WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Proposed Rule Language for the Amendments to the Model Toxics Control Act Cleanup Regulation Chapter 173-340 WAC

Combined document includes:

- **Fact Sheet**
- **CR 102**
- **Proposed Rule Language**
- **Background Document**

Washington State Department of Ecology
Toxics Cleanup Program

April 2007
Publication No. 07-09-101

If you have special accommodation needs, please contact the Toxics Cleanup Program (360) 407-7170 (voice), 711 for Washington Relay Service, or persons with a speech disability can call 1-877-833-6341.

This Background Document is available on the Department of Ecology's website at: http://www.ecy.wa.gov/programs/tcp/regs/amend_2007/proposed_amend.html

For additional copies of this publication, please contact:

Department of Ecology
Toxics Cleanup Program
P.O. Box 47600
Olympia, WA 98504-7600
(360) 407-7170

Refer to Publication Number 07-09-101

Questions or comments regarding this Background Document for the Proposed Amendments to the Model Toxics Control Act Cleanup Regulation should be addressed to:

Pete Kmet
Washington State Department of Ecology
Toxics Cleanup Program
P. O. Box 47600
Olympia, WA 98504-7600

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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Proposed Changes to the Model Toxics Control Act Cleanup Regulation

Now is the time to comment!

Ecology has prepared this fact sheet to update you on proposed changes to the MTCA rule. We hope you will take this opportunity to learn more about the proposed changes and tell us what you think.

The public comment period is: April 4 through May 25, 2007

If you have comments on the proposed rule, please send them to:

Mr. Pete Kmet
Department of Ecology,
Toxics Cleanup Program
PO Box 47600
Olympia, WA 98504-7600
E-mail: pkme461@ecy.wa.gov

Ecology has scheduled three public hearings to receive written or oral comments on the proposed changes to the rule. At each public hearing, an overview presentation and question and answer period will be held prior to the start of the official public hearing. Following are the dates, times, and locations of the public hearings:

Public hearing dates, times and locations:

Seattle
May 10, 2007 - 5:30 p.m.
St. Benedict School Auditorium
4811 Wallingford AVE N

Port Angeles
May 14, 2007 - 5:30 p.m.
County Commissioners Board Room
Clallam County Courthouse
223 E 4th ST

Spokane
May 17, 2007 - 5:30 p.m.
Department of Ecology
Eastern Regional Office
N 4601 Monroe ST, STE 100
Second Floor Conference Room

For more information or questions, please call (360) 407-7187 or TCP Receptionist (360) 407-7170, or view the website at:

http://www.ecy.wa.gov/programs/tcp/regs/amend_2007/proposed_amend.html

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The Washington State Department of Ecology (Ecology) is proposing changes to the Model Toxics Control Act (MTCA) Cleanup Regulation (Chapter 173-340 WAC). The rule revisions will update the policies and procedures for establishing and evaluating compliance with cleanup levels and remediation levels for several types of chemicals.

Reasons for the Proposed Rule Changes

The Model Toxics Control Act was passed by Washington voters in November 1988. The law establishes the basic authorities and requirements for cleaning up contaminated sites.

Ecology originally adopted cleanup standards in February 1991 and completed significant changes to the cleanup standards in February 2001. Under the revised rule, a person undertaking a cleanup action may use the Environmental Protection Agency's toxicity equivalency factor (TEF) values and methodology when assessing dioxin and furan mixtures. Later that year, Ecology published a guidance document that explains how to use the TEF methodology when establishing cleanup levels.

In November 2005, the Rayonier Corporation filed a lawsuit challenging Ecology's use of the guidance document at the Port Angeles mill site. Rayonier argued that the MTCA rule requires Ecology to establish cleanup levels for each dioxin congener. This was based on using a cancer risk level of one-in-one million (or 10^{-6}), as opposed to applying 10^{-6} risk level to the whole mixture. In April 2006, Ecology settled the lawsuit and agreed that Rayonier's approach was also a possible interpretation of the current MTCA rule. Ecology agreed to settle the lawsuit because neither the current MTCA rule nor the federal guidance referenced in the MTCA rule clearly requires the procedures in the CLARC guidance.

Publication number 07-09-049

If you need this publication in an alternate format, please call the Toxic Cleanup Program at (360) 407-7205. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call (877) 833-6341.

Along with settlement discussions, several environmental organizations presented a rulemaking petition to Ecology in March 2006. These groups requested that Ecology amend the rule. This would clarify that the policies and procedures mentioned in the Ecology guidance are used when establishing cleanup levels for dioxins/furans and other similar mixtures. Ecology reviewed the petition and decided to begin the rulemaking process to address the issues raised in the lawsuit and rulemaking petition. Ecology decided that amending the MTCA rule to define key policy choices is preferable versus resolving those policies on a site-specific basis.

Summary of the Proposed Rule Changes

Ecology proposes revising the policies and procedures. These revisions set cleanup levels and remediation levels for certain chemical mixtures and establish compliance with those levels. The changes apply to mixtures of dioxins and furans, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). The proposed revisions include:

- Risk Policies Applicable to Certain Mixtures. Ecology proposes:
  - Cleanup levels for dioxin and furan mixtures are based on a cancer risk of one-in-a-million.
  - Cleanup levels for PAH mixtures are based on a cancer risk of one-in-a-million.
  - Cleanup levels for PCB mixtures are based on a cancer risk of one-in-a-million.
- Toxic Equivalency Factors Used to Characterize Mixtures. Ecology proposes amending the rule to add the most recent toxicity equivalency factors (TEFs) for dioxins/furans and PCBs recommended by the World Health Organization. Ecology also proposes updating potency equivalency factors (PEFs) for carcinogenic PAHs adopted by the California Environmental Protection Agency.
- Default Parameters Used to Calculate Cleanup Levels. Ecology proposes revising the default Gastrointestinal Absorption Fraction used to establish soil cleanup levels for dioxins and furans.
- Evaluating Cross-Media Impacts. Ecology proposes requiring that cleanup proponents consider the physical-chemical properties of individual PAH compounds or dioxin-congeners when evaluating cross-media impacts.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Department of Ecology
Toxics Cleanup Program
P.O. Box 47600
Olympia, WA 98504-7600

PUBLIC COMMENT REQUESTED
We use several mailing lists. If you receive a duplicate, please pass it on.

CR 102

PROPOSED RULE MAKING

CR-102 (June 2004)
(Implements RCW 34.05.320)
Do **NOT** use for expedited rule making

Agency: Department of Ecology   A.O # 06-10

☒ **Preproposal Statement of Inquiry was filed as WSR** 06-12-122 **; or**
☐ **Expedited Rule Making--Proposed notice was filed as WSR** ________; **or**
☐ **Proposal is exempt under RCW 34.05.310(4).**

☒ **Original Notice**
☐ **Supplemental Notice to WSR** ________
☐ **Continuance of WSR** ________

Title of rule and other identifying information: (Describe Subject) Chapter 173-340 WAC – Model Toxics Control Act Cleanup Regulation. The rule revisions will update and clarify the policies and procedures for establishing and evaluating compliance with cleanup levels and remediation levels for mixtures of polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans (dioxins/furans), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).

Hearing location(s):

See Attached

Date: see attached Time: see attached

Submit written comments to:
Name: Pete Kmet, P.E.
Address: Department of Ecology
Toxics Cleanup Program,
P.O Box 47600
Olympia, WA 98504-7600
e-mail pkmet461@ecy.wa.gov
fax (360) 407-7154
post mark May 25, 2007

Date of intended adoption: June 30, 2007
(Note: This is **NOT** the **effective** date)

Assistance for persons with disabilities: Contact Ann McNeely by April 23, 2007
TTY ( ) ________ or (360) 407-7205

Purpose of the proposal and its anticipated effects, including any changes in existing rules:
Ecology is proposing these rule changes in order to update the policies and procedures for establishing cleanup levels for mixtures of dioxins and furans, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).

- Risk Policies Applicable to Certain Mixtures: Ecology is proposing changes to require that cleanup levels for mixtures of dioxins and furans, PAHs and PCBs must each be based on a cancer risk of one-in-a-million
- Toxic Equivalency Factors Used to Characterize Mixtures: Ecology is proposing to amend the rule to incorporate the most recent toxicity equivalency factors (TEFs) for dioxins/furans and PCBs recommended by the World Health Organization and updated potency equivalency factors (PEFs) for carcinogenic PAHs adopted by the California Environmental Protection Agency.
- Methods for Calculating Soil Cleanup Levels: Ecology is proposing a method for considering the relative bioavailability of soil-bound dioxins and furans when establishing soil cleanup levels.
- Evaluating Cross-Media Impacts: Ecology is proposing to require that cleanup proponents consider the physical-chemical properties of individual PAH compounds or dioxin-congeners when evaluating cross-media impacts

Reasons supporting proposal: Ecology is proposing these rule changes for the following reasons:

- Ensure a consistent and predictable level of protection for Washington communities;
- Ensure that the most current scientific information is used to establish cleanup levels; and
- Minimize administrative cost and project delays.

Statutory authority for adoption: RCW 70.105D.030(2)

Statute being implemented: Chapter 70.105D RCW

Is rule necessary because of a:
Federal Law? ☐ Yes ☒ No
Federal Court Decision? ☐ Yes ☒ No
State Court Decision? ☐ Yes ☒ No
If yes, CITATION:

DATE 4/2/07

NAME (type or print)
Polly Zehm

SIGNATURE Polly Zehm

TITLE
Deputy Director

CODE REVISER USE ONLY

(COMPLETE REVERSE SIDE)

Agency comments or recommendations, if any, as to statutory language, implementation, enforcement, and fiscal matters:

Name of proponent: (person or organization) Department of Ecology, Toxics Cleanup Program

☐ Private
☐ Public
☒ Governmental

Name of agency personnel responsible for:

	Name	Office Location	Phone
Drafting	Dave Bradley	Department of Ecology, Headquarters	(360) 407-6907
Implementation	Jim Pendowski	Department of Ecology, Headquarters	(360) 407-7177
Enforcement	Jim Pendowski	Department of Ecology, Headquarters	(360) 407-7177

Has a small business economic impact statement been prepared under chapter 19.85 RCW?

☐ Yes. Attach copy of small business economic impact statement.

A copy of the statement may be obtained by contacting:
Name: Ann McNeely
Address: 300 Desmond Drive
Lacey WA 98504
phone (360) 407-7205
fax (360) 407-7154
e-mail amcn461@ecy.wa.gov

☒ No Explain why no statement was prepared.

A small business is defined as, "any business entity, including a sole proprietorship, corporation, partnership, or other legal entity, that is owned and operated independently from all other businesses and that has fifty or fewer employees" (RCW 19.85.020). Based on an analysis of actual cleanup levels, and experience administering the existing MICA rule, Ecology has concluded that small businesses are not likely to be affected by the proposed rule. The rationale for this conclusion can be found in the preliminary Cost-Benefit Analysis.

Is a cost-benefit analysis required under RCW 34.05.328?

☒ Yes A preliminary cost-benefit analysis may be obtained by contacting:
Name: Ann McNeely
Address: 300 Desmond Drive
Lacey WA 98504
phone (360) 407-7205
fax (360) 407-7154
e-mail amcn461@ecy.wa.gov

☐ No: Please explain:

Hearing location for MTCA Rule Revision:

- Seattle
  St. Benedict School Cafeteria
  4811 Wallingford Avenue N., Seattle, WA 78103
  May 10, 2007
  Workshop begins at 5:30 P.M, hearing immediately following

- Port Angeles
  Clallam County Courthouse
  223 E. 4th Street, Port Angeles
  May 14, 2007
  Workshop begins at 5:30 P.M, hearing immediately following;

- Spokane
  Department of Ecology Eastern Regional Office (Second Floor Conference Room)
  May 17, 2007
  4601 N. Monroe Street, Spokane, WA 99205
  Workshop begins at 5:30 P M, hearing immediately following.

Proposed Rule Language

AMENDATORY SECTION (Amending Order 97-09A, filed 2/12/01, effective 8/15/01)

WAC 173-340-708 Human health risk assessment procedures. (1) **Purpose.** This section defines the risk assessment framework that shall be used to establish cleanup levels, and remediation levels using a quantitative risk assessment, under this chapter. As used in this section, cleanup levels and remediation levels means the human health risk assessment component of these levels. This chapter defines certain default values and methods to be used in calculating cleanup levels and remediation levels. This section allows varying from these default values and methods under certain circumstances. When deciding whether to approve alternate values and methods the department shall ensure that the use of alternative values and methods will not significantly delay site cleanups.

(2) **Selection of indicator hazardous substances.**

When defining cleanup requirements at a site that is contaminated with a large number of hazardous substances, the department may eliminate from consideration those hazardous substances that contribute a small percentage of the overall threat to human health and the environment. The remaining hazardous substances shall serve as indicator hazardous substances for purposes of defining site cleanup requirements. See WAC 173-340-703 for additional information on establishing indicator hazardous substances.

(3) **Reasonable maximum exposure.**

(a) Cleanup levels and remediation levels shall be based on estimates of current and future resource uses and reasonable maximum exposures expected to occur under both current and potential future site use conditions, as specified further in this chapter.

(b) The reasonable maximum exposure is defined as the highest exposure that is reasonably expected to occur at a site under current and potential future site use. WAC 173-340-720 through 173-340-760 define the reasonable maximum exposures for ground water, surface water, soil, and air. These reasonable maximum exposures will apply to most sites where individuals or groups of individuals are or could be exposed to hazardous substances. For example, the reasonable maximum exposure for most ground water is defined as exposure to hazardous substances in drinking water and other domestic uses.

(c) Persons performing cleanup actions under this chapter may use the evaluation criteria in WAC 173-340-720 through 173-

340-760, where allowed in those sections, to demonstrate that the reasonable maximum exposure scenarios specified in those sections are not appropriate for cleanup levels for a particular site. For example, the criteria in WAC 173-340-720(2) could be used to demonstrate that the reasonable maximum exposure for ground water beneath a site does not need to be based on drinking water use. The use of an alternate exposure scenario shall be documented by the person performing the cleanup action. Documentation for the use of alternate exposure scenarios under this provision shall be based on the results of investigations performed in accordance with WAC 173-340-350.

(d) Persons performing cleanup actions under this chapter may also use alternate reasonable maximum exposure scenarios to help assess the protectiveness to human health of a cleanup action alternative that incorporates remediation levels and uses engineered controls and/or institutional controls to limit exposure to the contamination remaining on the site.

(i) An alternate reasonable maximum exposure scenario shall reflect the highest exposure that is reasonably expected to occur under current and potential future site conditions considering, among other appropriate factors, the potential for institutional controls to fail and the extent of the time period of failure under these scenarios and the land uses at the site.

(ii) Land uses other than residential and industrial, such as agricultural, recreational, and commercial, shall not be used as the basis for a reasonable maximum exposure scenario for the purpose of establishing a cleanup level. However, these land uses may be used as a basis for an alternate reasonable maximum exposure scenario for the purpose of assessing the protectiveness of a remedy. For example, if a cap (with appropriate institutional controls) is the proposed cleanup action at a commercial site, the reasonable maximum exposure scenario for assessing the protectiveness of the cap with regard to direct soil contact could be changed from a child living on the site to a construction or maintenance worker and child trespasser scenario.

(iii) The department expects that in evaluating the protectiveness of a remedy with regard to the soil direct contact pathway, many types of commercial sites may, where appropriate, qualify for alternative exposure scenarios under this provision since contaminated soil at these sites is typically characterized by a cover of buildings, pavement, and landscaped areas. Examples of these types of sites include:

(A) Commercial properties in a location removed from single family homes, duplexes or subdivided individual lots;

(B) Private and public recreational facilities where access to these facilities is physically controlled (e.g., a private golf course to which access is restricted by fencing);

(C) Urban residential sites (e.g., upper-story residential units over ground floor commercial businesses);

(D) Offices, restaurants, and other facilities primarily devoted to support administrative functions of a commercial/industrial nature (e.g., an employee credit union or cafeteria in a large office or industrial complex).

(e) A conceptual site model may be used to identify when individuals or groups of individuals may be exposed to hazardous substances through more than one exposure pathway. For example, a person may be exposed to hazardous substances from a site by drinking contaminated ground water, eating contaminated fish, and breathing contaminated air. At sites where the same individuals or groups of individuals are or could be consistently exposed through more than one pathway, the reasonable maximum exposure shall represent the total exposure through all of those pathways. At such sites, the cleanup levels and remediation levels derived for individual pathways under WAC 173-340-720 through 173-340-760 and WAC 173-340-350 through 173-340-390 shall be adjusted downward to take into account multiple exposure pathways.

(4) **Cleanup levels for individual hazardous substances.** Cleanup levels for individual hazardous substances will generally be based on a combination of requirements in applicable state and federal laws and risk assessment.

(5) **Multiple hazardous substances.**

(a) Cleanup levels for individual hazardous substances established under Methods B and C and remediation levels shall be adjusted downward to take into account exposure to multiple hazardous substances. This adjustment needs to be made only if, without this adjustment, the hazard index would exceed one (1) or the total excess cancer risk would exceed one in one hundred thousand (1×10^{-5}).

(b) Adverse effects resulting from exposure to two or more hazardous substances with similar types of toxic response are assumed to be additive unless scientific evidence is available to demonstrate otherwise. Cancer risks resulting from exposure to two or more carcinogens are assumed to be additive unless scientific evidence is available to demonstrate otherwise.

(c) For noncarcinogens, for purposes of establishing cleanup levels under Methods B and C, and for remediation levels, the health threats resulting from exposure to two or more hazardous substances with similar types of toxic response may be apportioned between those hazardous substances in any combination as long as the hazard index does not exceed one (1).

(d) For carcinogens, for purposes of establishing cleanup levels under Methods B and C, and for remediation levels, the cancer risks resulting from exposure to multiple hazardous substances may be apportioned between hazardous substances in any combination as long as the total excess cancer risk does not exceed one in one hundred thousand (1×10^{-5}).

(e) The department may require biological testing to assess the potential interactive effects associated with chemical mixtures.

(f) When making adjustments to cleanup levels and remediation levels for multiple hazardous substances, the concentration for individual hazardous substances shall not be adjusted downward to less than the practical quantitation limit or natural background.

(6) **Multiple pathways of exposure.**

(a) Estimated doses of individual hazardous substances resulting from more than one pathway of exposure are assumed to be additive unless scientific evidence is available to demonstrate otherwise.

(b) Cleanup levels and remediation levels based on one pathway of exposure shall be adjusted downward to take into account exposures from more than one exposure pathway. The number of exposure pathways considered at a given site shall be based on the reasonable maximum exposure scenario as defined in WAC 173-340-708(3). This adjustment needs to be made only if exposure through multiple pathways is likely to occur at a site and, without the adjustment, the hazard index would exceed one (1) or the total excess cancer risk would exceed one in one hundred thousand (1×10^{-5}).

(c) For noncarcinogens, for purposes of establishing cleanup levels under Methods B and C, and remediation levels, the health threats associated with exposure via multiple pathways may be apportioned between exposure pathways in any combination as long as the hazard index does not exceed one (1).

(d) For carcinogens, for purposes of establishing cleanup levels under Methods B and C, and for remediation levels, the cancer risks associated with exposure via multiple pathways may be apportioned between exposure pathways in any combination as long as the total excess cancer risk does not exceed one in one hundred thousand (1×10^{-5}).

(e) When making adjustments to cleanup levels and remediation levels for multiple pathways of exposure, the concentration for individual hazardous substances shall not be adjusted downward to less than the practical quantitation limit or natural background.

(7) **Reference doses.**

(a) The chronic reference dose/reference concentration and the developmental reference dose/reference concentration shall be used to establish cleanup levels and remediation levels under this chapter. Cleanup levels and remediation levels shall be established using the value which results in the most protective concentration.

(b) Inhalation reference doses/reference concentrations shall be used in WAC 173-340-750. Where the inhalation reference dose/reference concentration is reported as a concentration in air, that value shall be converted to a corresponding inhaled intake (mg/kg-day) using a human body weight of 70 kg and an inhalation rate of 20 m^3/day, and take into account, where available, the respiratory deposition and absorption characteristics of the gases and inhaled particles.

(c) A subchronic reference dose/reference concentration may be used to evaluate potential noncarcinogenic effects resulting from exposure to hazardous substances over short periods of time. This value may be used in place of the chronic reference dose/reference concentration where it can be demonstrated that a particular hazardous substance will degrade to negligible concentrations during the exposure period.

(d) For purposes of establishing cleanup levels and remediation levels for hazardous substances under this chapter, a reference dose/reference concentration established by the United States Environmental Protection Agency and available through the "integrated risk information system" (IRIS) data base shall be used. If a reference dose/reference concentration is not available through the IRIS data base, a reference dose/reference concentration from the U.S. EPA Health Effects Assessment Summary Table ("HEAST") data base or, if more appropriate, the National Center for Environmental Assessment ("NCEA") shall be used.

(e) If a reference dose/reference concentration is available through IRIS, HEAST, or the NCEA, it shall be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of this value is inappropriate.

(f) If a reference dose/reference concentration for a hazardous substance including petroleum fractions and petroleum constituents is not available through IRIS, HEAST or the NCEA or is demonstrated to be inappropriate under (e) of this subsection and the department determines that development of a reference dose/reference concentration is necessary for the hazardous substance at the site, then a reference dose/reference concentration shall be established on a case-by-case basis. When establishing a reference dose on a case-by-case basis, the methods described in "Reference Dose (RfD): Description and Use in Health Risk Assessment: Background Document 1A", USEPA, March 15, 1993, shall be used.

(g) In estimating a reference dose/reference concentration for a hazardous substance under (e) or (f) of this subsection, the department shall, as appropriate, consult with the science advisory board, the department of health, and the United States Environmental Protection Agency and may, as appropriate, consult with other qualified persons. Scientific data supporting such a change shall be subject to the requirements under WAC 173-340-702 (14), (15) and (16). Once the department has established a reference dose/reference concentration for a hazardous substance under this provision, the department is not required to consult again for the same hazardous substance.

(h) Where a reference dose/reference concentration other than those established under (d) or (g) of this subsection is used to establish a cleanup level or remediation level at individual sites, the department shall summarize the scientific rationale for the use of those values in the cleanup action plan. The department shall provide the opportunity for public review and comment on this value in accordance with the requirements of WAC 173-340-380 and 173-340-600.

(8) **Carcinogenic potency factor.**

(a) For purposes of establishing cleanup levels and remediation levels for hazardous substances under this chapter, a carcinogenic potency factor established by the United States Environmental Protection Agency and available through the IRIS data base shall be used. If a carcinogenic potency factor is not available from the IRIS data base, a carcinogenic potency factor from HEAST or, if more appropriate, from the NCEA shall be used.

(b) If a carcinogenic potency factor is available from the IRIS, HEAST or the NCEA, it shall be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of this value is inappropriate.

(c) If a carcinogenic potency factor is not available through IRIS, HEAST or the NCEA or is demonstrated to be inappropriate under (b) of this subsection and the department determines that development of a cancer potency factor is necessary for the hazardous substance at the site, then one of the following methods shall be used to establish a carcinogenic potency factor:

(i) The carcinogenic potency factor may be derived from appropriate human epidemiology data on a case-by-case basis; or

(ii) The carcinogenic potency factor may be derived from animal bioassay data using the following procedures:

(A) All carcinogenicity bioassays shall be reviewed and data of appropriate quality shall be used for establishing the carcinogenic potency factor.

(B) The linearized multistage extrapolation model shall be used to estimate the slope of the dose-response curve unless the department determines that there is clear and convincing scientific data which demonstrates that the use of an alternate extrapolation model is more appropriate;

(C) All doses shall be adjusted to give an average daily dose over the study duration; and

(D) An interspecies scaling factor shall be used to take into account differences between animals and humans. For oral carcinogenic toxicity values this scaling factor shall be based on the assumption that milligrams per surface area is an equivalent dose between species unless the department determines there is clear and convincing scientific data which demonstrates that an alternate procedure is more appropriate. The slope of the dose response curve for the test species shall be multiplied by this scaling factor in order to obtain the carcinogenic potency factor, except where such scaling factors are incorporated into the extrapolation model under (B) of this subsection. The procedure to derive a human equivalent concentration of inhaled particles and gases shall take into account, where available, the respiratory deposition and absorption characteristics of the gases and inhaled particles. Where adequate pharmacokinetic and metabolism studies are available, data from these studies may be used to adjust the interspecies scaling factor.

(d) ((~~When assessing the potential carcinogenic risk of mixtures of chlorinated dibenzo-p-dioxins (CDD) and chlorinated dibenzofurans (CDF) either of the following methods shall be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of these methods is inappropriate:~~

~~(i) The entire mixture is assumed to be as toxic as 2, 3, 7, 8 CDD or 2, 3, 7, 8 CDF, as applicable; or~~

~~(ii) The toxicity equivalency factors and methodology described in: EPA. 1989. "*Interim procedures for estimating risks associated with exposure to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs) and 1989 update*", USEPA, Risk Assessment Forum, Washington, D.C., publication number EPA/625/3-89/016.~~)) **Mixtures of dioxins and furans.** When establishing and determining compliance with cleanup levels and remediation levels for mixtures of chlorinated dibenzo-p-dioxins (dioxins) and/or chlorinated dibenzofurans (furans), the following procedures shall be used:

(i) **Assessing as single hazardous substance.** When establishing and determining compliance with cleanup levels and remediation levels, including when determining compliance with the excess cancer risk requirements in this chapter, mixtures of dioxins and/or furans shall be considered a single hazardous substance.

(ii) **Establishing cleanup levels and remediation levels.** The cleanup levels and remediation levels established for 2,3,7,8 tetrachloro dibenzo-p-dioxin (2,3,7,8-TCDD) shall be used, respectively, as the cleanup levels and remediation levels for mixtures of dioxins and/or furans.

(iii) **Determining compliance with cleanup levels and remediation levels.** When determining compliance with the cleanup levels and remediation levels established for mixtures of dioxins and/or furans, the following procedures shall be used:

(A) Calculate the total toxic equivalent concentration of 2,3,7,8-TCDD for each sample of the mixture. The total toxic equivalent concentration shall be calculated using the following method, unless the department determines that there is clear and convincing scientific data which demonstrates that the use of this method is inappropriate:

(I) Analyze samples from the medium of concern to determine the concentration of each dioxin and furan congener listed in Table 708-1;

(II) For each sample analyzed, multiply the measured concentration of each congener in the sample by its corresponding toxicity equivalency factor (TEF) in Table 708-1 to obtain the toxic equivalent concentration of 2,3,7,8-TCDD for that congener; and

(III) For each sample analyzed, add together the toxic equivalent concentrations of all the congeners within the sample to obtain the total toxic equivalent concentration of 2,3,7,8-TCDD for that sample.

(B) After calculating the total toxic equivalent concentration of each sample of the mixture, use the applicable compliance monitoring requirements in WAC 173-340-720 through 173-340-760 to determine whether the total toxic equivalent concentrations of the samples comply with the cleanup level or remediation level for the mixture at the applicable point of compliance.

(iv) **Protecting the quality of other media.** When establishing cleanup levels and remediation levels for mixtures of dioxins and/or furans in a medium of concern that are based on protection of another medium (the receiving medium) (e.g., soil levels protective of ground water quality), the following procedures shall be used:

(A) The cleanup level or remediation level for 2,3,7,8-TCDD in the receiving medium shall be used, respectively, as the cleanup level or remediation level for the receiving medium.

(B) When determining the concentrations in the medium of concern that will achieve the cleanup level or remediation level in the receiving medium, the congener-specific physical and chemical properties shall be considered during that assessment.

(e) ((~~When assessing the potential carcinogenic risk of mixtures of polycyclic aromatic hydrocarbons, either of the following methods shall be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of these methods is inappropriate:~~

~~(i) The entire mixture is assumed to be as toxic as benzo(a)pyrene; or~~

~~(ii) The toxicity equivalency factors and methodology described in "*CalEPA. 1994. Benzo(a)pyrene as a toxic air contaminant. Part B: Health Assessment.*" Published by the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.~~)) **Mixtures of carcinogenic PAHs.** When establishing and determining compliance with cleanup levels and remediation levels for mixtures of carcinogenic polycyclic aromatic hydrocarbons (carcinogenic PAHs), the following procedures shall be used:

(i) **Assessing as single hazardous substance.** When establishing and determining compliance with cleanup levels and remediation levels, including when determining compliance with the excess cancer risk requirements in this chapter, mixtures of carcinogenic PAHs shall be considered a single hazardous substance.

(ii) **Establishing cleanup levels and remediation levels.** The cleanup levels and remediation levels established for benzo(a)pyrene shall be used, respectively, as the cleanup levels and remediation levels for mixtures of carcinogenic PAHs.

(iii) **Determining compliance with cleanup levels and remediation levels.** When determining compliance with cleanup levels and remediation levels established for mixtures of carcinogenic PAHs, the following procedures shall be used:

(A) Calculate the total toxic equivalent concentration of benzo (a) pyrene for each sample of the mixture. The total toxic equivalent concentration shall be calculated using the following method, unless the department determines that there is clear and convincing scientific data which demonstrates that the use of this method is inappropriate:

(I) Analyze samples from the medium of concern to determine the concentration of each carcinogenic PAH listed in Table 708-2 and, for those carcinogenic PAHs required by the department under WAC 173-340-708 (8)(e)(iv), in Table 708-3;

(II) For each sample analyzed, multiply the measured concentration of each carcinogenic PAH in the sample by its corresponding toxicity equivalency factor (TEF) in Tables 708-2 and 708-3 to obtain the toxic equivalent concentration of benzo(a)pyrene for that carcinogenic PAH; and

(III) For each sample analyzed, add together the toxic equivalent concentrations of all the carcinogenic PAHs within the sample to obtain the total toxic equivalent concentration of benzo(a)pyrene for that sample.

(B) After calculating the total toxic equivalent concentration of each sample of the mixture, use the applicable compliance monitoring requirements in WAC 173-340-720 through 173-340-760 to determine whether the total toxic equivalent concentrations of the samples comply with the cleanup level or remediation level for the mixture at the applicable point of compliance.

(iv) **Protecting the quality of other media.** When establishing cleanup levels and remediation levels for mixtures of carcinogenic PAHs in a medium of concern that are based on protection of another medium (the receiving medium) (e.g., soil levels protective of ground water quality), the following procedures shall be used:

(A) The cleanup level or remediation level for benzo(a)pyrene in the receiving medium shall be used, respectively, as the cleanup level or remediation level for the receiving medium.

(B) When determining the concentrations in the medium of concern that will achieve the cleanup level or remediation level in the receiving medium, the carcinogenic PAH-specific physical and chemical properties shall be considered during that assessment.

(v) When using this methodology, at a minimum, the ((~~following~~)) compounds in Table 708-2 shall be analyzed for and included in the calculations((~~: Benzo[a]pyrene, Benz[a]anthracene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Chrysene, Dibenz[a,h]anthracene, Indeno[1,2,3cd]pyrene~~)). The department may require additional compounds ((~~from the CalEPA list~~)) in Table 708-3 to be included in the methodology should site testing data or information from other comparable sites or waste types indicate the additional compounds are potentially present at the site. *NOTE: Many of the polycyclic aromatic hydrocarbons ((~~on the CalEPA list~~)) in Table 708-3 are found primarily in air emissions from combustion sources and may not be present in the soil or water at contaminated sites. Users should consult with the department for information on the need to test for these additional compounds.*

(f) **PCB mixtures.** When establishing and determining compliance with cleanup levels and remediation levels for polychlorinated biphenyls (PCBs) mixtures, the following procedures shall be used:

(i) **Assessing as single hazardous substance.** When establishing and determining compliance with cleanup levels and remediation levels, including when determining compliance with the excess cancer risk requirements in this chapter, PCB mixtures shall be considered a single hazardous substance.

(ii) **Establishing cleanup levels and remediation levels.** When establishing cleanup levels and remediation levels under Methods B and C for PCB mixtures, the following procedures shall be used unless the department determines that there is clear and convincing scientific data which demonstrates that the use of these methods is inappropriate:

(A) Assume the PCB mixture is equally potent and use the appropriate carcinogenic potency factor provided for under WAC 173-340-708 (8)(a) through (c) for the entire mixture; or

(B) Use the toxicity equivalency factors for the dioxin-like PCBs congeners in Table 708-4 and procedures approved by the department. When using toxicity equivalency factors, the department may require that the health effects posed by the dioxin-like PCB congeners and nondioxin-like PCB congeners be considered in the evaluation.

(iii) **Determining compliance with cleanup levels and**

remediation levels. When determining compliance with cleanup levels and remediation levels established for PCB mixtures, the following procedures shall be used:

(A) Analyze compliance monitoring samples for a total PCB concentration and use the applicable compliance monitoring requirements in WAC 173-340-720 through 173-340-760 to determine whether the total PCB concentrations of the samples complies with the cleanup level or remediation level for the mixture at the applicable point of compliance; or

(B) When using toxicity equivalency factors to determine compliance with cleanup or remediation levels for PCB mixtures, use procedures approved by the department.

(g) In estimating a carcinogenic potency factor for a hazardous substance under (c) of this subsection, or approving the use of a toxicity equivalency factor other than that established under (d), (e) or (f) of this subsection, the department shall, as appropriate, consult with the science advisory board, the department of health, and the United States Environmental Protection Agency and may, as appropriate, consult with other qualified persons. Scientific data supporting such a change shall be subject to the requirements under WAC 173-340-702 (14), (15) and (16). Once the department has established a carcinogenic potency factor or approved an alternative toxicity equivalency factor for a hazardous substance under this provision, the department is not required to consult again for the same hazardous substance.

(((g))) (h) Where a carcinogenic potency factor other than that established under (a)((, (d) and (e))) of this subsection or a toxicity equivalency factor other than that established under (d), (e) or (f) of this subsection is used to establish cleanup levels or remediation levels at individual sites, the department shall summarize the scientific rationale for the use of that value in the cleanup action plan. The department shall provide the opportunity for public review and comment on this value in accordance with the requirements of WAC 173-340-380 and 173-340-600.

(9) **Bioconcentration factors.**

(a) For purposes of establishing cleanup levels and remediation levels for a hazardous substance under WAC 173-340-730, a bioconcentration factor established by the United States Environmental Protection Agency and used to establish the ambient water quality criterion for that substance under section 304 of the Clean Water Act shall be used. These values shall be used unless the department determines that there is adequate scientific data which demonstrates that the use of an alternate value is more appropriate. If the department determines that a bioconcentration factor is appropriate for a specific hazardous substance and no such factor has been established by USEPA, then other appropriate EPA documents, literature sources or empirical information may be used to determine a bioconcentration factor.

(b) When using a bioconcentration factor other than that used to establish the ambient water quality criterion, the department shall, as appropriate, consult with the science advisory board, the department of health, and the United States Environmental Protection Agency. Scientific data supporting such a value shall be subject to the requirements under WAC 173-340-702 (14), (15) and (16). Once the department has established a bioconcentration factor for a hazardous substance under this provision, the department is not required to consult again for the same hazardous substance.

