/kg/day = the derived RfD
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Therefore, the specific ground water quality criterion for 2-(2-methyl-4-chlorophenoxy)propionic acid is 7 µg/L.

Derivation of PQL: 2-(2-Methyl-4-chlorophenoxy)propanoic acid appears as a listed parameter in the National Environmental Methods Index (NEMI) with a method detection limit (MDL) of 0.09 ppb using published method – "OSW USEPA 8151A, Chlorinated Herbicides and Related Compounds in Water, Soil, and Waste Samples by Capillary GC-ECD". Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL was derived by multiplying the MDL by 5, rounded to one significant figure and expressed in µg/L, as shown below:

PQL = 0.09 ppb x 5 = 0.45 ppb

PQL rounded to one significant figure = 0.5 ppb = 0.5 µg/L

Therefore, the PQL for of 0.5 ppb for 2-(2-methyl-4-chlorophenoxy)propanoic acid is 0.5 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 7 µg/L and a PQL of 0.5 µg/L for 2-(2-methyl-4-chlorophenoxy)proionic acid. In accordance with N.J.A.C. 7:9C-1.9(c), since the criterion is higher than the PQL for this constituent, **the ground water quality standard for 2-(2-methyl-4-chlorophenoxy)propionic acid is 7 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for 2-(2-Methyl-4-chlorophenoxy)propionic acid (MCPP) CASRN# 93-65-2*. February 2008. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/mcpp.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for 2-(2-Methyl-4-chlorophenoxy) propionic acid (MCPP)*. Dr. Gloria Post. NJDEP. February 7, 2007 (available upon request).
- *Procedure for Describing Process for Development of an Analytical Practical Quantitation Level (PQL) for 2-(2-Methyl-4-chlorophenoxy) propionic acid.* R. Lee Lippincott, Ph.D. NJDEP.

March 17, 2006 (available upon request)

References:

BASF, Aktiengesellschaft. 1985. MRID No. 00158359. Available from USEPA. Write to FOI, EPA, Washington DC 20460 (Cited in USEPA, 2002).

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

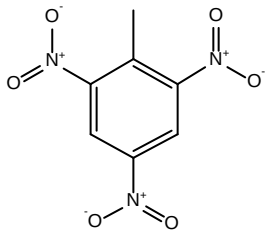
USEPA. 2002. Integrated Risk Information System. 2-(2-Methyl-4-chlorophenoxy)propionic acid (MCPP) (CASRN 93-65-2). Last modified, 12/3/2002.

Appendix G: 2,4,6-Trinitrotoluene (TNT)

Ground Water Quality Standard for
2,4,6-Trinitrotoluene (TNT)
CASRN 118-96-7

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 1 µg/L and a practical quantitation level (PQL) of 0.3 µg/L for 2,4,6-trinitrotoluene (also known as "TNT" and 1-methyl-2,4,6-trinitrobenzene). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 2,4,6-trinitrotoluene is 1 µg/L**.

2,4,6-Trinitrotoluene (TNT)
1-methyl-2,4,6-trinitrobenzene
Molecular Formula:
$C_7H_5N_3O_6$
Molecular Structure:



Background: Nitroaromatic explosives contain three NO_2 groups in various positions on the ring. TNT is the most extensively used of these explosives.

Reference Dose (RfD) and Cancer Slope Factor: 2,4,6-Trinitrotoluene has been evaluated by the U.S. Environmental Protection Agency's (USEPA) and an assessment is available from USEPA's Integrated Risk Information System (IRIS) database. USEPA classified 2,4,6-trinitrotoluene as Group C, Possible Human Carcinogen and derived both an RfD for non-carcinogenic effects and a cancer slope factor for carcinogenic effects. An RfD of 0.0005 mg/kg/day was derived in 1988 (USEPA, 2002) based on a Lowest Observed Adverse Effect Level (LOAEL) of 0.5 mg/kg/day (US DOD, 1983) and an uncertainty factor of 1,000. A Cancer Slope Factor of 0.03 $(mg/kg/day)^{-1}$ was derived based on the urinary bladder carcinomas and papillomas in female rats.

Derivation of Ground Water Quality Criterion: For chemicals classified as Group C which have a cancer slope factor, the Department generally uses the slope factor to develop a ground water

criterion at the 10^{-6} risk level; however, for comparison, the Department derived a ground water quality criterion based on the RfD as well as the Cancer Slope Factor to ensure that the criterion based on carcinogenicity is also protective for systemic toxicity.

USEPA applied a total uncertainty factor of 1,000 to account for interindividual sensitivity, interspecies extrapolation, subchronic-to-chronic extrapolation, and LOAEL-to-NOAEL extrapolation, to derive an RfD of 0.0005 mg/kg/day. However, the Department applied a total uncertainty factor of 3,000 to account for interindividual sensitivity, interspecies variability, subchronic-to-chronic extrapolation, and for extrapolation from a LOAEL to a NOAEL, as shown below.

The uncertainty factors applied to derive the RfD are:

10: Interindividual sensitivity
10: Intraspecies variability
10: Subchronic-to-chronic extrapolation
3: LOAEL-to-NOAEL extrapolation

Total Uncertainty Factor = 3,000

RfD = LOAEL/ UFtotal = 0.5 mg/kg/day = 0.00017 mg/kg/day

Therefore, the RfD used to derive the ground water quality criterion is 0.00017 mg/kg/day.

A ground water criterion was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, the derived RfD (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.00017 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 1.2 \text{ µg/L}$$

Where:
0.00017 mg/kg/day = the RfD
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 1 µg/L

A ground water quality criterion was also derived using the formula for carcinogens and the derived cancer slope factor (as explained above), standard default assumptions, and rounded to

one significant figure, as follows:

$$\text{Criterion} = \frac{10^{-6} \times 70 \text{ kg} \times 1{,}000 \text{ µg/mg}}{0.03 \text{ (mg/kg/day)}^{-1} \times 2 \text{ L/day}} = 1.2 \text{ µg/L}$$

Where:
10^{-6} = Upper Bound Lifetime Excess Cancer Risk
0.03 $(mg/kg/day)^{-1}$ = Cancer Slope Factor
70 kg = average adult weight
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 1 µg/L

As shown above, the ground water criterion is the same using either carcinogenic or systemic endpoints. **Therefore, the specific ground water quality criterion for 2,4,6-Trinitrotoluene is 1 µg/L.**

Derivation of PQL:
No published method was listed for 2,4,6-trinitrotoluene in the National Environmental Methods Index (NEMI); however, there are many analytical method references for the determination of a method detection limit (MDL). The best literature detection level that meets the criterion of 1 µg/L is a Gas Chromatography Electron Capture Detector method with a reported level of 0.06 ppb (Walsh, M.E. and T. Ranney, 1998). Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL for trinitrotoluene was derived by multiplying the MDL by 5, rounded to one significant figure and expressed in µg/L, as shown below:

PQL = 0.06 ppb x 5 = 0.3 ppb = 0.3 µg/L

Therefore, the PQL for 2,4,6-trinitrotoluene is 0.3 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 1 µg/L and a PQL of 0.3 µg/L for 2,4,6-trinitrotoluene. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for 2,4,6-trinitrotoluene (TNT) is 1 µg/L**.

Technical Support Documents:
- *Ground Water Quality Standard for 2,4,6-Trinitrotoluene (TNT). CASRN# 118-96-7. NJDEP. February 2008.* http://www.state.nj.us/dep/wms/bears/docs/tnt.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for 2,4,6-Trinitrotoluene (TNT)*. Dr. Gloria Post. NJDEP. September 7, 2006 (available upon request).

- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQLs) for* 2,4,6-Trinitrotoluene. R. Lee Lippincott, Ph.D. NJDEP. September 14, 2006 (available upon request).

References:

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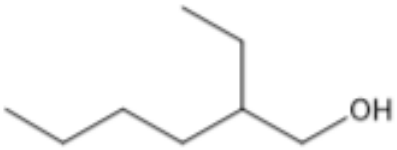
Appendix H: 2-Ethyl-1-hexanol

Ground Water Quality Standard for
2-Ethyl-1-hexanol
CASRN 104-76-7

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 200 µg/L and a practical quantitation level (PQL) of 0.5 µg/L for 2-ethyl-1-hexanol (also known as "2-EH"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 2-ethyl-1-hexanol is 200 µg/L**.

2-Ethyl-1-hexanol
Molecular Formula:
$C_8H_{18}O$
Molecular Structure:



Background: 2-Ethyl-1-hexanol is used in mercerizing textiles; as a solvent for dyes, resins, and oils; as a plasticizer for PVC resins; as a wetting agent; in solvent mixtures for nitrocellulose, paints, lacquers, baking finishes, inks, rubber, paper, lubricants, photography, and dry cleaning (NTP, 2005). 2-Ethyl-1-hexanol can be emitted from carpets and some plastics.

Reference Dose (RfD): 2-Ethyl-1-hexanol was evaluated under the U.S. Environmental Protection Agency's (USEPA) Guidelines for Carcinogen Risk Assessment (2005) as "inadequate to assess human carcinogenic potential"; therefore, it was treated as a non-carcinogen in developing a specific ground water quality criterion. The RfD was derived based on a Lowest Observed Adverse Effect Level (LOAEL) of 50 mg/kg/day (Astill et al., 1996), adjusted to 35.7 mg/kg/day to account for exposure over 5 days/week. This LOAEL is considered a minimal LOAEL and, as such, calls for an uncertainty factor of 3, rather than the more customary 10, to obtain a No Observed Adverse Effect Level (NOAEL). Based on the adjusted LOAEL of 35.7 mg/kg/day in male rats, the RfD is derived as follows:

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Intraspecies variability to protect sensitive subpopulations
3: LOAEL-to-NOAEL extrapolation[3]
3: Database insufficiencies[4]

Total Uncertainty Factor = 1,000

$$RfD_{oral} = LOAEL / UF_{total} = \frac{35.7\ mg/kg/day}{1{,}000} = 0.0357\ mg/kg/day$$

Therefore, the RfD used to derive the ground water quality criterion for 2-ethyl-1-hexanol is 0.0357 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 2-ethyl-1-hexanol was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.0357 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$Criterion = \frac{0.0357\ mg/kg/day \times 1{,}000\ \mu g/mg \times 70\ kg \times 0.2}{2\ L/day} = 249.9\ \mu g/L$$

Where:
0.0357 mg/kg/day = the RfD
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 200 µg/L

Therefore, the specific ground water quality criterion for 2-ethyl-1-hexanol is 200 µg/L.

Derivation of PQL: No published method was listed in the National Environmental Methods Index (NEMI) database for this chemical. A Dialog search located a peer-reviewed journal article that contained sufficient performance information to generate a PQL. According to this article, Solid Phase Micro Extraction (SPME) headspace/GC/MS has been used extensively over the past seven years to detect purgeable organoleptic compounds that impart an undesirable taste and odor to finished drinking water. 2-Ethyl-1-hexanol is a purgeable organic compound and performance of this method has been observed down to sub parts-per-billion levels. A method detection limit of 0.1 ppb was reported (Furton, 2003). Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL for 2-ethyl-1-

[3] Note: Uncertainty factors of 3 are considered to be 1/2 logs of 10; therefore, the use of 2 factors of 3 is equivalent to one factor of 10 (USEPA, 2002).

hexanol was derived by multiplying the MDL by 5 and expressed in µg/L, as shown below:

PQL = 0.1 ppb x 5 = 0.5 ppb = 0.5 µg/L

Therefore, the PQL for 2-ethyl-1-hexanol is 0.5 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 200 µg/L and a PQL of 0.5 µg/L for 2-ethyl-1-hexanol. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for 2-ethyl-1-hexanol is 200 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for 2-Ethyl-1-Hexanol CASRN# 104-76-7. NJDEP. February 2008.* http://www.state.nj.us/dep/wms/bears/docs/2-ethyl-1-hexanol.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for 2-Ethyl-1-Hexanol* and *2-Ethyl-1-Hexanol Health-based Ground Water Quality Criterion Support Document.* Thomas Ledoux, Ph.D. NJDEP. May 2006 (both available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQLs) for 2-Ethyl-1-Hexanol*. R. Lee Lippincott, Ph.D. NJDEP. May 8, 2005 (available upon request).

References:

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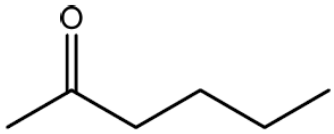
Appendix I: 2-Hexanone

Ground Water Quality Standard for
2-Hexanone
CASRN 591-78-6

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 40 µg/L and a practical quantitation level (PQL) of 1 µg/L for 2-hexanone (also known as "methyl n-butyl ketone"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), the **ground water quality standard (constituent standard) for 2-hexanone is 40 µg/L.**

2-Hexanone (methyl n-butyl ketone)
Molecular Formula:
$C_6H_{12}O$
Molecular Structure:



Background: 2-Hexanone is an industrial solvent which causes neurological toxicity. It is a clear, colorless liquid with a sharp odor. It dissolves very easily in water and can evaporate easily into the air as a vapor. It was used in the past in paint and paint thinner, to make other chemical substances, and to dissolve oils and waxes. It is no longer made or used in the United States because of its adverse health effects. It is formed as a waste product resulting from industrial activities such as making wood pulp and producing gas from coal, and in oil shale operations.[4]

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on 2-hexanone indicate that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, 2-hexanone was considered a noncarcinogen in the development of a human health-based ground water quality criterion. A provisional RfD of 0.04 mg/kg/day had been developed by USEPA's National Center for Environmental Assessment (NCEA) in 1993 based on neurological effects in a 40-week rat gavage study using one dose of 2-hexanone (Eben et al., 1970) and a total uncertainty factor of 10,000. A more recent IRIS assessment and IRIS Toxicological Profile resulted in an updated RfD of 0.005 mg/kg/day for 2-hexanone (USEPA, 2009) based on benchmark dose modeling of the incidence of neurological effects (axonal swelling of the peripheral nerve) in a 13-month

[4] https://pubchem.ncbi.nlm.nih.gov/compound/2-hexanone#section=Top

drinking water study in male rats (O'Donoghue et al., 1978). A benchmark response level of 10% extra risk (BMD_{10}) for this effect was selected for this assessment. The lower 95% confidence limit on the BMD_{10} (i.e., $BMDL_{10}$) was 5.1 mg/kg-day. USEPA applied a total uncertainty factor of 1,000: 10 for extrapolation for interspecies differences, 10 for consideration of intraspecies variation, and 10 for deficiencies in the database, including lack of multigenerational reproductive study or developmental studies, along with evidence for reproductive and immune system toxicity in inhalation studies, and rounded to one significant figure to derive the RfD of 0.005 mg/kg/day. The Department concurs with the RfD derived by USEPA and reported in IRIS. **Therefore, the RfD used to derive the ground water quality criterion for 2-hexanone is 0.005 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 2-hexanone was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.005 mg/kg/day, standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.005 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 35 \text{ µg/L}$$

Where:
0.005 mg/kg/day = the RfD
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded by one significant figure = 40 µg/L

Therefore, the specific ground water quality criterion for 2-hexanone is 40 µg/L.

Derivation of PQL: 2-Hexanone appears as a listed parameter in the National Environmental Methods Index (NEMI) with a method detection limit (MDL) of 0.39 ppb using published analytical Method, "USEPA 524.2, VOCs in Water by GC/MS". However, performance data submitted to the Department indicated a low point on the calibration curve concentration of 1 ppb (or 1 µg/L) that is lower than a PQL derived from the MDL (2 ppb). Because the low point on the calibration curve (LPCC) is quantifiable under laboratory conditions, the Department determined that the LPCC is a more appropriate PQL than one derived from the MDL in NEMI. **Therefore, the PQL for 2-hexanone is 1 µg/L.**

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 40 µg/L and a PQL of 1 µg/L for 2-hexanone. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, the **ground water quality standard for 2-hexanone is**

40 µg/L.

Technical Support Documents:

- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQL) 2-Hexanone CAS #591-78-6.* R. Lee Lippincott, Ph.D. NJDEP. March 28, 2017 (available upon request).
- *Recommendation of revised interim specific ground water quality criterion and Interim Specific Ground Water Quality Standard for 2-hexanone,* Dr. Gloria Post, NJDEP, August 9, 2016 (available upon request).
- *Ground Water Quality Standard for 2-Hexanone CASRN# 591-78-6.* NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/2-hexanone.pdf
- *Interim Specific Ground Water Quality Criterion 2-Hexanone CAS # 591-78-6.* Dr. Gloria Post. NJDEP. August 17, 2007 (available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQL) for 2-Hexanone.* R. Lee Lippincott Ph.D. NJDEP. August 3, 2016; February 26, 2007; May 6, 2004 and February 26, 2003 (all available upon request).
- *Recommendation for Ground Water Quality Criterion for 2-Hexanone.* Dr. Gloria Post, NJDEP. April 29, 2004 (available upon request).

References:

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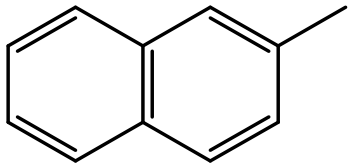
Appendix J: 2-Methylnaphthalene

Ground Water Quality Standard for
2-Methylnaphthalene
CASRN 91-57-6

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 30 µg/L and a practical quantitation level (PQL) of 10 µg/L for 2-methylnaphthalene (also known as "beta-methylnaphthalene"). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 2-methylnaphthalene is 30 µg/L**.

2-Methylnaphthalene
Molecular Formula:
$C_{11}H_{10}$
Molecular Structure:



Background: 2-Methylnaphthalene is a polycyclic aromatic hydrocarbon (PAH). 2-methylnaphthalene is a solid like naphthalene, which is more commonly known as mothballs, moth flakes, white tar, and tar camphor. 2-Methylnaphthalene is used to make chemicals such as dyes and resins, as well as vitamin K. It is also present in cigarette smoke, wood smoke, tar, asphalt, and at some hazardous waste sites.[5]

Reference Dose (RfD): 2-Methylnaphthalene was evaluated under the U.S. Environmental Protection Agency's (USEPA) Guidelines for Carcinogen Risk Assessment (2005) as "inadequate to assess human carcinogenic potential"; therefore, it was treated as a noncarcinogen in developing a specific ground water quality criterion. The USEPA's Integrated Risk Information System (IRIS) database shows an RfD for 2-methylnaphthalene of 0.004 mg/kg/day, which was developed by USEPA in 2003 (USEPA, 2003a, b) based on benchmark dose modeling of the incidence of pulmonary alveolar proteinosis in B6C3F1 mice fed 2-methylnaphthalene for 81 weeks (Murata et al., 1997). A benchmark response level of 5% extra risk (BMD_{05}) of the critical effect, pulmonary alveolar proteinosis, was selected for this assessment. The lower 95% confidence limit on the BMD_{05} (i.e., $BMDL_{05}$) was 3.5 mg/kg-day. USEPA applied a total

[5] https://www.atsdr.cdc.gov/ToxProfiles/tp67-c1-b.pdf

uncertainty factor of 1,000 to the $BMDL_{05}$: 10 for extrapolation for interspecies differences, 10 for consideration of intraspecies variation, and 10 for deficiencies in the database, including lack of adequate studies of oral developmental toxicity, reproductive toxicity, and neurotoxicity, and rounded the RfD to one significant figure. The Department concurs with the USEPA-derived RfD of 0.004 mg/kg/day. **Therefore, the RfD used to derive the ground water quality criterion for 2-methylnaphthalene is 0.004 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 2-methylnaphthalene was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.004 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.004\ \text{mg/kg/day} \times 1{,}000\ \mu\text{g/mg} \times 70\ \text{kg} \times 0.2}{2\ \text{L/day}} = 28\ \mu\text{g/L}$$

Where:
0.004 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 30 µg/L

Therefore, the specific ground water quality criterion for 2-methylnaphthalene is 30 µg/L.

Derivation of PQL: 2-Methylnaphthalene appears as a listed parameter in the National Environmental Methods Index (NEMI). The published method – "OSW USEPA 8270D, Semivolatile Organic Compounds by GC/MS" – does not specify a method detection limit; however, it does identify an estimated quantification level (EQL) of 10 ppb, which can be used as a PQL. **Therefore, the PQL for 2-methylnaphthalene is 10 µg/L.**

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 30 µg/L and a PQL of 10 µg/L for 2-methylnaphthalene. In accordance with N.J.A.C. 7:9C-1.9(c), since the criterion is higher than the PQL for this constituent, **the ground water quality standard for 2-methylnaphthalene is 30 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for 2-Methylnaphthalene CASRN# 91-57-6.* NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/2-methylnaphthalene.pdf.
- *Interim Specific Ground Water Quality Criterion 2-Methylnaphthalene CAS # 91-57-6*. Dr. Gloria Post. NJDEP. September 7, 2006 (available upon request).

- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for 2-Methylnaphthalene CAS #91-57-6.* R. Lee Lippincott. Ph.D. NJDEP. May 11, 2006 (available upon request).

References:

Murata, Y., A. Denda, H. Maruyama et al. 1997. Short communication. Chronic toxicity and carcinogenicity studies of 2-methylnaphthalene in B6C3F1 mice. Fundam Appl Toxicol 36:90-93 (cited in USEPA, 2003a, 2003b).

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

USEPA. 2005. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum, USEPA, Washington, DC. EPA/630.P-03/001F, March 2005. https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment

USEPA. 2003a. U.S. Environmental Protection Agency. Integrated Risk Information System. 2-Methylnaphthalene (CASRN 91-57-6). Last modified, 12/22/2003. USEPA, Washington, DC.

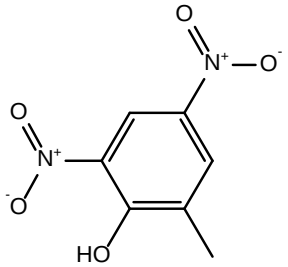
USEPA. 2003b. United States Environmental Protection Agency. Toxicological review of 2-methylnaphthalene in support of summary information on Integrated Risk Information System (IRIS). USEPA National Center for Environmental Assessment, Washington, DC; EPA 635/R 03/010.

Appendix K: 4,6-Dinitro-o-cresol

Ground Water Quality Standard for
4,6-Dinitro-o-cresol
CASRN 534-52-1

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 0.7 µg/L and a practical quantitation level (PQL) of 0.03 µg/L for 4,6-dinitro-o-cresol. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for 4,6-Dinitro-o-cresol is 0.7 µg/L.**

4,6-Dinitro-o-cresol
Molecular Formula:
$C_7H_6N_2O_5$
Molecular Structure:



Background: 4,6-dinitro-o-cresol is a yellow solid with no smell. It is used primarily for insect control and crop protection. It may be sold under several trade names, including Antinonnin, Detal, and Dinitrol. It was used in diet pills in the 1930s, but has since been banned for this use. 4,6-Dinitro-o-cresol is soluble in alcohol, acetone, ether and solutions of sodium or potassium hydroxides; emits toxic oxides of nitrogen fumes when heated to decomposition; and is toxic by skin absorption, inhalation or ingestion.[6]

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on 4,6-dinitro-o-cresol indicate that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, 4,6-dinitro-o-cresol was considered a noncarcinogen in the development of a human health-based ground water quality criterion. USEPA's National Center for Environmental Assessment (NCEA, 2002) developed a provisional RfD of 1 x 10^{-4} mg/kg/day based on several studies of humans

[6] https://pubchem.ncbi.nlm.nih.gov/compound/2-Methyl-4_6-dinitrophenol#section=Top

ingesting the compound for up to a year. The Department concurs with this provisional RfD. **Therefore, the RfD used to derive the ground water quality criterion for 4,6-dinitro-o-cresol is 1 x 10^{-4} mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for 4,6-dinitro-o-cresol was derived pursuant to the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 1 x 10^{-4} mg/kg/day (as explained above), and standard default assumptions, as follows:

$$\text{Criterion} = \frac{1 \times 10^{-4} \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 0.7 \text{ µg/L}$$

Where:
1 x 10^{-4} = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Therefore, the specific ground water quality criterion for 4,6-dinitro-o-cresol is 0.7 µg/L.

Derivation of PQL: A PQL of 1 µg/L was previously established by the Department for 4,6-dinitro-o-cresol in 2004. The previous PQL was based on a method detection limit (MDL) of 0.26 ppb established in "USEPA 528, Phenols in Water by GC/MS", which was multiplied by 5, rounded to one significant figure, and expressed in µg/L, as shown below:

PQL = 0.26 ppb x 5 = 1.3 ppb
PQL rounded to one significant figure = 1 ppb = 1 µg/L

A more recent MDL for 4,6-dinitro-o-cresol appears in the National Environmental Methods Index (NEMI)). The new MDL is specified as 0.006 ppb in a published analytical method, "Determination of Pesticides in Water by CarboPak-B Solid-Phase Extraction and HPLC, Method #O-1131-95", which is a more accurate method than the previously used USEPA 528. Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL for 4,6-dinitro-o-cresol was derived by multiplying the MDL by 5, and expressed in µg/L, as shown below:

PQL = 0.006 ppb x 5 = 0.03 ppb = 0.03 µg/L.

Therefore, the PQL for 4,6-dinitro-o-cresol is 0.03 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 0.7 µg/L and a PQL of 0.03 µg/L. In

accordance with N.J.A.C. 7:9C-1.9(c), since the PQL is higher than the ground water quality criterion is for this constituent, **the ground water quality standard for 4,6-dinitro-o-cresol is 0.7 µg/L.**

Technical Support Documents:

- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQLs) for 4,6-Dinitro-o-cresol*, R. Lee Lippincott, Ph.D., NJDEP, August 3, 2016 (available upon request).
- *Ground Water Quality Standard for 4,6-Dinitro-O-Cresol CASRN# 534-52-1.* NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/4,6dinitro-o-cresol.pdf.
- *Interim Ground Water Quality Criterion 4,6-Dinitro-o-cresol* CAS # 534-52-1. Dr. Gloria Post, NJDEP, August 17, 2007 (available upon request).
- *Recommendation for Ground Water Quality Criterion for 4,6-Dinitro-o-cresol.* Dr. Gloria Post, NJDEP, April 29, 2004 (available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) 4,6-Dinitro-O-Cresol CAS #534-52-1.* R. Lee Lippincott Ph.D. NJDEP. May 6, 2004 (available upon request).