(c) Where a bioconcentration factor other than that established under (a) of this subsection is used to establish cleanup levels or remediation levels at individual sites, the department shall summarize the scientific rationale for the use of that factor in the draft cleanup action plan. The department shall provide the opportunity for public review and comment on the value in accordance with the requirements of WAC 173-340-380 and 173-340-600.

(10) **Exposure parameters.**

(a) As a matter of policy, the department has defined in WAC 173-340-720 through 173-340-760 the default values for exposure parameters to be used when establishing cleanup levels and remediation levels under this chapter. Except as provided for in (b) and (c) of this subsection and in WAC 173-340-720 through 173-340-760, these default values shall not be changed for individual hazardous substances or sites.

(b) Exposure parameters that are primarily a function of the exposed population characteristics (such as body weight and lifetime) and those that are primarily a function of human behavior that cannot be controlled through an engineered or institutional control (such as: Fish consumption rate; soil ingestion rate; drinking water ingestion rate; and breathing rate) are not expected to vary on a site-by-site basis. The default values for these exposure parameters shall not be changed when calculating cleanup levels except when necessary to establish a more stringent cleanup level to protect human health. For remediation levels the default values for these exposure parameters may only be changed when an alternate reasonable maximum exposure scenario is used, as provided for in WAC 173-340-708 (3)(d), that reflects a different exposed population such as using an adult instead of a child exposure scenario. Other exposure parameters may be changed only as follows:

(i) For calculation of cleanup levels, the types of exposure parameters that may be changed are those that are:

(A) Primarily a function of reliably measurable characteristics of the hazardous substance, soil, hydrologic or hydrogeologic conditions at the site; and

(B) Not dependent on the success of engineered controls or institutional controls for controlling exposure of persons to the hazardous substances at the site.

The default values for these exposure parameters may be changed where there is adequate scientific data to demonstrate that use of an alternative or additional value would be more appropriate for the conditions present at the site. Examples of exposure parameters for which the default values may be changed under this provision are as follows: Contaminant leaching and transport variables (such as the soil organic carbon content, aquifer permeability and soil sorption coefficient); inhalation correction factor; fish bioconcentration factor; soil gastrointestinal absorption fraction; and inhalation absorption percentage.

(ii) For calculation of remediation levels, in addition to the exposure parameters that may be changed under (b)(i) of this subsection, the types of exposure parameters that may be changed from the default values are those where a demonstration can be made that the proposed cleanup action uses engineered controls and/or institutional controls that can be successfully relied on, for the reasonably foreseeable future, to control contaminant mobility and/or exposure to the contamination remaining on the site. In general, exposure parameters that may be changed under this provision are those that define the exposure frequency, exposure duration and exposure time. The default values for these exposure parameters may be changed where there is adequate scientific data to demonstrate that use of an alternative or additional value would be more appropriate for the conditions present at the site. Examples of exposure parameters for which the default value may be changed under this provision are as follows: Infiltration rate; frequency of soil contact; duration of soil exposure; duration of drinking water exposure; duration of air exposure; drinking water fraction; and fish diet fraction.

(c) When the modifications provided for in (b) of this subsection result in significantly higher values for cleanup levels or remediation levels than would be calculated using the default values for exposure parameters, the risk from other potentially relevant pathways of exposure shall be addressed under the procedures provided for in WAC 173-340-720 through 173-340-760. For exposure pathways and parameters for which default values are not specified in this chapter, the framework provided for by this subsection, along with the quality of information requirements in WAC 173-340-702, shall be used to establish appropriate or additional assumptions for these parameters and pathways.

(d) Where the department approves the use of exposure parameters other than those established under WAC 173-340-720 through 173-340-760 to establish cleanup levels or remediation levels at individual sites, the department shall summarize the scientific rationale for the use of those parameters in the cleanup action plan. The department shall provide the opportunity for public review and comment on those values in accordance with the requirements of WAC 173-340-380 and 173-340-600. Scientific data supporting such a change shall be subject to the requirements under WAC 173-340-702 (14), (15) and (16).

(11) **Probabilistic risk assessment.** Probabilistic risk assessment methods may be used under this chapter only on an informational basis for evaluating alternative remedies. Such methods shall not be used to replace cleanup standards and remediation levels derived using deterministic methods under this chapter until the department has adopted rules describing adequate technical protocols and policies for the use of probabilistic risk assessment under this chapter.

AMENDATORY SECTION (Amending Order 97-09A, filed 2/12/01, effective 8/15/01)

WAC 173-340-740 Unrestricted land use soil cleanup standards. (1) **General considerations.**

(a) Presumed exposure scenario soil cleanup levels shall be based on estimates of the reasonable maximum exposure expected to occur under both current and future site use conditions. The department has determined that residential land use is generally the site use requiring the most protective cleanup levels and that exposure to hazardous substances under residential land use conditions represents the reasonable maximum exposure scenario. Unless a site qualifies for use of an industrial soil cleanup level under WAC 173-340-745, soil cleanup levels shall use this presumed exposure scenario and be established in accordance with this section.

(b) In the event of a release of a hazardous substance to the soil at a site, a cleanup action complying with this chapter shall be conducted to address all areas where the concentration of hazardous substances in the soil exceeds cleanup levels at the relevant point of compliance.

(c) The department may require more stringent soil cleanup standards than required by this section where, based on a site-specific evaluation, the department determines that this is necessary to protect human health and the environment. Any imposition of more stringent requirements under this provision shall comply with WAC 173-340-702 and 173-340-708. The following are examples of situations that may require more stringent cleanup levels.

(i) Concentrations that eliminate or substantially reduce the potential for food chain contamination;

(ii) Concentrations that eliminate or substantially reduce the potential for damage to soils or biota in the soils which could impair the use of soils for agricultural or silvicultural purposes;

(iii) Concentrations necessary to address the potential health risk posed by dust at a site;

(iv) Concentrations necessary to protect the ground water at a particular site;

(v) Concentrations necessary to protect nearby surface waters from hazardous substances in runoff from the site; and

(vi) Concentrations that eliminate or minimize the potential for the accumulation of vapors in buildings or other structures.

(d) Relationship between soil cleanup levels and other cleanup standards. Soil cleanup levels shall be established at concentrations that do not directly or indirectly cause violations of ground water, surface water, sediment, or air cleanup standards established under this chapter or applicable state and federal laws. A property that qualifies for a Method C soil cleanup level under WAC 173-340-745 does not necessarily qualify for a Method C cleanup level in other media. Each medium must be evaluated separately using the criteria applicable to that medium.

(2) **Method A soil cleanup levels for unrestricted land use.**

(a) **Applicability.** Method A soil cleanup levels may only be used at sites qualifying under WAC 173-340-704(1).

(b) **General requirements.** Method A soil cleanup levels shall be at least as stringent as all of the following:

(i) Concentrations in Table 740-1 and compliance with the corresponding footnotes;

(ii) Concentrations established under applicable state and federal laws;

(iii) Concentrations that result in no significant adverse effects on the protection and propagation of terrestrial ecological receptors using the procedures specified in WAC 173-340-7490 through 173-340-7493, unless it is demonstrated under those sections that establishing a soil concentration is unnecessary; and

(iv) For a hazardous substance that is deemed an indicator hazardous substance under WAC 173-340-708(2) and for which there is no value in Table 740-1 or applicable state and federal laws, a concentration that does not exceed the natural background concentration or the practical quantification limit, subject to the limitations in this chapter.

(3) **Method B soil cleanup levels for unrestricted land use.**

(a) **Applicability.** Method B soil cleanup levels consist of standard and modified cleanup levels determined using the procedures in this subsection. Either standard or modified Method B soil cleanup levels may be used at any site.

(b) **Standard Method B soil cleanup levels.** Standard Method B cleanup levels for soils shall be at least as stringent as all of the following:

(i) **Applicable state and federal laws.** Concentrations established under applicable state and federal laws;

(ii) **Environmental protection.** Concentrations that result in no significant adverse effects on the protection and propagation of terrestrial ecological receptors established using the procedures specified in WAC 173-340-7490 through 173-340-7494 unless it is demonstrated under those sections that establishing a soil concentration is unnecessary.

(iii) **Human health protection.** For hazardous substances for which sufficiently protective, health-based criteria or standards have not been established under applicable state and federal laws, those concentrations that protect human health as determined by evaluating the following exposure pathways:

(A) **Ground water protection.** Concentrations that will not cause contamination of ground water at levels which exceed ground water cleanup levels established under WAC 173-340-720 as determined using the methods described in WAC 173-340-747.

(B) **Soil direct contact.** Concentrations that, due to direct contact with contaminated soil, are estimated to result in no acute or chronic noncarcinogenic toxic effects on human health using a hazard quotient of one (1) and concentrations for which the upper bound on the estimated excess cancer risk is less than or equal to one in one million (1×10^{-6}). Equations 740-1 and 740-2 and the associated default assumptions shall be used to calculate the concentration for direct contact with contaminated soil.

(I) **Noncarcinogens.** For noncarcinogenic toxic effects of hazardous substances due to soil ingestion, concentrations shall be determined using Equation 740-1. For petroleum mixtures and components of such mixtures, see (b)(iii)(B)(III) of this subsection.

[Equation 740-1]

$$\text{Soil Cleanup Level (mg/kg)} = \frac{\text{RfD} \times \text{ABW} \times \text{UCF} \times \text{HQ} \times \text{AT}}{\text{SIR} \times \text{AB1} \times \text{EF} \times \text{ED}}$$

Where:

RfD	=	Reference dose as defined in WAC 173-340-708(7) (mg/kg-day)
ABW	=	Average body weight over the exposure duration (16 kg)
UCF	=	Unit conversion factor (1,000,000 mg/kg)
SIR	=	Soil ingestion rate (200 mg/day)

AB1 = Gastrointestinal absorption fraction (1.0) (unitless)

EF = Exposure frequency (1.0) (unitless)

HQ = Hazard quotient (1) (unitless)

AT = Averaging time (6 years)

ED = Exposure duration (6 years)

(II) **Carcinogens.** For carcinogenic effects of hazardous substances due to soil ingestion, concentrations shall be determined using Equation 740-2. For petroleum mixtures and components of such mixtures, see (b)(iii)(B)(III) of this subsection.

[Equation 740-2]

$$\text{Soil Cleanup Level (mg/kg)} = \frac{\text{RISK x ABW x AT x UCF}}{\text{CPF x SIR x AB1 x ED x EF}}$$

Where:

RISK = Acceptable cancer risk level (1 in 1,000,000) (unitless)

ABW = Average body weight over the exposure duration (16 kg)

AT = Averaging time (75 years)

UCF = Unit conversion factor (1,000,000 mg/kg)

CPF = Carcinogenic potency factor as defined in WAC 173-340-708(8) (kg-day/mg)

SIR = Soil ingestion rate (200 mg/day)

AB1 = Gastrointestinal absorption fraction (1.0) (unitless). May use 0.6 for mixtures of dioxins and/or furans

ED = Exposure duration (6 years)

EF = Exposure frequency (1.0) (unitless)

(III) **Petroleum mixtures.** For noncarcinogenic effects of petroleum mixtures, a total petroleum hydrocarbon cleanup level shall be calculated taking into account the additive effects of the petroleum fractions and volatile organic compounds substances present in the petroleum mixture. Equation 740-3 shall be used for this calculation. This equation takes into account concurrent exposure due to ingestion and dermal contact with petroleum contaminated soils. Cleanup levels for other noncarcinogens and known or suspected carcinogens within the petroleum mixture shall be calculated using Equations 740-4 and 740-5. See Table 830-1 for the analyses required for various petroleum products to use this method.

[Equation 740-3]

$$C_{soil} = \frac{HI \times ABW \times AT}{EF \times ED \left[\left(\frac{SIR \times AB1}{10^6 mg/kg} \sum_{i=1}^{n} \frac{F(i)}{RfDo(i)} \right) + \left(\frac{SA \times AF}{10^6 mg/kg} \sum_{i=1}^{n} \frac{F(i) \times ABS(i)}{RfDd(i)} \right) \right]}$$

Where:

C_{soil} =	TPH soil cleanup level (mg/kg)
HI =	Hazard index (1) (unitless)
ABW =	Average body weight over the exposure duration (16 kg)
AT =	Averaging time (6 years)
EF =	Exposure frequency (1.0) (unitless)
ED =	Exposure duration (6 years)
SIR =	Soil ingestion rate (200 mg/day)
AB1 =	Gastrointestinal absorption fraction (1.0) (unitless)
F(i) =	Fraction (by weight) of petroleum component (i) (unitless)
SA =	Dermal surface area (2,200 cm^2)
AF =	Adherence factor (0.2 mg/cm^2-day)
ABS =	Dermal absorption fraction for petroleum component (i) (unitless). May use chemical-specific values or the following defaults:
✎	0.0005 for volatile petroleum components with vapor press > = benzene
✎	0.03 for volatile petroleum components with vapor press < benzene
✎	0.1 for other petroleum components
RfDo(i) =	Oral reference dose of petroleum component (i) as defined in WAC 173-340-708(7) (mg/kg-day)
RfDd(i) =	Dermal reference dose for petroleum component (i) (mg/kg-day) derived by RfDo x GI
GI =	Gastrointestinal absorption conversion factor (unitless). May use chemical-specific values or the following defaults:
✎	0.8 for volatile petroleum components
✎	0.5 for other petroleum components
n =	The number of petroleum components (petroleum fractions plus volatile organic compounds with an RfD) present in the petroleum mixture. (See Table 830-1.)

(C) **Soil vapors.** The soil to vapor pathway shall be evaluated for volatile organic compounds whenever any of the following conditions exist:

(I) For gasoline range organics, whenever the total petroleum hydrocarbon (TPH) concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(6) using the default assumptions;

(II) For diesel range organics, whenever the total petroleum hydrocarbon (TPH) concentration is greater than 10,000 mg/kg;

(III) For other volatile organic compounds, including petroleum components, whenever the concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(4).

See subsection (3)(c)(iv)(B) of this section for methods that may be used to evaluate the soil to vapor pathway.

(c) **Modified Method B soil cleanup levels.**

(i) **General.** Modified Method B soil cleanup levels are standard Method B soil cleanup levels, modified with chemical-specific or site-specific data. When making these modifications, the resultant cleanup levels shall meet applicable state and federal laws, meet health risk levels for standard Method B soil cleanup levels, and be demonstrated to be environmentally protective using the procedures specified in WAC 173-340-7490 through 173-340-7494. Changes to exposure assumptions must comply with WAC 173-340-708(10).

(ii) **Allowable modifications.** The following modifications can be made to the default assumptions in the standard Method B equations to derive modified Method B soil cleanup levels:

(A) For the protection of ground water, see WAC 173-340-747;

(B) For soil ingestion, the gastrointestinal absorption fraction, may be modified if the requirements of WAC 173-340-702 (14), (15), (16), and 173-340-708(10) are met;

(C) For dermal contact, the adherence factor, dermal absorption fraction and gastrointestinal absorption conversion factor may be modified if the requirements of WAC 173-340-702 (14), (15), (16), and 173-340-708(10) are met;

(D) The toxicity equivalent factors((~~, as described~~)) provided in WAC 173-340-708 (8)((~~, may be used for assessing the potential carcinogenic risk of mixtures of chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans and polycyclic aromatic hydrocarbons~~)) (d), (e), and (f), may be modified if the requirements of WAC 173-340-708 (8)(g) and (h) are met;

(E) The reference dose and cancer potency factor may be modified if the requirements in WAC 173-340-708 (7) and (8) are met; and

(F) Other modifications incorporating new science as provided for in WAC 173-340-702 (14), (15) and (16).

(iii) **Dermal contact.** For hazardous substances other than petroleum mixtures, dermal contact with the soil shall be evaluated whenever the proposed changes to Equations 740-1 or 740-2 would result in a significantly higher soil cleanup level than would be calculated without the proposed changes. When conducting this evaluation, the following equations and default assumptions shall be used.

(A) For noncarcinogens use Equation 740-4. This equation takes into account concurrent exposure due to ingestion and dermal contact with soil.

[Equation 740-4]

[illegible]

Where:

C_{soil} =	Soil cleanup level (mg/kg)
HQ =	Hazard quotient (unitless)
ABW =	Average body weight over the exposure duration (16 kg)
AT =	Averaging time (6 years)
EF =	Exposure frequency (1.0) (unitless)
ED =	Exposure duration (6 years)
SIR =	Soil ingestion rate (200 mg/day)
AB1 =	Gastrointestinal absorption fraction (1.0) (unitless)
SA =	Dermal surface area (2,200 cm^2)
AF =	Adherence factor (0.2 mg/cm^2-day)
ABS =	Dermal absorption fraction (unitless).
	May use chemical-specific values or the following defaults:
✐	0.01 for inorganic hazardous substances
✐	0.0005 for volatile organic compounds with vapor press > = benzene
✐	0.03 for volatile organic compounds with vapor press < benzene
✐	0.1 for other organic hazardous substances
RfDo =	Oral reference dose as defined in WAC 173-340-708(7) (mg/kg-day)
RfDd =	Dermal reference dose (mg/kg-day) derived by RfDo x GI
GI =	Gastrointestinal absorption conversion factor (unitless).
	May use chemical specific values or the following defaults:
✐	0.2 for inorganic hazardous substances
✐	0.8 for volatile organic compounds
✐	0.5 for other organic hazardous substances

(B) For carcinogens use Equation 740-5. This equation takes into account concurrent exposure due to ingestion and dermal contact with soil.

[Equation 740-5]

$$C_{soil} = \frac{RISK \times ABW \times AT}{EF \times ED \left[\left(\frac{SIR \times AB1 \times CPFo}{10^6 mg/kg} \right) + \left(\frac{SA \times AF \times ABS \times CPFd}{10^6 mg/kg} \right) \right]}$$

Where:

C_{soil} = Soil cleanup level (mg/kg)

RISK = Acceptable cancer risk (1 in 1,000,000) (unitless)

ABW = Average body weight over the exposure duration (16 kg)

AT = Averaging time (75 years)

EF = Exposure frequency (1.0) (unitless)

ED = Exposure duration (6 years)

SIR = Soil ingestion rate (200 mg/day)

AB1 = Gastrointestinal absorption fraction (1.0) (unitless). May use 0.6 for mixtures of dioxins and/or furans

CPFo = Oral cancer potency factor as defined in WAC 173-340-708(8) (kg-day/mg)

CPFd = Dermal cancer potency factor (kg-day/mg) derived by CPFo/GI

GI = Gastrointestinal absorption conversion factor (unitless).

May use chemical-specific values or the following defaults:

- 0.2 for inorganic hazardous substances
- 0.8 for volatile organic compounds and for mixtures of dioxins and/or furans
- 0.5 for other organic hazardous substances

SA = Dermal surface area (2,200 cm^2)

AF = Adherence factor (0.2 mg/cm^2-day)

ABS = Dermal absorption fraction (unitless). May use chemical-specific values or the following defaults:

- 0.01 for inorganic hazardous substances
- 0.0005 for volatile organic compounds with vapor press > = benzene
- 0.03 for volatile organic compounds with vapor press < benzene and for mixtures of dioxins and/or furans
- 0.1 for other organic hazardous substances

(C) Modifications may be made to Equations 740-4 and 740-5 as provided for in subsection (3)(c)(ii) of this section.

(iv) **Soil vapors.**

(A) **Applicability.** The soil to vapor pathway shall be evaluated for volatile organic compounds whenever any of the following conditions exist:

(I) For other than petroleum hydrocarbon mixtures, the proposed changes to the standard Method B equations (Equations 740-1 and 740-2) or default values would result in a significantly higher soil cleanup level than would be calculated without the proposed changes;

(II) For petroleum hydrocarbon mixtures, the proposed changes to the standard Method B equations (Equations 740-3, 740-4 and 740-5) or default values would result in a significantly higher soil cleanup level than would be calculated without the proposed changes;

(III) For gasoline range organics, whenever the total petroleum hydrocarbon (TPH) concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(6) using the default assumptions;

(IV) For diesel range organics, whenever the total petroleum hydrocarbon (TPH) concentration is greater than 10,000 mg/kg;

(V) For other volatile organic compounds, including petroleum components, whenever the concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(4).

(B) **Evaluation methods.** Soil cleanup levels that are protective of the indoor and ambient air shall be determined on a site-specific basis. Soil cleanup levels may be evaluated as being protective of air pathways using any of the following methods:

(I) Measurements of the soil vapor concentrations, using methods approved by the department, demonstrating vapors in the soil would not exceed air cleanup levels established under WAC 173-340-750.

(II) Measurements of ambient air concentrations and/or indoor air vapor concentrations throughout buildings, using methods approved by the department, demonstrating air does not exceed cleanup levels established under WAC 173-340-750. Such measurements must be representative of current and future site conditions when vapors are likely to enter and accumulate in structures. Measurement of ambient air may be excluded if it can be shown that indoor air is the most protective point of exposure.

(III) Use of modeling methods approved by the department to demonstrate the air cleanup standards established under WAC 173-340-750 will not be exceeded. When this method is used, the department may require soil vapor and/or air monitoring to be conducted to verify the calculations and compliance with air cleanup standards.

(IV) Other methods as approved by the department demonstrating the air cleanup standards established under WAC 173-340-750 will not be exceeded.

(d) **Using modified Method B to evaluate soil remediation levels.** In addition to the adjustments allowed under subsection (3)(c) of this section, adjustments to the reasonable maximum exposure scenario or default exposure assumptions are allowed when using a quantitative site-specific risk assessment to evaluate the protectiveness of a remedy. See WAC 173-340-355, 173-340-357, and 173-340-708 (3)(d) and (10)(b).

(4) **Method C soil cleanup levels.** This section does not provide procedures for establishing Method C soil cleanup levels. Except for qualifying industrial properties, Method A and Method B, as described in this section, are the only methods available for establishing soil cleanup levels at sites. See WAC 173-340-745 for use of Method C soil cleanup levels at qualifying industrial properties. See also WAC 173-340-357 and 173-340-708 (3)(d) for how land use may be considered when selecting a cleanup action at a site.

(5) **Adjustments to cleanup levels.**

(a) **Total site risk adjustments.** Soil cleanup levels for individual hazardous substances developed in accordance with subsection (3) of this section, including cleanup levels based on applicable state and federal laws, shall be adjusted downward to take into account exposure to multiple hazardous substances and/or exposure resulting from more than one pathway of exposure. These adjustments need to be made only if, without these adjustments, the hazard index would exceed one (1) or the total excess cancer risk would exceed one in one hundred thousand (1×10^{-5}). These adjustments shall be made in accordance with the procedures specified in WAC 173-340-708 (5) and (6). In making these adjustments, the hazard index shall not exceed one (1) and the total excess cancer risk shall not exceed one in one hundred thousand (1×10^{-5}).

(b) **Adjustments to applicable state and federal laws.** Where a cleanup level developed under subsection (2) or (3) of this section is based on an applicable state or federal law and the level of risk upon which the standard is based exceeds an excess cancer risk of one in one hundred thousand (1×10^{-5}) or a hazard index of one (1), the cleanup level must be adjusted downward so that the total excess cancer risk does not exceed one in one hundred thousand (1×10^{-5}) and the hazard index does not exceed one (1) at the site.

(c) **Natural background and PQL considerations.** Cleanup levels determined under subsection (2) or (3) of this section, including cleanup levels adjusted under subsection (5)(a) and (b) of this section, shall not be set at levels below the practical quantitation limit or natural background, whichever is higher. See WAC 173-340-707 and 173-340-709 for additional requirements pertaining to practical quantitation limits and natural background.

(6) **Point of compliance.**

(a) The point of compliance is the point or points where the soil cleanup levels established under subsection (2) or (3) of this section shall be attained.

(b) For soil cleanup levels based on the protection of ground water, the point of compliance shall be established in the soils throughout the site.

(c) For soil cleanup levels based on protection from vapors, the point of compliance shall be established in the soils throughout the site from the ground surface to the uppermost ground water saturated zone (e.g., from the ground surface to the uppermost water table).

(d) For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to fifteen feet below the ground surface. This represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities.

(e) For soil cleanup levels based on ecological considerations, see WAC 173-340-7490 for the point of compliance.

(f) The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:

(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;

(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;

(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;

(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;

(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and

(vi) The types, levels and amount of hazardous substances remaining on-site and the measures that will be used to prevent migration and contact with those substances are specified in the draft cleanup action plan.

(7) **Compliance monitoring.**

(a) Compliance with soil cleanup levels shall be based on total analyses of the soil fraction less than two millimeters in size. When it is reasonable to expect that larger soil particles could be reduced to two millimeters or less during current or future site use and this reduction could cause an increase in the concentrations of hazardous substances in the soil, soil cleanup levels shall also apply to these larger soil particles. Compliance with soil cleanup levels shall be based on dry weight concentrations. The department may approve the use of alternate procedures for stabilized soils.

(b) When soil levels have been established at a site, sampling of the soil shall be conducted to determine if compliance with the soil cleanup levels has been achieved. Sampling and analytical procedures shall be defined in a compliance monitoring plan prepared under WAC 173-340-410. The sample design shall provide data that are representative of the area where exposure to hazardous substances may occur.

(c) The data analysis and evaluation procedures used to evaluate compliance with soil cleanup levels shall be defined in a compliance monitoring plan prepared under WAC 173-340-410. These procedures shall meet the following general requirements:

(i) Methods of data analysis shall be consistent with the sampling design. Separate methods may be specified for surface soils and deeper soils;

(ii) When cleanup levels are based on requirements specified in applicable state and federal laws, the procedures for evaluating compliance that are specified in those requirements shall be used to evaluate compliance with cleanup levels unless those procedures conflict with the intent of this section;

(iii) Where procedures for evaluating compliance are not specified in an applicable state and federal law, statistical methods shall be appropriate for the distribution of sampling data for each hazardous substance. If the distributions for hazardous substances differ, more than one statistical method may be required; and

(iv) The data analysis plan shall specify which parameters are to be used to determine compliance with soil cleanup levels.

(A) For cleanup levels based on short-term or acute toxic effects on human health or the environment, an upper percentile soil concentration shall be used to evaluate compliance with cleanup levels.

(B) For cleanup levels based on chronic or carcinogenic threats, the true mean soil concentration shall be used to evaluate compliance with cleanup levels.

(d) When data analysis procedures for evaluating compliance are not specified in an applicable state or federal law the following procedures shall be used:

(i) A confidence interval approach that meets the following requirements:

(A) The upper one sided ninety-five percent confidence limit on the true mean soil concentration shall be less than the soil cleanup level. For lognormally distributed data, the upper one-sided ninety-five percent confidence limit shall be calculated using Land's method; and

(B) Data shall be assumed to be lognormally distributed unless this assumption is rejected by a statistical test. If a lognormal distribution is inappropriate, data shall be assumed to be normally distributed unless this assumption is rejected by a statistical test. The W test, D'Agostino's test, or, censored probability plots, as appropriate for the data, shall be the statistical methods used to determine whether the data are lognormally or normally distributed;

(ii) For an evaluation conducted under (c)(iv)(A) of this subsection, a parametric test for percentiles based on tolerance intervals to test the proportion of soil samples having concentrations less than the soil cleanup level. When using this method, the true proportion of samples that do not exceed the soil cleanup level shall not be less than ninety percent. Statistical tests shall be performed with a Type I error level of 0.05;

(iii) Direct comparison of soil sample concentrations with cleanup levels may be used to evaluate compliance with cleanup levels where selective sampling of soil can be reliably expected to find suspected soil contamination. There must be documented, reliable information that the soil samples have been taken from the appropriate locations. Persons using this method must demonstrate that the basis used for selecting the soil sample locations provides a high probability that any existing areas of soil contamination have been found; or

(iv) Other statistical methods approved by the department.

(e) All data analysis methods used, including those specified in state and federal law, must meet the following requirements:

(i) No single sample concentration shall be greater than two times the soil cleanup level. Higher exceedances to control false positive error rates at five percent may be approved by the department when the cleanup level is based on background concentrations; and

(ii) Less than ten percent of the sample concentrations shall exceed the soil cleanup level. Higher exceedances to control false positive error rates at five percent may be approved by the department when the cleanup level is based on background concentrations.

(f) When using statistical methods to demonstrate compliance with soil cleanup levels, the following procedures shall be used for measurements below the practical quantitation limit:

(i) Measurements below the method detection limit shall be assigned a value equal to one-half the method detection limit when not more than fifteen percent of the measurements are below the practical quantitation limit.

(ii) Measurements above the method detection limit but below the practical quantitation limit shall be assigned a value equal to the method detection limit when not more than fifteen percent of the measurements are below the practical quantitation limit.

(iii) When between fifteen and fifty percent of the measurements are below the practical quantitation limit and the data are assumed to be lognormally or normally distributed, Cohen's method shall be used to calculate a corrected mean and standard deviation for use in calculating an upper confidence limit on the true mean soil concentration.

(iv) If more than fifty percent of the measurements are below the practical quantitation limit, the largest value in the data set shall be used in place of an upper confidence limit on the true mean soil concentration.

(v) The department may approve alternate statistical procedures for handling nondetected values or values below the practical quantitation limit.

(vi) If a hazardous substance or petroleum fraction has never been detected in any sample at a site and these substances are not suspected of being present at the site based on site history and other knowledge, that hazardous substance or petroleum fraction may be excluded from the statistical analysis.

AMENDATORY SECTION (Amending Order 97-09A, filed 2/12/01, effective 8/15/01)

WAC 173-340-745 Soil cleanup standards for industrial properties. (1) **Applicability.**

(a) Criteria. This section shall be used to establish soil cleanup levels where the department has determined that industrial land use represents the reasonable maximum exposure. Soil cleanup levels for this presumed exposure scenario shall be established in accordance with this section. To qualify as an industrial land use and to use an industrial soil cleanup level a site must meet the following criteria:

(i) The area of the site where industrial property soil cleanup levels are proposed must meet the definition of an industrial property under WAC 173-340-200;

Industrial soil cleanup levels are based on an adult worker exposure scenario. It is essential to evaluate land uses and zoning for compliance with this definition in the context of this exposure scenario. Local governments use a variety of zoning categories for industrial land uses so a property does not necessarily have to be in a zone called "industrial" to meet the definition of "industrial property." Also, there are land uses allowed in industrial zones that are actually commercial or residential, rather than industrial, land uses. Thus, an evaluation to determine compliance with this definition should include a review of the actual text in the comprehensive plan and zoning ordinance pertaining to the site and a visit to the site to observe land uses in the zone. When evaluating land uses to determine if a property use not specifically listed in the definition is a "traditional industrial use" or to determine if the property is "zoned for industrial use," the following characteristics shall be considered:

(A) People do not normally live on industrial property. The primary potential exposure is to adult employees of businesses located on the industrial property;

(B) Access to industrial property by the general public is generally not allowed. If access is allowed, it is highly limited and controlled due to safety or security considerations;

(C) Food is not normally grown/raised on industrial property. (However, food processing operations are commonly considered industrial facilities);

(D) Operations at industrial properties are often (but not always) characterized by use and storage of chemicals, noise, odors and truck traffic;

(E) The surface of the land at industrial properties is often (but not always) mostly covered by buildings or other structures, paved parking lots, paved access roads and material storage areas--minimizing potential exposure to the soil; and

(F) Industrial properties may have support facilities consisting of offices, restaurants, and other facilities that are commercial in nature but are primarily devoted to administrative functions necessary for the industrial use and/or are primarily intended to serve the industrial facility employees and not the general public.

(ii) The cleanup action provides for appropriate institutional controls implemented in accordance with WAC 173-340-440 to limit potential exposure to residual hazardous substances. This shall include, at a minimum, placement of a covenant on the property restricting use of the area of the site where industrial soil cleanup levels are proposed to industrial property uses; and

(iii) Hazardous substances remaining at the property after remedial action would not pose a threat to human health or the environment at the site or in adjacent nonindustrial areas. In evaluating compliance with this criterion, at a minimum the following factors shall be considered:

(A) The potential for access to the industrial property by the general public, especially children. The proximity of the industrial property to residential areas, schools or childcare facilities shall be considered when evaluating access. In addition, the presence of natural features, manmade structures, arterial streets or intervening land uses that would limit or encourage access to the industrial property shall be considered. Fencing shall not be considered sufficient to limit access to an industrial property since this is insufficient to assure long term protection;

(B) The degree of reduction of potential exposure to residual hazardous substances by the selected remedy. Where the residual hazardous substances are to be capped to reduce exposure, consideration shall be given to the thickness of the cap and the likelihood of future site maintenance activities, utility and drainage work, or building construction reexposing residual hazardous substances;

(C) The potential for transport of residual hazardous substances to off-property areas, especially residential areas, schools and childcare facilities;

(D) The potential for significant adverse effects on wildlife caused by residual hazardous substances using the procedures in WAC 173-340-7490 through 173-340-7494; and

(E) The likelihood that these factors would not change for the foreseeable future.

(b) **Expectations.** In applying the criteria in (a) of this subsection, the department expects the following results:

(i) The department expects that properties zoned for heavy industrial or high intensity industrial use and located within a city or county that has completed a comprehensive plan and adopted implementing zoning regulations under the Growth Management Act (chapter 36.70A RCW) will meet the definition of industrial property. For cities and counties not planning under the Growth Management Act, the department expects that spot zoned industrial properties will not meet the definition of industrial property but that properties that are part of a larger area zoned for heavy industrial or high intensity industrial use will meet the definition of an industrial property;

(ii) For both GMA and non-GMA cities and counties, the department expects that light industrial and commercial zones and uses should meet the definition of industrial property where the land uses are comparable to those cited in the definition of industrial property or the land uses are an integral part of a qualifying industrial use (such as, ancillary or support facilities). This will require a site-by-site evaluation of the zoning text and land uses;

(iii) The department expects that for portions of industrial properties in close proximity to (generally, within a few hundred feet) residential areas, schools or childcare facilities, residential soil cleanup levels will be used unless:

(A) Access to the industrial property is very unlikely or, the hazardous substances that are not treated or removed are contained under a cap of clean soil (or other materials) of substantial thickness so that it is very unlikely the hazardous substances would be disturbed by future site maintenance and construction activities (depths of even shallow footings, utilities and drainage structures in industrial areas are typically three to six feet); and

(B) The hazardous substances are relatively immobile (or have other characteristics) or have been otherwise contained so that subsurface lateral migration or surficial transport via dust or runoff to these nearby areas or facilities is highly unlikely; and

(iv) Note that a change in the reasonable maximum exposure to industrial site use primarily affects the direct contact exposure pathway. Thus, for example, for sites where the soil cleanup level is based primarily on the potential for the hazardous substance to leach and cause ground water contamination, it is the department's expectation that an industrial land use will not affect the soil cleanup level. Similarly, where the soil cleanup level is based primarily on surface water protection or other pathways other than direct human contact, land use is not expected to affect the soil cleanup level.