References:

NCEA. 2002. National Center for Environmental Assessment. Risk Assessment Issue Paper for: Derivation of a Provisional RfD for 4,6-Dinitro-o-cresol. U.S. Environmental Protection Agency. Washington, DC. CASRN 534-52-1. October 16, 2002.

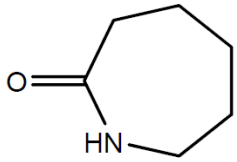
NEMI. National Environmental Methods Index. http://www.nemi.gov/.

Appendix L: Caprolactam

Ground Water Quality Standard for
Caprolactam
CASRN 105-60-2

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 4,000 µg/L and a practical quantitation level (PQL) of 60 µg/L for caprolactam. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for caprolactam is 4,000 µg/L**.

Caprolactam
Molecular Formula:
$C_6H_{11}NO$
Molecular Structure:



Background: Caprolactam is utilized as starting material for production of Nylon-6. It is produced by polycondensation, and the seven-membered ring monomer is present in unwashed Nylon-6 in relatively large amounts. It has also been detected in water that has been in contact with polyolefin bottles at ambient temperatures.

Reference Dose (RfD): Caprolactam has been evaluated by the U.S. Environmental Protection Agency (USEPA) and an RfD is available on USEPA's Integrated Risk Information System (IRIS) database. IRIS does not provide a carcinogenicity assessment, but caprolactam was negative for carcinogenicity in a chronic dietary bioassay in male and female F344 rats and B6C3F1 mice (NTP, 1982) and was evaluated as "probably not carcinogenic to humans" by the International Agency for Research on Cancer (IARC, 1999). Therefore, caprolactam was considered a non-carcinogen in the development of a human health-based ground water quality criterion. The IRIS RfD for caprolactam is 0.5 mg/kg/day and was developed in 1988 based on a dietary three-generation reproduction study in rats (Serotta et al., 1984). In this study, the No Observed Adverse Effect Level (NOAEL) was 1,000 ppm in the diet, which is equivalent to a dose of 50 mg/kg/day. At higher doses, (5,000 and 10,000 ppm) reduced body weight of offspring was seen, as well as reduced body weight and food consumption of the parental generation. At the highest dose (10,000

ppm), a slight increase in the severity of nephropathy was seen in males of the first parental generation. USEPA used an uncertainty factor of 100, appropriate for a NOAEL in a chronic study, to derive the RfD of 0.5 mg/kg/day. The Department concurs with the USEPA-derived RfD of 0.5 mg/kg/day. **Therefore, the RfD used to derive the ground water quality criterion for caprolactam is 0.5 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for caprolactam was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.5 mg/kg/day (as explained above), standard default assumptions, and rounding to one significant figure:

$$\text{Criterion } (\mu g/L) = \frac{0.5 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 3{,}500 \text{ µg/L}$$

Where:
0.5 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 4,000 µg/L

Therefore, the specific ground water quality criterion for caprolactam is 4,000 µg/L.

Derivation of PQL: No published method was listed in the National Environmental Methods Index (NEMI) database for caprolactam. A PQL of 5,000 ppb was previously established by the Department for caprolactam in 2006. The previous PQL was based on one OSHA method and a method citation from the European Union of a food method that utilized Liquid Chromatography with Ultraviolet detection at 210 nm. The low-end detection range of 1,000 ppb was used as the MDL to derive a PQL of 5,000 ppb. A more recent Dialog search located a peer-reviewed journal article that reported a quantitation concentration of 62.5 ppb in water and urine using an analytical method that consisted of direct injection liquid chromatography tandem mass spectrometry (Wu, et al, 2012). Because the quantitation concentration is quantifiable under laboratory conditions, the Department determined that it is a more appropriate PQL than one derived from the MDL in NEMI. In accordance with N.J.A.C. 7:9C-1.9(c)3, 62.5 ppb was rounded to one significant figure and expressed in µg/L. T**herefore, the PQL for caprolactam is 60 µg/L.**

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 4,000 µg/L and a PQL of 60 µg/L for caprolactam. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for caprolactam is 4,000 µg/L.**

Technical Support Documents:

- *Procedure for Describing Process for Development of an Analytical Practical Quantitation Level (PQL) for Caprolactam CAS #105-60-28.* R. Lee Lippincott, Ph.D., NJDEP. August 3, 2016 (available upon request).
- *Ground Water Quality Standard for Caprolactam CASRN# 105-60-2*. NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/caprolactam.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for Caprolactam (CAS # 105-60-2).* Dr. Gloria Post. NJDEP. September 7, 2006 (available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) Caprolactam CAS # 105-60-28*. R. Lee Lippincott Ph.D. NJDEP. September 14, 2006 (available upon request).

References:

IARC. 1999. International Agency for Research on Cancer. Summaries and Evaluations. Volume 71, p. 383. Caprolactam.

NTP. 1982. National Toxicology Program. Technical Report No. 214 on the Carcinogenesis Bioassay of Caprolactam. National Institutes of Health Pub. No. 81-770.

Serota, D.G., A.M. Hoberman, M.A. Friedman, and S.C. Gad. 1988. Three-generation reproduction study with caprolactam in rats. J. Appl. Toxicol. 8(4): 285-293. (Cited in USEPA IRIS database.)

Skjevrak, Ingun; et. al. 2005. Non-targeted multi-component analytical surveillance of plastic food contact materials: Identification of substances not included in EU positive lists and their risk assessment. J. Food Additives and Contaminants. October 2005. 22 (10): 1012-1022.

USEPA. 2002. Integrated Risk Information System. Caprolactam (CASRN 105-60-2). Last modified, 12/3/2002.

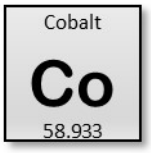
Wu, Y., M. Wu, C. Lin, W. Chu, C. Yang, R. Lin and J. Deng. 2012. Determination of caprolactam and 6-aminocaproic acid in human urine using hydrophilic interaction liquid chromatography-tandem mass spectrometry, Journal of Chromatography B, Vol. 885-886, pp. 61-65.

Appendix M: Cobalt

Ground Water Quality Standard for Cobalt CASRN 7440-48-4

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 100 µg/L and a practical quantitation level (PQL) of 0.5 µg/L for cobalt. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for cobalt is 100 µg/L**.

Cobalt



Background: Cobalt is a trace element that is a component of vitamin B12. It has the atomic symbol Co, atomic number 27, and atomic weight 58.93. It is used in nuclear weapons, alloys, and pigments. Cobalt deficiency in animals leads to anemia; its excess in humans can lead to erythrocytosis.

Reference Dose (RfD): There is no information available about cobalt in the U.S. Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) database. USEPA's National Center for Environmental Assessment (NCEA) developed a provisional RfD of 0.02 mg/kg/day (NCEA, 2002) based on a study conducted by Duckham and Lee (1976) in which hemoglobin increased in patients undergoing renal dialysis given 0.18 mg cobalt/day. The Department concurs with the NCEA RfD of 0.02 mg/kg/day. **Therefore, the RfD used to derive the ground water quality criterion for cobalt is 0.02 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for cobalt was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.02 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.02 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 140 \text{ µg/L}$$

Where:
0.02 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 100 µg/L

Therefore, the specific ground water quality criterion for cobalt is 100 µg/L.

Derivation of PQL: Cobalt appears in the National Environmental Methods Index (NEMI). The MDL is specified as 0.09 µg/L in a published analytical method, "– "*USEPA 200.8, Metals in Waters by ICP/MS".* Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL for cobalt was derived by multiplying the MDL by five, rounded to one significant figure, and expressed in µg/L, as shown below:

PQL = 0.09 µg/L x 5 = 0.45 µg/L

PQL rounded to one significant figure = 0.5 ppb = 0.5 µg/L.

Therefore, the PQL for cobalt is 0.5 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 100 µg/L and a PQL of 0.5 µg/L for cobalt. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for cobalt is 100 µg/L**.

Technical Support Documents:
- Ground Water Quality Standard for Cobalt. NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/cobalt.pdf.
- *Interim Ground Water Quality Criterion Cobalt CAS # 7740-48-4.* Dr. Gloria Post, NJDEP, August 17, 2007 (available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for Cobalt.* R. Lee Lippincott Ph.D. NJDEP. February 26, 2007 and May 6, 2004 (both available upon request).

References:
NEMI. National Environmental Methods Index. http://www.nemi.gov/.

USEPA. 2002. U.S. Environmental Protection Agency's (USEPA) National Center for Environmental Assessment (NCEA) document entitled "Risk Assessment Issue Paper for: Derivation of a Provisional RfD for Cobalt and Compounds (CASRN 7440-48-4)" (NCEA, 2002)

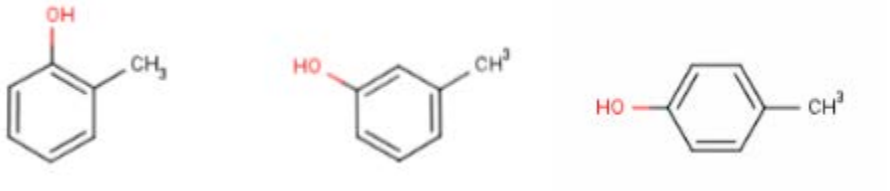
USEPA. "Method 200.8: Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry". Revision 505. EMMC Version. Environmental Monitoring Systems Laboratory. Office of Research and Development. I.S. Environmental Protection Agency. Cincinnati, Ohio.

Appendix N: Cresols (Mixed Isomers)

Ground Water Quality Standard for o-, m-, and p-Cresol CASRN 95-48-7, 108-39-4, 106-44-5

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 50 µg/L and a practical quantitation level (PQL) of 0.1 µg/L for cresols (mixed isomers: o-, m-, and p-cresol). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for cresols (mixed isomers) is 50 µg/L**.

Cresols (mixed isomers: o-, m-, and p-cresol)
Molecular Formula:
C_7H_8O
Molecular Structure:



Background: The cresols comprise a group of three closely related isomers: o-, m-, and p-cresol. As environmental contaminants, they are most commonly found as a mixture with varying proportions of these three isomers. Cresols are used as solvents, disinfectants, and as intermediates in chemical manufacture, including pharmaceuticals, dyes, epoxides, pesticides, paints and textiles and as an additive to phenol-formaldehyde resins.

Reference Dose (RfD): The U.S. Environmental Protection Agency (USEPA) designated cresols as a Class C: possible human carcinogen in 1991 (USEPA, 2010a, b, c) based on two dermal studies reported by Boutwell and Bosch (1959) and short-term mutagenicity studies on cresol (unpublished data cited by USEPA in IRIS). Based on USEPA's subsequent Guidelines for Carcinogen Risk Assessment (USEPA, 2005), the cresols were characterized as having "suggestive evidence of carcinogenic potential"; however, insufficient data are available to derive a cancer slope factor (cancer potency estimate) for cresols. The current USEPA Integrated Risk Information System (IRIS) database provides an RfD of 0.05 mg/kg/day for o- and m-cresol based on a No Observed Adverse Effect Level (NOAEL) of 50 mg/kg/day. USEPA applied a total uncertainty factor of 1,000: 10 for interspecies variability, 10 for intraspecies variability, and 10 for subchronic-chronic extrapolation. There is currently no RfD for p-cresol. The Department derived a modified

RfD for all three cresol isomers based on decreased hematocrit in mice (USEPA, 1988b). The point of departure (POD) for that endpoint was the $BMDL_{10}$ (lower confidence limit on the benchmark dose for a 10% change) of 21.9 mg/kg/day. This POD was divided by additional uncertainty factors as described below, which includes an additional uncertainty factor of 10 to address suggestive evidence of carcinogenic potential (USEPA, 2005; NTP 2008). The difference in the POD is based on the use of benchmark dose modeling. The difference in the total UF is based on the conclusion that a duration of exposure UF is not necessary because effects at lower doses were not observed in the more recently available NTP (2008) chronic bioassay. The RfD was derived as the quotient of the POD and the product of the uncertainty factors, including an additional uncertainty factor of 10 to address potential cancer risk at the exposure corresponding to the RfD, as shown below:

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Intraspecies variability, to protect sensitive subpopulations
3: Subchronic-to-chronic extrapolation
10: Potential cancer risk adjustment

Total Uncertainty Factor = 3,000

$$RfD = POD/UF_{total} = \frac{21.9 \text{ mg/kg/day}}{3{,}000} = 0.0073 \text{ mg/kg/day}$$

Therefore, the RfD used to derive the ground water quality criterion for o-, m-, and p-cresols is 0.0073 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for cresols (mixed isomers) was derived pursuant to N.J.A.C. 7:9C-1.7(c)4, using the formula for non-carcinogens and carcinogens with no available slope factor, an RfD of 0.0073 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.0073 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 51.1 \text{ µg/L}$$

Where:
0.0073 mg/kg/day = derived RfD
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 50 µg/L

Therefore, the specific ground water quality criterion for cresols, mixed isomers is 50 µg/L.