(2) **General considerations.**

(a) In the event of a release of a hazardous substance at a site qualifying as industrial property, a cleanup action that complies with this chapter shall be conducted to address those soils with hazardous substance concentrations which exceed industrial soil cleanup levels at the relevant point of compliance.

(b) Soil cleanup levels for areas beyond the industrial property boundary that do not qualify for industrial soil cleanup levels under this section (including implementation of institutional controls and a covenant restricting use of the property to industrial property uses) shall be established in accordance with WAC 173-340-740.

(c) Industrial soil cleanup levels shall be established at concentrations that do not directly or indirectly cause violations of ground water, surface water, sediment or air cleanup standards established under this chapter or under applicable state and federal laws. A property that qualifies for an industrial soil cleanup level under this section does not necessarily qualify for a Method C cleanup level in other media. Each medium must be evaluated separately using the criteria applicable to that medium.

(d) The department may require more stringent soil cleanup standards than required by this section when, based on a site-specific evaluation, the department determines that this is necessary to protect human health and the environment, including consideration of the factors in WAC 173-340-740 (1)(c). Any imposition of more stringent requirements under this provision shall comply with WAC 173-340-702 and 173-340-708.

(3) **Method A industrial soil cleanup levels.**

(a) **Applicability.** Method A industrial soil cleanup levels may be used only at any industrial property qualifying under WAC 173-340-704(1).

(b) **General requirements.** Method A industrial soil cleanup levels shall be at least as stringent as all of the following:

(i) Concentrations in Table 745-1 and compliance with the corresponding footnotes;

(ii) Concentrations established under applicable state and federal laws;

(iii) Concentrations that result in no significant adverse effects on the protection and propagation of terrestrial ecological receptors using the procedures specified in WAC 173-340-7490 through 173-340-7493, unless it is demonstrated under those sections that establishing a soil concentration is unnecessary; and

(iv) For a hazardous substance that is deemed an indicator hazardous substance under WAC 173-340-708(2) and for which there is no value in Table 745-1 or applicable state and federal laws, a concentration that does not exceed the natural background concentration or the practical quantification limit, subject to the limitations in this chapter.

(4) **Method B industrial soil cleanup levels.** This section does not provide procedures for establishing Method B industrial soil cleanup levels. Method C is the standard method for establishing soil cleanup levels at industrial sites and its use is conditioned upon the continued use of the site for industrial purposes. The person conducting the cleanup action also has the option of establishing unrestricted land use soil cleanup levels under WAC 173-340-740 for qualifying industrial properties. This option may be desirable when the person wants to avoid restrictions on the future use of the property. When a site does not qualify for a Method A or Method C industrial soil cleanup level under this section, or the user chooses to establish unrestricted land use soil cleanup levels at a site, soil cleanup levels must be established using Methods A or B under WAC 173-340-740.

(5) **Method C industrial soil cleanup levels.**

(a) **Applicability.** Method C industrial soil cleanup levels consist of standard and modified cleanup levels as described in this subsection. Either standard or modified Method C soil cleanup levels may be used at any industrial property qualifying under subsection (1) of this section.

(b) **Standard Method C industrial soil cleanup levels.** Standard Method C industrial soil cleanup levels for industrial properties shall be at least as stringent as all of the following:

(i) **Applicable state and federal laws.** Concentrations established under applicable state and federal laws;

(ii) **Environmental protection.** Concentrations that result in no significant adverse effects on the protection and propagation of wildlife established using the procedures specified in WAC 173-340-7490 through 173-340-7494, unless it is demonstrated under those sections that establishing a soil concentration is unnecessary.

(iii) **Human health protection.** For hazardous substances for which sufficiently protective, health-based criteria or standards have not been established under applicable state and federal laws, those concentrations that protect human health as determined by evaluating the following exposure pathways:

(A) **Ground water protection.** Concentrations that will not cause contamination of ground water to concentrations which exceed ground water cleanup levels established under WAC 173-340-720 as determined using the methods described in WAC 173-340-747.

(B) **Soil direct contact.** Concentrations that, due to direct contact with contaminated soil, are estimated to result in no acute or chronic noncarcinogenic toxic effects on human health using a hazardous quotient of one (1) and concentrations for which the upper bound on the estimated excess cancer risk is less than or equal to one in one hundred thousand (1×10^{-5}). Equations 745-1 and 745-2 and the associated default assumptions shall be used to conduct this calculation.

(I) **Noncarcinogens.** For noncarcinogenic toxic effects of hazardous substances due to soil ingestion, concentrations shall be determined using Equation 745-1. For petroleum mixtures and components of such mixtures, see (b)(iii)(B)(III) of this subsection.

[Equation 745-1]

$$\text{Soil Cleanup Level (mg/kg)} = \frac{\text{RfD x ABW x UCF x HQ x AT}}{\text{SIR x AB1 x EF x ED}}$$

Where:

RfD	=	Reference dose as specified in WAC 173-340-708(7) (mg/kg-day)
ABW	=	Average body weight over the exposure duration (70 kg)

UCF = Unit conversion factor (1,000,000 mg/kg)

SIR = Soil ingestion rate (50 mg/day)

AB1 = Gastrointestinal absorption fraction (1.0) (unitless)

EF = Exposure frequency (0.4) (unitless)

HQ = Hazard quotient (1) (unitless)

AT = Averaging time (20 years)

ED = Exposure duration (20 years)

(II) **Carcinogens.** For carcinogenic effects of hazardous substances due to soil ingestion, concentrations shall be determined using Equation 745-2. For petroleum mixtures and components of such mixtures, see (b)(iii)(B)(III) of this subsection.

[Equation 745-2]

$$\text{Soil Cleanup Level (mg/kg)} = \frac{\text{RISK x ABW x AT x UCF}}{\text{CPF x SIR x AB1 x ED x EF}}$$

Where:

RISK = Acceptable cancer risk level (1 in 100,000) (unitless)

ABW = Average body weight over the exposure duration (70 kg)

AT = Averaging time (75 years)

UCF = Unit conversion factor (1,000,000 mg/kg)

CPF = Carcinogenic Potency Factor as specified in WAC 173-340-708(8) (kg-day/mg)

SIR = Soil ingestion rate (50 mg/day)

AB1 = Gastrointestinal absorption fraction (1.0) (unitless).
May use 0.6 for mixtures of dioxins and/or furans

ED = Exposure duration (20 years)

EF = Exposure frequency (0.4) (unitless)

(III) **Petroleum mixtures.** For noncarcinogenic effects of petroleum mixtures, a total petroleum hydrocarbon cleanup level shall be calculated taking into account the additive effects of the petroleum fractions and volatile organic compounds present in the petroleum mixture. Equation 745-3 shall be used for this calculation. This equation takes into account concurrent exposure due to ingestion and dermal contact with petroleum contaminated soils. Cleanup levels for other noncarcinogens and known or suspected carcinogens within the petroleum mixture shall be calculated using Equations 745-4 and 745-5. See Table 830-1 for the analyses required for various petroleum products to use this method.

[Equation 745-3]

$$C_{soil} = \frac{HI \times ABW \times AT}{EF \times ED \left[\left(\frac{SIR \times AB1}{10^6 mg/kg} \sum_{i=1}^{n} \frac{F(i)}{RfDo(i)} \right) + \left(\frac{SA \times AF}{10^6 mg/kg} \sum_{i=1}^{n} \frac{F(i) \times ABS(i)}{RfDd(i)} \right) \right]}$$

Where:

C_{soil} =	TPH soil cleanup level (mg/kg)
HI =	Hazard index (1) (unitless)
ABW =	Average body weight over the exposure duration (70 kg)
AT =	Averaging time (20 years)
EF =	Exposure frequency (0.7) (unitless)
ED =	Exposure duration (20 years)
SIR =	Soil ingestion rate (50 mg/day)
AB1 =	Gastrointestinal absorption fraction (1.0) (unitless)
F(i) =	Fraction (by weight) of petroleum component (i) (unitless)
SA =	Dermal surface area (2,500 cm^2)
AF =	Adherence factor (0.2 mg/cm^2-day)
ABS =	Dermal absorption fraction for petroleum component (i) (unitless). May use chemical-specific values or the following defaults:
✎	0.0005 for volatile petroleum components with vapor press > = benzene
✎	0.03 for volatile petroleum components with vapor press < benzene
✎	0.1 for other petroleum components
RfDo(i) =	Oral reference dose of petroleum component (i) as defined in WAC 173-340-708(7) (mg/kg-day)
RfDd(i) =	Dermal reference dose for petroleum component (i) (mg/kg-day) derived by RfDo x GI
GI =	Gastrointestinal absorption conversion factor (unitless). May use chemical-specific values or the following defaults:
✎	0.8 for volatile petroleum components
✎	0.5 for other petroleum components
n =	The number of petroleum components (petroleum fractions plus volatile organic compounds with an RfD) present in the petroleum mixture. (See Table 830-1.)

(C) **Soil vapors.** The soil to vapor pathway shall be evaluated for volatile organic compounds whenever any of the following conditions exist:

(I) For gasoline range organics, whenever the total petroleum hydrocarbon (TPH) concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(6) using the default assumptions;

(II) For diesel range organics, whenever the total petroleum hydrocarbon (TPH) concentration is greater than 10,000 mg/kg;

(III) For other volatile organic compounds, including petroleum components, whenever the concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(4).

See subsection (5)(c)(iv)(B) of this section for methods that may be used to evaluate the soil to vapor pathway.

(c) **Modified Method C soil cleanup levels.**

(i) **General.** Modified Method C soil cleanup levels are standard Method C soil cleanup levels modified with chemical-specific or site-specific data. When making these adjustments, the resultant cleanup levels shall meet applicable state and federal laws, meet health risk levels for standard Method C soil cleanup levels, and be demonstrated to be environmentally protective using the procedures specified in WAC 173-340-7490 through 173-340-7494. Changes to exposure assumptions must comply with WAC 173-340-708(10).

(ii) **Allowable modifications.** The following modifications may be made to the default assumptions in the standard Method C equations to derive modified Method C soil cleanup levels:

(A) For the protection of ground water see WAC 173-340-747;

(B) For soil ingestion, the gastrointestinal absorption fraction may be modified if the requirements of WAC 173-340-702 (14), (15), (16), and 173-340-708(10) are met;

(C) For dermal contact, the adherence factor, dermal absorption fraction and gastrointestinal absorption conversion factor may be modified if the requirements of WAC 173-340-702 (14), (15), (16), and 173-340-708(10) are met;

(D) The toxicity equivalent factors((~~, as described~~)) provided in WAC 173-340-708 (8)((~~, may be used for assessing the potential carcinogenic risk of mixtures of chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans and polycyclic aromatic hydrocarbons~~)) (d), (e) and (f), may be modified provided the requirements of WAC 173-340-708 (8)(g) and (h) are met;

(E) The reference dose and cancer potency factor may be modified if the requirements in WAC 173-340-708 (7) and (8) are met; and

(F) Modifications incorporating new science as provided for in WAC 173-340-702 (14), (15) and (16).

(iii) **Dermal contact.** For hazardous substances other than petroleum mixtures, dermal contact with the soil shall be evaluated whenever the proposed changes to Equations 745-1 and 745-2 would result in a significantly higher soil cleanup level than would be calculated without the proposed changes. When conducting this evaluation, the following equations and default assumptions shall be used:

(A) For noncarcinogens use Equation 745-4. This equation takes into account concurrent exposure due to ingestion and dermal contact with soil.

[Equation 745-4]

$$C_{soil} = \frac{HQ \times ABW \times AT}{EF \times ED \left[\left(\frac{1}{RfDo} \times \frac{SIR \times AB1}{10^6 mg/kg} \right) + \left(\frac{1}{RfDd} \times \frac{SA \times AF \times ABS}{10^6 mg/kg} \right) \right]}$$

Where:

- C_{soil} = Soil cleanup level (mg/kg)
- HQ = Hazard quotient (unitless)
- ABW = Average body weight over the exposure duration (70 kg)
- AT = Averaging time (20 years)
- EF = Exposure frequency (0.7) (unitless)
- ED = Exposure duration (20 years)
- SIR = Soil ingestion rate (50 mg/day)
- AB1 = Gastrointestinal absorption fraction (1.0) (unitless)
- SA = Dermal surface area (2,500 mg/cm^2)
- AF = Adherence factor (0.2 mg/cm^2-day)
- ABS = Dermal absorption fraction (unitless). May use chemical-specific values or the following defaults:
  - 0.01 for inorganic hazardous substances
  - 0.0005 for volatile organic compounds with vapor press > = benzene
  - 0.03 for volatile organic compounds with vapor press < benzene
  - 0.1 for other organic hazardous substances
- RfDo = Oral reference dose as defined in WAC 173-340-708(7) (mg/kg-day)
- RfDd = Dermal reference dose (mg/kg-day) derived by RfDo x GI
- GI = Gastrointestinal absorption conversion factor (unitless). May use chemical-specific values or the following defaults:
  - 0.2 for inorganic hazardous substances
  - 0.8 for volatile organic compounds
  - 0.5 for other organic hazardous substances

(B) For carcinogens use Equation 745-5. This equation takes into account concurrent exposure due to ingestion and dermal contact with soil.

[Equation 745-5]

$$C_{soil} = \frac{RISK \times ABW \times AT}{EF \times ED \left[\left(\frac{SIR \times AB1 \times CPFo}{10^6 mg / kg} \right) + \left(\frac{SA \times AF \times ABS \times CPFd}{10^6 mg / kg} \right) \right]}$$

Where:

C_{soil} =	Soil cleanup level (mg/kg)
RISK =	Acceptable cancer risk (1 in 100,000) (unitless)
ABW =	Average body weight over the exposure duration (70 kg)
AT =	Averaging time (75 years)
EF =	Exposure frequency (0.7) (unitless)
ED =	Exposure duration (20 years)
SIR =	Soil ingestion rate (50 mg/day)
AB1 =	Gastrointestinal absorption fraction (1.0) (unitless). May use 0.6 for mixtures of dioxins and/or furans
CPFo =	Oral cancer potency factor as defined in WAC 173-340-708(8) (kg-day/mg)
CPFd =	Dermal cancer potency factor (kg-day/mg) derived by CPFo/GI
GI =	Gastrointestinal absorption conversion factor (unitless). May use chemical-specific values or the following defaults:
	0.2 for inorganic hazardous substances
	0.8 for volatile organic compounds and mixtures of dioxins and/or furans
	0.5 for other organic hazardous substances
SA =	Dermal surface area (2,500 cm^2)
AF =	Adherence factor (0.2 mg/cm^2-day)
ABS =	Dermal absorption fraction (unitless). May use chemical-specific values or the following defaults:
	0.01 for inorganic hazardous substances
	0.0005 for volatile organic compounds with vapor press > = benzene
	0.03 for volatile organic compounds substances with vapor press < benzene and for mixtures of dioxins and/or furans
	0.1 for other organic hazardous substances

(C) Modifications may be made to Equations 745-4 and 745-5 as provided for in subsection (5)(c)(ii) of this section.

(iv) **Soil vapors.**

(A) **Applicability.** The soil to vapor pathway shall be evaluated for volatile organic compounds whenever any of the following conditions exist:

(I) For other than petroleum hydrocarbon mixtures, the proposed changes to the standard Method C equations (Equations 745-1 and 745-2) or default values would result in a significantly higher soil cleanup level than would be calculated without the proposed changes;

(II) For petroleum hydrocarbon mixtures, the proposed changes to the standard Method C equations (Equations 745-3, 745-4 and 745-5) or default values would result in a significantly higher soil cleanup level than would be calculated without the proposed changes;

(III) For gasoline range organics, whenever the total petroleum hydrocarbon (TPH) concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(6) using the default assumptions;

(IV) For diesel range organics, whenever the total petroleum hydrocarbon (TPH) concentration is greater than 10,000 mg/kg;

(V) For other volatile organic compounds, including petroleum components, whenever the concentration is significantly higher than a concentration derived for protection of ground water for drinking water beneficial use under WAC 173-340-747(4).

(B) **Evaluation methods.** Soil cleanup levels that are protective of the indoor and ambient air shall be determined on a site-specific basis. Soil cleanup levels may be evaluated as being protective of air pathways using any of the following methods:

(I) Measurements of the soil vapor concentrations, using methods approved by the department, demonstrating vapors in the soil would not exceed air cleanup levels established under WAC 173-340-750.

(II) Measurements of ambient air concentrations and/or indoor air vapor concentrations throughout buildings, using methods approved by the department, demonstrating air does not exceed cleanup levels established under WAC 173-340-750. Such measurements must be representative of current and future site conditions when vapors are likely to enter and accumulate in structures. Measurement of ambient air may be excluded if it can be shown that indoor air is the most protective point of exposure.

(III) Use of modeling methods approved by the department to demonstrate the air cleanup standards established under WAC 173-340-750 will not be exceeded. When this method is used, the department may require soil vapor and/or air monitoring to be conducted to verify the calculations and compliance with air cleanup standards.

(IV) Other methods as approved by the department demonstrating the air cleanup standards established under WAC 173-340-750 will not be exceeded.

(d) **Using modified Method C to evaluate industrial soil remediation levels.** In addition to the adjustments allowed under subsection (5)(c) of this section, other adjustments to the reasonable maximum exposure scenario or default exposure assumptions are allowed when using a quantitative site-specific risk assessment to evaluate the protectiveness of a remedy. See WAC 173-340-355, 173-340-357, and 173-340-708 (3)(d) and (10)(b).

(6) **Adjustments to industrial soil cleanup levels.**

(a) **Total site risk adjustments.** Soil cleanup levels for individual hazardous substances developed in accordance with subsection (5) of this section, including cleanup levels based on state and federal laws, shall be adjusted downward to take into account exposure to multiple hazardous substances and/or exposure resulting from more than one pathway of exposure. These adjustments need to be made only if, without these adjustments, the hazard index would exceed one (1) or the total excess cancer risk would exceed one in one hundred thousand (1×10^{-5}). These adjustments shall be made in accordance with the procedures specified in WAC 173-340-708 (5) and (6). In making these adjustments, the hazard index shall not exceed one (1) and the total excess cancer risk shall not exceed one in one hundred thousand (1×10^{-5}).

(b) **Adjustments to applicable state and federal laws.** Where a cleanup level developed under subsection (3) or (5) of this section is based on an applicable state or federal law and the level of risk upon which the standard is based exceeds an excess cancer risk of one in one hundred thousand (1×10^{-5}) or a hazard index of one (1), the cleanup level shall be adjusted downward so that total excess cancer risk does not exceed one in one hundred thousand (1×10^{-5}) and the hazard index does not exceed one (1) at the site.

(c) **Natural background and analytical considerations.** Cleanup levels determined under subsection (3) or (5) of this section, including cleanup levels adjusted under subsection (6)(a) and (b) of this section, shall not be set at levels below the practical quantitation limit or natural background concentration, whichever is higher. See WAC 173-340-707 and 173-340-709 for additional requirements pertaining to practical quantitation limits and natural background.

(7) **Point of compliance.** The point of compliance for industrial property soil cleanup levels shall be established in accordance with WAC 173-340-740(6).

(8) **Compliance monitoring.** Compliance monitoring and data analysis and evaluation for industrial property soil cleanup

levels shall be performed in accordance with WAC 173-340-410 and 173-340-740(7).

AMENDATORY SECTION (Amending Order 97-09A, filed 2/12/01, effective 8/15/01)

WAC 173-340-900 Tables.

Table 708-1: Toxicity Equivalency Factors for Chlorinated dibenzo-p-dioxins and Chlorinated Dibenzofurans Congeners

CAS Number	Hazardous Substance	Toxicity Equivalency Factor (unitless)[1]
	Dioxin Congeners	
1746-01-6	2,3,7,8-Tetrachloro dibenzo-p-dioxin	1
40321-76-4	1,2,3,7,8-Pentachloro dibenzo-p-dioxin	1
3927-28-6	1,2,3,4,7,8-Hexachloro dibenzo-p-dioxin	0.1
57653-85-7	1,2,3,6,7,8-Hexachloro dibenzo-p-dioxin	0.1
19408-74-3	1,2,3,7,8,9-Hexachloro dibenzo-p-dioxin	0.1
35822-46-9	1,2,3,4,6,7,8-Heptachloro dibenzo-p-dioxin	0.01
3268-87-9	1,2,3,4,6,7,8,9-Octachloro dibenzo-p-dioxin	0.0003
	Furan Congeners	
51207-31-9	2,3,7,8-Tetrachloro dibenzofuran	0.1
57117-41-6	1,2,3,7,8-Pentachloro dibenzofuran	0.03
57117-31-4	2,3,4,7,8-Pentachloro dibenzofuran	0.3
70648-26-9	1,2,3,4,7,8-Hexachloro dibenzofuran	0.1
57117-44-9	1,2,3,6,7,8-Hexachloro dibenzofuran	0.1
72918-21-9	1,2,3,7,8,9-Hexachloro dibenzofuran	0.1
60851-34-5	2,3,4,6,7,8-Hexachloro dibenzofuran	0.1
67562-39-4	1,2,3,4,6,7,8-Heptachloro dibenzofuran	0.01
55673-89-7	1,2,3,4,7,8,9-Heptachloro dibenzofuran	0.01
39001-02-0	1,2,3,4,6,7,8,9-Octachloro dibenzofuran	0.0003

[1] Source: Van den Berg et al. 2006. The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds.
Toxicological Sciences 2006 93(2):223-241; doi:10.1093/toxsci/kfl055.

Table 708-2: Toxicity Equivalency Factors for Minimum Required Carcinogenic Polyaromatic Hydrocarbons (cPAHs) under WAC 173-340-708(e)

CAS Number	Hazardous Substance	TEF (unitless)[(1)]
50-32-08	benzo[a]pyrene	1
56-55-3	benzo[a]anthracene	0.1
205-99-2	benzo[b]fluoranthene	0.1
207-08-9	benzo[k]fluoranthene	0.1
218-01-9	chrysene	0.01
53-70-3	dibenz[a, h]anthracene	0.1
193-39-5	indeno[1,2,3-cd]pyrene	0.1

[(1)] Source: Cal-EPA, 2005. Air Toxics Hot Spots Program Risk Assessment Guidelines, Part II Technical Support Document for Describing Available Cancer Potency Factors. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. May 2005.

Table 708-3: Toxicity Equivalency Factors for Carcinogenic Polyaromatic Hydrocarbons (cPAHs) that May be Required under WAC 173-340-708 (8)(e)(v)

CAS Number	Hazardous Substance	TEF (unitless)[(1)]
205-82-3	benzo(j)fluoranthene	0.1
224-42-0	dibenz[a, j]acridine	0.1
226-36-8	dibenz[a, h]acridine	0.1
194-59-2	7H-dibenzo[c, g]carbazole	1
192-65-4	dibenzo[a, e]pyrene	1
189-64-0	dibenzo[a, h]pyrene	10
189-55-9	dibenzo[a, i]pyrene	10
191-30-0	dibenzo[a, l]pyrene	10
3351-31-3	5-methylchrysene	1
5522-43-0	1-nitropyrene	0.1
57835-92-4	4-nitropyrene	0.1
42397-64-8	1,6-dinitropyrene	10
42397-65-9	1,8-dinitropyrene	1
7496-02-8	6-nitrochrysene	10
607-57-8	2-nitrofluorene	0.01
57-97-6	7,12-dimethylbenzanthracene	10
56-49-5	3-methylcholanthrene	1
602-87-9	5-nitroacenaphthene	0.01

[(1)]Source: Cal-EPA, 2005. Air Toxics Hot Spots Program Risk Assessment Guidelines, Part II Technical Support Document for Describing Available Cancer Potency Factors. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. May 2005.

Table 708-4: Toxicity Equivalency Factors for Dioxin-Like Polychlorinated Biphenyls (PCBs)

CAS Number	Hazardous Substance	TEF (unitless)[(1)]
	Dioxin-Like PCBs	
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	0.0001
70362-50-4	3,4,4',5- Tetrachlorobiphenyl (PCB 81)	0.0003
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)	0.00003
74472-37-0	2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	0.00003
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl (PCB 118)	0.00003
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	0.00003
57465-28-8	3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	0.1
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	0.00003
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	0.00003
52663-72-6	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	0.00003
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	0.03
39635-31-9	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	0.00003

[(1)]Source: Van den Berg et al. 2006. The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Toxicological Sciences 2006 93(2):223-241; doi:10.1093/toxsci/kfl055.

Table 720-1
Method A Cleanup Levels for Ground Water.[a]

Hazardous Substance	CAS Number	Cleanup Level
Arsenic	7440-38-2	5 ug/liter[b]
Benzene	71-43-2	5 ug/liter[c]
Benzo(a)pyrene	50-32-8	0.1 ug/liter[d]
Cadmium	7440-43-9	5 ug/liter[e]
Chromium (Total)	7440-47-3	50 ug/liter[f]
DDT	50-29-3	0.3 ug/liter[g]
1,2 Dichloroethane (EDC)	107-06-2	5 ug/liter[h]
Ethylbenzene	100-41-4	700 ug/liter[i]
Ethylene dibromide (EDB)	106-93-4	0.01 ug/liter[j]
Gross Alpha Particle Activity		15 pCi/liter[k]

Gross Beta Particle Activity		4 mrem/yr[l]
Lead	7439-92-1	15 ug/liter[m]
Lindane	58-89-9	0.2 ug/liter[n]
Methylene chloride	75-09-2	5 ug/liter[o]
Mercury	7439-97-6	2 ug/liter[p]
MTBE	1634-04-4	20 ug/liter[q]
Naphthalenes	91-20-3	160 ug/liter[r]
PAHs (carcinogenic)		See benzo(a)pyrene[d]
PCB mixtures		0.1 ug/liter[s]
Radium 226 and 228		5 pCi/liter[t]
Radium 226		3 pCi/liter[u]
Tetrachloroethylene	127-18-4	5 ug/liter[v]
Toluene	108-88-3	1,000 ug/liter[w]
Total Petroleum Hydrocarbons[x]		
[Note: Must also test for and meet cleanup levels for other petroleum components--see footnotes!]		
Gasoline Range Organics		
Benzene present in ground water		800 ug/liter
No detectable benzene in ground water		1,000 ug/liter
Diesel Range Organics		500 ug/liter
Heavy Oils		500 ug/liter
Mineral Oil		500 ug/liter
1,1,1 Trichloroethane	71-55-6	200 ug/liter[y]
Trichloroethylene	79-01-6	5 ug/liter[z]
Vinyl chloride	75-01-4	0.2 ug/liter[aa]
Xylenes	1330-20-7	1,000 ug/liter[bb]

Footnotes:

a **Caution on misusing this table.** This table has been developed for specific purposes. It is intended to provide conservative cleanup levels for drinking water beneficial uses at sites undergoing routine cleanup actions or those sites with relatively few hazardous substances. This table may not be appropriate for defining cleanup levels at other sites. For these reasons, the values in this table should not automatically be used to define cleanup levels that must be met for financial, real estate, insurance coverage or placement, or similar transactions or purposes. Exceedances of the values in this table do not necessarily mean the ground water must be restored to those levels at all sites. The level of restoration depends on the remedy selected under WAC 173-340-350 through 173-340-390.

b **Arsenic.** Cleanup level based on background concentrations for state of Washington.

c **Benzene.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

d **Benzo(a)pyrene.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61), adjusted to a 1 x 10^{-5} risk. If other carcinogenic PAHs are suspected of being present at the site, test for them and use this value as the total concentration that all carcinogenic PAHs must meet using the toxicity equivalency methodology in WAC

173-340-708(8).

e **Cadmium.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.62).

f **Chromium (Total).** Cleanup level based on concentration derived using Equation 720-1 for hexavalent chromium. This is a total value for chromium III and chromium VI. If just chromium III is present at the site, a cleanup level of 100 ug/l may be used (based on WAC 246-290-310 and 40 C.F.R. 141.62).

g **DDT (dichlorodiphenyltrichloroethane).** Cleanup levels based on concentration derived using Equation 720-2.

h **1,2 Dichloroethane (ethylene dichloride or EDC).** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

i **Ethylbenzene.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

j **Ethylene dibromide (1,2 dibromoethane or EDB).** Cleanup level based on concentration derived using Equation 720-2, adjusted for the practical quantitation limit.

k **Gross Alpha Particle Activity, excluding uranium.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.15).

l **Gross Beta Particle Activity, including gamma activity.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.15).

m **Lead.** Cleanup level based on applicable state and federal law (40 C.F.R. 141.80).

n **Lindane.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

o **Methylene chloride (dichloromethane).** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

p **Mercury.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.62).

q **Methyl tertiary-butyl ether (MTBE).** Cleanup level based on federal drinking water advisory level (EPA-822-F-97-009, December 1997).

r **Naphthalenes.** Cleanup level based on concentration derived using Equation 720-1. This is a total value for naphthalene, 1-methyl naphthalene and 2-methyl naphthalene.

s **PCB mixtures.** Cleanup level based on concentration derived using Equation 720-2, adjusted for the practical quantitation limit. This cleanup level is a total value for all PCBs.

t **Radium 226 and 228.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.15).

u **Radium 226.** Cleanup level based on applicable state law (WAC 246-290-310).

v **Tetrachloroethylene.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

w **Toluene.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

x **Total Petroleum Hydrocarbons (TPH).** TPH cleanup values have been provided for the most common petroleum products encountered at contaminated sites. Where there is a mixture of products or the product composition is unknown, samples must be tested using both the NWTPH-Gx and NWTPH-Dx methods and the lowest applicable TPH cleanup level must be met.

Gasoline range organics means organic compounds measured using method NWTPH-Gx. Examples are aviation and automotive gasoline. The cleanup level is based on protection of ground water for noncarcinogenic effects during drinking water use. Two cleanup levels are provided. The higher value is based on the assumption that no benzene is present in the ground water sample. If any detectable amount of benzene is present in the ground water sample, then the lower TPH cleanup level must be used. No interpolation between these cleanup levels is allowed. The ground water cleanup level for any carcinogenic components of the petroleum [such as benzene, EDB and EDC] and any noncarcinogenic components [such as ethylbenzene, toluene, xylenes and MTBE], if present at the site, must also be met. See Table 830-1 for the minimum testing requirements for gasoline releases.

Diesel range organics means organic compounds measured using NWTPH-Dx. Examples are diesel, kerosene, and #1 and #2 heating oil. The cleanup level is based on protection from noncarcinogenic effects during drinking water use. The ground water cleanup level for any carcinogenic components of the petroleum [such as benzene and PAHs] and any noncarcinogenic components [such as ethylbenzene, toluene, xylenes and naphthalenes], if present at the site, must also be met. See Table 830-1 for the minimum testing requirements for diesel releases.

Heavy oils means organic compounds measured using NWTPH-Dx. Examples are #6 fuel oil, bunker C oil, hydraulic oil and waste oil. The cleanup level is based on protection from noncarcinogenic effects during drinking water use, assuming a product composition similar to diesel fuel. The ground water cleanup level for any carcinogenic components of the petroleum [such as benzene, PAHs and PCBs] and any noncarcinogenic components [such as ethylbenzene, toluene, xylenes and naphthalenes], if present at the site, must also be met. See Table 830-1 for the minimum testing requirements for heavy oil releases.

Mineral oil means non-PCB mineral oil, typically used as an insulator and coolant in electrical devices such as transformers and capacitors measured using NWTPH-Dx. The cleanup level is based on protection from noncarcinogenic effects during drinking water use. Sites using this cleanup level must analyze ground water samples for PCBs and meet the PCB cleanup level in this table unless it can be demonstrated that: (1) The release originated from an electrical device manufactured after July 1, 1979; or (2) oil containing PCBs was never used in the equipment suspected as the source of the release; or (3) it can be documented that the oil released was recently tested and did not contain PCBs. Method B (or Method C, if applicable) must be used for releases of oils containing greater than 50 ppm PCBs. See Table 830-1 for the minimum testing requirements for mineral oil releases.

y **1,1,1 Trichloroethane.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

z **Trichloroethylene.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61).

aa **Vinyl chloride.** Cleanup level based on applicable state and federal law (WAC 246-290-310 and 40 C.F.R. 141.61), adjusted to a 1 x 10^{-5} risk.

bb **Xylenes.** Cleanup level based on xylene not exceeding the maximum allowed cleanup level in this table for total petroleum hydrocarbons and on prevention of adverse aesthetic characteristics. This is a total value for all xylenes.

Table 740-1
Method A Soil Cleanup Levels for Unrestricted Land Uses.[a]

Hazardous Substance	CAS Number	Cleanup Level
Arsenic	7440-38-2	20 mg/kg[b]
Benzene	71-43-2	0.03 mg/kg[c]
Benzo(a)pyrene	50-32-8	0.1 mg/kg[d]
Cadmium	7440-43-9	2 mg/kg[e]
Chromium		
Chromium VI	18540-29-9	19 mg/kg[f1]
Chromium III	16065-83-1	2,000 mg/kg[f2]
DDT	50-29-3	3 mg/kg[g]
Ethylbenzene	100-41-4	6 mg/kg[h]
Ethylene dibromide (EDB)	106-93-4	0.005 mg/kg[i]
Lead	7439-92-1	250 mg/kg[j]
Lindane	58-89-9	0.01 mg/kg[k]
Methylene chloride	75-09-2	0.02 mg/kg[l]
Mercury (inorganic)	7439-97-6	2 mg/kg[m]
MTBE	1634-04-4	0.1 mg/kg[n]
Naphthalenes	91-20-3	5 mg/kg[o]
PAHs (carcinogenic)		See benzo(a)pyrene[d]
PCB Mixtures		1 mg/kg[p]
Tetrachloroethylene	127-18-4	0.05 mg/kg[q]
Toluene	108-88-3	7 mg/kg[r]
Total Petroleum Hydrocarbons[s]		
[Note: Must also test for and meet cleanup levels for other petroleum components--see footnotes!]		
Gasoline Range Organics		
Gasoline mixtures without benzene and the total of ethylbenzene, toluene and xylene are less than 1% of the gasoline mixture		100 mg/kg
All other gasoline mixtures		30 mg/kg
Diesel Range Organics		2,000 mg/kg
Heavy Oils		2,000 mg/kg
Mineral Oil		4,000 mg/kg
1,1,1 Trichloroethane	71-55-6	2 mg/kg[t]
Trichloroethylene	79-01-6	0.03 mg/kg[u]

Xylenes	1330-20-7	9 mg/kg[v]

Footnotes:

a **Caution on misusing this table.** This table has been developed for specific purposes. It is intended to provide conservative cleanup levels for sites undergoing routine cleanup actions or for sites with relatively few hazardous substances, and the site qualifies under WAC 173-340-7491 for an exclusion from conducting a simplified or site-specific terrestrial ecological evaluation, or it can be demonstrated using a terrestrial ecological evaluation under WAC 173-340-7492 or 173-340-7493 that the values in this table are ecologically protective for the site. This table may not be appropriate for defining cleanup levels at other sites. For these reasons, the values in this table should not automatically be used to define cleanup levels that must be met for financial, real estate, insurance coverage or placement, or similar transactions or purposes. Exceedances of the values in this table do not necessarily mean the soil must be restored to these levels at a site. The level of restoration depends on the remedy selected under WAC 173-340-350 through 173-340-390.

b **Arsenic.** Cleanup level based on direct contact using Equation 740-2 and protection of ground water for drinking water use using the procedures in WAC 173-340-747(4), adjusted for natural background for soil.

c **Benzene.** Cleanup level based on protection of ground water for drinking water use, using the procedures in WAC 173-340-747 (4) and (6).

d **Benzo(a)pyrene.** Cleanup level based on direct contact using Equation 740-2. If other carcinogenic PAHs are suspected of being present at the site, test for them and use this value as the total concentration that all carcinogenic PAHs must meet using the toxicity equivalency methodology in WAC 173-340-708(8).

e **Cadmium.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4), adjusted for the practical quantitation limit for soil.

f1 **Chromium VI.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

f2 **Chromium III.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4). Chromium VI must also be tested for and the cleanup level met when present at a site.

g **DDT (dichlorodiphenyltrichloroethane).** Cleanup level based on direct contact using Equation 740-2.

h **Ethylbenzene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

i **Ethylene dibromide (1,2 dibromoethane or EDB).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4), adjusted for the practical quantitation limit for soil.

j **Lead.** Cleanup level based on preventing unacceptable blood lead levels.

k **Lindane.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4), adjusted for the practical quantitation limit.

l **Methylene chloride (dichloromethane).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

m **Mercury.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

n **Methyl tertiary-butyl ether (MTBE).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

o **Naphthalenes.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4). This is a total value for naphthalene, 1-methyl naphthalene and 2-methyl naphthalene.

p **PCB Mixtures.** Cleanup level based on applicable federal law (40 C.F.R. 761.61). This is a total value for all PCBs.

q **Tetrachloroethylene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

r **Toluene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

s **Total Petroleum Hydrocarbons (TPH).** TPH cleanup values have been provided for the most common petroleum products encountered at contaminated sites. Where there is a mixture of products or the product composition is unknown, samples must be tested using both the NWTPH-Gx and NWTPH-Dx methods and the lowest applicable TPH cleanup level must be met.