Derivation of PQL: Individual cresol isomers appears as listed parameters in the National Environmental Methods Index (NEMI) with a method detection limit (MDL) of 0.026 ppb using published USEPA method "528, Phenols in Water by GC/MS". In accordance with N.J.A.C. 7:9C-1.9(c)3, the PQL was derived by multiplying the MDL by 5, rounded to one significant figure, and expressed in µg/L, as shown below.

PQL = 0.026 ppb x 5 = 0.13 ppb

PQL rounded to one significant figure = 0.1 ppb = 0.1 µg/L

Therefore, the PQL for cresols (mixed isomers: o-, m, and p-cresol) is 0.1 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 50 µg/L and a PQL of 0.1 µg/L for cresols (mixed isomers: o, m-, and p-cresol). In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for cresols (mixed isomers: o, m-, and p-cresol) is 50 µg/L.**

Technical Support Documents:

- *Ground Water Quality Standard for o-, m-, and p-Cresol CASRN# 95-48-7, 108-39-4, 106-44-5.* October 2015. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/cresols_mixed_fact_sheet.pdf.
- *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*. NJDEP. 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) Cresols (mixed isomers) CAS #95-48-7, 108-39-4, 106-44-5*. R. Lee Lippincott, Ph.D. NJDEP. March 13, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/Cresols-pql.pdf.
- *Interim Specific Ground Water Quality Criterion o, m, p-Cresol.* Alan H. Stern, D.Ph., D.A.B.T. NJDEP. February 25, 2010. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/Cresols.pdf.

References:

ATSDR (2008). Toxicological Profile for Cresols. U.S. Department of Health and Human Services, Public Health Service.

Boutwell, R.K. and D.K. Bosch. 1959. The tumor-promoting action of phenol and related compounds for mouse skin. Cancer Res. 19: 413-424.

Hornshaw TC, Aulerich RJ, Ringer RK (1996). Toxicity of o-cresol to mink and European ferrets. Env. Tox. Chem. 5:713-720.

IARC (International Agency for Research on Cancer) (1999). Predictive Value of Rodent Forestomach and Gastric Neuroendocrine Tumours in Evaluating Carcinogenic Risks to Humans. IARC Technical Publication No. 39, World Health Organization, Lyon.

Izard MK, George J, Fail P, Grizzle T (1997). m-/p-Cresol. Environ. Health Perspect. 105:295-296 (supplement).

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Koizumi M, Noda A, Ito Y, Furukawa M, Fujii S, Kamata E, Ema M, Hasegawa R. (2003). Higher susceptibility of newborn than young rats to 3-methylphenol. J Toxicol Sci. 28:59-70.

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

NTP (National Toxicology Program) (1992a). NTP Report of the Toxicity Studies of Cresol in F344/N Rats and B6C3F Mice (Feed Studies), NTP TOX 9. National Institutes of Health, Public Health Service, U.S. Department of Health and Human Services.

NTP (National Toxicology Program) (1992b). Final Report on the Reproductive Toxicity of Meta-Para-Cresol (MPCRE) in CD-1 Swiss Mice, RACB0003. National Institutes of Health, Public Health Service, U.S. Department of Health and Human Services.

NTP (National Toxicology Program) (2008). NTP Technical Report on the Toxicology and Carcinogenesis Studies of Cresols in Male F344/N Rats and Female B6C3F1 Mice (Feed Studies), NTP TR 550. National Institutes of Health, Public Health Service, U.S. Department of Health and Human Services.

Sanders JM, Bucher JR, Peckham JC, Kissling GE, Hejtmancik MR, Chhabra RS. Carcinogenesis studies of cresols in rats and mice. Toxicology. 257:33-9. Epub 2008 Dec 9

TRL (1986). Subchronic neurotoxicity study in rats of orhto-, meta-, and para-cresol. TRL study #032-009. Unpublished data, submitted by Toxicity Research Laboratories to EPA.

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New Zealand white rabbits. Submitted by the Chemical Manufacturers Assoc. to USEPA-OTS. USEPA doc. #40-860253.

Tyl RW, Neeper-Bradley, TL (1989). Two-generation reproduction study of o-cresol administered by gavage to Sprague-Dawley (CD) rats (unpublished). Submitted by the Chemical Manufacturers Assoc. to USEPA-OTS. USEPA doc. #40-8960311.

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USEPA. 1988. Subchronic toxicity of para-cresol in Sprague Dawley rats. Washington, DC: U.S. Environmental Protection Agency. PB88195292.

USEPA (2005). Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum, USEPA, Washington, DC. EPA/630.P-03/001F, March 2005. https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment, also accessed at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=116283, 7/7/10.

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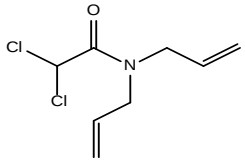
USEPA (2010). Integrated Risk Information System (IRIS), 4-methylphenol. Accessed at: http://www.epa.gov/ncea/iris/subst/0302.htm, 7/6/10.

Appendix O: Dichlormid

Ground Water Quality Standard for
Dichlormid
CASRN 37764-25-3

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 600 µg/L and a practical quantitation level (PQL) of 50 µg/L for dichlormid (also known as N, N-diallyl dichloroacetamide). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for dichlormid is 600 µg/L**.

Dichlormid (N, N-diallyl dichloroacetamide)
Molecular Formula:
$C_8H_{11}Cl_2NO$
Molecular Structure:



Background: Dichlormid is an herbicide "safener" currently approved by the U.S. Environmental Protection Agency (USEPA) for use on corn forage and stover to protect corn from injury when using chloroacetanilide and thiocarbamate herbicides; and to protect rice and wheat from the injury of acetochlor, butachlor, metolachlor, vernolate, Lasso, tri-allate, Ordram, Simagine, etc. Its intended function is to protect the target crops against the unintended effects of herbicides rather than cause an adverse effect itself.

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on dichlormid indicate that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, dichlormid was considered a noncarcinogen in the development of a human health-based ground water quality criterion. There is no indication of carcinogenicity or specific developmental or reproductive effects. The critical effects seen in both mice and rats in chronic studies occurs within a consistent and narrow range of No Observed Adverse Effect Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELs). It is assumed that the primary route of exposure to groundwater contaminated by dichlormid will be ingestion of water. The NOAEL for critical effect in chronic studies in rats and mice (changes in liver and kidney histopathology) is 7 mg/kg/day. Results from a sub-chronic dog study raise the possibility that rodents may not be the most

sensitive species. In the dog study, degeneration of voluntary muscle was observed at a dose similar to that producing the critical effects in chronic rodent studies, although the same effects were not seen in another sub-chronic dog study of similar duration with a higher dose. While this sub-chronic effect is not sufficiently robust either across species or within species to be identified as the critical effect, its occurrence is accounted for in the derivation of the RfD.

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Intraspecies variability, to protect sensitive subpopulations
3: Modifying factor, based on observation of muscle degeneration in single sub-chronic dog study

Total Uncertainty Factor = 300

$$RfD = NOAEL/ UF_{total} = \frac{7\ mg/kg/day}{300} = 0.02\ mg/kg/day$$

Therefore, the RfD used to derive the ground water quality criterion for dichlormid is 0.02 mg/kg/day.

Relative Source Contribution Factor: Data presented by USEPA (Fed. Reg. 67. P. 35996, May 22, 2002) indicates that, for the most highly exposed subgroup (children 1-6 years old), the estimated background exposure to dichlormid (including crop residues, drinking water, and non-dietary sources) would result in a dose of 0.0002 mg/kg/day. This is 1% of the RfD calculated by the Department (see above). USEPA guidance (USEPA, 2000) for considering non-water sources of exposure when developing water quality criteria recommends using a ceiling of 80% even when data indicates that non-water exposures are less than 20%. Therefore, the Department selected a relative source contribution factor of 0.8 in deriving the ground water quality criterion for dichlormid rather than the default 0f 0.2.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion was derived pursuant to N.J.A.C. 7:9C-1.7(c)4, using the formula for non-carcinogens, an RfD of 0.02 mg/kg/day (as explained above), a Relative Source Contribution Factor of 0.8 (as explained above), standard default assumptions, and rounded to one significant figure:

$$Criterion = \frac{0.02\ mg/kg/day \times 1{,}000\ \mu g/mg \times 70\ kg \times 0.8}{2\ L/day} = 560\ \mu g/L$$

Where:
0.02 mg/kg/day = Reference Dose
70 kg = average adult weight
0.8 = relative source contribution factor
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 600 µg/L

Derivation of PQL: The analytical method was developed by the USEPA ACL (Analytical Chemical Laboratory) using gas chromatography with nitrogen selective thermionic detection. The method detection limit (MDL) is specified as 10 ppb. In accordance with N.J.A.C. 7:9C-1.9(c)3, the PQL for dichlormid was derived by multiplying the MDL by 5 and expressed in µg/L, as shown below:

PQL = 10 µg/L x 5 = 50 µg/L

Therefore, the PQL for dichlormid is 50 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 600 µg/L and a PQL of 50 µg/L for dichlormid. Since the ground water quality criterion is higher than the PQL for this constituent, pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard for dichlormid is 600 µg/L**.

Technical Support Documents:
- *Ground Water Quality Standard for Dichlormid CASRN# 37764-25-3.* February 2008. NJDEP. http://www.state.nj.us/dep/wms/bears/docs/dichlormid.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for Dichlormid* and *Dichlormid (CASRN #37764-25-3) Groundwater Interim Criterion Development*. Alan H. Stern. D.Ph. D.A.B.T. NJDEP. Both dated May 24, 2004, revised June 16, 2004 and November 27, 2007 (both available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for Dichlormid*. R. Lee Lippincott, Ph.D. NJDEP. June 23, 2004 (available upon request).

References:
MacAskill, S.M. 1987. "EPA Acute Inhalation Study with Surpass Extra 6-E" Vol 1: Final Report. Stauffer Chemical Co., Farmington, CT. January 9, 1987.

United States. 2005. Fed. Reg. vol. 70, No. 35, February 23, 2005

United States. 2002. Fed. Reg. vol. 67, No. 99, May 22, 2002; pp 35996-3600 (a petition from Dow AgroSciences)

United States. 2000. Fed. Reg. vol. 65, No. 59, March 27, 2000; pp 16143-16149.

United States. 1998. Fed. Reg. vol. 63, No. 179, Sept. 16, 1998; pp 49571-49574

USEPA. USEPA Data Evaluation Report, N,N-diallyl dichloracetamide; R-25788, pp# 6F3344

USEPA. 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000). USEPA Office of Science and Technology/Office of Water. Washington, DC. EPA-822-B-00-004. October 2000.

USEPA. 1999a. Drinking Water assessment for the "inert" Herbicide Safener Dichlormid (D258095, ID# 6F03344); memo from Alex Clem, Env. Scientist EFED, ERB3; to Robert Forrest and Treva Alston, Registration Div., July 30, 1999.

USEPA. 1999b. Dynamac Corp. Data Evaluation Record — Dichlormid. Prepared for Health Effect Div., U.S.EPA 1999.

USEPA. 1999c. Report to the HIARC, "Time limited tolerance dichlormid (PC Code 099497) for use as a safener on corn." August 5, 1999.

USEPA. 1994. Memo from George Z. Ghali, Ph.D., Manager, RfD/Quality Assurance Peer Review, Health Effects Division, OPPTS; to Tina Levine, Ph.D. Registration Support Branch, Registration Division, OPPTS, "RfD/Peer Review Report of Dichlormid." February 17, 1994.

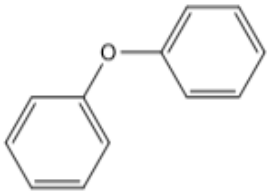
USEPA. 1972. Opp Official Record, Health Effects Div. Scientific Data Reviews, USEPA series 361. R- 25788; N,N-diallyl dichloroacetamide, proposal for an exemption from tolerances (inert), August 7, 1972.

Appendix P: Diphenyl ether

Ground Water Quality Standard for
Diphenyl ether
CASRN 101-84-8

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 100 µg/L and a practical quantitation level (PQL) of 10 µg/L for diphenyl ether. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for diphenyl ether is 100 µg/L**.

Diphenyl Ether
Molecular Formula:
$C_{12}H_{10}O$
Molecular Structure:



Background: Diphenyl ether is used in the manufacture of high-temperature lubricants and surfactants; as a fragrance, particularly in soap and detergents; as a heat-transfer medium in resins for laminated electrical insulation; as a dye carrier in the production of polyesters; and as a chemical intermediate for such reactions as halogenation, acylation, and alkylation.