Gasoline range organics means organic compounds measured using method NWTPH-Gx. Examples are aviation and automotive gasoline. The cleanup level is based on protection of ground water for noncarcinogenic effects during drinking water use using the procedures described in WAC 173-340-747(6). Two cleanup levels are provided. The lower value of 30 mg/kg can be used at any site. When using this lower value, the soil must also be tested for and meet the benzene soil cleanup level. The higher value of 100 mg/kg can only be used if the soil is tested and found to contain no benzene and the total of ethylbenzene, toluene and xylene are less than 1% of the gasoline mixture. No interpolation between these cleanup levels is allowed. In both cases, the soil cleanup level for any other carcinogenic components of the petroleum [such as EDB and EDC], if present at the site, must also be met. Also, in both cases, soil cleanup levels for any noncarcinogenic components [such as toluene, ethylbenzene, xylenes, naphthalene, and MTBE], also must be met if these substances are found to exceed ground water cleanup levels at the site. See Table 830-1 for the minimum testing requirements for gasoline releases.

Diesel range organics means organic compounds measured using method NWTPH-Dx. Examples are diesel, kerosene, and #1 and #2 heating oil. The cleanup level is based on preventing the accumulation of free product on the ground water, as described in WAC 173-340-747(10). The soil cleanup level for any carcinogenic components of the petroleum [such as benzene and PAHs], if present at the site, must also be met. Soil cleanup levels for any noncarcinogenic components [such as toluene, ethylbenzene, xylenes and naphthalenes], also must be met if these substances are found to exceed the ground water cleanup levels at the site. See Table 830-1 for the minimum testing requirements for diesel releases.

Heavy oils means organic compounds measured using NWTPH-Dx. Examples are #6 fuel oil, bunker C oil, hydraulic oil and waste oil. The cleanup level is based on preventing the accumulation of free product on the ground water, as described in WAC 173-340-747(10) and assuming a product composition similar to diesel fuel. The soil cleanup level for any carcinogenic components of the petroleum [such as benzene, PAHs and PCBs], if present at the site, must also be met. Soil cleanup levels for any noncarcinogenic components [such as toluene, ethylbenzene, xylenes and naphthalenes], also must be met if found to exceed the ground water cleanup levels at the site. See Table 830-1 for the minimum testing requirements for heavy oil releases.

Mineral oil means non-PCB mineral oil, typically used as an insulator and coolant in electrical devices such as transformers and capacitors, measured using NWTPH-Dx. The cleanup level is based on preventing the accumulation of free product on the ground water, as described in WAC 173-340-747(10). Sites using this cleanup level must also analyze soil samples and meet the soil cleanup level for PCBs, unless it can be demonstrated that: (1) The release originated from an electrical device that was manufactured after July 1, 1979; or (2) oil containing PCBs was never used in the equipment suspected as the source of the release; or (3) it can be documented that the oil released was recently tested and did not contain PCBs. Method B must be used for releases of oils containing greater than 50 ppm PCBs. See Table 830-1 for the minimum testing requirements for mineral oil releases.

t **1,1,1 Trichloroethane.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

u **Trichloroethylene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

v **Xylenes.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4). This is a total value for all xylenes.

Table 745-1
Method A Soil Cleanup Levels for Industrial Properties.[a]

Hazardous Substance	**CAS Number**	**Cleanup Level**
Arsenic	7440-38-2	20 mg/kg[b]
Benzene	71-43-2	0.03 mg/kg[c]
Benzo(a)pyrene	50-32-8	2 mg/kg[d]
Cadmium	7440-43-9	2 mg/kg[e]
Chromium		
Chromium VI	18540-29-9	19 mg/kg[f1]
Chromium III	16065-83-1	2,000 mg/kg[f2]
DDT	50-29-3	4 mg/kg[g]
Ethylbenzene	100-41-4	6 mg/kg[h]
Ethylene dibromide (EDB)	106-93-4	0.005 mg/kg[i]
Lead	7439-92-1	1,000 mg/kg[j]
Lindane	58-89-9	0.01 mg/kg[k]
Methylene chloride	75-09-2	0.02 mg/kg[l]
Mercury (inorganic)	7439-97-6	2 mg/kg[m]
MTBE	1634-04-4	0.1 mg/kg[n]
Naphthalene	91-20-3	5 mg/kg[o]
PAHs (carcinogenic)		See benzo(a)pyrene[d]
PCB Mixtures		10 mg/kg[p]
Tetrachloroethylene	127-18-4	0.05 mg/kg[q]
Toluene	108-88-3	7 mg/kg[r]
Total Petroleum Hydrocarbons[s]		
[Note: Must also test for and meet cleanup levels for other petroleum components--see footnotes!]		
Gasoline Range Organics		

Gasoline mixtures without benzene and the total of ethylbenzene, toluene and xylene are less than 1% of the gasoline mixture		100 mg/kg
All other gasoline mixtures		30 mg/kg
Diesel Range Organics		2,000 mg/kg
Heavy Oils		2,000 mg/kg
Mineral Oil		4,000 mg/kg
1,1,1 Trichloroethane	71-55-6	2 mg/kg[t]
Trichloroethylene	79-01-6	0.03 mg/kg[u]
Xylenes	1330-20-7	9 mg/kg[v]

Footnotes:

a **Caution on misusing this table.** This table has been developed for specific purposes. It is intended to provide conservative cleanup levels for sites undergoing routine cleanup actions or for industrial properties with relatively few hazardous substances, and the site qualifies under WAC 173-340-7491 for an exclusion from conducting a simplified or site-specific terrestrial ecological evaluation, or it can be demonstrated using a terrestrial ecological evaluation under WAC 173-340-7492 or 173-340-7493 that the values in this table are ecologically protective for the site. This table may not be appropriate for defining cleanup levels at other sites. For these reasons, the values in this table should not automatically be used to define cleanup levels that must be met for financial, real estate, insurance coverage or placement, or similar transactions or purposes. Exceedances of the values in this table do not necessarily mean the soil must be restored to these levels at a site. The level of restoration depends on the remedy selected under WAC 173-340-350 through 173-340-390.

b **Arsenic.** Cleanup level based on protection of ground water for drinking water use, using the procedures in WAC 173-340-747(4), adjusted for natural background for soil.

c **Benzene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747 (4) and (6).

d **Benzo(a)pyrene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4). If other carcinogenic PAHs are suspected of being present at the site, test for them and use this value as the total concentration that all carcinogenic PAHs must meet using the toxicity equivalency methodology in WAC 173-340-708(8).

e **Cadmium.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4), adjusted for the practical quantitation limit for soil.

f1 **Chromium VI.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

f2 **Chromium III.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4). Chromium VI must also be tested for and the cleanup level met when present at a site.

g **DDT (dichlorodiphenyltrichloroethane).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

h **Ethylbenzene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

i **Ethylene dibromide (1,2 dibromoethane or EDB).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4), adjusted for the practical quantitation limit for soil.

j **Lead.** Cleanup level based on direct contact.

k **Lindane.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4), adjusted for the practical quantitation limit.

l **Methylene chloride (dichloromethane).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

m **Mercury.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

n **Methyl tertiary-butyl ether (MTBE).** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

o **Naphthalenes.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4). This is a total value for naphthalene, 1-methyl naphthalene and 2-methyl naphthalene.

p **PCB Mixtures.** Cleanup level based on applicable federal law (40 C.F.R. 761.61). This is a total value for all PCBs. This value may be used only if the PCB contaminated soils are capped and the cap maintained as required by 40 C.F.R. 761.61. If this condition cannot be met, the value in Table 740-1 must be used.

q **Tetrachloroethylene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

r **Toluene.** Cleanup level based on protection of ground water for drinking water use, using the procedure described in WAC 173-340-747(4).

s **Total Petroleum Hydrocarbons (TPH).** TPH cleanup values have been provided for the most common petroleum products encountered at contaminated sites. Where there is a mixture of products or the product composition is unknown, samples must be tested using both the NWTPH-Gx and NWTPH-Dx methods and the lowest applicable TPH cleanup level must be met.

Gasoline range organics means organic compounds measured using method NWTPH-Gx. Examples are aviation and automotive gasoline. The cleanup level is based on protection of ground water for noncarcinogenic effects during drinking water use using the procedures described in WAC 173-340-747(6). Two cleanup levels are provided. The lower value of 30 mg/kg can be used at any site. When using this lower value, the soil must also be tested for and meet the benzene soil cleanup level. The higher value of 100 mg/kg can only be used if the soil is tested and found to contain no benzene and the total of ethylbenzene, toluene and xylene are less than 1% of the gasoline mixture. No interpolation between these cleanup levels is allowed. In both cases, the soil cleanup level for any other carcinogenic components of the petroleum [such as EDB and EDC], if present at the site, must also be met. Also, in both cases, soil cleanup levels for any noncarcinogenic components [such as toluene, ethylbenzene, xylenes, naphthalene, and MTBE], also must be met if these substances are found to exceed ground water cleanup levels at the site. See Table 830-1 for the minimum testing requirements for gasoline releases.

Diesel range organics means organic compounds measured using method NWTPH-Dx. Examples are diesel, kerosene, and #1 and #2 heating oil. The cleanup level is based on preventing the accumulation of free product on the ground water, as described in WAC 173-340-747(10). The soil cleanup level for any carcinogenic components of the petroleum [such as benzene, and PAHs], if present at the site, must also be met. Soil cleanup levels for any noncarcinogenic components [such as toluene, ethylbenzene, xylenes and naphthalenes], also must be met if these substances are found to exceed the ground water cleanup levels at the site. See Table 830-1 for the minimum testing requirements for diesel releases.

Heavy oils means organic compounds measured using NWTPH-Dx. Examples are #6 fuel oil, bunker C oil, hydraulic oil and waste oil. The cleanup level is based on preventing the accumulation of free product on the ground water, as described in WAC 173-340-747(10) and assuming a product composition similar to diesel fuel. The soil cleanup level for any carcinogenic components of the petroleum [such as benzene, PAHs and PCBs], if present at the site, must also be met. Soil cleanup levels for any noncarcinogenic components [such as toluene, ethylbenzene, xylenes and naphthalenes], also must be met if found to exceed the ground water cleanup levels at the site. See Table 830-1 for the minimum testing requirements for heavy oil releases.

Mineral oil means non-PCB mineral oil, typically used as an insulator and coolant in electrical devices such as transformers and capacitors, measured using NWTPH-Dx. The cleanup level is based on preventing the accumulation of free product on the ground water, as described in WAC 173-340-747(10). Sites using this cleanup level must also analyze soil samples and meet the soil cleanup level for PCBs, unless it can be demonstrated that: (1) The release originated from an electrical device that was manufactured after July 1, 1979; or (2) oil containing PCBs was never used in the equipment suspected as the source of the release; or (3) it can be documented that the oil released was recently tested and did not contain PCBs. Method B or C must be used for releases of oils containing greater than 50 ppm PCBs. See Table 830-1 for the minimum testing requirements for mineral oil releases.

t **1,1,1 Trichloroethane.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

u **Trichloroethylene.** Cleanup level based on protection of ground water for drinking water use, using the procedures described in WAC 173-340-747(4).

v **Xylenes.** Cleanup level based on protection of ground water for drinking water use, using the procedure in WAC 173-340-747(4). This is a total value for all xylenes.

Table 747-1
Soil Organic Carbon-Water Partitioning Coefficient (K_{oc}) Values: Nonionizing Organics.

Hazardous Substance	K_{oc} (ml/g)
ACENAPHTHENE	4,898
ALDRIN	48,685
ANTHRACENE	23,493
BENZ(a)ANTHRACENE	357,537
BENZENE	62
BENZO(a)PYRENE	968,774
BIS(2-CHLOROETHYL)ETHER	76
BIS(2-ETHYLHEXYL)PHTHALATE	111,123
BROMOFORM	126
BUTYL BENZYL PHTHALATE	13,746

CARBON TETRACHLORIDE	152
CHLORDANE	51,310
CHLOROBENZENE	224
CHLOROFORM	53
DDD	45,800
DDE	86,405
DDT	677,934
DIBENZO(a,h)ANTHRACENE	1,789,101
1,2-DICHLOROBENZENE (o)	379
1,4-DICHLOROBENZENE (p)	616
DICHLOROETHANE-1,1	53
DICHLOROETHANE-1,2	38
DICHLOROETHYLENE-1,1	65
trans-1,2 DICHLOROETHYLENE	38
DICHLOROPROPANE-1,2	47
DICHLOROPROPENE-1,3	27
DIELDRIN	25,546
DIETHYL PHTHALATE	82
DI-N-BUTYLPHTHALATE	1,567
EDB	66
ENDRIN	10,811
ENDOSULFAN	2,040
ETHYL BENZENE	204
FLUORANTHENE	49,096
FLUORENE	7,707
HEPTACHLOR	9,528
HEXACHLOROBENZENE	80,000
✂-HCH (✂-BHC)	1,762
👓-HCH (👓-BHC)	2,139
☎-HCH (LINDANE)	1,352
MTBE	11
METHOXYCHLOR	80,000

METHYL BROMIDE	9
METHYL CHLORIDE	6
METHYLENE CHLORIDE	10
NAPHTHALENE	1,191
NITROBENZENE	119
PCB-Arochlor 1016	107,285
PCB-Arochlor 1260	822,422
PENTACHLOROBENZENE	32,148
PYRENE	67,992
STYRENE	912
1,1,2,2,-TETRACHLOROETHANE	79
TETRACHLOROETHYLENE	265
TOLUENE	140
TOXAPHENE	95,816
1,2,4-TRICHLOROBENZENE	1,659
TRICHLOROETHANE -1,1,1	135
TRICHLOROETHANE-1,1,2	75
TRICHLOROETHYLENE	94
o-XYLENE	241
m-XYLENE	196
p-XYLENE	311

Sources:
Except as noted below, the source of the K_{oc} values is the 1996 *EPA Soil Screening Guidance: Technical Background Document*. The values obtained from this document represent the geometric mean of a survey of values published in the scientific literature. Sample populations ranged from 1-65. EDB value from *ATSDR Toxicological Profile* (TP 91/13). MTBE value from *USGS Final Draft Report on Fuel Oxygenates* (March 1996). PCB-Arochlor values from 1994 *EPA Draft Soil Screening Guidance*.

Table 747-2
Predicted Soil Organic Carbon-Water Partitioning Coefficient (K_{oc}) as a Function of pH: Ionizing Organics.

Hazardous Substance	K_{oc} Value (ml/g)		
	pH = 4.9	pH = 6.8	pH = 8.0
Benzoic acid	5.5	0.6	0.5
2-Chlorophenol	398	388	286
2-4-Dichlorophenol	159	147	72

2-4-Dinitrophenol	0.03	0.01	0.01
Pentachlorophenol	9,055	592	410
2,3,4,5-Tetrachlorophenol	17,304	4,742	458
2,3,4,6-Tetrachlorophenol	4,454	280	105
2,4,5-Trichlorophenol	2,385	1,597	298
2,4,6-Trichlorophenol	1,040	381	131

Source: 1996 *EPA Soil Screening Guidance: Technical Background Document*. The predicted K_{oc} values in this table were derived using a relationship from thermodynamic equilibrium considerations to predict the total sorption of an ionizable organic compound from the partitioning of its ionized and neutral forms.

Table 747-3
Metals Distribution Coefficients (K_d).

Hazardous Substance	K_d (L/kg)
Arsenic	29
Cadmium	6.7
Total Chromium	1,000
Chromium VI	19
Copper	22
Mercury	52
Nickel	65
Lead	10,000
Selenium	5
Zinc	62

Source: Multiple sources compiled by the department of ecology.

Table 747-4
Petroleum EC Fraction Physical/Chemical Values.

Fuel Fraction	Equivalent Carbon Number[1]	Water Solubility[2] (mg/L)	Mol. Wt.[3] (g/mol)	Henry's Constant[4] (cc/cc)	GFW[5] (mg/mol)	Density[6] (mg/l)	Soil Organic Carbon-Water Partitioning Coefficient K_{oc}[7] (L/kg)
ALIPHATICS							
EC 5 - 6	5.5	36.0	81.0	33.0	81,000	670,000	800
EC > 6 - 8	7.0	5.4	100.0	50.0	100,000	700,000	3,800
EC > 8 - 10	9.0	0.43	130.0	80.0	130,000	730,000	30,200

EC > 10 - 12	11.0	0.034	160.0	120.0	160,000	750,000	234,000
EC > 12 - 16	14.0	7.6E-04	200.0	520.0	200,000	770,000	5.37E+06
EC > 16 - 21	19.0	1.3E-06	270.0	4,900	270,000	780,000	9.55E+09
EC > 21 - 34	28.0	1.5E-11	400.0	100,000	400,000	790,000	1.07E+10
AROMATICS							
EC > 8 - 10	9.0	65.0	120.0	0.48	120,000	870,000	1,580
EC > 10 - 12	11.0	25.0	130.0	0.14	130,000	900,000	2,510
EC > 12 - 16	14.0	5.8	150.0	0.053	150,000	1,000,000	5,010
EC > 16 - 21	19.0	0.51	190.0	0.013	190,000	1,160,000	15,800
EC > 21 - 34	28.0	6.6E-03	240.0	6.7E-04	240,000	1,300,000	126,000
TPH COMPONENTS							
Benzene	6.5	1,750	78.0	0.228	78,000	876,500	62.0
Toluene	7.6	526.0	92.0	0.272	92,000	866,900	140.0
Ethylbenzene	8.5	169.0	106.0	0.323	106,000	867,000	204.0
Total Xylenes[8] **(average of 3)**	8.67	171.0	106.0	0.279	106,000	875,170	233.0
n-Hexane[9]	6.0	9.5	86.0	74.0	86,000	659,370	3,410
MTBE[10]		50,000	88.0	0.018	88,000	744,000	10.9
Naphthalenes	11.69	31.0	128.0	0.0198	128,000	1,145,000	1,191

Sources:

1 **Equivalent Carbon Number.** Gustafson, J.B. et al., *Selection of Representative TPH Fractions Based on Fate and Transport Considerations. Total Petroleum Hydrocarbon Criteria Working Group Series*, Volume 3 (1997) [hereinafter *Criteria Working Group*].

2 **Water Solubility.** For aliphatics and aromatics EC groups, *Criteria Working Group.* For TPH components except n-hexane and MTBE, *1996 EPA Soil Screening Guidance: Technical Background Document.*

3 **Molecular Weight.** *Criteria Working Group.*

4 **Henry's Constant.** For aliphatics and aromatics EC groups, *Criteria Working Group.* For TPH components except n-hexane and MTBE, *1996 EPA Soil Screening Guidance: Technical Background Document.*

5 **Gram Formula Weight (GFW).** Based on 1000 x Molecular Weight.

6 **Density.** For aliphatics and aromatics EC groups, based on correlation between equivalent carbon number and data on densities of individual hazardous substances provided in *Criteria Working Group.* For TPH components except n-hexane and MTBE, *1996 EPA Soil Screening Guidance: Technical Background Document.*

7 **Soil Organic Carbon-Water Partitioning Coefficient.** For aliphatics and aromatics EC groups, *Criteria Working Group.* For TPH components except n-hexane and MTBE, *1996 EPA Soil Screening Guidance: Technical Background Document.*

8 **Total Xylenes.** Values for total xylenes are a weighted average of m, o and p xylene based on gasoline

composition data from the *Criteria Working Group* (m= 51% of total xylene; o= 28% of total xylene; and p=21% of total xylene).

9 **n-Hexane.** For values other than density, *Criteria Working Group*. For the density value, *Hawley's Condensed Chemical Dictionary,* 11th ed., revised by N. Irving Sax and Richard J. Lewis (1987).

10 **MTBE.** *USGS Final Report on Fuel Oxygenates* (March 1996).

Table 747-5
Residual Saturation Screening Levels for TPH.

Fuel	Screening Level (mg/kg)
Weathered Gasoline	1,000
Middle Distillates (e.g., Diesel No. 2 Fuel Oil)	2,000
Heavy Fuel Oils (e.g., No. 6 Fuel Oil)	2,000
Mineral Oil	4,000
Unknown Composition or Type	1,000

Note: The residual saturation screening levels for petroleum hydrocarbons specified in Table 747-5 are based on coarse sand and gravelly soils; however, they may be used for any soil type. Screening levels are based on the presumption that there are no preferential pathways for NAPL to flow downward to ground water. If such pathways exist, more stringent residual saturation screening levels may need to be established.

Table 749-1
Simplified Terrestrial Ecological Evaluation - Exposure Analysis Procedure under WAC 173-340-7492 (2)(a)(ii).[a]

Estimate the area of contiguous (connected) undeveloped land on the site or within 500 feet of any area of the site to the nearest 1/2 acre (1/4 acre if the area is less than 0.5 acre). "Undeveloped land" means land that is not covered by existing buildings, roads, paved areas or other barriers that will prevent wildlife from feeding on plants, earthworms, insects or other food in or on the soil.	
1) From the table below, find the number of points corresponding to the area and enter this number in the box to the right.	
Area (acres) Points 0.25 or less 4 0.5 5 1.0 6	

1.5	7	
2.0	8	
2.5	9	
3.0	10	
3.5	11	
4.0 or more	12	
2) Is this an industrial or commercial property? See WAC 173-340-7490 (3)(c). If yes, enter a score of 3 in the box to the right. If no, enter a score of 1.		
3) Enter a score in the box to the right for the habitat quality of the site, using the rating system shown below[b]. (High = 1, Intermediate = 2, Low = 3)		
4) Is the undeveloped land likely to attract wildlife? If yes, enter a score of 1 in the box to the right. If no, enter a score of 2. See footnote c.		
5) Are there any of the following soil contaminants present: Chlorinated dibenzo-p-dioxins/dibenzofurans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, benzene hexachloride, toxaphene, hexachlorobenzene, pentachlorophenol, pentachlorobenzene? If yes, enter a score of 1 in the box to the right. If no, enter a score of 4.		
6) Add the numbers in the boxes on lines 2 through 5 and enter this number in the box to the right. If this number is larger than the number in the box on line 1, the simplified terrestrial ecological evaluation may be ended under WAC 173-340-7492 (2)(a)(ii).		

Footnotes:

a It is expected that this habitat evaluation will be undertaken by an experienced field biologist. If this is not the case, enter a conservative score (1) for questions 3 and 4.

b Habitat rating system. Rate the quality of the habitat as high, intermediate or low based on your professional judgment as a field biologist. The following are suggested factors to consider in making this evaluation:
Low: Early successional vegetative stands; vegetation predominantly noxious, nonnative, exotic plant species or weeds. Areas severely disturbed by human activity, including intensively cultivated croplands. Areas isolated from other habitat used by wildlife.
High: Area is ecologically significant for one or more of the following reasons: Late-successional native plant communities present; relatively high species diversity; used by an uncommon or rare species; priority habitat (as defined by the Washington department of fish and wildlife); part of a larger area of habitat where size or fragmentation may be important for the retention of some species.
Intermediate: Area does not rate as either high or low.

c Indicate "yes" if the area attracts wildlife or is likely to do so. Examples: Birds frequently visit the area to feed; evidence of high use by mammals (tracks, scat, etc.); habitat "island" in an industrial area; unusual features of an area that make it important for feeding animals; heavy use during seasonal migrations.

Table 749-2
Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure.[a]

Priority contaminant	Soil concentration (mg/kg)	
	Unrestricted land use[b]	Industrial or commercial site

METALS[c]		
Antimony	See note d	See note d
Arsenic III	20 mg/kg	20 mg/kg
Arsenic V	95 mg/kg	260 mg/kg
Barium	1,250 mg/kg	1,320 mg/kg
Beryllium	25 mg/kg	See note d
Cadmium	25 mg/kg	36 mg/kg
Chromium (total)	42 mg/kg	135 mg/kg
Cobalt	See note d	See note d
Copper	100 mg/kg	550 mg/kg
Lead	220 mg/kg	220 mg/kg
Magnesium	See note d	See note d
Manganese	See note d	23,500 mg/kg
Mercury, inorganic	9 mg/kg	9 mg/kg
Mercury, organic	0.7 mg/kg	0.7 mg/kg
Molybdenum	See note d	71 mg/kg
Nickel	100 mg/kg	1,850 mg/kg
Selenium	0.8 mg/kg	0.8 mg/kg
Silver	See note d	See note d
Tin	275 mg/kg	See note d
Vanadium	26 mg/kg	See note d
Zinc	270 mg/kg	570 mg/kg
PESTICIDES		
Aldicarb/aldicarb sulfone (total)	See note d	See note d
Aldrin	0.17 mg/kg	0.17 mg/kg
Benzene hexachloride (including lindane)	10 mg/kg	10 mg/kg
Carbofuran	See note d	See note d
Chlordane	1 mg/kg	7 mg/kg
Chlorpyrifos/chlorpyrifos-methyl (total)	See note d	See note d
DDT/DDD/DDE (total)	1 mg/kg	1 mg/kg
Dieldrin	0.17 mg/kg	0.17 mg/kg
Endosulfan	See note d	See note d

Endrin	0.4 mg/kg	0.4 mg/kg
Heptachlor/heptachlor epoxide (total)	0.6 mg/kg	0.6 mg/kg
Hexachlorobenzene	31 mg/kg	31 mg/kg
Parathion/methyl parathion (total)	See note d	See note d
Pentachlorophenol	11 mg/kg	11 mg/kg
Toxaphene	See note d	See note d
OTHER CHLORINATED ORGANICS		
Chlorinated dibenzofurans (total)	3E-06 mg/kg	3E-06 mg/kg
Chlorinated dibenzo-p-dioxins (total)	5E-06 mg/kg	5E-06 mg/kg
Hexachlorophene	See note d	See note d
PCB mixtures (total)	2 mg/kg	2 mg/kg
Pentachlorobenzene	168 mg/kg	See note d
OTHER NONCHLORINATED ORGANICS		
Acenaphthene	See note d	See note d
Benzo(a)pyrene	30 mg/kg	300 mg/kg
Bis (2-ethylhexyl) phthalate	See note d	See note d
Di-n-butyl phthalate	200 mg/kg	See note d
PETROLEUM		
Gasoline Range Organics	200 mg/kg	12,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.
Diesel Range Organics	460 mg/kg	15,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.

Footnotes:

a Caution on misusing these chemical concentration numbers. These values have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. The table is not intended for purposes such as evaluating sludges or wastes.
This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site.

b Applies to any site that does not meet the definition of industrial or commercial.

c For arsenic, use the valence state most likely to be appropriate for site conditions, unless laboratory information is available. Where soil conditions alternate between saturated, anaerobic and unsaturated, aerobic states, resulting in the alternating presence of arsenic III and arsenic V, the arsenic III concentrations shall apply.

d Safe concentration has not yet been established. See WAC 173-340-7492 (2)(c).

Table 749-3

Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals[a]. For chemicals where a value is not provided, see footnote b.			
Note: These values represent soil concentrations that are expected to be protective at any MTCA site and are provided for use in eliminating hazardous substances from further consideration under WAC 173-340-7493 (2)(a)(i). Where these values are exceeded, various options are provided for demonstrating that the hazardous substance does not pose a threat to ecological receptors at a site, or for developing site-specific remedial standards for eliminating threats to ecological receptors. See WAC 173-340-7493 (1)(b)(i), 173-340-7493 (2)(a)(ii) and 173-340-7493(3).			
Hazardous Substance[b]	**Plants[c]**	**Soil biota[d]**	**Wildlife[e]**
METALS[f]:			
Aluminum (soluble salts)	50		
Antimony	5		
Arsenic III			7
Arsenic V	10	60	132
Barium	500		102
Beryllium	10		
Boron	0.5		
Bromine	10		
Cadmium	4	20	14
Chromium (total)	42[g]	42[g]	67
Cobalt	20		
Copper	100	50	217
Fluorine	200		
Iodine	4		
Lead	50	500	118
Lithium	35[g]		
Manganese	1,100[g]		1,500
Mercury, inorganic	0.3	0.1	5.5
Mercury, organic			0.4
Molybdenum	2		7
Nickel	30	200	980
Selenium	1	70	0.3
Silver	2		

Technetium	0.2		
Thallium	1		
Tin	50		
Uranium	5		
Vanadium	2		
Zinc	86[g]	200	360
PESTICIDES:			
Aldrin			0.1
Benzene hexachloride (including lindane)			6
Chlordane		1	2.7
DDT/DDD/DDE (total)			0.75
Dieldrin			0.07
Endrin			0.2
Hexachlorobenzene			17
Heptachlor/heptachlor epoxide (total)			0.4
Pentachlorophenol	3	6	4.5
OTHER CHLORINATED ORGANICS:			
1,2,3,4-Tetrachlorobenzene		10	
1,2,3-Trichlorobenzene		20	
1,2,4-Trichlorobenzene		20	
1,2-Dichloropropane		700	
1,4-Dichlorobenzene		20	
2,3,4,5-Tetrachlorophenol		20	
2,3,5,6-Tetrachloroaniline	20	20	
2,4,5-Trichloroaniline	20	20	
2,4,5-Trichlorophenol	4	9	
2,4,6-Trichlorophenol		10	
2,4-Dichloroaniline		100	
3,4-Dichloroaniline		20	
3,4-Dichlorophenol	20	20	
3-Chloroaniline	20	30	
3-Chlorophenol	7	10	

Chlorinated dibenzofurans (total)			2E-06
Chloroacetamide		2	
Chlorobenzene		40	
Chlorinated dibenzo-p-dioxins (total)			2E-06
Hexachlorocyclopentadiene	10		
PCB mixtures (total)	40		0.65
Pentachloroaniline		100	
Pentachlorobenzene		20	
OTHER NONCHLORINATED ORGANICS:			
2,4-Dinitrophenol	20		
4-Nitrophenol		7	
Acenaphthene	20		
Benzo(a)pyrene			12
Biphenyl	60		
Diethylphthalate	100		
Dimethylphthalate		200	
Di-n-butyl phthalate	200		
Fluorene		30	
Furan	600		
Nitrobenzene		40	
N-nitrosodiphenylamine		20	
Phenol	70	30	
Styrene	300		
Toluene	200		
PETROLEUM:			
Gasoline Range Organics		100	5,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.
Diesel Range Organics		200	6,000 mg/kg except that the concentration shall not exceed residual saturation at the soil surface.

Footnotes:

a Caution on misusing ecological indicator concentrations. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. Natural background concentrations may be substituted for ecological indicator concentrations provided in this table. The table is not intended for purposes such as evaluating sludges or wastes.
This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site.

b For hazardous substances where a value is not provided, plant and soil biota indicator concentrations shall be based on a literature survey conducted in accordance with WAC 173-340-7493(4) and calculated using methods described in the publications listed below in footnotes c and d. Methods to be used for developing wildlife indicator concentrations are described in Tables 749-4 and 749-5.

c Based on benchmarks published in *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision*, Oak Ridge National Laboratory, 1997.

d Based on benchmarks published in *Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process*, Oak Ridge National Laboratory, 1997.

e Calculated using the exposure model provided in Table 749-4 and chemical-specific values provided in Table 749-5. Where both avian and mammalian values are available, the wildlife value is the lower of the two.

f For arsenic, use the valence state most likely to be appropriate for site conditions, unless laboratory information is available. Where soil conditions alternate between saturated, anaerobic and unsaturated, aerobic states, resulting in the alternating presence of arsenic III and arsenic V, the arsenic III concentrations shall apply.

g Benchmark replaced by Washington state natural background concentration.

Table 749-4
Wildlife Exposure Model for Site-specific Evaluations.[a]

Plant	
K_{Plant}	Plant uptake coefficient (dry weight basis)
	Units: mg/kg plant/mg/kg soil
	Value: chemical-specific (see Table 749-5)
Soil biota Surrogate receptor: Earthworm	
BAF_{Worm}	Earthworm bioaccumulation factor (dry weight basis)
	Units: mg/kg worm/mg/kg soil
	Value: chemical-specific (see Table 749-5)
Mammalian predator Surrogate receptor: Shrew (*Sorex*)	
$P_{SB\ (shrew)}$	Proportion of contaminated food (earthworms) in shrew diet
	Units: unitless
	Value: 0.50
$FIR_{Shrew,DW}$	Food ingestion rate (dry weight basis)
	Units: kg dry food/kg body weight - day
	Value: 0.45
$SIR_{Shrew,DW}$	Soil ingestion rate (dry weight basis)
	Units: kg dry soil/kg body weight - day
	Value: 0.0045

$RGAF_{Soil, shrew}$	Gut absorption factor for a hazardous substance in soil expressed relative to the gut absorption factor for the hazardous substance in food.	
	Units: unitless	
	Value: chemical-specific (see Table 749-5)	
T_{Shrew}	Toxicity reference value for shrew	
	Units: mg/kg - day	
	Value: chemical-specific (see Table 749-5)	
Home range	0.1 Acres	
Avian predator Surrogate receptor: American robin (*Turdus migratorius*)		
$P_{SB\ (Robin)}$	Proportion of contaminated food (soil biota) in robin diet	
	Unit: unitless	
	Value: 0.52	
$FIR_{Robin,DW}$	Food ingestion rate (dry weight basis)	
	Units: kg dry food/kg body weight - day	
	Value: 0.207	
$SIR_{Robin,DW}$	Soil ingestion rate (dry weight basis)	
	Units: kg dry soil/kg body weight - day	
	Value: 0.0215	
$RGAF_{Soil, robin}$	Gut absorption factor for a hazardous substance in soil expressed relative to the gut absorption factor for the hazardous substance in food.	
	Units: unitless	
	Value: chemical-specific (see Table 749-5)	
T_{Robin}	Toxicity reference value for robin	
	Units: mg/kg - day	
	Value: chemical-specific (see Table 749-5)	
Home range	0.6 Acres	
Mammalian herbivore Surrogate receptor: Vole (*Microtus*)		
$P_{Plant, vole}$	Proportion of contaminated food (plants) in vole diet	
	Units: unitless	
	Value: 1.0	
$FIR_{Vole,DW}$	Food ingestion rate (dry weight basis)	

	Units: kg dry food/kg body weight - day
	Value: 0.315
$SIR_{Vole,DW}$	Soil ingestion rate (dry weight basis)
	Units: kg dry soil/kg body weight - day
	Value: 0.0079
$RGAF_{Soil,\ vole}$	Gut absorption factor for a hazardous substance in soil expressed relative to the gut absorption factor for the hazardous substance in food.
	Units: unitless
	Value: chemical-specific (see Table 749-5)
T_{Vole}	Toxicity reference value for vole
	Units: mg/kg - day
	Value: chemical-specific (see Table 749-5)
Home range	0.08 Acres
Soil concentrations for wildlife protection[b]	
(1) Mammalian predator: $SC_{MP} = (T_{Shrew})/[(FIR_{Shrew,DW} \times P_{SB\ (shrew)} \times BAF_{Worm}) + (SIR_{Shrew,DW} \times RGAF_{Soil,\ shrew})]$	
(2) Avian predator: $SC_{AP} = (T_{Robin})/[(FIR_{Robin,DW} \times P_{SB\ (Robin)} \times BAF_{Worm}) + (SIR_{Robin,DW} \times RGAF_{Soil,\ robin})]$	
(3) Mammalian herbivore: $SC_{MH} = (T_{Vole})/[(FIR_{Vole,DW} \times P_{Plant,\ vole} \times K_{Plant}) + (SIR_{Vole,DW} \times RGAF_{Soil,\ vole})]$	

Footnotes:

a Substitutions for default receptors may be made as provided for in WAC 173-340-7493(7). If a substitute species is used, the values for food and soil ingestion rates, and proportion of contaminated food in the diet, may be modified to reasonable maximum exposure estimates for the substitute species based on a literature search conducted in accordance with WAC 173-340-7493(4).
Additional species may be added on a site-specific basis as provided in WAC 173-340-7493 (2)(a).
The department shall consider proposals for modifications to default values provided in this table based on new scientific information in accordance with WAC 173-340-702(14).

b Use the lowest of the three concentrations calculated as the wildlife value.

Table 749-5
Default Values for Selected Hazardous Substances for use with the Wildlife Exposure Model in Table 749-4.[a]

			Toxicity reference value (mg/kg - d)		
Hazardous Substance	**BAF_{Worm}**	**K_{Plant}**	**Shrew**	**Vole**	**Robin**
METALS:					
Arsenic III	1.16	0.06	1.89	1.15	
Arsenic V	1.16	0.06	35	35	22
Barium	0.36		43.5	33.3	

Cadmium	4.6	0.14	15	15	20
Chromium	0.49		35.2	29.6	5
Copper	0.88	0.020	44	33.6	61.7
Lead	0.69	0.0047	20	20	11.3
Manganese	0.29		624	477	
Mercury, inorganic	1.32	0.0854	2.86	2.18	0.9
Mercury, organic	1.32		0.352	0.27	0.064
Molybdenum	0.48	1.01	3.09	2.36	35.3
Nickel	0.78	0.047	175.8	134.4	107
Selenium	10.5	0.0065	0.725	0.55	1
Zinc	3.19	0.095	703.3	537.4	131
PESTICIDES:					
Aldrine	4.77	0.007[b]	2.198	1.68	0.06
Benzene hexachloride (including lindane)	10.1				7
Chlordane	17.8	0.011[b]	10.9	8.36	10.7
DDT/DDD/DDE	10.6	0.004[b]	8.79	6.72	0.87
Dieldrin	28.8	0.029[b]	0.44	0.34	4.37
Endrin	3.6	0.038[b]	1.094	0.836	0.1
Heptachlor/heptachlor epoxide	10.9	0.027[b]	2.857	2.18	0.48
Hexachlorobenzene	1.08				2.4
Pentachlorophenol	5.18	0.043[b]	5.275	4.03	
OTHER CHLORINATED ORGANICS:					
Chlorinated dibenzofurans	48				1.0E-05
Chlorinated dibenzo-p-dioxins	48	0.005[b]	2.2E-05	1.7E-05	1.4E-04
PCB mixtures	4.58	0.087[b]	0.668	0.51	1.8
OTHER NONCHLORINATED ORGANICS:					
Benzo(a)pyrene	0.43	0.011	1.19	0.91	

Footnotes:

a For hazardous substances not shown in this table, use the following default values. Alternatively, use values established from a literature survey conducted in accordance with WAC 173-340-7493(4) and approved by the department.

K_{Plant}: Metals (including metalloid elements): 1.01
Organic chemicals: $K_{Plant}=10^{(1.588-(0.578\log Kow))}$,
where log K_{ow} is the logarithm of the octanol-water partition coefficient.

BAF_{Worm}: Metals (including metalloid elements): 4.6
Nonchlorinated organic chemicals:

log $K_{ow} < 5$: 0.7
log $K_{ow} > 5$: 0.9
Chlorinated organic chemicals:
log $K_{ow} < 5$: 4.7
log $K_{ow} > 5$: 11.8

$RGAF_{Soil}$ (all receptors): 1.0
Toxicity reference values (all receptors): Values established from a literature survey conducted in accordance with WAC 173-340-7493(4).

Site-specific values may be substituted for default values, as described below:

K_{Plant} Value from a literature survey conducted in accordance with WAC 173-340-7493(4) or from empirical studies at the site.

BAF_{Worm} Value from a literature survey conducted in accordance with WAC 173-340-7493(4) or from empirical studies at the site.

$RGAF_{Soil}$ (all receptors): Value established from a literature survey conducted in accordance with WAC 173-340-7493(4).
Toxicity reference values (all receptors): Default toxicity reference values provided in this table may be replaced by a value established from a literature survey conducted in accordance with WAC 173-340-7493(4).

b Calculated from log K_{ow} using formula in footnote a.

Table 830-1
Required Testing for Petroleum Releases.

	Gasoline Range Organics (GRO) (1)	Diesel Range Organics (DRO) (2)	Heavy Oils (DRO) (3)	Mineral Oils (4)	Waste Oils and Unknown Oils (5)
Volatile Petroleum Compounds					
Benzene	X (6)	X (7)			X (8)
Toluene	X (6)	X (7)			X (8)
Ethyl benzene	X (6)	X (7)			X (8)
Xylenes	X (6)	X (7)			X (8)
n-Hexane	X (9)				
Fuel Additives and Blending Compounds					
Dibromoethane, 1-2 (EDB); and Dichloroethane, 1-2 (EDC)	X (10)				X (8)
Methyl tertiary-butyl ether (MTBE)	X (11)				X (8)
Total lead &other additives	X (12)				X (8)
Other Petroleum Components					
Carcinogenic PAHs		X (13)	X (13)		X (8)
Naphthalenes	X (14)	X (14)	X (14)		X (14)
Other Compounds					
Polychlorinated Biphenyls (PCBs)			X (15)	X (15)	X (8)

Halogenated Volatile Organic Compounds (VOCs)					X [8]
Other	X [16]	X [16]	X [16]	X [16]	X [16]
Total Petroleum Hydrocarbons Methods					
TPH Analytical Method for Total TPH (Method A Cleanup Levels) (17)	NWTPH-Gx	NWTPH-Dx	NWTPH-Dx	NWTPH-Dx	NWTPH-Gx & NWTPH-Dx
TPH Analytical Methods for TPH fractions (Methods B or C) (17)	VPH	EPH	EPH	EPH	VPH and EPH

Use of Table 830-1: An "X" in the box means that the testing requirement applies to ground water and soil if a release is known or suspected to have occurred to that medium, unless otherwise specified in the footnotes. A box with no "X" indicates (except in the last two rows) that, for the type of petroleum product release indicated in the top row, analyses for the hazardous substance(s) named in the far-left column corresponding to the empty box are not typically required as part of the testing for petroleum releases. However, such analyses may be required based on other site-specific information. Note that testing for Total Petroleum Hydrocarbons (TPH) is required for every type of petroleum release, as indicated in the bottom two rows of the table. The testing method for TPH depends on the type of petroleum product released and whether Method A or Method B or C is being used to determine TPH cleanup levels. See WAC 173-340-830 for analytical procedures. **The footnotes to this table are important for understanding the specific analytical requirements for petroleum releases.**

Footnotes:

(1) The following petroleum products are common examples of GRO: automotive and aviation gasolines, mineral spirits, stoddard solvents, and naphtha. To be in this range, 90 percent of the petroleum components need to be quantifiable using the NWTPH-Gx; if NWTPH-HCID results are used for this determination, then 90 percent of the "area under the TPH curve" must be quantifiable using NWTPH-Gx. Products such as jet fuel, diesel No. 1, kerosene, and heating oil may require analysis as both GRO and DRO depending on the range of petroleum components present (range can be measured by NWTPH-HCID). (See footnote 17 on analytical methods.)

(2) The following petroleum products are common examples of DRO: Diesel No. 2, fuel oil No. 2, light oil (including some bunker oils). To be in this range, 90 percent of the petroleum components need to be quantifiable using the NWTPH-Dx quantified against a diesel standard. Products such as jet fuel, diesel No. 1, kerosene, and heating oil may require analysis as both GRO and DRO depending on the range of petroleum components present as measured in NWTPH-HCID.

(3) The following petroleum products are common examples of the heavy oil group: Motor oils, lube oils, hydraulic fluids, etc. Heavier oils may require the addition of an appropriate oil range standard for quantification.

(4) Mineral oil means non-PCB mineral oil, typically used as an insulator and coolant in electrical devices such as transformers and capacitors.

(5) The waste oil category applies to waste oil, oily wastes, and unknown petroleum products and mixtures of petroleum and nonpetroleum substances. Analysis of other chemical components (such as solvents) than those listed may be required based on site-specific information. Mixtures of identifiable petroleum products (such as gasoline and diesel, or diesel and motor oil) may be analyzed based on the presence of the individual products, and need not be treated as waste and unknown oils.

(6) When using Method A, testing soil for benzene is required. Furthermore, testing ground water for BTEX is necessary when a petroleum release to ground water is known or suspected. If the ground water is tested and toluene, ethyl benzene or xylene is in the ground water above its respective Method A cleanup level, the soil must also be tested for that chemical. When using Method B or C, testing the soil for BTEX is required and testing for BTEX in ground water is required when a release to ground water is known or suspected.

(7)(a) For DRO releases from other than home heating oil systems, follow the instructions for GRO releases in Footnote (6).

(b) For DRO releases from typical home heating oil systems (systems of 1,100 gallons or less storing heating oil for residential consumptive use on the premises where stored), testing for BTEX is not usually required for either ground water or soil. Testing of the ground water is also not usually required for these systems; however, if the ground water is tested and benzene is found in the ground water, the soil must be tested for benzene.

(8) Testing is required in a sufficient number of samples to determine whether this chemical is present at concentrations of concern. If the chemical is found to be at levels below the applicable cleanup level, then no further analysis is required.

(9) Testing for n-hexane is required when VPH analysis is performed for Method B or C. In this case, the concentration of n-hexane should be deleted from its respective fraction to avoid double-counting its concentration. n-Hexane's contribution to overall toxicity is then evaluated using its own reference dose.

(10) Volatile fuel additives (such as dibromoethane, 1 - 2 (EDB) (CAS# 106-93-4) and dichloroethane, 1 - 2 (EDC) (CAS# 107-06-2)) must be part of a volatile organics analysis (VOA) of GRO contaminated ground water. If any is found in ground

water, then the contaminated soil must also be tested for these chemicals.

(11) Methyl tertiary-butyl ether (MTBE) (CAS# 1634-04-4) must be analyzed in GRO contaminated ground water. If any is found in ground water, then the contaminated soil must also be tested for MTBE.

(12)(a) For automotive gasoline where the release occurred prior to 1996 (when "leaded gasoline" was used), testing for lead is required unless it can be demonstrated that lead was not part of the release. If this demonstration cannot be made, testing is required in a sufficient number of samples to determine whether lead is present at concentrations of concern. Other additives and blending compounds of potential environmental significance may need to be considered for testing, including: tertiary-butyl alcohol (TBA); tertiary-amyl methyl ether (TAME); ethyl tertiary-butyl ether (ETBE); ethanol; and methanol. Contact the department for additional testing recommendations regarding these and other additives and blending compounds.

(b) For aviation gasoline, racing fuels and similar products, testing is required for likely fuel additives (especially lead) and likely blending compounds, no matter when the release occurred.

(13) Testing for carcinogenic PAHs is required for DRO and heavy oils, except for the following products for which adequate information exists to indicate their absence: Diesel No. 1 and 2, home heating oil, kerosene, jet fuels, and electrical insulating mineral oils. The carcinogenic PAHs include benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, benzo(k)fluoranthene, benzo(a)anthracene, and benzo(b)fluoranthene.

(14)(a) Except as noted in (b) and (c), testing for the noncarcinogenic PAHs, including the "naphthalenes" (naphthalene, 1-methyl-naphthalene, and 2-methyl-naphthalene) is not required when using Method A cleanup levels, because they are included in the TPH cleanup level.

(b) Testing of soil for naphthalenes is required under Methods B and C when the inhalation exposure pathway is evaluated.

(c) If naphthalenes are found in ground water, then the soil must also be tested for naphthalenes.

(15) Testing for PCBs is required unless it can be demonstrated that: (1) the release originated from an electrical device manufactured for use in the United States after July 1, 1979; (2) oil containing PCBs was never used in the equipment suspected as the source of the release (examples of equipment where PCBs are likely to be found include transformers, electric motors, hydraulic systems, heat transfer systems, electromagnets, compressors, capacitors, switches and miscellaneous other electrical devices); or, (3) the oil released was recently tested and did not contain PCBs.

(16) Testing for other possible chemical contaminants may be required based on site-specific information.

(17) The analytical methods NWTPH-Gx, NWTPH-Dx, NWTPH-HCID, VPH, and EPH are methods published by the department of ecology and available on the department's internet web site: http://www.ecy.wa.gov/programs/tcp/cleanup.html.

Background Document

Background Document

For The
Proposed Amendments to the
Model Toxics Control Act
Cleanup Regulation
Chapter 173-340 WAC

Washington State Department of Ecology
Toxics Cleanup Program

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This Background Document is available on the Department of Ecology's website at: http://www.ecy.wa.gov/programs/tcp/regs/amend_2007/proposed_amend.html

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Table of Contents

List of Abbreviations and Acronyms

General

ARARs	Applicable or Relevant and Appropriate Requirements
ASTSWMO	Association of State & Territorial Solid Waste Management Officials
B(a)P	Benzo[a]pyrene
Cal EPA	California Environmental Protection Agency
CLARC	Cleanup Levels and Risk Calculation Guidance Document
CDDs	Polychlorinated dibenzo-p-dioxins
CDFs	Polychlorinated dibenzofurans
Ecology	Washington Department of Ecology
EPA	United States Environmental Protection Agency
HpCB	Heptachlorobiphenol
HpCDD	Heptachlorodibenzo-p-dioxin
HpCDF	Heptachlorodibenzofuran
HxCB	Hexachlorobiphenyl
HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlordibenzofuran
IRIS	Integrated Risk Information System
MTCA	Model Toxics Control Act
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PeCB	Pentachlorobiphenyl
PeCDD	Pentachlorodibenzo-p-dioxin
PeCDF	Pentachlorodibenzofuran
PEF	Potency Equivalency Factor
OCDD	Octachlorodibenzo-p-dioxin
ODCF	Octoachlorodibenzofuran
RPF	Relative Potency Factor
TCDD	2, 3, 7, 8-Tetrachlorodibenzo-p-dioxin
TeCB	Tetrachlorobiphenyl
TCP	Toxics Cleanup Program
TEC	Toxicity Equivalent Concentration
TEF	Toxicity Equivalency Factor
TEQ	Total toxicity equivalent concentration or total toxicity equivalence
WAC	Washington Administrative Code
WHO	World Health Organization
10^{-6}; 1×10^{-6}	One in one million risk level
10^{-5}; 1×10^{-5}	One in one hundred thousand risk level

Weight and Concentration Units

kg	Kilogram
g	Gram, one thousandth of a kilogram, 1×10^{-3} kg
mg	Milligram, one-millionth of a kilogram, 1×10^{-6} kg
µg	Microgram, one-billionth of a kilogram, 1×10^{-9} kg
ng	Nanogram, one-trillionth of a kilogram, 1×10^{-12} kg
pg	Picogram, one-quadrillionth of a kilogram, 1×10^{-15} kg

ppm	Parts per million (mg/kg; mg/L)
ppb	Parts per billion (µg/kg; µg/L)
ppt	Parts per trillion (ng/kg; ng/L)
ppq	Parts per quadrillion (pg/kg; pg/L)

1 Introduction

1.1 Overview

The Department of Ecology (Ecology) is proposing to amend the Model Toxics Control Act (MTCA) Cleanup Regulation (Chapter 173-340 WAC). This rulemaking will update and clarify the policies and procedures for establishing cleanup levels for mixtures of polychlorinated dibenzo-p-dioxins/ polychlorinated dibenzofurans, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).

The MTCA Cleanup Regulation currently specifies that cleanup proponents may use an Environmental Protection Agency (EPA) methodology to characterize mixtures of dioxins and furans. In 2001, Ecology published guidance explaining how to use the EPA methodology to establish cleanup levels for dioxin and furan mixtures. A recent lawsuit raised issues related to the applicability of this guidance under the regulation. At the same time, several environmental groups petitioned Ecology to incorporate the guidance into the rule. In response to these events, Ecology decided to explicitly define in the rule how the federal methodology should be used within the MTCA regulatory framework.

Ecology has prepared this document to assist public review and discussion of the MTCA rule revisions being considered by the Toxics Cleanup Program (TCP). Specifically, the document is designed to achieve two main purposes:

- Describe the revisions that Ecology plans to make to the MTCA Cleanup Regulation.
- Describe the key rulemaking issues that Ecology considered when preparing the proposed rule revisions, options for resolving those issues and Ecology's rationale for choosing particular options when preparing the draft rule revisions.

1.2 Reasons for the Rulemaking

The Model Toxics Control Act was passed by Washington voters in November 1988. The law establishes the basic authorities and requirements for cleaning up contaminated sites. Ecology originally adopted cleanup standards in February 1991. Ecology completed significant changes to the cleanup standards in February 2001.

Under the revised rule, a person undertaking a cleanup action may use the Environmental Protection Agency's toxicity equivalency factor (TEF) values and methodology when assessing dioxin and furan mixtures. In November 2001, Ecology published a guidance document, the Cleanup Levels and Risk Calculations (CLARC), that explains how to use the TEF methodology when establishing cleanup levels.

In November 2005, the Rayonier Corporation filed a lawsuit challenging Ecology's use of the guidance document at the Port Angeles mill site. Rayonier's argument was the MTCA rule requires Ecology to establish cleanup levels for each dioxin congener. This was based on using a cancer risk level of one-in-one million (or 10^{-6}), as opposed to applying 10^{-6} risk level to the whole mixture.

In April 2006, Ecology settled the lawsuit and agreed that Rayonier's approach was also a plausible interpretation of the current MTCA rule. Ecology agreed to settle the lawsuit. Since neither the current MTCA rule nor the federal guidance referenced in the MTCA rule clearly requires the procedures in the CLARC guidance.

Along with settlement discussions, several environmental groups presented a rulemaking petition to Ecology in March 2006. These groups requested that Ecology amend the rule to clarify that policies and procedures in the Ecology guidance be used when establishing cleanup levels for dioxins/furans and other similar mixtures.

Ecology reviewed the rulemaking petition and decided to begin a focused rulemaking process to address the issues raised in the lawsuit and rulemaking petition. Specifically, Ecology decided to define in the rule how the federal methodology should be used within the MTCA regulatory framework. Furthermore, Ecology decided that amending the MTCA rule to explicitly define key policy choices is preferable to repeatedly resolving those policies on a site-specific basis.

1.3 Rulemaking Process

Ecology began the rulemaking process on June 7, 2006. This process began with filing the CR-101 with the Office of the Code Reviser. Later that month, Ecology prepared draft rule language that was distributed to interested parties for review and comment. Ecology held several meetings to discuss the draft rule language and key rulemaking issues.

Ecology received many comments on the draft rule language. Ecology also held four meetings with the MTCA Science Advisory Board to discuss key rulemaking issues. Ecology has modified the June draft rule language based on the comments received from the public and the MTCA Science Advisory Board.

Ecology published the proposed rule for formal public comment on April 4, 2007. Public hearings will be held in May. Ecology will then review the public comments and make a final decision on the rule amendments.

1.4 Relationship to Five-Year Rule Review

Ecology's actions to clarify the methods and procedures for evaluating mixtures of dioxins/furans, PAHs, and PCBs is the first phase of a two-phase rulemaking process. In the second phase of the process, Ecology will conduct the five-year review process specified in the MTCA rule. WAC 173-340-702 (11) states Ecology will review and, as appropriate, update WAC 173-340-700 through 173-340-760 at least once every five years.

Ecology plans to initiate the five-year rule review process in 2007 following the completion of this focused rulemaking. As part of the review process, Ecology plans to hold several scoping meetings to obtain recommendations on issues and/or rule provisions. Ecology will review the public comments and then decide (1) whether to begin a second rulemaking phase and (2) what issues will be addressed during the second rulemaking phase.

1.5 Organization of the Document

The remaining parts of this document are organized into the following sections:

- **Section 2 – Background Information:** This section provides a brief summary of the MTCA Cleanup Regulation and the TEF methodology and describes how the TEF methodology has been used to establish cleanup levels.
- **Section 3 - Description of the Proposed Rule Revisions**: This section summarizes the rule revisions that Ecology is considering during the rulemaking process. This section also provides a comparison of cleanup levels under the current and proposed rule language.
- **Section 4 – Rulemaking Issues:** This section provides a discussion of ten key policy and technical issues central to this rulemaking effort. The section is divided into ten subsections (one issue per subsection) that include:
  - A brief description of the issue.
  - The options for resolving the issue.
  - Ecology's preferred option and the rationale for choosing that option.
- **Section 5 – References**
- **Section 6 – Representative Structural Formulas**

2 Background Information

2.1 Statutory Background

The Model Toxics Control Act (Initiative 97), Chapter 70.105D RCW, was passed by the voters of the State of Washington in November 1988 and became effective March 1, 1989. The law establishes the basic authorities and requirements for cleaning up contaminated sites in a manner that will protect human health and the environment.

As a general declaration of policy, MTCA, chapter 70.105D RCW, states that:

> Each person has a fundamental and inalienable right to a healthful environment, and each person has a responsibility to preserve and enhance that right. The beneficial stewardship of the land, air, and waters of the state is a solemn obligation of the present generation for the benefit of future generations.

The statute also states that:

> A healthful environment is now threatened by the irresponsible use and disposal of hazardous substances. There are hundreds of hazardous waste sites in this state, and more will be created if current waste practices continue. Hazardous waste sites threaten the state's water resources, including those used for public drinking water. Many of our municipal landfills are current or potential hazardous waste sites and present serious threats to human health and the environment. (RCW 70.105D.010(1))

The main purpose of MTCA is to prevent or remedy these threats to human health and the environment.[1] To achieve these statutory goals, MTCA establishes a wide range of duties and responsibilities for Ecology. The law directs Ecology "to immediately implement all provisions of this chapter to the maximum extent practicable, including investigative and remedial actions where appropriate." (RCW 70.105D.030(2)). In particular, MTCA requires Ecology to adopt, and thereafter enforce, rules under chapter 34.05 RCW. Ecology must:

> Publish and periodically update minimum cleanup standards for remedial actions at least as stringent as the cleanup standards under section 121 of the federal cleanup law, 42 U.S.C. Sec. 9621, and at least as stringent as all applicable state and federal laws, including health-based standards under state and federal law[.][2]

2.2 MTCA Cleanup Standards – The Current Rule

Ecology originally adopted cleanup standards in 1991 ("MTCA Cleanup Regulations" or MTCA Rule"). Ecology completed significant changes to the cleanup standards in February 2001. Under the current MTCA rules, there are three methods (Methods A, B and C) for establishing cleanup levels.

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[1] MTCA's general declaration of policy states "[t]he main purpose of [the law]is to raise sufficient funds to clean up all hazardous waste sites and to prevent the creation of future hazards due to improper disposal of toxic wastes into the state's land and waters." (RCW 70.105D.010(2))

[2] The federal cleanup law referenced in MTCA is the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) 42 U.S.C. 9601 et seq.

- ***Method A*** can be used to establish cleanup levels at relatively small sites that involve few contaminants. Under Method A, cleanup levels must be at least as stringent as the following:
  - Applicable & Relevant & Appropriate Requirements (ARARs). MTCA requires that cleanup levels must be at least as stringent as requirements in other applicable state and federal laws and regulations. For example, Method A cleanup levels must be at least as strict as any applicable surface water quality standards in the National Toxics Rule.
  - Method A Tables. Cleanup levels are listed in Tables 720-1, 740-1, and 745-1. These tables provide values for carcinogenic PAHs and PCBs but not for dioxins and furans.
  - Plants and Wildlife. Concentrations that result in no significant adverse effects on the protection and propagation of terrestrial ecological receptors using the procedures in WAC 173-340-7490 through WAC 173-340-7493, unless it is demonstrated under those sections that establishing a soil concentration is unnecessary.
- ***Method B*** can be used to establish cleanup levels at any site. Under Method B, cleanup levels must be at least as stringent as the following:
  - Applicable & Relevant & Appropriate Requirement (ARARs). Standards in applicable state and federal laws. MTCA requires that cleanup levels must be at least as stringent as requirements in other applicable state and federal laws and regulations. For example, Method B cleanup levels must be at least as strict as any applicable surface water quality standards in the National Toxics Rule.
  - Risk-Based Cleanup Levels. Cleanup levels calculated using the methods in WAC 173-340-720 through 173-340-750.
    - Individual Hazardous Substances. The cancer risk for individual substances cannot exceed one in one million (10^{-6}). The non-cancer risk for individual substances cannot exceed a hazard quotient of one.
    - Total Site Risk. The total site risk for carcinogens cannot exceed one-in-one hundred thousand (10^{-5}). Non-cancer total site risk cannot exceed a hazard quotient of one. The MTCA rules require that the cleanup levels established for individual substances be adjusted downward if the total risk posed by the entire mixture exceeds either of these limits. Total site risk includes consideration of multiple hazardous substances and multiple pathways of exposure.
  - Plants and Wildlife. Concentrations that are estimated to result in no adverse effects on the protection and propagation of aquatic life and no significant adverse effects on terrestrial ecological receptors using the procedures in WAC 173-340-7490 through WAC 173-340-7493.
- ***Method C*** can be used to establish cleanup levels in limited situations—typically for soil cleanup levels for industrial land uses. Method C cleanup levels must be at least as stringent as the following:
  - Applicable & Relevant & Appropriate Requirements (ARARs). MTCA requires that cleanup levels must be at least as stringent as requirements in other applicable state and federal laws and regulations. For example, Method C cleanup levels must be at least as strict as any applicable surface water quality standards in the National Toxics Rule.

- Risk-Based Cleanup Levels. Cleanup levels calculated using the methods in WAC 173-340-720 through 173-340-750.
  - Individual Hazardous Substances. The cancer risk for individual substances cannot exceed one in one hundred thousand (10^{-5}). The non-cancer risk for individual substances cannot exceed a hazard quotient of one.
  - Total Site Risk. The total site risk for carcinogens cannot exceed one-in-one hundred thousand (10^{-5}). Non-cancer total site risk cannot exceed a hazard index of one (1). The MTCA rules require that the cleanup levels established for individual substances be adjusted downward if the total risk posed by the entire mixture exceeds either of these limits. Total site risk includes consideration of multiple hazardous substances and multiple pathways of exposure.
- Plants and Wildlife. Concentrations that are estimated to result in no significant adverse effects on the protection and propagation of aquatic life, and no significant adverse effects on wildlife using the procedures in WAC 173-340-7490 through WAC 173-340-7493.

2.3 Toxicity Equivalency Factors (TEFs)3

People and other organisms are exposed to a wide range of complex environmental mixtures. However, toxicological information is available for only a limited number of individual chemicals in those mixtures. This makes it very difficult to for scientists to characterize the toxicity of the whole mixture. Over the last 20 years, scientists have developed several approaches for evaluating and characterizing the toxicity of mixtures.

One of the most frequently-used approaches is the "Toxicity Equivalency Factor" or "TEF" methodology (see Figure 1). Under this approach, the toxicity of one member of the chemical group is selected as the index chemical. The remaining members of the chemical group are assigned TEF values which provide an order of magnitude estimate of toxicity or cancer potency relative to an index chemical. The toxicity of each member of the chemical group is evaluated by multiplying the concentration of that member by its TEF value. The product is called the toxicity equivalent concentration. The whole mixture can be characterized by as the sum of these toxicity equivalent concentrations. This is often referred to as the total toxicity equivalent concentration (TTEC) or the total toxic equivalence (TEQ) of the chemical mixture. In this way, the health risks posed by the whole mixture can be assessed using the TEQ and the toxicological information for the index chemical.

[3] For the purposes of this document, the toxicity equivalency factor (TEF), potency equivalency factor (PEF), and relative equivalency factor (REF) are all referred to as "toxicity equivalency factor" or "TEF"

Figure 1: Characterizing Dioxin and Furan Mixtures

$$\text{Total Toxicity Equivalence (TEQ)} = \sum C_n * TEF_n$$

Where:

TEQ = Total Toxicity Equivalence

TEF_n = Toxic equivalency factor of the individual congener associated with its respective mixture

C_n = Concentration of the individual congener in the mixture

Dioxins and furans are generally present in the environment as a complex mixture of chemical "congeners" that differ in terms of the number and location of chlorine atoms. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD = index chemical) is the most toxic and best-studied of the 210 polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran congeners (CDDs and CDFs). EPA first adopted the TEF methodology as an interim procedure for evaluating the toxicity and risks associated with exposures to dioxin and furan mixtures (EPA, 1987, 1989). The majority of state, federal and international environmental agencies currently use the TEF values developed by the World Health Organization (Van den Berg, et al., 1998) when evaluating the health risks posed by dioxin/furan mixtures.

Polycyclic aromatic hydrocarbons (PAHs) are a group of chemicals formed during the incomplete burning of organic materials such as wood, garbage, oil, coal, gas and tobacco. There are more than 100 different PAHs. EPA (1993) published provisional guidance for evaluating the carcinogenic risks associated with PAH mixtures using a relative potency factor (RPF) approach. The EPA (1993) approach uses benzo(a)pyrene [BaP] as the index chemical (i.e., having a relative potency of 1.0) and includes RPF values for seven (7) carcinogenic PAHs. The California Environmental Protection Agency (Cal EPA, 1994) expanded upon the EPA approach when it developed Potency Equivalency Factors (PEFs) for use in evaluating PAH mixtures. The Cal EPA approach also uses BaP as the index chemical and includes PEFs for twenty-two (22) carcinogenic PAHs[4].

In February 2001, Ecology revised WAC 173-340-708(8) by adding new provisions applicable to mixtures of chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans, and polycyclic aromatic hydrocarbons:

- Chlorinated Dioxins/Furans. WAC 173-340-708(8)(d) states that cleanup proponents may use EPA's TEF values and methodology when assessing the potential carcinogenic risk of mixtures of chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans. Under the EPA methodology, 2,3,7,8 TCDD is the index chemical. The total toxicity equivalent concentration of the mixture is represented by the sum of the products of the TEF and the concentration of the respective dioxin or furan congener.

[4] In 2001, Ecology amended the MTCA rule to explicitly authorize use of the Cal EPA (1994) methodology to evaluate the toxicity and assess the risks from exposure to carcinogenic PAH mixtures.

- Polycyclic Aromatic Hydrocarbons (PAHs). WAC 173-340-708(8)(d) states that cleanup proponents may use the Relative Potency Factors (RPFs) and methodology developed by the California EPA (Cal-EPA) when assessing the potential carcinogenic risk of mixtures of cPAH. Under the Cal-EPA methodology, benzo[a]pyrene (B[a]P) is the index chemical. The total toxicity equivalent concentration of the mixture is represented by the sum of the products of the TEF and the respective cPAH compound concentrations.

2.4 Two Approaches Have Been Used to Set Cleanup Levels with the TEF Methodology

The current MTCA rule does not clearly specify how the TEF methodology must be used when calculating cleanup levels for mixtures of dioxins/furans and PAHs. Two approaches have been used to establish cleanup levels using the EPA TEF methodology under the MTCA rule:

- Cleanup Levels Established for the Whole Mixture. In November 2001, Ecology published guidance[5] on how to use the TEF methodology when establishing and evaluating compliance with MTCA cleanup levels. The guidance includes the following approach:
  - Analyze a sample from the medium of concern to determine the congeners (or cPAH) and the concentration of each congener (or cPAH);
  - Multiply each congener (or cPAH) concentration identified in the sample by the applicable toxicity equivalency factor to obtain a toxicity equivalent concentration; and
  - Add the products of the concentration of each congener (or cPAH) and its TEF to obtain the total equivalency of the mixture (TEQ) or total toxicity equivalent concentration.
  - Compare the calculated value[6] to the applicable cleanup level for the reference chemical (either 2,3,7,8 TCDD or benzo[a]pyrene).

  Under this approach, the mixture is characterized by a single value (the total toxicity equivalent concentration). Cleanup levels for the mixture are then established using a cancer risk level of one-in-one million (10^{-6}). Under this approach, the mixture is treated like it is a single hazardous substance.