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on diphenyl ether indicate that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, diphenyl ether was considered a noncarcinogen in the development of a human health-based ground water quality criterion. Diphenyl ether was reviewed by the Health Council of the Netherlands (2005), a rat dietary subchronic study was conducted by ITT Research Institute (ITTRI, 1990), and a rat gavage developmental toxicity study was conducted by Bio/dynamics (1987) on Therminol VP-1 heat transfer fluid (a mixture of diphenyl ether and biphenyl). In the rat dietary subchronic study (IITRI, 1990), the No Observed Adverse Effect Level (NOAEL) was 15 mg/kg/day, as effects on body weight occurred at higher doses in females.

The uncertainty factors applied to derive the RfD are:

10: interspecies extrapolation
10: intraspecies extrapolation
10: less-than-lifetime duration of the subchronic study

Total Uncertainty Factor = 1,000

$$RfD = NOAEL/UF_{total} = \frac{15\ mg/kg/day}{1{,}000} = 0.015\ mg/kg/day$$

Therefore, the RfD used to derive the ground water quality criterion for diphenyl ether is 0.015 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.015 mg/kg/day (as explained above), standard default assumption, and rounded to one significant figure, as follows:

$$Criterion = \frac{0.015\ mg/kg/day \times 1{,}000\ \mu g/mg \times 70\ kg \times 0.2}{2\ L/day} = 105\ \mu g/L$$

Where:
0.015 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 100 µg/L

Therefore, the specific ground water quality criterion for diphenyl ether is 100 µg/L.

Derivation of PQL: Diphenyl ether appears as a listed parameter in the National Environmental Methods Index (NEMI)); however, the method detection limit is not specified. The Minimum Reporting Level (ML), which is a quantitation level, is specified as 10 ppb (or 10 µg/L). Because the ML concentration is quantifiable under laboratory conditions, the Department determined that it is appropriate for PQL development in the absence of a reported MDL in NEMI. **Therefore, the PQL for diphenyl ether is 10 µg/L.**

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 100 µg/L and a PQL of 10 µg/L for diphenyl ether. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for diphenyl ether is 100 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for Diphenyl Ether CASRN# 101-84-8.* NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/diphenyl_ether.pdf.
- *Interim Ground Water Quality Criterion Diphenyl Ether CAS # 101-84-8* and *Interim Specific Ground Water Quality Criterion for Diphenyl Ether (CAS # 101-84-8).* Dr. Gloria Post. NJDEP. June 11, 2007 (both documents available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Level (PQL) for Diphenyl*, R. Lee Lippincott, Ph.D., NJDEP, September 7, 2007 (available upon request).

References:

Api, A.M. and R.A. Ford. 2003. Evaluation of the dermal subchronic toxicity of diphenyl ether in the rat. Food Chem. Toxicol. 41: 259-264.

Bio/dynamics. 1987. A developmental toxicity study in rats with Therminol VP-1 heat transfer fluid. Project No. 86-3096 (BD-86-379). Final Report. Submitted to Monsanto Co., October 29, 1987.

Carlson, G.P. 1980. Induction of xenobiotic metabolism in rats by short-term administration of brominated diphenyl ethers. Toxicol. Lett. 5: 19-25. (Cited in Health Council of the Netherlands, 2005).

Health Council of the Netherlands. 2005. Diphenyl ether (CAS No. 101-84-8). Health-based reassessment of Administrative Occupational Exposure Limits). Committee on Updating of Occupational Exposure Limits. October 27, 2005.

Hefner et al. 1975. Repeated inhalation toxicity of diphenyl ether in experimental animals. Toxicol. Appl. Pharmacol. 33: 78-86. (Cited in Health Council of the Netherlands, 2005).

HSDB. 2007. Hazardous Substances Data Bank. Diphenyl ether. http://toxnet.nlm.nih.gov accessed 2007.

IITRI. 1990. IIT Research Institute. Thirteen-week oral (diet) toxicity study of diphenyl ether in rats. Final Report. Chicago, IL. November 8, 1990.

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

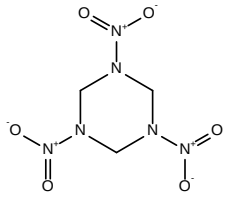
Solutia, Inc. 2006. Material Safety Data Sheet. Therminol VP-1 Heat transfer fluid. May 16, 2006.

Appendix Q: Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)

Ground Water Quality Standard for
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
CASRN 121-82-4

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 0.3 µg/L and a practical quantitation level (PQL) of 0.5 µg/L for hexahydro-1,3,5-trinitro-1,3,5-triazine (also known as "RDX" and cyclotrimethylenetrinitramine). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for hexahydro-1,3,5-trinitro-1,3,5-triazine is 0.5 µg/L**.

Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX, Cyclotrimethylenetrinitramine)
Molecular Formula:
$C_3H_6N_6O_6$
Molecular Structure:



Background: Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) is one of the four most important nitramine high energy explosives and is also incorporated into high performance rocket propellants.

Reference Dose (RfD): RDX has been evaluated by the U.S. Environmental Protection Agency (USEPA) and an assessment is available from the USEPA's Integrated Risk Information System (IRIS) database. USEPA classified RDX as a Group C, Possible Human Carcinogen in 1990 (USEPA, 2000). An increased incidence of hepatocellular adenomas and carcinomas was seen in female mice in a chronic dietary study (US DOD, 1984). No statistically significant increase in tumors was seen in the male mice, nor in male or female Fischer 344 rats in a similar chronic study (US DOD, 1983). USEPA derived both an RfD in 1988 for non-carcinogenic effects (USEPA, 2000) and a cancer slope factor for carcinogenic effects in 1990 (USEPA, 2000). The IRIS RfD of 0.003 mg/kg/day was derived based on a two-year dietary study in rats (US DOD, 1983). In this study, the most sensitive endpoint was inflammation of the prostate, which occurred at doses of 1.5 mg/kg/day and above but was not seen at 0.3 mg/kg/day. Therefore, 0.3 mg/kg/day was considered to be the No Observed Adverse Effect Level (NOAEL). An uncertainty factor of 100,

appropriate for a NOAEL from a chronic study, was applied to derive the RfD of 0.003 mg/kg/day. The IRIS Cancer Slope Factor of 0.11 $(mg/kg/day)^{-1}$ was derived based on the combined incidence of hepatocellular carcinomas and adenomas in female mice.

Derivation of Ground Water Quality Criterion: For chemicals classified as Group C, the Department uses the cancer slope factor to develop a ground water criterion at the 10^{-6} risk level when a slope factor is available; however, for comparison, the Department derived a ground water quality criterion based on the RfD as well as the Cancer Slope Factor to ensure that the criterion based on carcinogenicity is also protective for systemic toxicity.

A ground water quality criterion was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.003 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.003\ mg/kg/day \times 1{,}000\ \mu g/mg \times 70\ kg \times 0.2}{2\ L/day} = 21\ \mu g/L$$

Where:
0.003 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 20 µg/L

A ground water quality criterion was also derived using the formula for carcinogens, a Cancer Slope Factor 0.11 $(mg/kg/day)^{-1}$ (as explained above), standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{10^{-6} \times 70\ kg \times 1{,}000\ \mu g/mg}{0.11\ (mg/kg/day)^{-1} \times 2\ L/day} = 0.32\ \mu g/L$$

Where:
10^{-6} = Upper Bound Lifetime Excess Cancer Risk
0.11 $(mg/kg/day)^{-1}$ = Cancer Slope Factor
70 kg = average adult weight
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 0.3 µg/L

As shown above, the ground water quality criterion derived based on the cancer slope factor is 0.3 µg/l (carcinogenic end-point), which is more protective than the ground water quality criterion derived based on the RfD, which is 20 µg/L (noncarcinogenic end-point**). Therefore, the specific ground water quality criterion for RDX is 0.3 µg/L.**

Derivation of PQL: No published method was listed for RDX in the National Environmental Methods Index (NEMI). However, TM Chow (2004) describes a trace level analysis of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and its biodegradation intermediates in liquid media by solid-phase extraction and high pressure liquid chromatography analysis. The method detection limit (MDL)using this method is 0.1 ppb (µg/L). Pursuant to N.J.A.C. 7:9C-1.9(c)3, the PQL was derived by multiplying the MDL by five, as shown below:

PQL = 0.1 ppb x 5 = 0.5 µg/L

Therefore, the PQL for RDX is 0.5 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 0.3 µg/L and a PQL of 0.5 µg/L for RDX. Pursuant to N.J.A.C. 7:9C-1.9(c), since the PQL is higher than the criterion for this constituent, **the ground water quality standard for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) is 0.5 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) CASRN# 121-82-4*. NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/hexahydro.pdf.
- *Interim Specific Ground Water Quality Criterion for Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX) (CASRN 121-82-4).* Dr. Gloria Post. NJDEP. September 11, 2006, revised December 19, 2006 (available upon request).
- *Interim Ground Water Quality Criterion Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX) (CASRN 121-82-4).* Dr. Gloria Post, NJDEP, December 19, 2006 (available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQL) for Hexahydro-1,3,5-Trinitro-1,3,5-Triazine (RDX),* R. Lee Lippincott, Ph.D., NJDEP, September 18, 2005 (available upon request).

References:

Chow, T.M., M. R. Wilcoxon, M.D. Piwoni and N.R. Adrian. 2004. Trace level analysis of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and its biodegradation intermediates in liquid media by solid-phase extraction and high-pressure liquid chromatography analysis. J Chromatogr Sci. 2004 Oct 42(9):470-3.

USDOD. 1983. U.S. Department of Defense. Available from U.S. Army Medical Research and Development Command. DAMD17-79-C-9161. Ft. Detrick, Frederick, MD 20701. (Cited in USEPA, 2000).

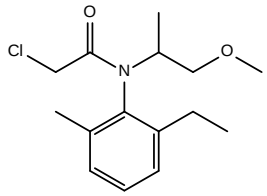
USEPA. 2000. United States Environmental Protection Agency. Integrated Risk Information System. Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (CASRN 121-82-4). Last updated May 17, 2000.

Appendix R: Metolachlor

Ground Water Quality Standard for
Metolachlor
CASRN 51218-45-2

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 100 µg/L and a practical quantitation level (PQL) of 0.5 µg/L for metolachlor (also known as 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for metolachlor is 100 µg/L**.

Metolachlor
(2-Chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide)
Molecular Formula:
$C_{15}H_{22}ClNO_2$
Molecular Structure:



Background: Metolachlor is a general use pesticide usually applied to crops before plants emerge from the soil. It is used to control certain broadleaf and annual grassy weeds in field corn, soybeans, peanuts, grain sorghum, potatoes, pod crops, cotton, safflower, stone fruits, nut trees, highway right-of-way's and woody ornamentals. Metolachlor acts by inhibiting protein synthesis. Certain additives are included in product formulations to help protect sensitive crops like sorghum from injury.[7]

Reference Dose (RfD): Metolachlor has been evaluated by the U.S. Environmental Protection Agency (USEPA) and an assessment is available from the USEPA's Integrated Risk Information System (IRIS) database. USEPA classified metolachlor as a Group C, possible human carcinogen and derived an RfD for non-carcinogenic effects. The RfD of 0.15 mg/kg/day was derived by USEPA based on a No Observed Adverse Effect Level (NOAEL) of 300 ppm (15 mg/kg/day) in two separate rat dietary studies (Ciba Geigy, 1981 and Ciba Geigy, 1983) and a total uncertainty factor of 100: 10 for interspecies extrapolation and 10 for intraspecies extrapolation. The Department

[7] http://pmep.cce.cornell.edu/profiles/extoxnet/metiram-propoxur/metolachlor-ext.html

applied an additional uncertainty factor of 10 to protect for possible carcinogenicity, resulting in an RfD of 0.015 mg/kg/day. **Therefore, the RfD used to derive the ground water quality criterion for metolachlor is 0.015 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for metolachlor was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens or carcinogens with no available slope factor, an RfD of 0.015 mg/kg/day (as explained above), and standard default assumptions:

$$\text{Criterion} = \frac{0.015 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 105 \text{ µg/L}$$

Where:
0.015 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 100 µg/L

Therefore, the specific ground water quality criterion for metolachlor is 100 µg/L.