- Cleanup Levels Established for Individual Congeners or PAH Compounds. In November 2005, Rayonier Properties, LLC argued that the MTCA rule requires Ecology to establish cleanup levels for dioxin mixtures using a cancer risk level of 10^{-5} (as opposed to applying 10^{-6} risk level to the whole mixture). Under this approach, cleanup levels for individual congeners would be established using a cancer risk level of 10^{-6}. Ecology agreed that Rayonier's approach was one plausible interpretation of the MTCA rule in terms of using the TEF methodology to establish cleanup levels. Under this approach:
  - Analyze a sample from the medium of concern to determine the congeners (or cPAH) and the concentration of each congener (or cPAH).

[5] Cleanup Levels and Risk Calculation (CLARC) Guidance

[6] NOTE: If statistics are being used to determine compliance, then the upper bound estimate of the mean of multiple samples would be compared to the cleanup level (or remediation level). If the total toxicity equivalent concentration for the sample (or upper bound of multiple samples) exceeds the Method B/C cleanup level (or remediation level) for the index chemical, then the cleanup level has not been met.

- o Divide the cleanup level for the reference chemical (TCDD or benzo[a]pyrene) by the applicable toxicity equivalency factor to obtain a cleanup level for each congener or cPAH compound.
- o Compare the measured concentration[7] of each congener (or cPAH) to the applicable cleanup level for the particular congener or cPAH.

The total site risk (accounting for all congeners, cPAHs, other hazardous substances and multiple exposure pathways) cannot exceed a cancer risk of 10^{-5}.

[7] NOTE: If statistics are being used to determine compliance, then the upper bound estimate of the mean of multiple samples would be compared to the cleanup level (or remediation level). If the total toxicity equivalent concentration for the sample (or upper bound of multiple samples) exceeds the Method B/C cleanup level (or remediation level) for the index chemical, then the cleanup level has not been met.

3 Description of the Proposed Rule

Ecology initiated the rulemaking process on June 7, 2006, by filing the CR-101 with the Office of the Code Reviser. Later that month, Ecology prepared draft rule language that was distributed to interested parties for review and comment.

Ecology received many comments on the draft rule language. Ecology also held four meetings with the MTCA Science Advisory Board to discuss key rulemaking issues. Ecology has modified the June draft rule language based on the comments received from the public and the MTCA Science Advisory Board.

3.1 Proposed Rule Revisions

Ecology is proposing to revise and update the policies and procedures for establishing cleanup levels for certain types of chemical mixtures. Key elements of the proposed rule amendments include the following:

- Risk Policies Applicable to Dioxins/Furans, PAHs and PCBs. Ecology proposes amending WAC 173-340-708(8) to revise and update the risk policies for mixtures of dioxins/furans, carcinogenic PAHs and PCBs. Ecology proposes to:
  - Require that cleanup levels for mixtures of dioxins and furans be based on a cancer risk of one-in-a-million (10^{-6}).
  - Require that cleanup levels for mixtures of carcinogenic PAHs be based on a cancer risk of one-in-a-million (10^{-6}).
  - Require that cleanup levels for PCB mixtures continue to be based on a cancer risk of one-in-a-million (10^{-6}).
- Toxic Equivalency Factors (TEF) Used to Characterize Mixtures. Ecology proposes amending the rule to require people to use the most current TEF values:
  - TEFs for dioxins/furans and PCBs recommended by the World Health Organization (Van den Berg, et al. 2006).
  - Updated potency equivalency factors (PEFs) for carcinogenic PAHs adopted by the California Environmental Protection Agency (California EPA, 2005).
- Default Parameters Used to Calculate Cleanup Levels. Ecology proposesmodifying the Gastrointestinal Absorption Fraction used to establish soil cleanup levels for dioxin and furan mixtures.
- Evaluating Cross-Media Impacts. Ecology proposes amending WAC 173-340-708(8) requiring cleanup proponents to consider the physical-chemical properties of individual PAH compounds or dioxin-congeners when evaluating cross-media impacts.

3.2 Comparison of Current and Proposed Cleanup Levels

The proposed rule revisions will result in changes to the procedures for calculating cleanup levels. This section also provides a comparison of cleanup levels under the current and proposed rule language. When making these comparisons, Ecology has used the Rayonier Settlement approach to describe the baseline regulatory requirements. Ecology chose this approach because neither the current MTCA rule, nor the federal guidance referenced in the MTCA rule, explicitly requires the procedures in the Cleanup Levels and Risk Calculations (CLARC) guidance.

- Cleanup Levels for Dioxins and Furans: Ecology expects the proposed rule revisions will have the following impacts on cleanup levels for dioxins and furans:

  - **Ground Water and Surface Water Cleanup Levels.** Ecology has concluded that the proposed rule revisions will not affect dioxin cleanup levels for ground and surface waters. Ground water cleanup levels established under WAC 173-340-720 will continue to be based on the Maximum Contaminant Limit (MCL) for dioxin in the state and federal drinking water regulations. Surface water cleanup levels established under WAC 173-340-730 will continue to be based on the National Toxics Rule and Section 304 water quality criteria documents.

  - **Method B Soil Cleanup Levels Based on Non-Cancer Risks.** The proposed rule revisions will not change the methods and policies for establishing Method B soil cleanup based on non-cancer human health risks.

  - **Method B Soil Cleanup Levels Based on Cancer Risks.** Ecology has concluded that the proposed rule revisions will result in changes to dioxin soil cleanup levels based on human cancer risks. When setting cleanup levels based on cancer risk, the proposed rule revisions will result in Method B soil cleanup levels for dioxin mixtures that are 30 to 50% lower (more stringent) than cleanup levels that would be established under the current rule (See Table 1). When estimating the baseline cleanup levels for dioxin/furan mixtures (16-24 ppt) in Table 1, Ecology considered both the regulatory limits for individual congeners (10^{-6}) and the whole mixture (10^{-5}). After reviewing data from Washington cleanup sites, Ecology concluded that requirements for individual congeners will result in cleanup levels that are more stringent than simply applying a cleanup level of 67 ppt for the whole mixture. Specifically, Ecology believes that dioxin/furan mixtures with TEQ values between 16 and 24 ppt will fail to meet the requirement that individual congener concentrations not exceed 6.7 ppt. This conclusion is based on data showing that one congener usually contributes 25-35% of the toxicity of the whole mixture.

  - **Industrial Soil Cleanup Levels.** Ecology has concluded that the proposed rule revisions will result in changes to industrial soil cleanup levels based on human health risks. In general, the levels established under the proposed rule revisions will be 60-70% higher (less stringent) than those established under the current rule.

  - **Soil Cleanup Levels Based on Ecological Protection.** The proposed rule revisions will not change the methods and policies for establishing soil cleanup levels based on ecological protection.

Table 1: Comparison of Soil Cleanup Levels for Dioxins/Furans

	Regulatory Baseline	Proposed Rule
Unrestricted – Human Health*		
2,3,7,8 TCDD	6.7 ppt	11 ppt
Dioxin/Furan Mixtures (TEQ)	16 – 24 ppt**	11 ppt
Industrial – Human Health*		
2,3,7,8 TCDD	875	1,460 ppt
Dioxin/Furan Mixtures (TEQ)	875	1,460 ppt
Ecological Screening		
Dioxins	2 – 5 ppt	2 – 5 ppt
Chlorinated Dibenzofurans	2 – 3 ppt	2 – 3 ppt

*Assumes direct contact via soil ingestion is the controlling exposure pathway and a gastrointestinal absorption fraction of 0.6.
** Based on median cleanup level at dioxin/furan contaminated sites in Washington State

- **Cleanup Standards to Protect Air Quality**:[8] Soil cleanup levels must be set at levels that prevent unacceptable risks due to inhalation of windblown soil particulates. The proposed rule revisions would result in changes to the Method B air cleanup levels based on carcinogenic risk. However, inhalation of windblown soil particulates is generally a minor exposure pathway relative to incidental soil ingestion and Ecology does not typically evaluate this pathway. Consequently, Ecology has concluded that the changes to Method B air cleanup levels will not significantly impact soil cleanup levels. Ecology also believes that the changes in Method B air cleanup standards will not significantly impact requirements for remedial actions. The proposed rule revisions might also result in revisions to emission limits for remedial actions that result in air emissions. However, Ecology believes that emission limits for such actions will continue to be established based on requirements in Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants).

- **Sediment Cleanup Standards**. Ecology uses the general policies and procedures in WAC 173-340-700 through -710 when establishing site-specific requirements for contaminated sediment sites. It is not clear how the proposed revisions would actually impact sediment cleanup standards and cleanup actions.[9] However, Ecology believes that the issue of how to establish MTCA sediment cleanup standards must be addressed as part of a larger set of regulatory questions on the relationships between requirements in the Sediment Management Standards (SMS) rule and the MTCA rule. Ecology is currently working with other sediment management agencies (e.g. EPA, Corp of Engineers, Department of Natural Resources, etc.) and interested parties to review a number of issues associated with dioxin-contaminated sediments in Puget Sound. Ecology has decided to wait until that process is completed before developing rule amendments (if any) to address sediment cleanup requirements.

[8] This section would be applicable at sites with dioxin and furan contamination if it was necessary to establish (1) a soil cleanup level that addresses inhalation of windblown soil particulates or (2) emission limits for remedial actions.
[9] Ecology believes that the proposed rule revisions would not have significant impacts on sediment cleanup standards and actions because: (1) cleanup requirements take into account background concentrations that are often higher than site-specific risk-based standards; (2) cleanup screening levels (CSLs) under the SMS rule are comparable to Method C cleanup levels under the MTCA rule and these cleanup levels are not impacted by the proposed rule revisions; (3) current sediment guidance and applicable water quality standards are based on similar methods and policies; and (4) there are a number of other site-specific and regulatory factors (biota sediment accumulation factor, fish and shell consumption rates, net environmental protection, costs, technical feasibility etc.) that influence sediment cleanup standards and cleanup actions.

- Cleanup Levels for Carcinogenic PAHs. Ecology expects that the proposed rule revisions will have the following impacts on cleanup levels for carcinogenic PAHs:
    - **Ground Water and Surface Water Cleanup Levels.** Ecology has concluded that the proposed rule revisions will not significantly change ground water and surface water cleanup levels for carcinogenic PAH mixtures. Ground water cleanup levels established under WAC 173-340-720 will continue to be based upon the Method A cleanup level or the Maximum Contaminant Limit (MCL) for benzo[a]pyrene in the state and federal drinking water regulations. Surface water cleanup levels established under WAC 173-340-730 will continue to be based on the National Toxics Rule.
    - **Method A Soil Cleanup Levels.** The proposed rule revisions will not change the Method A soil cleanup levels for carcinogenic PAH (cPAH) mixtures for unrestricted land use (0.1 mg/kg) and industrial land use (2 mg/kg). Because the TEF for dibenz(a,h)anthracene is somewhat less stringent under the proposed rule amendment, this could result in slightly higher cPAH mixture concentrations being able to demonstrate compliance with the Method A soil cleanup levels.
    - **Method B Soil Cleanup Levels Based on Non-Cancer Risks.** The proposed rule revisions will not change the methods and policies for establishing Method B soil cleanup levels based on non-cancer human health risks. The hazard quotient used to calculate cleanup levels for individual hazardous substances is the same as the hazard index used when evaluating total site risks.
    - **Method B Soil Cleanup Levels Based on Cancer Risks.** Ecology has concluded that the proposed rule revisions will result in changes to Method B soil cleanup levels for cPAHs that are based on cancer human health risk (See Table 2). The proposed rule revisions will not change the Method B cleanup level for benzo(a)pyrene (B(a)P) which is the reference chemical in the TEF approach. However, the proposed rule revisions will result in Method B soil cleanup levels for mixtures that are 25 to 50% lower (more stringent) than cleanup levels that would be established under the current rule. As with dioxins and furans, the relatively small difference is due to the fact that benzo[a]pyrene typically contributes 60-80% of the TEQ for the whole mixture.[10]
    - **Industrial Soil Cleanup Levels.** At industrial sites, the cancer risk target for the individual PAHs (10^{-5}) is the same as the cancer risk target for total site risk (10^{-5}). Consequently, the proposed rule revisions will not change Method C industrial soil cleanup levels that are based on cancer risk.[11]
    - **Soil Cleanup Levels Based on Ecological Protection.** The proposed rule revisions will not change the methods and policies for establishing soil cleanup levels based on ecological protection.

Table 2: Comparison of Soil Cleanup Levels for Carcinogenic PAHs		
	Regulatory Baseline	Proposed Rule

[10] Because the TEF for dibenz(a,h)anthracene is somewhat less stringent under the proposed rule amendment, this could result in slightly higher cPAH mixture concentrations being able to demonstrate compliance with the Method B soil cleanup levels.

[11] Because the TEF for dibenz(a,h)anthracene is somewhat less stringent under the proposed rule amendment, this could result in slightly higher cPAH mixture concentrations being able to demonstrate compliance with Method C cleanup levels.

Unrestricted – Human Health*		
Method A (BaP and cPAH)	0.1 mg/kg	0.1 mg/kg
Method B (BaP)	0.14 mg/kg	0.14 mg/kg
Method B (cPAHs)	0.16 – 0.26 mg/kg**	0.14 mg/kg
Industrial – Human Health* **		
Method A (BaP and cPAH)	2 mg/kg)	2 mg/kg
Method C (BaP)	18 mg/kg (2 mg/kg)	18 mg/kg (2 mg/kg)
Method C (cPAHs)	18 mg/kg (2 mg/kg)	18 mg/kg (2 mg/kg)
Ecological Screening		
BaP (unrestricted site use)	12-30 mg/kg	12-30 mg/kg
BaP (industrial and commercial)	12 – 300 mg/kg	12 – 300 mg/kg

*Assumes direct contact via soil ingestion is the controlling exposure pathway.
** Based on the median cleanup level at cPAH contaminated sites in Washington State.
***The cleanup level for the direct contact pathway is the first number. If the leaching pathway is a concern at the site, the cleanup level will be 2 ppm (based on the 3 phase model in WAC 173-340-747 using the standard assumptions for soil above the water table.

- **Cleanup Standards to Protect Air Quality**:[12] Soil cleanup levels must be set at levels that prevent unacceptable risks due to inhalation of windblown soil particulates. The proposed rule revisions would result in changes to the Method B air cleanup levels based on carcinogenic risk. However, inhalation of windblown soil particulates is generally a minor exposure pathway relative to incidental soil ingestion and Ecology does not typically evaluate this pathway. Consequently, Ecology has concluded that the changes to Method B air cleanup levels will not significantly impact soil cleanup levels. Ecology also believes that the changes in Method B air cleanup standards will not significantly impact requirements for remedial actions. The proposed rule revisions might also result in revisions to emission limits for remedial actions that result in air emissions. However, Ecology believes that emission limits for such actions will continue to be established based on requirements in Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants).

- **Sediment Cleanup Standards**. Ecology uses the general policies and procedures in WAC 173-340-700 through -710 when establishing site-specific requirements for contaminated sediment sites. It is not clear how the proposed revisions would actually impact sediment cleanup standards and cleanup actions.[13] However, Ecology believes that the issue of how to establish MTCA sediment cleanup standards must be addressed as part of a larger set of regulatory questions on the relationships between requirements in the Sediment Management Standards (SMS) rule and the MTCA rule. Ecology is currently working with other sediment management agencies (e.g. EPA, Corp of Engineers, Department of Natural Resources, etc.) and interested parties to review a number of issues associated with dioxin-contaminated sediments in Puget Sound.

[12] This section would be applicable at sites with dioxin and furan contamination if it was necessary to establish (1) a soil cleanup level that addresses inhalation of windblown soil particulates or (2) emission limits for remedial actions.
[13] Ecology believes that the proposed rule revisions would not have significant impacts on sediment cleanup standards and actions for PAH contaminated sediments because: (1) With some exceptions, most organisms metabolize PAH compounds which limits bioaccumulation; (2) cleanup screening levels (CSLs) under the SMS rule are comparable to Method C cleanup levels under the MTCA rule and these cleanup levels are not impacted by the proposed rule revisions; and (3) there are a number of other site-specific and regulatory factors (biota sediment accumulation factor, fish and shell consumption rates, net environmental protection, costs, technical feasibility etc.) that influence sediment cleanup standards and cleanup actions.

Ecology has decided to wait until that process is completed before developing rule amendments (if any) to address sediment cleanup requirements.

- Cleanup Levels for PCB Mixtures. Ecology has concluded that the proposed rule revisions will not result in significant changes to cleanup standards for PCBs because the use of the TEF methodology is optional.

  - **Ground Water and Surface Water Cleanup Levels.** The proposed rule revisions will not affect PCB cleanup levels for ground and surface waters. Ground water cleanup levels established under WAC 173-340-720 will continue to be based on the Maximum Contaminant Limit (MCL) for PCBs in the state and federal drinking water regulations. Surface water cleanup levels established under WAC 173-340-730 will continue to be based on the National Toxics Rule and Section 304 water quality criteria documents.
  - **Method A Soil Cleanup Levels.** The proposed rule revisions will not change the Method A soil cleanup levels for PCB mixtures for unrestricted land use (1 mg/kg) and industrial land use (10 mg/kg).
  - **Method B Soil Cleanup Levels Based on Non-Cancer Risks.** The proposed rule revisions will not change the methods and policies for establishing Method B soil cleanup based on non-cancer human health risks.
  - **Method B Soil Cleanup Levels Based on Cancer Risks.** Ecology has concluded that the proposed rule revisions will not result in significant changes to PCB soil cleanup levels based on human health risks because the use of the TEF methodology is optional.
  - **Industrial Soil Cleanup Levels.** The proposed rule revisions will not result in changes to industrial soil cleanup levels based on human health risks.
  - **Soil Cleanup Levels Based on Ecological Protection.** The proposed rule revisions will not change the methods and policies for establishing soil cleanup levels based on ecological protection.

Table 3: Comparison of Soil Cleanup Levels for PCB Mixtures

	Regulatory Baseline	Proposed Rule
Unrestricted – Human Health		
Method A (total PCBs)	1 mg/kg	1 mg/kg
Method B (total PCBs)*	0.2 - 1 mg/kg	0.2 - 1 mg/kg
Industrial – Human Health		
Method A (total PCBs)	10 mg/kg	10 mg/kg
Method C (total PCBs)*	0.2 - 10 mg/kg	0.2 - 10 mg/kg
Ecological Screening		
PCB Mixtures (unrestricted site use)	0.65 – 2 mg/kg	0.65 – 2 mg/kg
PCB Mixtures (industrial & commercial)	0.65 – 2 mg/kg	0.65 – 2 mg/kg

*Lowest value is for protection of ground water using the 3 phase model in WAC 173-340-747 and standard assumptions for soil above the water table; highest value is based on the ARAR.

  - **Cleanup Levels to Protect Air Quality.** Ecology has concluded that the proposed rule revisions will not result in significant changes to cleanup requirements based on protecting air quality because the use of the TEF methodology is optional.

- **Sediment Cleanup Standards.** Ecology has concluded that the proposed rule revisions will not result in significant changes to sediment cleanup standards because the use of the TEF methodology is optional.

3.3 Potential Impacts of Rule Revisions on Cleanup Actions

Ecology evaluated whether the proposed rule amendments are likely to result in significant changes to the cleanup actions implemented at these types of facilities. In performing this evaluation, Ecology considered the nature and extent of contamination typically found at these types of cleanup sites, the types of cleanup actions conducted at these types of facilities and the MTCA rule requirements that determine site cleanup requirements.

- Sites with Elevated Levels of Dioxin and Furans. Ecology does not expect that the proposed rule revisions will result in significant changes to the cleanup actions implemented at most sites with dioxin and furan contamination. Ecology reached this conclusion based on the following considerations:
  - Small differences in cleanup levels are unlikely to alter cleanup actions where capping/ containment is an important element of the cleanup action (such as landfills, wood treating).
  - The proposed rule revisions are unlikely to result in meaningful differences in soil removal volumes because (1) there is very little difference in cleanup levels under the current rule and the proposed rule revisions because one congener generally contributes 25-35% of the TEQ for the whole mixture and Ecology is proposing to modify the default absorption value and (2) soil removal at the types of sites listed in Table 2 is generally limited to highly contaminated soils with residual contamination being contained on-site.
  - Cleanup requirements at many of these types of sites will continue to be driven by cleanup levels for other contaminants (e.g. total petroleum hydrocarbons, metals).
  - Industrial properties may need to remediate a smaller area of soil under the proposed rule.
  - Ecology believes that the proposed rule revisions may increase the acreage defined as being impacted by air deposition. However, Ecology expects that the incremental increases in acreage (relative to the current MTCA rule) will be small[14] because (1) aerial deposition of dioxin mixtures is not an issue at most cleanup sites, (2) there is very little difference in cleanup levels selected under the current rule and the proposed rule revisions because one congener generally contributes @25-35% of the TEQ for the whole mixture and (3) Ecology is proposing to modify the default GI absorption fraction.

- Sites with Elevated Levels of Carcinogenic PAHs. Carcinogenic PAHs are primarily found at MTCA sites due to use of heavy fuel oils, lubricating oils and wood preservatives. Ecology does not expect that the proposed rule revisions will result in significant changes to the cleanup actions implemented at sites with elevated levels of PAHs because:
  - Ecology expects that many of these types of sites will continue to use Method A to establish cleanup levels. Ecology is not proposing to revise the Method A cleanup levels.

[14] Ecology has compared the sampling results obtained from 20 locations in Port Angeles. Twelve locations exceed cleanup levels using Option 1, four locations exceed cleanup levels using Option 2 and four locations exceed cleanup levels using the proposed rule revision.

- Cleanup requirements at many of these types of sites will continue to be driven by cleanup levels for other contaminants (such as total petroleum hydrocarbons, metals).
- Ecology does not expect that the proposed rule revisions will result in meaningful differences in soil removal volumes because (1) there is very little difference in cleanup levels selected under the two rulemaking options because benzo[a]pyrene generally contributes 60-80% of the TEQ for the whole mixture and (2) it is difficult to make fine distinctions in soil contamination levels during soil removal (such as removal via backhoe).
- Ecology does not expect that the small differences in cleanup levels selected under the two rulemaking options will alter cleanup actions where capping /containment is an important element of the cleanup action (such as landfills, wood treating).

- Sites with Elevated Levels of PCBs. Ecology does not expect that the proposed rule revisions will result in significant changes to cleanup actions at sites with elevated levels of PCBs because the use of the TEF methodology is optional.

4 Rulemaking Issues

Ecology staff and management considered a wide range of issues when preparing the draft rule revisions. Figure 2 identifies ten issues that are central to this rulemaking. This section is divided into ten subsections (one issue per subsection). Each subsection includes (1) a brief description of the issue; (2) the options for resolving the issue; and (3) Ecology's proposed option and the rationale for choosing that option.

Figure 2
Key Rulemaking Issues

Dioxin/Furan Mixtures

Issue #1 Should Ecology revise the MTCA rule to require people to use the toxic equivalency factors (TEFs) developed by the World Health Organization when evaluating the human health risks of dioxin/furan mixtures?

Issue #2 Should Ecology revise the MTCA rule to require that Method B cleanup levels for dioxin/furan mixtures be based on a cancer risk of one-in-one million?

Issue #3 Should Ecology revise the default assumptions in the MTCA rule to take into account the relative bioavailability of soil-bound dioxins and furans?

PAH Mixtures

Issue #4 Should Ecology revise the MTCA rule to require people to use the latest relative potency factors developed by the California Environmental Protection Agency when evaluating the human health risks of PAH mixtures?

Issue #5 When characterizing the carcinogenic risks of PAH mixtures, should Ecology continue to focus its' evaluation on the seven PAH compounds identified in the current MTCA rule?

Issue #6 Should Ecology revise the MTCA rule to require that Method B cleanup levels for carcinogenic PAH mixtures be based on a cancer risk of one-in-one million?

PCB Mixtures

Issue #7 Should Ecology revise the MTCA rule to explicitly allow or require people to use of the TEF values and methodology developed by the World Health Organization when evaluating the human health risks of PCB mixtures?

Issue #8 Should Ecology continue to require that cleanup levels for PCB mixtures be based on a cancer risk of one-in-one million?

Issue #9 How should Ecology take into account non-dioxin-like health effects when using the TEF methodology to assess PCB mixtures?

General Issues

Issue #10 How should Ecology apply the TEF methodology when evaluating cross-media impacts?

Choice of TEF Values for Dioxin/Furan Mixtures

Issue #1

Should Ecology revise the MTCA rule to require people to use the toxic equivalency factors (TEFs) developed by the World Health Organization when evaluating the human health risks of dioxin/furan mixtures?

Background

Polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran congeners (dioxins and furans) are generally present in the environment as a complex mixture of chemical "congeners" that differ in terms of the number and location of chlorine atoms. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic and best-studied of the 210 dioxin and furan congeners. Because of the need to evaluate the risks associated with the whole mixture, scientists have developed the "Toxicity Equivalency Factor" or "TEF" methodology. Under this approach, each congener is assigned a TEF, which is some fraction of the toxicity of TCDD. The total toxic equivalency (TEQ) of a mixture is the sum of the products of the concentration of each congener in the contaminated medium and the TEF value for that congener.

The TEF methodology has evolved over the last twenty years as a result of scientific reviews and evaluations conducted by several organizations. EPA first adopted the TEF methodology as an interim procedure for evaluating the toxicity and risks associated with exposures to dioxin and furan mixtures (EPA, 1987). EPA subsequently updated its TEF values based on international consensus regarding the interpretation of relevant toxicological information for dioxin and furan mixtures (EPA, 1989). The MTCA rule (WAC 173-340-708(8)) references the 1989 EPA document and specifies that those TEFs may be used when assessing the potential carcinogenic risk of dioxin/furan mixtures.

The World Health Organization (WHO) and International Programme on Chemical Safety (IPCS) initiated a joint project in 1997 to review available toxicity data for dioxin-like compounds. The expert panel completed its evaluation and published recommended TEF values (Van den Berg, et al., 1998). These values are generally referred to as the WHO-98 TEFs. Table 4 compares the WHO-98 TEF values with the earlier EPA values. The majority of state, federal and international environmental agencies currently use the WHO-98 values when evaluating the health risks posed by dioxin/furan mixtures. For example, EPA used the WHO-1998 TEF values when preparing the dioxin reassessment report (EPA, 2003c).

The World Health Organization convened a meeting of scientific experts in June 2005 to review the WHO-98 TEF values and other related issues. The scientific experts participating in that meeting recommended changes to the TEF values for 4 of the 17 dioxin and furan congeners (See Table 4). The results of that meeting are summarized in Van den Berg et al. (2006).

In 2004, EPA asked the National Academy of Sciences to review the agency's dioxin reassessment report. The NAS report was recently published and the committee concluded that the "...the toxic equivalency factor methodology provides a reasonable, scientifically justifiable, and widely accepted method to assess the relative potency of DLCs[15]..." (NAS, 2006, p. 6)[16].

Table 4

Toxicity Equivalency Factors (TEFs) For Chlorinated Dioxins and Furans

Congener	EPA 1987[17]	EPA 1989 (Current MTCA Rule)	NATO 1989[18]	WHO 1998[19]	WHO 2005 TEFs[20]
TEFs for Chlorinated Dibenzo-p-Dioxins					
2,3,7,8-TCDD	1	1	1	1	1
1, 2,3,7,8-PeCDD	0.5	0.5	0.5	1	1
1, 2,3,4,7,8-HxCDD	0.04	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDD	0.04	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	0.04	0.1	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.001	0.01	0.1	0.01	0.01
1,2,3,4,6,7,8,9-OCDD	0	0.001	0.001	0.0001	0.0003
TEFs for Chlorinated Dibenzofurans					
2,3,7,8-TCDF	0.1	0.1	0.1	0.1	0.1
1,2,3,7,8-PeCDF	0.1	0.05	0.05	0.05	0.03
2,3,4,7,8-PeCDF	0.1	0.5	0.5	0.5	0.3
1,2,3,4,7,8-HxCDF	0.01	0.1	0.1	0.1	0.1
1,2,3,6,7,8-HxCDF	0.01	0.1	0.1	0.1	0.1
1,2,3,7,8,9-HxCDF	0.01	0.1	0.1	0.1	0.1
2,3,4,6,7,8- HxCDF	0.01	0.1	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.001	0.01	0.01	0.01	0.01
1,2,3,4,7,8,9- HpCDF	0.001	0.01	0.01	0.01	0.01
1,2,3,4,6,7,8,9-OCDF	0	0.001	0.001	0.0001	0.0003

MTCA Rulemaking Options

Ecology has considered three options for this rulemaking issue:

1. EPA-89 Values. Under this option, Ecology would continue to use the TEF values from the 1989 EPA Guidance Document when evaluating the human health risks associated with mixtures of dioxins and furans.
2. WHO-1998 Values. Under this option, Ecology would revise the MTCA rule to specify that the WHO-98 TEF values should be used when evaluating the human health risks associated with mixtures of dioxins and furans.
3. WHO-2005 Values. Under this option, Ecology would revise the MTCA to specify that the WHO-2005 TEF values (Van den Berg et al. 2006[21]) should be used when evaluating the human health risks associated with mixtures of dioxins and furans.

[15] DLC = Dioxin-Like Compounds.
[16] The NAS committee also recommended that EPA acknowledge the need for better uncertainty analysis of the toxicity values and should include an initial uncertainty analysis of overall toxicity in the final EPA report.
[17] U.S. EPA's 1989. Update to the Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and-dibenzofurans (CDDs and CDFs), EPA/625/3-89/016, March 1989.
[18] NATO/CCMS. (1988) Scientific basis for the development of the International Toxicity Equivalency Factor (I-TEF) method of risk assessment for complex mixtures of dioxins and related compounds. Report No. 178, Dec. 1988.
[19] Van den Berg, M; Birnbaum, L; Bosveld, ATC; et al. (1998) Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106(12):775-792.
[20] Van den Berg et al. (2006).

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to require that the WHO-2005 TEF values should be used when evaluating the human health risks of mixtures of dioxins and furans (Option 3). Ecology's rationale for using more the current TEF values includes the following:

- The TEF methodology has a strong biological basis. The TEF methodology is a relative potency approach that is grounded in the concept that dioxin/furan mixtures act through a common mechanism of action that involves binding to the Ah receptor (aryl hydrocarbon hydroxylase receptor). The methodology is based on the assumption that the total dose can be represented by the sum of the doses for individual chemicals in the whole mixture. This assumption (dose additivity) has been evaluated for a number of toxic endpoints. Of particular relevance to the current rulemaking process, Walker et al. (2005) evaluated the dose-additive carcinogenicity of a mixture of dioxin-like compounds and found that (1) the dose-response for the mixture could be predicted from a combination of the potency-adjusted doses of the individual congeners; (2) the WHO-98 TEF values adequately predicted the increased incidence of liver tumors associated with exposure to a mixture of dioxin-like compounds; and (3) the shapes of the dose-response curves were the same in the studies of three individual congeners and the mixture.

- The WHO-2005 TEF values are based on current scientific information. The WHO-2005 TEF values reflect the current scientific consensus on the relative toxicity of dioxin-like compounds. These values were developed after a rigorous scientific review performed by international experts. These values are consistent with earlier scientific reviews by the EPA Risk Assessment Forum (EPA, 2000), EPA's Science Advisory Board (EPA, 2001) and the National Research Council (NAS, 2003; NAS, 2006). The NAS panel (2006) specifically recommended that EPA consider the results of the WHO/IPCS review when revising the dioxin reassessment report. In addition, the MTCA Science Advisory Board recently concluded:

  The Board stated that the 2005 TEF values for dioxin and furans recommended by the WHO are consistent with current scientific information. As noted above, the Board stated that it was fortuitous that the WHO had recently completed a review and evaluation of available scientific information which resulted in updated TEF values for dioxins and furans (Attachment to March 19, 2007 Meeting Summary).

- The WHO expert panel considered the scientific uncertainties associated with current information when revising the TEF values. Ecology recognizes that there are uncertainties in the TEF values and the application of this approach to predict health risks and calculate cleanup levels. However, a scientific panel convened by EPA and the Department of Interior concluded that "...the uncertainties associated with using RePs or TEFs are not thought to be larger than other sources of uncertainty within the risk assessment process (e.g. dose-response assessment, exposure assessment and risk characterization)..."(EPA, 2001b). The EPA Science Advisory Board also noted that five of the 29 dioxin-like compounds (17 PCDDs/PCDFs and 12 dioxin-like PCB congeners) considered by EPA account for over 70% of the TEQ in the human diet. The Board noted that the variability in relative potency

[21] The scientific experts expressed continued support for the TEF approach. However, they identified changes to the TEF values for four of the seventeen dioxin and furan congeners: 2,3,4,7,8-pentachlorodibenzofuran (TEF revised from 0.5 to 0.3); 1,2,3,7,8-pentachlorodibenzofuran (TEF revised from 0.05 to 0.03); and octachlorodibenzo-p-dioxin and octachlorodibenzofuran (TEF revised from 0.0001 to 0.00003)

factors for these five congeners is much lower than the variability in TEFs for congeners that are minor contributors to human exposure (EPA, 2001a). Hawes et al. (2006) reached similar conclusions.

- Ecology's proposal to use the WHO-2005 TEF values is consistent with approaches being used by Ecology and other environmental agencies. Ecology believes that the use of the most current TEF values published by the World Health Organization is consistent with the current MTCA rule and reflects a logical update based on more recent scientific information. Numerous agencies currently use the WHO-98 TEF values when evaluating the health risks associated with dioxin and furan mixtures. For example:
    - The Water Quality Program used the WHO-98 TEFs when establishing the Total Maximum Daily Load (TMDL) for Lake Chelan (Ecology, 2005).
    - The Environmental Assessment Program used the WHO-98 TEFs to prepare the 2004 303(d) list of impaired waterbodies (Ecology, 2004).
    - The Solid Waste and Financial Assistance Program used the WHO-98 TEFs when preparing the initial list of persistent, bioaccumulative toxins (PBTs).
    - EPA used the WHO-98 TEF values when preparing the 2003 dioxin reassessment report.
    - The EPA Superfund program recommends that the WHO-98 TEF values be used when evaluating the health risks posed by dioxin/furan mixtures.
    - EPA used the WHO-98 TEF values when establishing reporting requirements for dioxin and dioxin-like compounds under Section 313 of the Emergency Planning and Community Right-to-Know Act.
    - ATSDR used the WHO-98 TEF values to establish a Minimal Risk Level (MRL) for dioxin-like compounds.
    - Several state health and environmental agencies currently use the WHO-98 TEF values to evaluate dioxin and furan mixtures (See Table 8, p. 34).