Derivation of PQL: Metolachlor appears as a listed parameter in the National Environmental Methods Index (NEMI). The published method – "USEPA 508.1, Chlorinated Pesticides, Herbicides, and Organohalides in Water by GCECD". The method detection limit (MDL) is specified as 0.015 ppb. In accordance with N.J.A.C. 7:9C-1.9(c)3, the PQL was derived by multiplying the MDL by 5, rounding to one significant figure and expressed in µg/L, as shown below:

PQL = 0.015 ppb x 5 = 0.075 ppb

PQL rounded to one significant figure = 0.7 ppb = 0.07 µg/L

However, the difference between this result and the theoretical detection limit is not statistically significant. **Therefore, the PQL for metolachlor is 0.5 µg/L.**

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 100 µg/L and a PQL of 0.5 µg/L for metolachlor. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for metolachlor is 100 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for Metolachlor CASRN# 51218-45-2*. NJDEP. February 2008. http://www.state.nj.us/dep/wms/bears/docs/metolachlor.pdf.
- *Interim Ground Water Quality Criterion Metolachlor CAS # 51218-45-2.* Dr. Gloria Post. NJDEP. February 27, 2007 and *Interim Specific Ground Water Quality Criterion for Metolachlor (CASRN 51218-45-2)*, Dr. Gloria Post, NJDEP, February 27, 2007 (both available upon request).
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQL) for Metolachlor*, R. Lee Lippincott, Ph.D., NJDEP, May 5, 2006 (available upon request).

References:

Ciba-Geigy Corporation. 1983. MRID No. 00063398, 00084005, 00129377, 00144364, 00158924. Available from EPA. Write to FOI, EPA, Washington, DC 20460.

Ciba-Geigy Corporation. 1981. MRID No. 00080897. Available from EPA. Write to FOI, USEPA, Washington, DC 20460.

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

USEPA. 2005. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum, USEPA, Washington, DC. EPA/630.P-03/001F, March 2005. https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment

USEPA. 2004. Integrated Risk Information System. Metolachlor (CASRN 51218-45-2). Last modified, 2/9/2004.

USEPA. 2003. USEPA Protocol for the Review of Existing National Primary Drinking Water Regulations, 2003 (EPA 815-R-03-002).

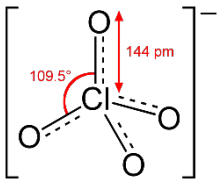
USEPA. 1986. United States Environmental Protection Agency. The Risk Assessment Guidelines of 1986. Washington, DC. EPA/600/8-87/045. August 1987.

Appendix S: Perchlorate

Ground Water Quality Standard for
Perchlorate
CASRN 14797-73-0

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 5 µg/L and a practical quantitation level (PQL) of 3 µg/L for perchlorate. The basis for this criterion and PQL are discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for perchlorate is 5 µg/L**.

Perchlorate
Molecular Formula:
ClO_4^-
Molecular Structure:



Background: Perchlorate is an inorganic ion that has been detected in drinking water supplies in New Jersey and nationally. It is used as an oxidizer in explosives, is found in fertilizer from Chile, and may also occur naturally. The adverse effects of perchlorate arise from inhibition of iodine uptake into the thyroid gland, which may lead to disturbance of thyroid function at sufficient doses. Pregnant women and infants are considered to be sensitive subpopulations for perchlorate's effects, as hypothyroidism can have serious consequences on neurodevelopment.

Reference Dose (RfD): Perchlorate has been evaluated by the U.S. Environmental Protection Agency (USEPA) and an assessment is available on USEPA's Integrated Risk Information System (IRIS) database (as Perchlorate (ClO4) CASRN 14797-73-0 and Perchlorate Salts CASRN 7790-98-9). The New Jersey Drinking Water Quality Institute (DWQI, 2005) and the National Research Council (NRC, 2005) have also evaluated perchlorate. USEPA characterized perchlorate as not likely to be carcinogenic to humans based on the Revised Draft Guidelines for Carcinogenic Risk Assessment (USEPA, 1999). Therefore, perchlorate is considered a non-carcinogen in the development of the human health-based ground water quality criterion. An RfD of 0.0007 mg/kg/day for perchlorate and perchlorate salts (CASRN 7790-98-9 Ammonium perchlorate, CASRN 7791-03-9 lithium perchlorate, CASRN 7778-74-7 potassium perchlorate, CASRN 7601-89-0, sodium perchlorate) was derived by USEPA based on a No Observed Effect Level (NOEL) of

0.007 mg/kg/day for inhibition of iodide uptake by the thyroid in a controlled human 14-day study (Greer et al., 2002) and an intraspecies uncertainty factor of 10 to protect the most sensitive population (pregnant women). The DWQI derived the same RfD, citing the recommendations of both the NRC (2005) and USEPA (1998, 2002), as well as the Greer et al. (2002) study. The Department concurs with the RfD of 0.0007 mg/kg/day for perchlorate derived by USEPA, NRC, and DWQI. **Therefore, the RfD used to derive the ground water quality criterion for perchlorate is 0.0007 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for perchlorate was derived pursuant to the N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.0007 mg/kg/day (as explained above), the assumed body weight of a pregnant woman, rather than the 70-kg default to be protective of the sensitive population, other standard default assumptions, and rounded to one significant figure, as follows:

$$\text{Criterion} = \frac{0.0007 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 67 \text{ kg} \times 0.2}{2 \text{ L/day}} = 4.7 \text{ µg/L}$$

Where:
0.0007 mg/kg/day = Reference Dose
67 kg = assumed body weight of pregnant adult (USEPA, 2004)
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 5 µg/L

Therefore, the specific ground water quality criterion for perchlorate is 5 µg/L.

Derivation of PQL: DWQI (2005) evaluated current testing technologies and recommended preferred analytical procedure(s) to be utilized by the certified laboratory community for the analysis of perchlorate in drinking water samples. DWQI (2005) recommended that USEPA Method 314.0 be used as the analytical method of choice for the determination of perchlorate in drinking water. This Method is proven to be accurate, precise, and rugged; is currently used by the certified drinking water laboratory community; and can measure perchlorate, with an accepted degree of confidence, below the ground water quality criterion of 5 µg/L. Method 314.0 operated "as currently written" is sufficient to measure perchlorate down to a reporting limit (RL) of 2.7 ppb. Because the RL is quantifiable under laboratory conditions, the Department determined that it is appropriate for PQL development. Pursuant to N.J.A.C. 7:9C-1.9(c)3, 2.7 ppb was rounded to one significant figure and expressed in µg/L. **Therefore, the PQL for perchlorate is 3 µg/L.**

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 5 µg/L and a PQL of 3 µg/L for perchlorate. In accordance with N.J.A.C. 7:9C-1.9(c), since the criterion is higher than the PQL for this constituent, **the ground water quality standard for perchlorate is 5 µg/L**.

Technical Support Documents: *Maximum Contaminant Level Recommendation for Perchlorate*, New Jersey Drinking Water Quality Institute (NJDWQI), October 7, 2005. http://www.nj.gov/dep/watersupply/pdf/perchlorate_mcl_10_7_05.pdf.

References:

DWQI. 2005. New Jersey Drinking Water Quality Institute. Maximum Contaminant Level Recommendation for Perchlorate. October 7, 2005.

Greer, M.A., G. Goodman, R.C. Pleus and S.E. Greer. 2002. Health effects assessment for environmental perchlorate contamination: the dose response for inhibition of thyroidal radioiodine uptake in humans. Envir Health Perspectives 110:927-937.

NRC. 2005. Health Implications of Perchlorate Ingestion. Board on Environmental Studies and Toxicology, Division on Earth and Life Sciences, National Research Council, Washington, DC.

USEPA. 2005. Integrated Risk Information System. Perchlorate (ClO_4^-) and Perchlorate Salts (CASRN 7790-98-9 Ammonium perchlorate CASRN 7791-03-9 Lithium perchlorate CASRN 7778-74-7 Potassium perchlorate CASRN 7601-89-0 Sodium perchlorate). Last modified, 02/18/2005. https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=1007 and https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1007_summary.pdf#nameddest=rfd

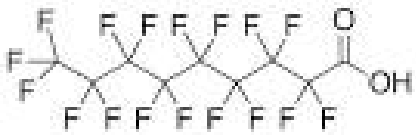
USEPA. 2004. Estimated Per Capita Water Ingestion and Body Weight in the United States- An Update Based on Data Collected by the United States Department of Agriculture's 1994-996 and 1998 Continuing Survey of Food Intakes by Individuals. U.S. Environmental Protection Agency. Office of Water and Office of Science and Technology, Washington, DC 20460. EPA-822-R-00-001

Appendix T: Perfluorononanoic acid (PFNA)

Ground Water Quality Standard for
Perfluorononanoic acid (PFNA)
CASRN 375-95-1

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 0.01 µg/L and a practical quantitation level (PQL) of 0.005 µg/L for perfluorononanoic acid (PFNA). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for PFNA is 0.01 µg/L**.

Perfluorononanoic acid (PFNA)
Molecular Formula:
$C_9HF_{17}O_2$
Molecular Structure:



Background: PFNA is a fully fluorinated carboxylic acid. PFNA was historically used primarily as a processing aid in the emulsion process used to make fluoropolymers, mainly polyvinylidene fluoride (Prevedouros et al., 2006). Like other perfluorinated chemicals (PFCs), PFNA is extremely persistent in the environment and is soluble in water (Post et al., 2013). The manufacture and use of PFNA and other long-chain perfluorinated carboxylates has been phased out by eight major manufacturers through a voluntary stewardship agreement with the U.S. Environmental Protection Agency (USEPA) which had the goal of eliminating emissions and product content by 2015 (USEPA, 2010, 2012) (see USEPA's website at http://www.epa.gov/oppt/pfoa/pubs/stewardship/). Notwithstanding the cessation of use by major manufacturers in the U.S., environmental contamination caused by PFNA is anticipated to continue for the foreseeable future due to its persistence in the environment, formation from precursor compounds (discussed below), and the potential for continued production by other manufacturers in the U.S. and/or overseas (USEPA, 2009; Lindstrom, et al., 2011).

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on PFNA indicate that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, PFNA was considered a noncarcinogen in the development of a human health-based ground water quality

criterion. An RfD was derived based on a developmental study conducted by USEPA (Das et al., 2014). Increased maternal liver weight was selected as the critical endpoint for quantitative risk assessment because serum levels and liver weights were both measured at the same time point (gestational day (GD) 17), one day after the last dose. The choice of this endpoint is further supported by data on numerous effects in the offspring in the same study, and on increased liver weight and other effects in additional rodent studies from the same and other laboratories. Liver weight increased in a dose-related manner, with a Lowest Observed Adverse Effect Level (LOAEL) of 1 mg/kg/day and a serum level BMDL (lower confidence limit on the benchmark dose) of 4,900 ng/ml (4.9 µg/ml) for increased liver weight (Das et al., 2015; numerical data and statistical parameters obtained from C. Lau, USEPA). A No Observed Adverse Effect Level (NOAEL) was not identified. An uncertainty factor of 1,000 was applied to the BMDL to derive a target human serum level (i.e., RfD in terms of serum level) of 4.9 ng/ml (4.9 µg/L). This includes uncertainty factors of 10 for intraspecies variability, 3 for interspecies variability, 10 to account for less-than-chronic study duration in Das et al. (2015), and 3 for gaps in the toxicological database.

A chemical specific Relative Source Contribution factor (RSC) of 0.5, based on the 95th percentile of serum PFNA in the U.S. general population from NHANES (CDC, 2015), was applied to the target human serum level of 4.9 ng/ml to derive the target human serum level from drinking water exposure only:

4.9 ng/ml x 0.5 = 2.45 ng/ml which rounds to 2.5 ng/ml = 2.5 µg/L

Pharmacokinetic data support a factor of 0.08 (ng/kg/day)/(ng/ml) relating PFNA intake and increase in PFNA serum level. This factor is used to derive the daily PFNA intake from drinking water (ng/kg/day) which will result in an increase in the serum level of 2.5 ng/ml (4.9 µg/L) as follows:

$$\frac{0.08 \text{ ng/kg/day}}{\text{ng/ml}} \times 2.5 \text{ ng/ml} = 0.2 \text{ ng/kg/day}$$

Based on the average daily water consumption value recommended by USEPA (2011) of 16 ml/kg/day (0.016 L/kg/day), the drinking water concentration that will result in exposure to 0.2 ng/kg/day is:

$$\frac{0.2 \text{ ng/kg/day}}{0.016 \text{ L/kg/day}} = 13 \text{ ng/L}$$

Using the chemical specific RSC of 0.5 and default assumptions for drinking water consumption and body weight, the RfD that supports the derivation of a criterion of 13 ng/L is 0.74 ng/kg/day, as follows:

$$RfD = \frac{13\ ng/L \times 2\ L/day}{70\ kg \times 0.5} = 0.74\ ng/kg/day$$

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for PFNA was derived pursuant to the formula established at N.J.A.C. 7:9C-1.7(c)4 for non-carcinogens, an RfD of 0.74 ng/kg/day (as explained above), Relative Source Contribution of 0.5 (as explained above), standard default assumptions for remaining factors, and rounded to one significant figure, as shown below:

$$Criterion = \frac{0.74\ ng/kg/day \times 0.001\ ng/\mu g \times 70\ kg \times 0.5}{2\ L/day} = 0.013\ \mu g/L$$

Where:
0.74 ng/kg/day = Reference Dose
70 kg = average adult weight
0.5 = Relative Source Contribution
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 0.01 µg/L

Therefore, the specific ground water quality criterion for PFNA is 0.01 µg/L.

Derivation of PQL: The Testing Subcommittee of the New Jersey Drinking Water Quality Institute (DWQI) received performance data from 13 Department-certified laboratories for PFNA analysis using USEPA Method 537 and/or proprietary methods. For PQL development, the Testing Subcommittee considered certified laboratories with reporting limits under 20 ng/L. The average of the reporting limits from eight laboratories was 4.9 ng/L. Because 4.9 ng/L is based on actual reporting limits obtained from laboratories performing PFNA analysis, the testing subcommittee recommends the PQL for PFNA be established at 4.9 ng/L. Pursuant to N.J.A.C. 7:9C-1.9(c)3, the quantification value was rounded to 5 ng/l and expressed in µg/L, as follows:

PQL = 4.9 ng/L

PQL rounded to one significant figure = 5 ng/L = 0.005 µg/L

Therefore, the PQL for PFNA is of 0.005 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 0.01 µg/L and a PQL of 0.005 µg/L for

PFNA. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for PFNA is 0.01 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for Perfluorononanoic acid CASRN# 375-95-1.* NJDEP. October 2015. http://www.state.nj.us/dep/wms/bears/docs/pfna_fact_sheet.pdf.
- *NJDEP Response Summary on Request for Public Input on The Draft Interim Specific Ground Water Quality Criterion and Draft Practical Quantitation Level for Perfluorononanoic Acid (PFNA)*. NJDEP. June 2015. http://www.state.nj.us/dep/dsr/supportdocs/pfna/Response%20Summary%20to%20public%20commentsPFNA%20documents%2010_20_15.pdf.
- *Interim Practical Quantitation Level (PQL) determination to support Interim Specific Ground Water Quality Standard development for Perfluorononanoic Acid (PFNA)*. R. Lee Lippincott, Ph.D. NJDEP. June 2015. http://www.state.nj.us/dep/dsr/supportdocs/pfna/Interim%20Practical%20Quantitation%20Level-PFNA.pdf.
- *Technical Support Document: Interim Specific Ground Water Criterion for Perfluorononanoic Acid (PFNA, C9) (CAS #: 375-95-1; Chemical Structure: CF3(CF2)7COOH).* NJDEP. Gloria B. Post. Ph.D. DABT. June 24, 2015, Revised November 28, 2016. http://www.state.nj.us/dep/dsr/supportdocs/pfna/PFNA%20FINAL%20%20interim%20GW%20criterion%206_26_15.pdf.

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Lindstrom, A.B., Strynar, M.J., Libelo, E.L. 2011a. Polyfluorinated compounds: Past, present, and future. Environ. Sci. Technol. 45: 7954–7961.

Post, G.B., Louis, J.B., Lippincott, R.L., and Procopio, N.A. 2013. Occurrence of perfluorinated chemicals in raw water from New Jersey public drinking water systems. Env. Sci. Technol. 47:13266-75.

Prevedouros, K., Cousins, I.T., Buck, R.C., Korzeniowski, S.H. 2006. Sources, fate and transport of perfluorocarboxylates. Environ. Sci. Technol. 40: 32−44.

USEPA. 2012. United States Environmental Protection Agency. Perfluorooctanoic Acid(PFOA) and

Fluorinated Telomers 2011 Annual Progress Reports.

USEPA. 2011. Exposure Factors Handbook 2011 Edition (Final). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-09/052F. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.

USEPA. 2010. United States Environmental Protection Agency. Office of Pollution Prevention and Toxics. 2010/2015 PFOA Stewardship Program.

USEPA. 2009. United States Environmental Protection Agency. Existing Chemical Action Plans. Office of Pollution Prevention and Toxics. Long-Chain Perfluorinated Chemicals (PFCs) Action Plan. December 30, 2009

Winslow, S.D., Pepich, B.V., Martin, J.J., Hallberg, G.R., Munch, D.J., Frebis, C.P., Hedrick, E.J., Krop, R.A. 2004. Statistical Procedures for determination and verification of minimum reporting levels for drinking water methods." Environ. Sci. Technol. 40: 281-288.

Appendix U: Strontium

Ground Water Quality Standard for Strontium CASRN 7440-24-6

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 2,000 µg/L and a practical quantitation level (PQL) of 5 µg/L for strontium. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for strontium is 2,000 µg/L.**

Strontium

Background: Strontium is a metal found in ores of celestite and strontianite. It is mined in the United Kingdom, Tunisia, Russia, Germany, Mexico, and the United States. Strontium is used in color television tubes, to make red flares in fireworks and in phosphorescent paint.

Reference Dose (RfD): Based on the U.S. Environmental Protection Agency (USEPA) Guidelines for Carcinogen Risk Assessment (2005), the available data on strontium indicate that it is "Not Likely to Be Carcinogenic to Humans" for the purposes of risk assessment. Therefore, strontium was considered a noncarcinogen in the development of a human health-based ground water quality criterion. USEPA's Integrated Risk Information System (IRIS) database shows an oral RfD for strontium of 0.6 mg/kg/day that was last updated on October 1, 1992. In 2014, the USEPA Office of Water published a revised Health Effects Support Document for Strontium (USEPA, 2014) with an updated RfD of 0.3 mg kg/day based on adverse alterations in bone calcification during post-natal bone growth (Marie et al., 1985). This study is a better basis for the derivation of an RfD for strontium than the study used in older IRIS assessment because of clear dose reporting; a longer duration of exposure; better quantitative reporting of effects; and ability to apply benchmark dose modeling to the dose-response data to more accurately assess a point of departure. **Therefore, the RfD used to derive the ground water quality criterion for strontium is 0.3 mg/kg/day.**

Derivation of Ground Water Quality Criterion: The ground water quality criterion was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.3 mg/kg/day

(as explained above) and standard default assumption for the relative source contribution, and rounded to one significant figure, as shown below. The default factors for average adult weight and assumed daily drinking water consumption were replaced with an age-adjusted time-weighted average drinking water intake for birth to 21 years of 0.040 L/kg/day because the adverse effects addressed by the USEPA-derived RfD are specific to earlier life stages when daily drinking water intake on a body weight basis is greater than during adulthood (USEPA, 2014, Appendix B).

$$\text{Criterion} = 0.3 \frac{\text{mg/kg/day} \times 1{,}000\ \mu\text{g/mg} \times 0.2}{0.040\ \text{L/kg/day}} = 1{,}500\ \mu\text{g/L}$$

Where:
0.3 mg/kg/day = the Reference Dose
0.2 = the assumed relative source contribution (20%)
0.040 L/kg/day= the age adjusted time-weighted average drinking water intake

Criterion rounded to one significant figure = 2,000 µg/L

Therefore, the specific ground water quality criterion for strontium is 2,000 µg/L.

Derivation of PQL: Strontium appears as a listed parameter in the National Environmental Methods Index (NEMI). The upper confidence interval (UCL) for a 7 lab inter-laboratory method detection limit (MDL) is 0.57 µg/L. Pursuant to N.J.A.C. 7:9C-1.9(c)3, a PQL can be derived by multiplying the MDL by five and rounded to one significant figure, as shown below:

PQL = 0.57 µg/L x 5 = 2.85 µg/L

PQL rounded to one significant figure = 3 µg/L

A PQL of 3 µg/L can be achieved by 96% of the labs using USEPA Method 200.7; however, current calibration procedures for the state primacy laboratory and Site Remediation Program contractual laboratories use a reporting limit of 5 µg/L for this parameter. The PQL of 5 µg/L is recommended to be consistent with these current calibration practices.

Therefore, the PQL for strontium is 5 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 2,000 µg/L and a PQL of 5 µg/L for strontium. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for strontium is 2,000 µg/L**.

Technical Support Documents:

- *Ground Water Quality Standard for Strontium CASRN# 7440-24-6*. NJDEP. October 2015. http://www.state.nj.us/dep/wms/bears/docs/strontium%20%20factsheet%20draft%20final%20for%20posting.pdf.
- NJDEP *Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*. NJDEP. June 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Development of a Draft Analytical Interim Practical Quantitation Levels (PQL) Strontium*. R. Lee Lippincott, Ph.D. NJDEP. June 4, 2015. http://nj.gov/dep/dsr/strontium/strontium%20draft%20final%20PQL.pdf.
- *Draft Interim Specific Ground Water Quality Criterion for Strontium*, Alan Stern, D.Ph. NJDEP. April 29, 2015. http://nj.gov/dep/dsr/strontium/Strontium%20ISGWQC%20final%20draft.pdf.

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Marie, P.J., M.T. Garba, M. Hott and L. Miravet. 1985. Effect of low doses of stable strontium on bone metabolism in rats. Miner Electrolyte Metab.; 11(1):5-13.

NEMI. National Environmental Methods Index. http://www.nemi.gov/.

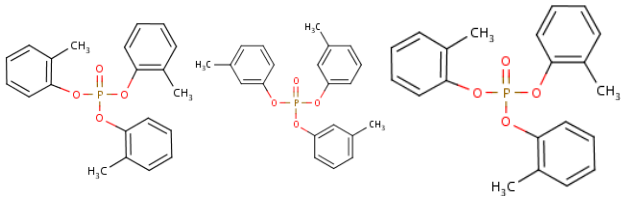
USEPA. 2014. Health Effects Support Document for Strontium. 820-P-14-001. U.S. Environmental Protection Agency Office of Water Health and Ecological Criteria Division. Washington, D.C. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OW-2012-0155-0008.

Appendix V: Tricresyl phosphate (mixed isomers)

Ground Water Quality Standard for
Tricresyl phosphate (mixed isomers)
CASRN 1330-78-5, 563-04-2, 78-32-0

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 3 µg/L and a practical quantitation level (PQL) of 0.1 µg/L for tricresyl phosphate (mixed isomers). The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for tricresyl phosphate (mixed isomers) is 3 µg/L.**

Tricresyl phosphate (mixed isomers)
Molecular Formula:
$C_{21}H_{21}O_4P$
Molecular Structure:



Background: Tricresyl phosphate is a mixture of three different isomers used as an additive in lubricating oils; as a plasticizer for chlorinated rubber, vinyl plastics, polystyrene, polyacrylic and polymethacrylic esters; as an adjuvant in milling pigment pastes; as a solvent and a binder in various natural resins; as a lubricant in synthetic lubricants and gasoline; as a hydraulic fluid; and as a fire retardant (NIOSH, 1977).

Reference Dose (RfD): The U.S. Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) database does not provide an evaluation of carcinogenicity for tricresyl phosphate or its isomers; therefore, it was considered a non-carcinogen in the development of a human health-based ground water quality criterion. The RfD for tricresyl phosphate (mixed isomers) was derived based on neuropathy in hens (Prentice and Majeed, 1983) and a No Observed Adverse Effect Level (NOAEL) of 1.25 mg/kg/day. In the absence of data on factors affecting sensitivity in humans, the lack of data specific to chicken-human extrapolation, the lack of developmental studies in additional species and/or strains of rodent, and the lack of a two-generation reproductive study warrant an overall database uncertainty adjustment of 3,000.

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Intraspecies variability, to protect sensitive subpopulations
10: Subchronic-to-chronic extrapolation
3: Database insufficiency, to account for lack of data specific to chicken-human extrapolation, the lack of developmental studies in additional species and/or strains of rodent, and the lack of a two-generation reproductive study

Total Uncertainty Factor = 3,000

$$RfD = NOAEL/UF_{total} = \frac{1.25 \text{ mg/kg/day}}{3{,}000} = 0.0004 \text{ mg/kg/day}$$

Therefore, the RfD used to derive the ground water quality criterion for tricresyl phosphate (mixed isomers) is 0.0004 mg/kg/day.

Derivation of Ground Water Quality Criterion: The specific ground water quality criterion for tricresyl phosphate (mixed isomers) was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.0004 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as shown below:

$$\text{Criterion} = \frac{0.0004 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 2.8 \text{ µg/L}$$

Where:
0.0004 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 3 µg/L

Therefore, the specific ground water quality criterion for tricresyl phosphate (mixed isomers) is 0.0004 mg/kg/day.

Derivation of PQL: Tricresyl phosphate isomers and their synonym, tri-tolyl phosphates, appear as listed parameters in the National Environmental Methods Index (NEMI) in two published USEPA methods "1618, Organo-Halide Pesticides, Organo Phosphorus pesticides, and Phenoxy-acid Herbicides by Wide-Bore Capillary Column Gas Chromatography with Selective Detectors, and 8270D Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)."

Although the meta- and para- isomers are not listed separately in the document, the chromatographic examples in the method indicate that they can be adequately resolved and that resolution can be improved further by the mass spectrometer resolution in the reconstructed ion chromatogram. The method detection limit (MDL) used in the published methods is 10 ppb. Pursuant to N.J.A.C. 7:9C-1.9(c)3, a PQL can be derived by multiplying the MDL by 5 and expressed in µg/L, as follows:

PQL = 10 ppb x 5 = 50 ppb = 50 µg/L.