- Ecology does not believe that the use of the WHO-2005 TEF values will significantly increase or decrease the stringency of cleanup requirements established under MTCA. As indicated in Table 4, the two approaches include identical TEF values for 12 of the 17 dioxin and furan congeners. Of the remaining five congeners, the WHO-2005 TEF values are lower than the 1989 EPA TEF values for four congeners (1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, OCDD and OCDF); the WHO-2005 TEF value for PeCDF is higher. While these differences may affect conclusions on individual samples, Ecology does not believe that the use of the WHO-98 TEF or the WHO-2005 values will significantly alter cleanup requirements on a statewide basis (relative to the current rule language).

Cleanup Levels for Dioxin/Furan Mixtures

Issue #2

Should Ecology revise the MTCA rule to require that Method B[22] cleanup levels for dioxin/furan mixtures be based on a cancer risk of one-in-one million?

Background

Ecology amended the MTCA rule in February 2001. Under the rule amendments, a person undertaking a cleanup action may use the Environmental Protection Agency's (EPA, 1989) interim methodology and the toxicity equivalency factor (TEF) values when assessing dioxin and furan mixtures.

The existing MTCA rule does not clearly specify how the TEF methodology must be used when calculating Method B cleanup levels for mixtures of dioxins/furans and PAHs. Two approaches have been used to establish cleanup levels using the EPA TEF methodology:

- Cleanup Levels for the Whole Mixture Based on a Cancer Risk Level of One-in-One Million. In November 2001, Ecology published guidance[23] on how to use the TEF methodology when establishing and evaluating compliance with MTCA cleanup levels. The guidance directed people to (1) use the TEF methodology to calculate a total toxic equivalency concentration and (2) compare the calculated value to the applicable cleanup level for the reference chemical (either 2,3,7,8 TCDD or benzo[a]pyrene). Under this approach, the mixture is characterized by a single value (the total toxicity equivalent concentration). Method B cleanup levels for the mixture are then established using a cancer risk level of one-in-one million (10^{-6}).

- Cleanup Levels for Individual Congeners Based on Cancer Risk Level of One-in-One Million. In November 2005, Rayonier Properties, LLC argued that the MTCA rule requires Ecology to establish cleanup levels for dioxin mixtures using a cancer risk level of 10^{-5} (as opposed to applying 10^{-6} risk level to the whole mixture). Under this approach, cleanup levels for individual congeners would be established using a cancer risk level of 10^{-6}. Ecology agreed that Rayonier's approach was a reasonable interpretation of the current MTCA rule and, consequently, represents a plausible approach for using the TEF methodology to implement the current MTCA rule. Under this approach, the TEF methodology is used to calculate a cleanup level for each congener. The total site risk (taking into account all congeners, other hazardous substances, and multiple exposure pathways) cannot exceed a cancer risk of one-in-a-hundred thousand (10^{-5})

MTCA Rulemaking Options

Ecology has considered three options for resolving this issue:

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[22] Under Method C, the cancer risk target for the individual PAHs (10^{-5}) is the same as the cancer risk target for total site risk (10^{-5}). Consequently, Method C cleanup levels based on cancer risk are not affected by the decision on whether to apply a 10-6 risk level to individual congeners or the whole mixture.

[23] Cleanup Levels and Risk Calculation (CLARC) Guidance

1. Cleanup Levels for Individual Congeners Based on a Cancer Risk Level of One-in-One Million. This is the approach specified in the Rayonier Settlement Agreement. Under this option, Method B cleanup levels for other dioxin and furan congeners would be established by dividing the TCDD cleanup level by the applicable congener-specific TEF. Because there is an overall limit on cancer risk under MTCA of one-in-one hundred thousand (10^{-5}), when more than 10 dioxin and furan congeners are present at a site (a likely occurrence), the cleanup levels for TCDD and other individual congeners would need to be adjusted downward to insure this overall site risk limit is not exceeded. If there are multiple pathways of exposure, a further downward adjustment for individual congeners would need to also be made.
2. Cleanup Levels for Dioxin/Furan Mixtures Based on a Cancer Risk Level of One-in-One Million. This is the approach specified in the Cleanup Levels and Risk Calculation (CLARC) Guidance. Under this option, Method B cleanup levels would be established for TCDD based on an incremental cancer risk of one in one million (10^{-6}). The TEF methodology would be used to calculate a TEQ (based on the 17 dioxin/furan congeners identified in Table 4) for environmental samples that would then be compared to TCDD cleanup level.
3. Cleanup Levels for Mixtures of All Dioxin-like Compounds (Dioxins, Furans and Dioxin-like PCBs) Based on a Cancer Risk Level of One-in-One Million. Under this option, Method B cleanup levels would be established for TCDD based on an incremental cancer risk of one in one million (10^{-6}). This option differs from option #2 because the TEF methodology would be used to calculate a TEQ based on a larger number of congeners. Under this option, the TEQ is calculated using information on the 17 dioxin/furan congeners identified in Table 4 and the 12 PCB congeners identified in Table 9. The resulting TEQ value is then compared to the TCDD cleanup level.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to state that dioxin and furan mixtures will be considered a single hazardous substance for assessing carcinogenic risk under MTCA. Under this approach, Method B cleanup levels for mixtures of dioxins and furans must be based on a cancer risk of one-in-one million (10^{-6}) (Option #2). Ecology's rationale for selecting this option includes the following:

- Dioxin/furan mixtures differ from the majority of mixtures found at MTCA sites. Most MTCA sites include mixtures of hazardous substances. However, the mixtures addressed in this rulemaking differ from most other types of mixtures in that (1) the congeners in the mixture always occur together and (2) scientists have concluded that the 17 dioxin/furan congeners identified in the rule act through common biological mechanisms and essentially behave like one chemical in the human body.[24]
- Ecology believes the proposed approach is an appropriate policy choice for regulating dioxins and furans within the overall MTCA decision-making framework. Ecology believes that it is appropriate to establish cleanup levels for dioxins and furan mixtures using a cancer risk level of one-in-one million because:

[24] The TEF approach is based on the concept that the various congeners of dioxin/furan essentially act as one chemical, affecting the Ah receptor (aryl hydrocarbon hydroxylase receptor).

- The proposed approach provides a margin of safety that minimizes the potential for health risks from exposure pathways that are not explicitly addressed in the MTCA rule. Ecology made a number of simplifying assumptions regarding exposure pathways when developing the MTCA rule. For example, soil cleanup levels are based on an evaluation of the direct contact pathway (e.g. soil ingestion and dermal contact) and migration from soil to ground water. For the majority of hazardous substances, this approach addresses the main human exposure pathways. However, dioxins and furans differ from many other hazardous substances because they are able to bioaccumulate in the terrestrial food chain (soil>plants>animals>humans). EPA (2003) has estimated that soil-related food chain exposure may equal or exceed exposures resulting from soil ingestion.
- The proposed approach provides a margin of safety that minimizes the potential that soil cleanup levels based on carcinogenic risks will result in unacceptable non-cancer health risks. Exposures to dioxins/furans have been shown to increase the risks of developing a wide range of non-cancer health problems including hepatic, immunological, dermal, endocrine effects, neurological effects and reproductive and development effects. The MTCA rule includes procedures for establishing cleanup levels based on non-cancer health effects. However, dioxins and furans differ from other hazardous substances because (1) EPA has not officially established a reference dose and (2) EPA has concluded that a reference dose for non-cancer effects may be below current background levels of exposure. Consequently, the proposed approach provides a margin of safety to address the data gaps for non-cancer health effects.

- <u>The proposed approach simplifies the procedures for establishing MTCA cleanup levels</u>. The MTCA Cleanup Regulation specifies that Method B and C cleanup levels established for individual hazardous substances based on a particular pathway (e.g. soil ingestion) must be adjusted downward to take into account exposure to multiple hazardous substances and/or multiple exposure pathways in situation where total excess cancer risk would exceed 10^{-5}. Treating dioxin and furan mixtures as a single hazardous substance minimizes the need to make such adjustments. This simplifies the process for establishing cleanup levels

- <u>The proposed approach is consistent with the policy choices underlying cleanup levels for PCB mixtures</u>. EPA (2003) has concluded that chlorinated dioxins and furans mixtures and PCB mixtures share many similar exposure and toxicity characteristics. The proposed approach for dioxins and furans is consistent with the policy choices underlying cleanup levels for PCB mixtures in the current MTCA rule. For example, the Method A soil cleanup levels for PCB mixtures in the current MTCA rule were established for the whole mixture using a cancer risk level of one-in-one million.

- <u>The proposed approach is consistent with approaches used by other Ecology programs</u>. The proposed approach is consistent with approaches used by other Ecology programs when evaluating the health risks associated with dioxin and furan mixtures. These requirements are often ARARs that establish minimum cleanup standards under MTCA. For example:
  - The Water Quality Program used the WHO-98 TEFs when establishing the TMDL for Lake Chelan. In that evaluation, Ecology used congener-specific data to calculate TEQs which were compared with the National Toxics Rule (NTR) criterion for TCDD[25].

[25] The NTR criterion for TCDD is based on a 10^{-6} cancer risk level.

- The Environmental Assessment Program identified impaired water bodies by comparing the TEQs for dioxins/furans to the NTR criteria for TCDD. (Ecology, 2004).
- The Hazardous Waste & Toxics Reduction Program specifies that fertilizers must contain no more than eight parts per trillion of dioxin, measured as toxic equivalent (TEQ).
- The Air Quality Program uses the TEF methodology to calculate TEQs for potential emissions from proposed new sources of dioxins/furans. The TEQ values are compared to a screening level for dioxin/furans that is expressed in terms of TCDD. The screening level is based on an incremental cancer risk of one-in-one million (WAC 173-460-060).

- The proposed approach is consistent with how EPA and other federal and international agencies have regulated and/or evaluated dioxin mixtures. EPA and other federal environmental agencies have established a wide range of regulatory requirements for dioxins and furans. Ecology recognizes that these requirements reflect a wide range of policy choices on acceptable cancer or non-cancer risks – many of which differ from the policy choices reflected in the MTCA rule. However, most agencies have established requirements for the whole mixture – not individual congeners. Essentially, these agencies have treated mixtures of dioxins and furans in the same way they treat other hazardous substances like arsenic and trichloroethylene. Consequently, Ecology believes the proposed approach for regulating dioxins and furans under MTCA is consistent with the approaches used by other federal and international agencies. For example:
  - EPA (1998) published a guidance memo for cleanup of dioxin-contaminated properties. The guidance specifies that compliance should be evaluated by comparing the 1 ppb cleanup standard to TEQs calculated from information on 17 dioxin/furan congeners.
  - EPA has published human health water quality criteria for TCDD in the NTR (EPA, 1992) and the California Toxics Rule (EPA, 2000). In promulgating the California Toxics Rule, EPA stated that water quality-based effluent limits for dioxin or dioxin-like compounds should be expressed using a TEQ approach (65 FR 31682 at 31695).
  - EPA established emission limits for medical waste incinerators that include limitations expressed in terms of either (1) allowable levels of total chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans or (2) allowable TEQs. The proposed rule for primary manganese refining facilities also includes emission limits for dioxin/furan mixtures expressed in terms of ng of toxic equivalents (TEQ) per dry standard cubic meter.
  - ATSDR (1998) established a Minimal Risk Level (MRL) for dioxin and dioxin-like compounds at a concentration of 1 pg TEQ/kg-day.
  - The WHO has established a tolerable daily intake of 1-4 pg TEQ/kg-day.
  - The FDA uses the TEF methodology and TEQs to monitor food and animal feed with the goal of reducing dietary exposure to dioxin-like compounds (FDA, 2005).

- The proposed approach is consistent with how many other state agencies have regulated dioxin and furan mixtures within their regulatory frameworks. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) recently completed a survey of state screening levels and action levels (ASTSWMO, 2006). They found that "...[t]he cancer risk basis of the standards and guidelines reported by States ranged from a stringent one-in-ten million (1E-07) to one-in-ten thousand (1E-04). The majority of standards utilize the more typical one-in-one million (1E-06) risk level criteria...." Ecology reviewed the web pages of several environmental agencies in other states to determine whether agencies were treating dioxin/furan mixtures as a single hazardous substance (Option 2) or a mixture of multiple hazardous substances (Option 1). While it is sometimes difficult to interpret some of the regulatory provisions, the results[26] indicate that many (but not all) states use approaches that are consistent with Option 2 (i.e. establish cleanup levels and/or criteria for TCDD and then use the TEQ for the mixture to evaluate compliance with those cleanup levels and/or criteria). One exception is the Oregon Superfund program which uses an approach similar to Option 1.

Table 5: Comparison of Approaches Used By Other State Environmental Agencies When Evaluating Dioxin/Furan Mixtures

State	Environmental Program	TEF Values	Regulatory Approach	Risk Level applicable to mixture
Florida[27]	Superfund	WHO-98	Mixture	10^{-6}
Minnesota[28]	Pollution Control Agency	WHO-98	Mixture	10^{-5} (includes PCBs)
New York[29]	Water Quality	EPA-89	Mixture	10^{-5}
Oregon[30]	Waste Mgt & Cleanup	WHO-98	Congener & Mixture	10^{-5}
Oregon[31]	Water Quality	WHO-98	Mixture	10^{-6}
Texas[32]	Superfund	WHO-98	Mixture	10^{-5} (includes PCBS)
Wisconsin[33]	Superfund	EPA-89	Mixture	10^{-6}

- The proposed approach reflects public concerns about exposure to toxic chemicals. Public concerns about health threats posed by toxic chemicals have grown over the last decade as new information on toxicity and body burdens have become available. Ecology has undertaken several initiatives to reduce and cleanup sources of toxic chemicals in Puget Sound and other parts of the state. Options 2 and 3 reflect risk policy choices that are consistent with public concerns and the high priority assigned to these initiatives.

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[26] Ecology has not surveyed all 50 states and, consequently, recognizes that the results may not reflect the full range of approaches used by different state agencies and/or the variability among programs within a single state agency
[27] FloridaTechnical Report: Development of Cleanup Target Levels (CTLs) For Chapter 62-777, Florida AdministrativeCode, Prepared for the Division of Waste Management Florida Department of Environmental Protection By Center for Environmental & Human Toxicology, University of Florida, Gainesville, Florida, February, 2005, Table 19, Page 61;
[28] Minnesota Pollution Control Agency, Site Remediation Section. Draft Guideline: Risk-Based Guidance for the Soil-Human Health Pathway Vol. 2 Technical Support Document Section 8.2.4. Calculation Spreadsheet: Tier 1 SRV Spreadsheet; Risk-tier1srv.xls, 01/06
[29] New York State Department of Environmental Conservation Rules and Regulations, 6NYCRR Part 703, Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations, Table 1
[30] Oregon Department of Environmental Quality, Waste Management & Cleanup Division. Policy on Toxicity Equivalency Factors. And Electronic Correspondence with Oregon DEQ M. Paulsen to McCormack, March 2006.
[31] Oregon Department of Environmental Quality, Toxic Compounds Criteria, 1999-2003 Water Quality Standards Review Draft Issue Paper, Section 2.3.
[32] Texas Commission on Environmental Quality, Texas Risk Reduction Program, Development of Protective Concentration Levels. Rule §350.76 Approaches for Specific Chemicals of Concern to Determine Human Health Protective Concentration Levels.
[33] Wisconsin Department of Natural Resources.

Relative Bioavailability of Dioxin/Furan Mixtures in Soils (Ingestion Pathway)

Issue #3

Should Ecology revise the default assumptions[34] in the MTCA rule to take into account the relative bioavailability of soil-bound dioxins and furans?

Background

The Model Toxics Control Act (MTCA) Cleanup Regulation provides methods to establish residential (unrestricted land use) and industrial (restricted land use) soil cleanup levels (WAC 173-340-740 through -745). The gastrointestinal (GI) absorption fraction is one of several factors considered when establishing soil cleanup levels. The MTCA rule establishes a default GI absorption fraction of 1.0. This value is based on the assumption that soil-bound dioxin and furans are absorbed to the same extent as dioxin and furans administered in the studies used to establish the cancer slope factor and/or reference dose.

The Department received a wide range of comments on the June 2006 draft rule language. Several organizations expressed the opinion that the default assumption was overly-conservative and recommended that Ecology revise the rule to incorporate a default value that is less than 1.0. In contrast, other organizations expressed the opinion that the default GI absorption fraction of 1.0 should be maintained under this rule revision.

Ecology held four meetings with the MTCA Science Advisory Board between September 2006 and March 2007. During that series of meetings, Ecology presented several options for addressing this issue that were reviewed by the Board.

MTCA Rulemaking Options

Ecology has considered four options for resolving this issue:

1. Default GI Absorption Fraction = 1.0: Under this option, Ecology would maintain the current MTCA rule language that establishes a GI absorption fraction of 1.0 for dioxin/furan mixtures. Method B soil cleanup levels for TCDD would continue to be established at a soil concentration of 6.7 ppt. Industrial soil cleanup levels would continue be established at a soil concentration of 875 ppt.
2. Default GI Absorption Fraction = 0.4: Under this option, Ecology would revise the MTCA rule to establish a default GI absorption fraction of 0.4 for mixtures of dioxins/furans. This value is based on the information in the EPA dioxin reassessment report. Under this option, Method B soil cleanup levels for TCDD would be established at a soil concentration of 17 ppt. Industrial soil cleanup levels would be established at a soil concentration of 2,200 ppt.
3. Default GI Absorption Fraction = 0.7 (tetra- and penta-congeners) and 0.4 (hexa-, hepta- and octa-congeners): Under this option, Ecology would revise the MTCA Cleanup Regulation to

[34] WAC 173-340-200 states that "Gastrointestinal absorption fraction" means the fraction of a substance transported across the gastrointestinal lining and taken up systematically into the body.

specify a default GI absorption fraction of 0.7 for tetra- and penta-congeners and 0.4 for hexa-, hepta- and octa- congeners. Method B soil cleanup levels would be established at a soil concentration of 11-17 ppt (cleanup levels would vary depending on the composition of the mixture). Industrial soil cleanup levels would be established at soil concentrations of 1,300 to 2,200 ppt (cleanup levels would vary depending upon the composition of the mixture).

4. Default GI Absorption Fraction = 0.6: Under this option, Ecology would revise the MTCA rule to establish a default GI absorption fraction of 0.6 for mixtures of dioxins/furans. Under this option, Method B soil cleanup levels for TCDD would be established at a soil concentration of 11 ppt. Industrial soil cleanup levels would be established at a soil concentration of 1,460 ppt.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-740 and -745 to establish a default GI absorption fraction of 0.6 (Option #4). Ecology's rationale for selecting this option includes the following:

- The proposed approach has a strong underlying scientific basis. The National Academy of Sciences, the World Health Organization and the Environmental Protection Agency have each concluded that soil-bound dioxins and furans are generally less bioavailable than dioxins and furans in food and water. The World Health Organization (Van den Berg et al. 2006) has also stated that the reduced bioavailability needs to be taken into account when applying TEF values to abiotic media such as soils. The MTCA Science Advisory Board has also said that it is reasonable to conclude that soil-bound dioxins and furans are less bioavailable that dioxins and furans in foods and drinking water.

- The proposed approach takes into account the results from available scientific studies performed to evaluate the relative bioavailability of TCDD. Ecology compiled and reviewed studies performed to evaluate the bioavailability of soil-bound dioxins and furans. The vast majority of studies have evaluated the bioavailability of 2,3,7,8 TCDD. There is high degree of variability in study results that reflect differences in study designs, soil types and evaluation endpoints (See Summary Tables at the end of this document). The MTCA Science Advisory Board concluded that a 0.5 absorption value for soil-bound dioxin and furans is consistent with current scientific information and represents a central tendency value. However, the Board also noted that this value should not be interpreted to be an upper bound value and absorption fractions for sensitive population groups or individuals would likely be higher. NOTE: When the 0.5 value is adjusted for the absorption in the studies the cancer slope factor for dioxin is based on (0.8), the result is a GI absorption fraction of 0.6.

- The proposed approach takes into account (on a qualitative basis) the congener-specific differences in the relative bioavailability of soil-bound dioxins and furans. Several scientific committees have concluded that more-chlorinated congeners are less bioavailable than less-chlorinated congeners such as 2,3,7,8 TCDD. Consequently, default values based solely on studies with TCDD may overestimate the bioavailability of mixtures that include a wide range of congeners. Ecology considered an option (option #3) that includes two default values (0.7 value for the dioxin and furan congeners with four and five chlorine atoms and 0.4 for higher-chlorinated congeners. The MTCA Science Advisory Board disagreed with this approach. They concluded that there is sufficient information to suggest that there may be congener-specific differences in bioavailability. However, the Board also concluded that the information is too uncertain and variable to assign a congener-specific point estimate based on the degree of chlorination for the different dioxin/furan congeners and that assigning congener-specific values confers a level of precision not warranted by the current scientific information.

- The proposed approach is consistent with EPA Dioxin Reassessment and default values established by state agencies that have evaluated this issue. EPA used a relative bioavailability of 0.4 when evaluating the risks of soil-bound dioxins. Michigan and Minnesota use relative bioavailability values between 0.5 and 0.6 when establishing soil cleanup levels. However, most states appear to be using a default value of 1.0.

- Ecology believes the revised approach will continue to result in soil cleanup levels that are protective. Ecology establishes soil cleanup levels based on reasonable maximum exposures. The "reasonable maximum exposure" is defined as "…the highest exposure that can reasonably expected to occur for humans or other living organisms at a site under current and potential future site use." In calculating reasonable maximum exposures, EPA and Ecology generally use a combination of upper-bound and average values for the individual exposure parameters. Ecology agrees with the Science Advisory Board that this value represents a central tendency value. However, Ecology believes the revised approach will continue to result in protective soil cleanup levels given the other parameters and assumptions used to calculate MTCA cleanup levels. Soil cleanup levels established using the revised approach (11 ppt) fall at the lower (more protective) end of soil cleanup levels and screening values used by EPA and other states.

Choice of TEF Values for cPAH Mixtures

Issue #4

Should Ecology revise the MTCA rule to require people to use the latest relative potency factors developed by the California Environmental Protection Agency when evaluating the human health risks of PAH mixtures?

Background

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of chemicals formed during the incomplete burning of organic materials such as wood, garbage, oil, coal, gas and tobacco. There are more than 100 different PAHs.

EPA (1993) published provisional guidance for evaluating the carcinogenic risks associated with PAH mixtures using a relative potency factor (RPF) approach. The EPA (1993) approach uses benzo(a)pyrene [BaP] as the index chemical (i.e., having a relative potency of 1.0) and includes RPF values for seven (7) carcinogenic PAHs.

The California Environmental Protection Agency (Cal EPA, 1994) expanded upon the EPA approach when it developed Potency Equivalency Factors (PEFs) for use in evaluating PAH mixtures. The Cal EPA 1994 approach also uses BaP as the index chemical and includes PEFs for twenty-two (22) carcinogenic PAHs. In 2001, Ecology amended the MTCA rule to explicitly authorize cleanup proponents to use the Cal EPA (1994) methodology to evaluate the toxicity and assess the risks from exposure to carcinogenic PAH mixtures.

The California EPA recently completed a review of the 1994 PEF values. Based on that review, Cal EPA published an update list of PEF values (Cal EPA, 2005). The Cal EPA (2005) approach continues to use BaP as the index chemical and includes PEFs for twenty-five (25) carcinogenic PAHs. Table 6 summarizes the PAH compounds and RPF/PEF values in the three approaches (i.e. EPA, 1993; Cal EPA, 1994; and Cal EPA, 2005).

MTCA Rulemaking Options

Ecology has considered two options for resolving this rulemaking issue:

1. Cal-EPA 1994 Values: Under this option, Ecology would continue to use the PEF values from the 1994 California Environmental Protection Agency's guidance document;
2. Cal-EPA 2005 Values: Under this option, Ecology would revise the MTCA rule to specify that the updated PEF values (Cal EPA 2005) should be used when assessing PAH mixtures.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to specify that the PEF values and methodology described in Cal EPA (2005) should be used when assessing the human health risks of PAH mixtures (Option #2). Ecology's rationale for selecting this option includes the following:

- The California EPA methodology has a strong scientific and biological basis. Polycyclic aromatic hydrocarbons are a well defined group of chemicals consisting of three or more fused aromatic rings. PAHs are ubiquitous multi-media contaminants commonly found as complex environmental mixtures. The carcinogenicity of PAHs is due to the generation of biologically active metabolites which covalently bind to DNA and is considered a common mode of action for all cPAHs (EPA, 1993; Naz, 1999). When preparing the 2001 rule amendments, Ecology concluded that Cal-EPA (1994) values had broader applicability than the EPA (1993) values:

  EPA's TEFs are all based on dermal studies which is good for internal relative ranking but may not be good for applying to ingestion or inhalation exposures. In fact, EPA explicitly cautions against applying their TEFs to inhalation exposures. Instead, EPA proposes that their TEFs be applied only to ingestion exposure and is silent on the issue of dermal exposure (which is surprising, since their TEFs are based on mouse skin painting). In contrast, CalEPA TEFs are based on a variety of exposure routes, including a drinking water study for dibenzo(a,h)anthracene (Snell and Stewart, 1962), an intrapulmonary study for benzo(k)fluoranthene (Deutsch-Wenzel et al, 1983), and a skin painting study for chrysene (Wynder and Hoffman, 1959). In general, CalEPA TEFs were based on tumor data from relevant exposure routes (i.e., intrapulmonary and intratracheal administration, since CalEPA TEFs were targeted at air contaminants), tumor data from other exposure routes, genotoxicity data, and structure-activity relationships (SARs), in that order. Because CalEPA TEFs were based on a broader array of carcinogenic endpoints, these appear to have more general applicability (e.g., for route to route extrapolation) than EPA's approach based on a single endpoint. (Ecology SAB Briefing Memorandum, 1998)

- The California EPA methodology and values are based on current scientific information. Cal EPA (2005) considered the most recent scientific information evaluating individual tumorigenic responses for 25 cPAHs when updating the 1994 values.

- The MTCA Science Advisory Board has concluded that the California EPA methodology and values are consistent with current scientific information. The MTCA Science Advisory Board reviewed and endorsed Ecology's use of the original Cal-EPA values during the 2001 rulemaking process. Ecology believes that the use of the updated Cal-EPA values is a logical extension of the initial decision to use the original Cal-EPA values. After reviewing Ecology's current rule proposal, the MTCA Science Advisory Board concluded:

  The Board stated that the 2005 PEF values for carcinogenic PAHs recommended by the California Environmental Protection Agency are consistent with current scientific information. As with dioxins and furans, the Board stated that it was fortuitous that the California EPA had recently completed a review and evaluation of available scientific information and published updated PEF values for carcinogenic PAHs. The Board noted that CalEPA considered a wide range of studies when establishing PEF values. The Board also observed that the California document describing the methodology provides information that is useful for Ecology as it proceeds with the MTCA rule update. (Attachment to March 19, 2007 Meeting Summary)

- The 2005 PEF values are similar to the PEF values specified in the current MTCA rule. The updated Cal-EPA values are similar to PEF values in 1994 Cal-EPA guidance materials. As indicated in Table 6, the 1994 and 2005 Cal-EPA approaches include identical PEF values for six of the seven cPAHs typically assessed at cleanup sites. The exception is dibenzo(a,h)anthacene which has a smaller PEF in the updated guidance. While this difference may impact conclusions on individual samples, Ecology does not believe that the use of the more current PEF values will significantly alter the stringency of cleanup requirements on a statewide basis.

- The 2005 PEF values are consistent with values used by EPA and other state agencies to characterize PAH mixtures. EPA and most other state environmental agencies use some type of relative potency approach to characterize PAH mixtures. However, EPA and most states use the methodology and values specified in an EPA guidance document (EPA 1993). The Cal-EPA approach is conceptually similar to the EPA approach. Scientists at EPA-Region 10 agree that the current California EPA's PEFs provide a scientifically valid way to evaluate the health risks associated with exposures to PAH mixtures.

Table 6: Comparison of Relative Potency Factors (RPFs) and Potency Equivalency Factors (PEFs) for Polycyclic Aromatic Hydrocarbons

Polycyclic Aromatic Hydrocarbon	Relative Potency Factors (RPF) (EPA, 1993[35])	Potency Equivalency Factors (PEF) (Cal-EPA, 1994[36]) (Current MTCA)	Potency Equivalency Factors (PEFs) (Cal-EPA, 2005[37]) (Planned Revisions)
Benzo(a)pyrene	1	1	1
Benz(a)anthracene	0.1	0.1	0.1
Benz(b)fluoranthene	0.1	0.1	0.1
Benz(j)fluoranthene	-----------------	0.1	0.1
Benz(k)fluoranthene	0.01	0.1	0.1
Dibenz(a,j)acridine	-----------------	0.1	0.1
Dibenz(a,h)acridine	-----------------	0.1	0.1
7H-dibenzo(c,g)carbazole	-----------------	1.0	1.0
Dibenzo(a,e)pyrene	-----------------	1.0	1.0
Dibenzo(a,h)pyrene	-----------------	10	10
Dibenzo(a,i)pyrene	-----------------	10	10
Dibenzo(a,l)pyrene	-----------------	10	10
Indeno(1,2,3-cd)pyrene	0.1	0.1	0.1
5-methylchrysene	-----------------	1.0	1.0
1-nitropyrene	-----------------	0.1	0.1
4-nitropyrene	-----------------	0.1	0.1
1,6-dinotropyrene	-----------------	10	10
1,8-dinotropyrene	-----------------	1.0	1.0
6-nitrochrysene	-----------------	10	10
2-nitrofluorene	-----------------	0.01	0.01
Chrysene	0.001	0.01	0.01
Dibenz(a,h)anthracene	1	0.4	0.1
7,12-dimethylbenzanthracene	-----------------	------------------	10
3-methylcholanthrene	-----------------	------------------	1
5-nitroacenaphthene	-----------------	------------------	0.01

[35] U.S. EPA, 1993. Provisional Guidance for Quantitative risk Assessment of Polycyclic Aromatic Hydrocarbons. July 1993. EPA/600/R-93/089.

[36] Cal-EPA, 1994. Benzo(a)pyrene as a toxic air contaminant. Part B: Health Assessment, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, California

[37] Cal-EPA, 2005. Air Toxics Hot Spots Program Risk Assessment Guidelines, Part II Technical Support Document for Describing Available Cancer Potency Factors. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. May 2005. Pages B-77 to B-97.

Range of PAH Compounds Used to Characterize cPAH Mixtures

Issue #5

When evaluating the carcinogenic risks of cPAH mixtures, should Ecology continue to focus on the seven PAH compounds identified in the current MTCA rule?

Background

EPA (1993) published provisional guidance for evaluating the carcinogenic risks associated with PAH mixtures using a relative potency factor (RPF) approach. The EPA (1993) approach uses benzo(a)pyrene [BaP] as the index chemical (i.e., having a relative potency of 1.0) and includes RPF values for seven (7) carcinogenic PAHs (See Table 7).

Cal EPA (1994) expanded upon the EPA approach when it developed Potency Equivalency Factors (PEFs) for use in evaluating PAH mixtures. The Cal EPA approach also uses BaP as the index chemical and includes PEFs for twenty-two (22) carcinogenic PAHs. The updated Cal-EPA guidance document (Cal EPA, 2005) includes PEFs for twenty-five (25) carcinogenic PAHs.

WAC 173-340-708(8)(e) specifies that, at a minimum, seven cPAH[38] compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd) pyrene) must be evaluated when using the TEF approach to characterize cPAH mixtures. However, the rule also states that Ecology may require other compounds from the Cal-EPA list to be evaluated at individual sites. To date, Ecology has not required other cPAH compounds to be evaluated at individual sites.

Table 7: cPAH Compounds Included in California EPA 2005 Guidance

cPAHs Listed in MTCA Rule	TEF	Other cPAHs on Cal-EPA List	TEF
benzo[a]pyrene	1	benzo(j)fluoranthene	0.1
benzo[a]anthracene	0.1	dibenz[a,j]acridine	0.1
benzo[b]fluoranthene	0.1	dibenz[a,h]acridine	0.1
benzo[k]fluoranthene	0.1	7H-dibenzo[c,g]carbazole	1
chrysene	0.01	dibenzo[a,e]pyrene	1
dibenz[a,h]anthracene	0.1	dibenzo[a,h]pyrene	10
indeno[1,2,3-cd]pyrene	0.1	dibenzo[a,i]pyrene	10
		dibenzo[a,l]pyrene	10
		5-methylchrysene	1
		1-nitropyrene	0.1
		4-nitropyrene	0.1
		1,6-dinitropyrene	10
		1,8-dinitropyrene	1
		6-nitrochrysene	10
		2-nitrofluorene	0.01
		7,12-dimethylbenzanthracene[a]	10
		3-methylcholanthrene	1
		5-nitroacenaphthene	0.01

[38] WAC 173-340-200 includes the following definition: "PAHs (carcinogenic)" or "cPAHs" means those polycyclic aromatic hydrocarbons substances, PAHs, identified as A (known human) or B (probable human) carcinogens by the United States Environmental Protection Agency. These include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd) pyrene."

MTCA Rulemaking Options

Ecology has considered three options for resolving this rulemaking issue:

1. Characterize PAH Mixtures Using Information on Seven PAH Compounds: Under this option, Ecology would revise WAC 173-340-708(8)(e)(ii) to state that PAH mixtures must be characterized using the seven PAH compounds listed in the definition of "carcinogenic PAHs".
2. Characterize PAH Mixtures Using Information on Seven PAH Compounds with the Option to Consider Other Carcinogenic PAHs: Under this option, Ecology would continue to use the current rule language which states that, at a minimum, analyses and TEF calculations must be based on the seven PAH compounds identified in the definition of "PAH (carcinogenic)" with Ecology retaining the discretion to require an evaluation of additional compounds at individual sites.
3. Characterize PAH Mixtures Using Information on Twenty-Five PAH Compounds: Under this option, Ecology would revise WAC 173-340-708(8)(e)(ii) to state that PAH mixtures must be characterized using the twenty-five PAH compounds listed in the California EPA guidance.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to continue to use the current language in WAC 173-340-708(8). Under the current rule, analyses and TEF calculations must be based on the seven PAH compounds identified in the definition of "PAH (carcinogenic)" with Ecology retaining the discretion to require an evaluation of additional compounds at individual sites (Option 2). Ecology's rationale for selecting this option includes the following:

- Scientific and regulatory agencies have identified a number of other PAH compounds as known or potential human carcinogens. Polycyclic aromatic hydrocarbons are a well-defined group of chemicals consisting of three or more fused aromatic rings. The carcinogenicity of PAHs is due to the generation of biologically active metabolites which covalently bind to DNA and is considered a common mode of actions for all cPAHs (EPA, 1993; Naz, 1999). EPA has identified seven (7) PAH[39] compounds as A (known human) or B (probable human) carcinogens[40]. The National Toxicology Program (NTP, 2005) has identified 15 PAH compounds as "reasonably anticipated to be a human carcinogen". Cal EPA considered the most recent scientific information evaluating individual tumorigenic responses for 25 cPAHs when updating the PEF values for cPAHs (Cal EPA, 2005).
- Ecology has not considered other PAH compounds beyond the seven cPAH compounds specified in the current rule when evaluating health risks associated with PAH mixtures: WAC 173-340-708(8)(e) specifies that, at a minimum, seven cPAH[41] compounds must be

[39] These include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd) pyrene.
[40] On March 29, 2005, EPA issued "Guidelines for Carcinogen Risk Assessment" which replaced the 1986 risk guidelines. The 2005 guidelines include a new set of weight of evidence descriptors that replace the previous system (A, B1, B2, C and D).
[41] WAC 173-340-200 includes the following definition: "PAHs (carcinogenic)" or "cPAHs" means those polycyclic aromatic hydrocarbons substances, PAHs, identified as A (known human) or B (probable human) carcinogens by the United States Environmental Protection Agency. These include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd) pyrene."

evaluated when using the TEF approach to characterize cPAH mixtures. However, the rule also states that Ecology may require other compounds from the Cal-EPA list to be evaluated at individual sites. To date, Ecology has not required cleanup proponents to evaluate other cPAH compounds when performing remedial investigations.