However, since a PQL of 50 µg/L is significantly higher than the human health-based criterion of 3 µg/L, a laboratory survey and literature review were conducted that yielded several peer reviewed references from MDL values of 20 ng/L to routine quantification values from environmental assessments of 0.3 to 4.3 ng/L sensitivity levels. In addition, USGS method O-1423-01 has a reporting limit (RL) of 60 ng/L for the flame-retardant tri-phenyl phosphate, which is structurally similar to these parameters. Pursuant to N.J.A.C. 7:9C-1.9(c)3, a PQL was derived by multiplying the RL by 5 and expressed in µg/L, as shown below:

PQL = 20 ng/L x 5 = 100 ng = 0.1 ppb = 0.1 µg/L

Therefore, the PQL for tricresyl phosphate is of 0.1 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 3 µg/L and a PQL of 0.1 µg/L for tricresyl phosphate. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for tricresyl phosphate is 3 µg/L.**

Technical Support Documents:

- *Ground Water Quality Standard for Tri-cresyl phosphate (mixed isomers) CASRN #1330-78-5, Tri-o-cresyl phosphate # 78-30-8, Tri-m-cresyl phosphate # 563-04-2 & Tri-p-cresyl phosphate # 78-32-0*. NJDEP. October 2015. http://www.state.nj.us/dep/wms/bears/docs/tri-cresol%20phosphate(mixed%20isomers)%20fact%20sheet%20final%20draft%20for%20posting.pdf.
- *NJDEP Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*. NJDEP. June 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Development of an Analytical Practical Quantitation Levels (PQL) for Tri-cresyl phosphate (mixed isomers) CAS #1330-78-5, Tri-o-cresyl phosphate # 78-30-8, Tri-m-cresyl phosphate # 563-04-2 & Tri-p-cresyl phosphate # 78-32-0*. R. Lee Lippincott, Ph.D. NJDEP. March 19, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/tri-ortho-cresyl-mixed-pql.pdf.

- *Interim Specific Ground Water Criterion Recommendation for Tricresyl phosphate (TCP) Mixtures*, Alan H. Stern, D.Ph., D.A.B.T. NJDEP. December 10, 2010. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/tri-ortho-cresyl-mixed.pdf.
- *Interim Specific Ground Water Quality Criterion Recommendation Report for Tri-ortho-cresyl phosphate*. Alan H. Stern. D.Ph., D.A.B.T. NJDEP. November 16, 2010 (available upon request).

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Marklund A et al; Environ Sci Technol 39: 3555-3562 (2005)

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NTP (National Toxicology Program) (1994). Toxicology and carcinogenesis studies of tricresyl phosphate (CAS No. 1330-78-5) in F344/N rats and B6C3F1 mice. US Department of Health and Human Services, Public Health Service. Accessed at: http://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr433.pdf.

Takimoto K et al; Atmos Environ 33: 3191-3200 (1999)

van der Veen I, de Boer J; Chemosphere 88: 1119-53 (2012)

Weiner ML, Jortner BS (1999). Organophosphate-induced delayed neurotoxicity of triarylphosphates. Neurotoxicology. 20:653-73.

Williams DT, Lebel GL; Bull Environ Contam Toxicol 27: 450-7 (1981)

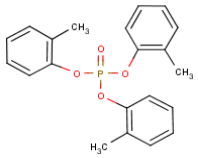
Williams DT et al; Chemosphere 11: 262-76 (1982)

Appendix W: Tri-ortho-cresyl phosphate

Ground Water Quality Standard for
Tri-ortho-cresyl phosphate
CASRN 78-30-8

Summary of Decision: In accordance with the New Jersey Ground Water Quality Standards rules at N.J.A.C. 7:9C-1.7, the Department of Environmental Protection (Department) has developed a specific ground water quality criterion of 3 µg/L and a practical quantitation level (PQL) of 0.1 µg/L for tri-ortho-cresyl phosphate. The basis for this criterion and PQL is discussed below. Pursuant to N.J.A.C. 7:9C-1.9(c), **the ground water quality standard (constituent standard) for tri-ortho-cresyl phosphate (also known as TOCP) is 3 µg/L.**

Tri-ortho-cresyl phosphate (TOCP)
Molecular Formula:
$(CH_3C_6H_40)_3PO$
Molecular Structure:



Background: Tri-ortho-cresyl phosphate (TOCP) occurs as a component of mixed tricresyl phosphates. Tricresyl phosphates have been used as a plasticizer for chlorinated rubber, vinyl plastics, polystyrene, polyacrylic and polymethacrylic esters; as an adjuvant in milling pigment pastes; as a solvent and a binder in various natural resins; as a lubricant in synthetic lubricants and gasoline; as a hydraulic fluid; and as a fire retardant (NIOSH, 1977). It does not appear that TOCP was manufactured or used extensively for industrial purposes as a pure substance.

Reference Dose (RfD): The U.S. Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) database does not provide an evaluation of carcinogenicity for TOCP; therefore, it was considered a non-carcinogen in the development of a human health-based ground water quality criterion. The RfD for TOCP was derived based on neuropathy in hens (Prentice and Majeed, 1983) and a No Observed Adverse Effect Level (NOAEL) of 1.25 mg/kg/day. In the absence of data on factors affecting sensitivity in humans, the lack of data specific to chicken-human extrapolation, the lack of developmental studies in additional species and/or strains of rodent, and the lack of a two-generation reproductive study warrant an overall database uncertainty adjustment of 3,000.

The uncertainty factors applied to derive the RfD are:

10: Interspecies, to account for animal-to-human variability
10: Intraspecies variability, to protect sensitive subpopulations
10: Subchronic-to-chronic extrapolation
3: Database insufficiency, to account for lack of data specific to chicken-human extrapolation, the lack of developmental studies in additional species and/or strains of rodent, and the lack of a two-generation reproductive study

Total Uncertainty Factor = 3,000

$$RfD = NOAEL/UF_{total} = \frac{1.25 \text{ mg/kg/day}}{3{,}000} = 0.0004 \text{ mg/kg/day}$$

Therefore, the RfD used to derive the ground water quality criterion for TOCP is 0.0004 mg/kg/day.

Derivation of Ground Water Quality Criterion: The ground water quality criterion was derived pursuant to N.J.A.C. 7:9C-1.7(c)4 using the formula for non-carcinogens, an RfD of 0.0004 mg/kg/day (as explained above), standard default assumptions, and rounded to one significant figure, as shown below:

$$\text{Criterion} = \frac{0.0004 \text{ mg/kg/day} \times 1{,}000 \text{ µg/mg} \times 70 \text{ kg} \times 0.2}{2 \text{ L/day}} = 2.8 \text{ µg/L}$$

Where:
0.0004 mg/kg/day = Reference Dose
70 kg = average adult weight
0.2 = the assumed relative source contribution (20%)
2 L/day = assumed daily drinking water consumption

Criterion rounded to one significant figure = 3 µg/L

Therefore, the specific ground water quality criterion for TOCP = 3 µg/L

Derivation of PQL: Tri-ortho-cresyl phosphate (TOCP), and its synonym tri-o-tolyl phosphate, appear as listed parameters in the National Environmental Methods Index (NEMI) in two published USEPA methods "1618, Organo-Halide Pesticides, Organo Phosphorus pesticides, and Phenoxy-acid Herbicides by Wide-Bore Capillary Column Gas Chromatography with Selective Detectors, and 8270D Semivolatile Organic Compounds by Gas Chromatography/Mass

Spectrometry (GC/MS)." The reported method detection limit (MDL) used by both methods is 10 ppb. Pursuant to N.J.A.C. 7:9C-1.9(c)3, a PQL can be derived by multiplying the MDL by 5 and expressed in µg/L, as follows: PQL = 10 ppb x 5 = 50 ppb = 50 µg/L. However, since a PQL of 50 µg/L is significantly higher than the human health-based criterion of 3 µg/L, a laboratory survey and literature review were conducted that yielded several peer reviewed references from MDL values of 20 ng/L to routine quantification values from environmental assessments of 0.3 to 4.3 ng/L sensitivity levels. In addition, USGS method O-1423-01 has a reporting limit (RL) of 60 ng/L for the flame-retardant tri-phenyl phosphate, which is structurally similar to these parameters. Pursuant to N.J.A.C. 7:9C-1.9(c)3, a PQL was derived by multiplying the RL by 5 and expressed in µg/L, as shown below:

PQL = 20 ng/L x 5 = 100 ng = 0.1 ppb = 0.1 µg/L

Therefore, the PQL for TOCP is of 0.1 µg/L.

Conclusion: Based on the information provided above (and cited below), the Department has established a specific ground water quality criterion of 3 µg/L and a PQL of 0.1 µg/L for TOCP. In accordance with N.J.A.C. 7:9C-1.9(c), since the ground water quality criterion is higher than the PQL for this constituent, **the ground water quality standard for tri-ortho-cresyl phosphate (TOCP) is 3 µg/L.**

Technical Support Documents:

- *Ground Water Quality Standard for Tri-ortho-cresyl phosphate CASRN# 78-30-8.* NJDEP. October 2015. http://www.state.nj.us/dep/wms/bears/docs/Tri-ortho-cresyl%20phosphate%20fact%20sheet%20draft%20final%20for%20posting.pdf.
- *NJDEP Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals*. NJDEP. June 2015. http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.
- *Procedure for Describing Process for Development of Analytical Practical Quantitation Levels (PQL) for Tri-ortho-cresyl phosphate CAS #78-30-8*, R. Lee Lippincott, Ph.D. NJDEP. March 19, 2014. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/tri-ortho-cresyl-pql.pdf.
- *Interim Specific Ground Water Criterion for Tri-ortho-cresyl phosphate (TOCP).* Alan H. Stern, D.Ph., D.A.B.T. NJDEP. November 16, 2010. http://www.state.nj.us/dep/dsr/gw-criteria-pql-public-comment/tri-ortho-cresyl.pdf.

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Ishikawa S et al; Water Res 19: 119-25 (1985)

Lapadula DM, Patton SE, Campbell GA, Abou-Donia MB (1985). Characterization of delayed neurotoxicity in the mouse following chronic oral administration of tri-o-cresyl phosphate. Toxicol Appl Pharmacol. 79:83-90.

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Tocco DR, Randall JL, York RG, Smith MK (1987). Evaluation of the teratogenic effects of Tri-ortho-cresyl phosphate in the Long-Evans hooded rat. Fundam Appl Toxicol. 8:291-7.
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Williams DT, Lebel GL; Bull Environ Contam Toxicol 27: 450-7 (1981)

Williams DT et al; Chemosphere 11: 262-76 (1982)

Appendix X: Response to Comments on Draft Interim Specific Criterion and Interim PQL for PFNA

On March 14, 2014, the NJDEP requested public input on two documents, the draft interim specific ground water quality criterion, and the draft practical quantitation level for perfluorononanoic acid (PFNA). Comments were requested by April 21, 2014. Based on requests for an extension, the public comment period was extended to May 1, 2014. After careful consideration of the comments received, interim ground water quality criteria, interim PQLs and interim ground water quality standards were established for these constituents on November 25, 2015. The public record supporting these interim values is available on the Department's website at http://www.state.nj.us/dep/dsr/supportdocs/pfna/Response%20Summary%20to%20public%20commentsPFNA%20documents%2010_20_15.pdf.

Appendix Y: Response to Public Input on Draft Interim Ground Water Quality Criteria and Draft Interim Practical Quantitation Levels for Eleven Chemicals

The Department developed and requested public input for draft Interim Ground Water Quality Criteria and analytical draft interim practical quantitation levels (PQLs) for the following eleven chemicals:

- 1,2,4-Trimethylbenzene
- 1,4-Dioxane[8]
- 1-Methylnaphthalene
- Cresols (mixed isomers)
- Tri-ortho-cresyl phosphate
- Tricresyl phosphate (mixed isomers)
- 1,1,1-Trifluoroethane
- 1-Chloro-1,1-difluoroethane
- 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
- 1,1-Dichloro-1-fluoroethane
- Strontium

The Department published these proposed values and their technical basis to solicit public input in the interest of transparency and obtaining additional relevant information. The Department was particularly interested in any new toxicity data or information relevant to the derivation of the draft interim criteria. The Department received comments on 7 of the 11 chemicals. No comments or information was received for tri-ortho-cresyl phosphate, tricresyl phosphate (mixed isomers), 1-chloro-1,1- difluoroethane or 1,1,2-trichloro-1,2,2-trifluoroethane. After careful consideration of the comments received, interim ground water quality criteria, interim PQLs and interim ground water quality standards were established for these constituents on November 25, 2015. The public record supporting these interim values is available on the Department's website at http://www.state.nj.us/dep/dsr/supportdocs/11-chemicals-response.pdf.

[8] The proposed draft interim specific ground water quality criterion and proposed interim PQL for 1,4-dioxane were revisions to the prior interim specific ground water quality criterion and PQL established by the Department on February 11, 2008.