- Most environmental programs use information on seven PAH compounds when evaluating the health risks posed by PAH mixtures. Ecology reviewed the methods and procedures used by other environmental programs to characterize PAH mixtures. Several Ecology programs[42] [43] consider more than the seven PAH compounds identified in EPA (1993) when evaluating PAH mixtures. However, it appears that most state and federal environmental agencies focus on the seven PAH compounds when evaluating carcinogenic risks. For example:
  - The Air Quality Program focuses on the seven cPAH compounds identified in EPA (1993) when evaluating new source emissions under Chapter 173-460 WAC (Controls For New Sources Of Toxic Air Pollutants).
  - EPA's Superfund Program generally uses the methods and procedures described in EPA (1993) when evaluating health risks associated with cPAH mixtures.
  - Ecology reviewed the methods and procedures used by several other state superfund programs. Based on that review, most states appear to be using the EPA (1993) methodology and focus their evaluation on the seven cPAHs identified in the EPA document (See Table 8).
- Standard analytical methods are not available and/or routinely used for many of the cPAH compounds included on the Cal-EPA list. Standard analytical methods typically do not analyze for the levels of many of the cPAH compounds included on the Cal-EPA list. As additional information becomes available on the presence of these cPAH compounds and the risk posed by these additional compounds, additional cPAH compounds can be addressed by retaining the current rule language.

[42] The Hazardous Waste Program. Polycyclic aromatic hydrocarbons are designated dangerous wastes based on persistence criteria consistent with WAC 173-303-100 (6). For the purposes of Chapter 173-303 WAC, the PAHs of concern for designation include a large suite of PAHs. A person whose waste contains PAHs as defined in WAC 173-303-040, must determine the total PAH concentration by summing the concentration percentages of each of the polycylic aromatic hydrocarbons for which they know the concentrations (Ecology, 1998b). The equivalent concentration percentage is the sum of all the concentration percentages for a particular toxic category, such as halogenated organic compounds or PAHs.

[43] Ecology considers 16 PAH compounds when evaluating compliance with the Sediment Management Standards (Chapter 173-204 WAC). PAH concentrations are reported on a weight-weight basis (ug/kg wet weight or mg/kg dry weight) for each individual low and high molecular weight PAH and then added together to reflect the total concentration for low and high molecular weight PAHs. Low molecular weight PAHs (LPAH) include naphthalene, 2-methylnaphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene and anthracene. High molecular weight PAHs (HPAH) include fluroanthene, pyrene, benzo(a)anthracene, chrysene, bewnzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,H)anthracene, and benzo(ghi)perylene.

Cleanup Levels for cPAH Mixtures

Issue #6

Should Ecology revise the MTCA rule to require that Method B cleanup levels for carcinogenic PAH mixtures be based on a cancer risk of one-in-one million?

Background

Ecology amended the MTCA Cleanup Regulation in February 2001. Under the rule amendments, a person undertaking a cleanup action may use the California EPA (1994) methodology and potency equivalence factors (PEFs) when assessing PAH mixtures.

The existing MTCA rule does not clearly specify how the TEF methodology must be used when calculating cleanup levels for PAH mixtures. Two approaches have been used to establish cleanup levels using the TEF methodology:

Ecology amended the MTCA rule in February 2001. Under the rule amendments, a person undertaking a cleanup action may use the Environmental Protection Agency's (EPA, 1989) interim methodology and the toxicity equivalency factor (TEF) values when assessing dioxin and furan mixtures.

The existing MTCA rule does not clearly specify how the TEF methodology must be used when calculating Method B cleanup levels for mixtures of dioxins/furans and PAHs. Two approaches have been used to establish cleanup levels using the EPA TEF methodology:

- Cleanup Levels for the Whole PAH Mixture Based on a Cancer Risk Level of One-in-One Million. In November 2001, Ecology published guidance[44] on how to use the TEF methodology when establishing and evaluating compliance with MTCA cleanup levels. The guidance directed people to (1) use the TEF methodology to calculate a total toxic equivalency concentration and (2) compare the calculated value to the applicable cleanup level for the reference chemical (either 2,3,7,8 TCDD or benzo[a]pyrene). Under this approach, the mixture is characterized by a single value (the total toxicity equivalent concentration). Method B cleanup levels for the mixture are then established using a cancer risk level of one-in-one million (10^{-6}).

- Cleanup Levels for Individual Congeners Based on Cancer Risk Level of One-in-One Million. In November 2005, Rayonier Properties, LLC argued that the MTCA rule requires Ecology to establish cleanup levels for dioxin mixtures using a cancer risk level of 10^{-5} (as opposed to applying 10^{-6} risk level to the whole mixture). Under this approach, cleanup levels for individual congeners would be established using a cancer risk level of 10^{-6}. Ecology agreed that Rayonier's approach was a reasonable interpretation of the current MTCA rule and, consequently, represents a plausible approach for using the TEF methodology to implement the current MTCA rule. Under this approach, the TEF methodology is used to calculate a cleanup level for each congener. This approach could also be used for PAH mixtures. Under this approach, the total site risk (taking into account all

[44] Cleanup Levels and Risk Calculation (CLARC) Guidance

cPAHs, other hazardous substances, and multiple exposure pathways) cannot exceed a cancer risk of one-in-a-hundred thousand (10^{-5})

MTCA Rulemaking Options

Ecology has considered two options for resolving this issue:

1. Cleanup Levels for each cPAH are Based on a Cancer Risk Level of One-in-One Million. This approach is similar to the approach for dioxin cleanup levels specified in the Rayonier Settlement Agreement. Under this option, Method B cleanup levels would be established for B(a)P based on an incremental cancer risk of one-in-one million (10^{-6}). Cleanup levels for other PAH compounds would be established by dividing the B(a)P cleanup level by the applicable TEF. Because there is an overall limit on cancer risk under MTCA of one-in-one hundred thousand (10^{-5}), when more than 10 carcinogens (PAHs or hazardous substances) are present at a site, the cleanup levels for B(a)P and other carcinogenic PAHs would need to be adjusted downward to insure this overall risk limitation is not exceeded. If there are multiple pathways of exposure, a further downward adjustment for carcinogenic PAHs would also need to be made.
2. Cleanup Levels for PAH Mixtures are Based on a Cancer Risk Level of One-in-One Million. This is the approach specified in the Cleanup Levels and Risk Calculation (CLARC) Guidance. Under this option, Method B cleanup levels would be established for B(a)P based on an incremental cancer risk of one-in-one million (10^{-6}). The PEF values in Cal-EPA (2005) would be used to calculate a TEQ (based on the 7 PAH compounds identified in the first column of Table 7) for environmental samples that would then be compared to the B(a)P cleanup level.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to state that cPAH mixtures will be considered a single hazardous substance for assessing carcinogenic risk under MTCA. Under this approach, Method B cleanup levels for mixtures of cPAHs must be based on a cancer risk of one-in-one million (10^{-6}) (Option #2). Ecology's rationale for selecting this option includes the following:

- PAH mixtures differ from the majority of mixtures found at MTCA sites. Most MTCA sites include mixtures of hazardous substances. However, the mixtures addressed in this rulemaking differ from most other types of mixtures in that (1) the different PAH compounds generally occur together and (2) scientists have concluded that the PAH compounds identified in the rule act through common biological mechanisms and essentially behave like one chemical in the human body[45].
- Ecology believes that the proposed approach provides a margin of safety that minimizes the potential for health risks from PAH compounds that are not routinely considered when establishing cleanup levels for PAH mixtures: WAC 173-340-708(8)(e) specifies that, at a

[45] Polycyclic aromatic hydrocarbons are a well defined group of chemicals consisting of three or more fused aromatic rings. The carcinogenicity of PAHs is due to the generation of biologically active metabolites which covalently bind to DNA and is considered a common mode of actions for all cPAHs (EPA, 1993; Naz, 1999). The TEF methodology is, in part, based on cPAHs collectively producing a similar biological responses – essentially acting as one chemical through a common mode of action.

minimum, seven cPAH[46] compounds (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd) pyrene) must be evaluated when using the TEF approach to characterize cPAH mixtures. However, scientific and regulatory agencies have identified a number of other PAH compounds as known or potential human carcinogens. For example, the National Toxicology Program (NTP, 2005) has identified 15 PAH compounds as "reasonably anticipated to be a human carcinogen". The California Environmental Protection Agency has established potency equivalency factors for twenty-five carcinogenic PAHs (Cal EPA, 2005). Under the proposed approach, the seven PAHs identified in the MTCA rule serve as surrogates or indicators for the broader suite of PAH compounds.

- Ecology believes that the proposed approach provides a margin of safety that minimizes the potential health risks resulting from early-life exposures to PAHs. Recent studies indicate that exposure to carcinogens during childhood can increase the risk of developing cancer later in life. In March 2005, EPA published the *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* (EPA, 2005b) that describes approaches for using this information when assessing health risks. In that document, EPA identified benzo[a]pyrene, dimethylbenz[a]anthracene and dibenzo[a,h]anthracene as chemicals that have a mutagenic mode of action for carcinogenicity. In June 2006, EPA published guidance for implementing the Supplemental Guidance. EPA (2006) recommended that risk assessors use the age-dependent adjustment factors in the Supplemental Guidance when using the cancer slope factors for these compounds. The use of these factors is a broader issue that Ecology plans to consider during the five-year process.

- The proposed approach simplifies the approach for establishing MTCA cleanup levels: The MTCA Cleanup Regulation specifies that Method B and C cleanup levels established for individual hazardous substances based on a particular pathway (e.g. soil ingestion) must be adjusted downward to take into account exposure to multiple hazardous substances and/or multiple exposure pathways in situation where total excess cancer risk would exceed 10^{-5}Treating PAH mixtures as a single hazardous substance minimizes the need to make such adjustments. This simplifies the process for establishing cleanup levels. —

- The proposed approach is consistent with the policies and procedures used to establish the Method A cleanup levels in the current MTCA rule: Option 2 is also consistent with the policies and procedures underlying the Method A soil cleanup levels[47]. This approach was extensively discussed with the TPH Policy Oversight Group during the 2001 MTCA rule making and developed based on those discussions.

- The proposed approach is consistent with the policies and procedures used by several other Ecology programs: Several other Ecology programs have adopted approaches that are similar to Option 2. For example:
    - The Air Quality Program treats PAH mixtures as a single toxic air pollutant when evaluating potential emissions from proposed new sources. Under this regulation, PAH emissions are compared to screening levels for mixtures of PAHs that are expressed in

[46] WAC 173-340-200 includes the following definition: "PAHs (carcinogenic)" or "cPAHs" means those polycyclic aromatic hydrocarbons substances, PAHs, identified as A (known human) or B (probable human) carcinogens by the United States Environmental Protection Agency. These include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd) pyrene."

[47] When developing the Method A values, cPAH mixtures were treated as a single hazardous substance and the Method A soil cleanup level was calculated using a target cancer risk of one-in-one million (10^{-6})

terms of B(a)P[48]. The screening levels are based on an incremental cancer risk of one-in-one million (WAC 173-460-060).

- o The Water Quality Program has established a ground water criterion for both PAHs and BaP (Chapter 173-200 WAC).

However, Ecology recognizes that not all programs use the same approach to evaluate/ regulate PAH mixtures. For example, the National Toxics Rule establishes surface water standards based on protection of human health and includes individual criteria for seven PAH compounds. Compliance is evaluated separately for each PAH compound.

- The proposed approach reflects public concerns about exposure to toxic chemicals: Public concerns about health threats posed toxic chemicals have grown over the last decade as new information on toxicity and body burdens have become available. Ecology has undertaken several initiatives to reduce and cleanup sources of bioaccumulative chemicals in Puget Sound and other parts of the state. Selection of an option that relaxes cleanup requirements for chemical mixtures (Option 1) would be inconsistent with these Ecology initiatives.

- The proposed approach is consistent with approaches used by some EPA programs: There is also a great deal of variability in the approaches used by federal programs to evaluate/ regulate PAH mixtures. EPA has established a maximum contaminant level (MCL) for BaP and compliance is evaluated based on BaP measurements in drinking water. However, several federal programs implement approaches that are similar to Option 2. For example:
  - o The EPA Superfund program continues to use the methods and procedures described in EPA (1993) and has reaffirmed the use of TEF methodology for cPAHs considered as a single hazardous substance for the whole mixture by summing the carcinogenic potential of individual PAHs relative to an index compound (e.g., benzo(a)pyrene)[49].
  - o EPA established emission limits for polycyclic organic matter, PAHs, as part of its list of 189 hazardous air pollutants using TEF methodology to evaluate the potential health risks from exposures to airborne particulate mater contaminated with PAHs.

- The proposed approach falls within the range of approaches use by other state environmental agencies. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) recently completed a survey of state screening levels and action levels (ASTSWMO, 2006). They found that "...[t]he cancer risk basis of the standards and guidelines reported by States ranged from a stringent one-in-ten million (1E-07) to one-in-ten thousand (1E-04). The majority of standards utilize the more typical one-in-one million (1E-06) risk level criteria...." Ecology reviewed the web pages of several environmental agencies in other states to determine whether agencies were treating PAH mixtures as a single hazardous substance (Option 2) or a mixture of multiple hazardous substances (Option 1). The results are shown in Table 8 on the following page. Ecology identified two states that treat PAH mixtures as single hazardous substances when establishing those requirements. However,

[48] For mixtures of PAHs, WAC 173-460-050 states "The owner or operator of a source that may emit a mixture of polyaromatic hydrocarbon emissions shall quantify the following PAHs and shall consider them together as one TAP equivalent in potency to benzo(a)pyrene: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h,)anthracene, indenol(1,2,3-cd)pyrene, benzo(a)pyrene." [WAC 173-460-050 (4) (iii) (c)].
[49] Lynn Flowers, Abstract:Toxicology of Polycyclic Aromatic Hydrocarbon (PAH) Mixtures. IRIS Staff, US Environmental Protection Agency. Presentation from Spring 2005 Society of Toxicology Meeting.

the majority of states surveyed by Ecology consider each PAH compound as an individual hazardous substance (Option 1).[50]

Table 8: Approaches Used By Other State Environmental Agencies When Evaluating PAH Mixtures

State	State Programs	TEF Value	Each PAH = Single Substance (Option 1)	Mixture = Single Substance (Option 2)	Cancer Risk Level Applied to PAHs
Florida[51]	Waste Management Div.	EPA 1993	X		$1x10^{-6}$
New Jersey[52]	Site Remediation Program	EPA 1993	X		$1x10^{-6}$
Idaho[53]	Waste Mngmt & Remed.	EPA 1993	X		$1x10^{-6}$
Louisiana[54]	Remediation Service Div.	EPA 1993	X		$1x10^{-6}$
Massachusetts[55]	MA Dept. of Env. Prot.	EPA 1993	X		$1x10^{-6}$
Minnesota[56]	Pollution Control Agency	Cal-EPA		X	$1x10^{-5}$ (mixture)
Oregon[57]	Oregon DEQ	EPA 1993	X		$1x10^{-6}$
Texas[58]	Remediation Division	EPA 1993	X		$1x10^{-5}$
Wisconsin[59]	Dept. of Nat. Resources	EPA 1993	X	X[60]	$7x10^{-7}$ (mixture)

[50] Ecology has not surveyed all 50 states and, consequently, recognizes that the results may not reflect the full range of approaches used by different state agencies and/or the variability among environmental programs within a single state agency.
[51] Technical Report: Development of Cleanup Target Levels (CTLs) For Chapter 62-777, F.A.C., Prepared for the Division of Waste Management Florida Department of Environmental Protection By Center for Environmental & Human Toxicology, Univ. of Florida, Gainesville, FL, Feb., 2005, Table 19, Page 61; and Table 1: page 4 of 41
[52] Site remediation Program; contact Linda Cullen (609-984-9778
[53] Idaho Risk Evaluation Manual, Final, July 2004; RBCA Tier 2 Software version 1.0, user's guide and Risk-based Corrective Action for Tier 2 Evaluation.
[54] LDEQ RECAP 2003; APPENDIX D: GUIDELINES FOR ASSESSING POLYCYCLIC AROMATIC HYDROCARBONS POLYCHLORINATED DIBENZODIOXINS/POLYCHLORINATED DIBENZOFURANS
[55] Massachusetts Department of Environmental Protection. Polycyclic Aromatic Hydrocarbons (PAHs). Guidance for Disposal Site Risk Characterization.
[56] Minnesota Department of Health. Risk Assessment Rules/Guidance. Polycyclic Aromatic Hydrocarbons:Methods for Estimating Health Risks from Carcinogenic PAHs. And Risk-Based Guidance for The Soil-Human Health Pathway. Volume 2. Technical support document Minnesota Pollution control Agency. Site Remediation Section, January 1999, page 53. Calculation Spreadsheet: Tier 1 SRV Spreadsheet; Risk-tier1srv.xls, 01/06.
[57] Oregon Department of Environmental Quality. E-Mail From M. Poulsen (OR DEQ) to Dr. M. Bailey (EPA, Region X) March 30, 2006; and email from Michael Anderson . OR DEQ) to Ecology Staff on June 27, 2006.
[58] Texas Natural Resource Conservation Commission; Chapter 350 – Texas Risk Reduction Program; SUBCHAPTER D : DEVELOPMENT OF PROTECTIVE CONCENTRATION LEVELS; §§350.71 - 350.79; September 23, 1999 page 89; and TNRCC Regulatory Guidance Remediation Division: RG-366/TRRP-18; Risk Levels, Hazard Indices, and Cumulative Adjustment; August 2002
[59] Wisconsin Department of Natural Resources. Soil Cleanup Levels for Polycyclic Aromatic Hydrocarbons (PAHs) Interim Guidance. Publication RR-519-97, April 1997.
[60] The Wisconsin DNR Interim Guidance specifies that cleanup proponents may develop soil cleanup levels based on BaP equivalent concentrations as an alternative to applying generic residual contamination levels (RCLs).

Use of the TEF Methodology for PCBs Mixtures

Issue #7

Should Ecology revise the MTCA rule to explicitly allow or require people to use the TEF values and methodology developed by the World Health Organization when assessing the human health risks of PCB mixtures?

Background

Polychlorinated biphenyls (PCBs) are a group of synthetic organic chemicals that include 209 individual chlorinated biphenyl compounds (known as congeners). Commercial mixtures of PCBs were manufactured in the United States from @ 1930 to 1977 under the trademark "**Aroclor**" followed by a four digit number; usually the first two digits indicate the parent biphenyl molecule and the last two digits indicate the percent chlorine by weight[61]. PCBs were used as coolants and lubricants in electrical equipment, such as capacitors and transformers, because of their inflammability, chemical stability, and insulating properties. There are no known natural sources of PCBs.

There are two general approaches for evaluating health risks associated with environmental concentrations of PCBs:

- Total PCB Concentrations. Under the MTCA Cleanup Regulation, excess cancer risks, cleanup levels and remediation levels for PCB mixtures are currently calculated using the cancer slope factor for PCBs published in the Integrated Risk Information System (IRIS) database. Compliance is evaluated using measurements of total PCB concentrations in environmental media using standard methods (e.g. EPA Methods 8080 and 8081) that involve the use of gas chromatography/electron capture detection systems. Specifically, total PCB concentrations are estimated by comparing the chromatographic pattern of peaks in the environmental sample with the pattern or number of peaks in a commercial Arochlor sample.

- Congener-specific analyses. PCB mixtures may include up to 209 individual congeners which differ in terms of the number and location of chlorine atoms. Over the last 30 years, the standard approach for estimating PCB environmental concentrations has begun to shift from the analysis of commercial mixtures to congener-based analyses. There is a now sizable body of scientific information supporting the use of TEFs to characterize PCB mixtures.

The TEF methodology for coplanar PCBs has evolved over the last fifteen years (see Table 12). EPA (1991)[62] concluded that selected PCBs may share a common mode of action with TCDD. Ahlborg et al. (1994)[63] concluded that TEFs are applicable to certain PCBs that display dioxin-

[61] For example, Aroclor 1260 contains 12 carbon atoms (parent biphenyl molecule) and approximately 60 percent chlorine by weight. Aroclor 1016 is an exception to this nomenclature scheme, as it contains 12 carbon atoms and contains over 41 percent chlorine by weight.

[62] U.S. EPA. 1991. Workshop report on toxicity equivalency factors for polychlorinated biphenyl congeners. Risk Assessment Forum. EPA/625/3-91/020. The purpose of the 1991 EPA workshop was to examine the existing toxicity and exposure database on PCBs to ascertain the feasibility of developing toxicity equivalency factors for dioxin-like PCB congeners.

[63] Ahlborg UG, Becking GC, Birnbaum LS, Brouwer A, Derks HJGM, Feeley M, Golor G, Hanberg A, Larsen JC, Liem AKD, et al. 1994. Toxic equivalency factors for dioxin-like PCBs; report on a WHO-ECEH and IPCS

like properties because they share a common mode of action with TCDD. In 1998, the World Health Organization (WHO)[64] generated a database consisting of approximately 1,200 peer-reviewed publications evaluating the toxicity of PCBs. Based on that review, the WHO proposed TEF values for 12 dioxin-like PCBs (Van den Berg et al., 1998)[65]. Several state and federal agencies currently use the WHO-98 values to characterize the health risks of PCB mixtures.

The WHO convened a meeting of scientific experts in June 2005 to review the WHO-98 TEF values and other related issues. The scientific experts participating in that meeting recommended changes to the TEF values for nine of the twelve dioxin-like PCB congeners (See Table 9). The results of that meeting are summarized in Van den Berg et al. (2006).

Table 9: Toxicity Equivalency Factors (TEFs) For Polychlorinated Biphenyls (PCBs)

IUPAC #	Structure	WHO/94[66]	WHO/98[67]	WHO/05
77	3,3',4,4'-TCB	0.0005	0.0001	0.0001
81	3,4,4',5-TCB	-------	0.0001	0.0003
105	2,3,3',4,4'-PeCB	0.0001	0.0001	0.00003
114	2,3,4,4',5-PeCB	0.0005	0.0005	0.00003
118	2,3,4,4',5-PeCB	0.0001	0.0001	0.00003
123	2,3,4,4',5-PeCB	0.0001	0.0001	0.00003
126	3,3',4,4',5- PeCB	0.1	0.1	0.1
156	2,3,3',4,4',5-HxCB	0.0005	0.0005	0.00003
157	2,3,3',4,4',5-HxCB	0.0005	0.0005	0.00003
167	2,3,4,4',5,5'- HxCB	0.00001	0.00001	0.00003
169	3,3',4,4',5,5'- HxCB	0.01	0.01	0.03
170	2,2',3,3',4,4',5-HpCB	0.0001	-------	-------
180	2,2',3,4,4',5,5'-HpCB	0.00001	-------	-------
189	2,3,3',4,4',5,5'-HpCB	0.0001	0.0001	0.00003

In 2004, EPA asked the National Academy of Sciences to review the agency's Dioxin Reassessment Report. The NAS report was recently published in 2006 and the committee concluded that the "...the toxic equivalency factor methodology provides a reasonable, scientifically justifiable, and widely accepted method to assess the relative potency of DLCs..." (NAS, 2006, p. 6)[68].

MTCA Rulemaking Options

Ecology has considered three options for resolving this rulemaking issue:

1. Require Evaluation of Dioxin-Like PCB Congeners. Under this option, Ecology would revise the MTCA Cleanup Regulation to require that excess cancer risks, cleanup levels and

consultation. Chemosphere 28 (6): 1049-1067. The results of the 1991 EPA workshop were published in this peer-reviewed technical publication

[64] European Center for Environmental Health and the International Program on Chemical Safety

[65] Van den Berg M, Birnbaum L, Bosveld, ATC, Brunstrom B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, et al. (1998). Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environmental Health Perspectives 106(12):775-792. This peer-reviewed publication is the technical standard for using WHO-recommended TEFs for polychlorinated dibenzo-*p*-dioxins and dibenzofurans and dioxin-like PCBs.

[66] Ahlborg, U; Becking, GC; Birnbaum, LS; et al. (1994) Toxic equivalency factors for dioxin-like PCBs: report on a WHO-ECEH and IPCS consultation, Dec. 1993. Chemosphere 28(6):1049-1067.

[67] Van den Berg, M; Birnbaum, L; Bosveld, ATC; et al. (1998) Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106(12):775-792.

[68] The NAS committee also recommended that EPA acknowledge the need for better uncertainty analysis of the toxicity values and should include an initial uncertainty analysis of overall toxicity in the final EPA report.

remediation levels for PCB mixtures be calculated using the WHO-2005 TEF values and methodology recommended by the World Health Organization (Van den Berg et al. 2006).

2. Provide Option to Evaluate Dioxin-Like PCB Congeners. Under this option, Ecology would revise the MTCA Cleanup Regulation to provide the option for calculating excess cancer risks, cleanup levels and remediation levels for PCB mixtures using the WHO-2005 TEF values and methodology recommended by the World Health Organization (Van den Berg et al. 2006).

3. Defer Issue to Future Rulemaking Process. Under this option, Ecology would defer this issue to a subsequent rulemaking and continue to calculate excess cancer risk, cleanup levels and remediation levels using information on total PCB concentrations and the cancer slope factor for PCB mixtures published in the Integrated Risk Information System (IRIS) database.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to provide the option for cleanup for Ecology and others to use the WHO-2005 TEF values and methodology when calculating excess cancer risk, cleanup levels and remediation levels for PCB mixtures (Option 2). Ecology's rationale for selecting this option includes the following:

- Application of the TEF methodology to coplanar PCBs has a sound biological basis. The TEF approach for dioxin-like PCBs is based on the concept that the various congeners of dioxin-like PCBs essentially act as one chemical, affecting the Ah receptor (aryl hydrocarbon hydroxylase receptor).

- The TEF values for dioxin-like PCB congeners have a sound scientific basis. The WHO-98 TEF values are based on a rigorous scientific review and professional consensus. More recent scientific reviews conducted by the EPA Risk Assessment Forum (EPA, 2000), EPA's Science Advisory Board (EPA, 1995; EPA, 2001), the World Health Organization (Van den Berg et. al., 1998) and the National Research Council (NAS, 2003; NRC, 2001) have re-affirmed the scientific basis for these values. In addition, the MTCA Science Advisory Board recently concluded:

  > *The Board stated that the 2005 TEF values for dioxin-like PCBs recommended by the WHO are consistent with current scientific information. As noted above, the Board stated that it was fortuitous that the WHO had recently completed a review and evaluation of available scientific information which resulted in updated TEF values for dioxins and furans.*

- The TEF methodology is an effective tool for assessing environmental risks. The TEF methodology is a tool that allows the assessor to evaluate the toxicity of a complex environmental mixture in the absence of complete knowledge of the toxicity for all of the components of the mixture. EPA has used the TEF methodology to evaluate the risks of PCB contamination in and around the Hudson River, the Housatonic River, and in the EPA's Great Lakes Initiative. The National Research Council (2001) concluded that congener-specific analyses often provide a better basis for assessing environmental risks because:

  - After release into the environment, PCB mixtures change through partitioning, transformation, and bioaccumulation, differing considerably from commercial mixtures.

  - There is a selective retention of persistent PCB congeners through the food chain (enrichment) that confers greater exposure and potential risks.

- Persistent congeners can retain biological activity long after exposure stops.
- Half-life estimates for a PCB mixture can underestimate its long – term persistence, because half-lives of its components differ widely.
- Environmental PCBs occur as mixtures, there are no cancer studies of PCB mixtures found in the environment. Studies are available for some commercial Aroclor mixtures, though similarity to an environmental mixture can be uncertain. This uncertainty results because mixtures are partitioned, transformed, and bioaccumulated in the environment. Testing an Aroclor mixture in the laboratory may not be a valid surrogate for assessing an Aroclor mixture that has been in the environment.

- Ecology and other environmental agencies are currently using congener-specific analyses to evaluate the health risks of PCB mixtures. Ecology has reviewed the methods and procedures used by other environmental programs to characterize PCB mixtures. Several agencies currently use the WHO-98 TEF values and methodology to evaluate health risks and establish regulatory requirements for PCB mixtures. For example:
  - When preparing the 303(d) list of impaired water bodies, the Environmental Assessment Program calculated TEQs for dioxins/furans and PCBs in fish tissue and surface water in freshwater environments using the WHO-98 TEF values. The Water Quality Program used this evaluation to identify impaired waterbodies by comparing the total TEQs for dioxins/furans and PCBs relative to the water quality criterion for 2, 3, 7, 8-TCDD (Ecology, 2004).
  - EPA's Superfund Program uses the methods and procedures described in IRIS for evaluating mixtures of PCBs[69]. The EPA Superfund program also recommends that the risk of dioxin-like congeners be considered (using WHO-98 values) when evaluating the health risks posed by PCB mixtures (EPA 2000 and 2003b).
  - Several environmental agencies in other states currently use the WHO-98 TEF values for dioxin-like PCBs when evaluating excess cancer risks and establishing regulatory requirements. States using the WHO-98 TEF values for dioxin-like PCBs include California[70], Louisiana[71], Massachusetts[72], Minnesota[73], Oregon[74] and Texas[75].
- There are several practical considerations that may limit the use of congener-specific analyses at individual sites. Ecology believes that congener-specific analysis provide a sound approach for evaluating PCB mixtures. However, there are several practical considerations that may limit the use of this approach at individual sites. Consequently, Ecology decided to revise the rule to provide the flexibility for cleanup proponents to continue to use the current rule provisions. These considerations include:

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[69] EPA includes the following statement in the IRIS database entry for PCBs: When congener concentrations are available, the slope-factor approach can be supplemented by analysis of dioxin TEQs to evaluate dioxin-like toxicity. Risks from dioxin-like congeners (evaluated using dioxin TEQs) would be added to risks from the rest of the mixture (evaluated using slope factors applied to total PCBs reduced by the amount of dioxin-like congeners).

[70] California EPA, 2005

[71] ATSDR Health Consultation, Review of 2002 Eunice City Lake Fish Investigation Eunice, Louisiana. July 27, 2005

[72] Housatonic Superfund Site Risk Assessment

[73] Minnesota Department of Health. Risk Assessment Rules/Guidance. Polycyclic Aromatic Hydrocarbons:Methods for Estimating Health Risks from Carcinogenic PAHs.

[74] Oregon Department of Environmental Quality. E-Mail From M. Poulsen (OR DEQ) to Dr. M. Bailey (EPA, Region 10) March 30, 2006.

[75] Texas Administrative Code, Title 30, Part 1, Chapter 350 subchapter D, Rule 350.76, (e)(1)(A)

- **Analytical Costs**. Congener-specific analyses are more expensive than total PCB analyses and, consequently, may not be appropriate for smaller cleanup sites.
- **Applicable Requirements**. MTCA cleanup levels must be at least as stringent as requirements in other applicable laws and regulations. Several existing regulatory requirements are based on total PCB measurements. Consequently, cleanup proponents may be required to measure total PCB concentrations.
- **Uncertainties on the Completeness of Assessment**. PCB toxicity includes both dioxin-like and non-dioxin-like modes of action that contribute to the overall toxicity of PCB mixtures. Dioxin equivalence evaluates the toxicity of only the dioxin-like PCB portion of the PCB mixtures. Non-dioxin-like toxicity, in turn, includes both cancer and non-cancer effects due to different modes of action.

Cleanup Levels for PCB Mixtures

Issue #8

Should Ecology continue to require that cleanup levels for PCB mixtures be based on a cancer risk of one-in-one million?

Background

Under the current MTCA rule, cleanup levels for PCB mixtures are established using the appropriate cancer slope factor for PCB's published in the Integrated Risk Information System (IRIS) database. Compliance with PCB cleanup levels is evaluated using measurements of total PCBs in soil or other environmental media (the sum of all Aroclors). Under this approach, PCB mixtures are treated as a single hazardous substance when establishing cleanup levels.

Application of the TEF approach to PCB congeners raises questions in terms of how this information will be used when establishing cleanup levels. These questions are similar to those identified for dioxin and furan mixtures (See Issue #2). Specifically, Ecology will need to decide whether to either (1) continue to treat PCB mixtures as a single hazardous substance (using a total toxic equivalence concentration to characterize the mixture) or (2) treat each congener as an individual hazardous substance.

MTCA Rulemaking Options

Ecology has considered three options for resolving this issue:

1. Cleanup Levels for Individual Dioxin-Like PCB Congeners Based on a Cancer Risk of One-in-One Million: Under this option, Method B cleanup levels would be established for TCDD based on an incremental cancer risk of one-in-one million (10^{-6}). Cleanup levels for dioxin-like PCB congeners would be established by dividing the TCDD cleanup level by the applicable congener-specific TEF. Because there is an overall limit on cancer risk under MTCA of one-in-one hundred thousand (10^{-5}), the cleanup levels for individual congeners might need to be adjusted downward to insure this overall risk limitation is not exceeded.
2. Cleanup Levels for PCB Mixtures Based on a Cancer Risk of One-in-One Million: Under this option, Method B cleanup levels would be established for TCDD based on an incremental cancer risk of one in one million (10^{-6}). The TEF methodology would be used to calculate a TEQ (based on the 12 dioxin-like PCB congeners identified in Table 9) for environmental samples that would then be compared to the TCDD cleanup level.
3. Cleanup Levels for Mixtures of All Dioxin-like Compounds (Dioxins, Furans and Dioxin-like PCBs) Based on a Cancer Risk Level of One-in-One Million: Under this option, Method B cleanup levels would be established for TCDD based on an incremental cancer risk of one in one million (10^{-6}). This option differs from option #2 because the TEF methodology would be used to calculate a TEQ based on a larger number of congeners. Under this option, the TEQ is calculated using information on the 17 dioxin/furan congeners identified in Table 4 and the 12 PCB congeners identified in Table 9. The resulting TEQ value is then compared to the TCDD cleanup level.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to clarify that PCB mixtures will continue to be considered a single hazardous substance for assessing carcinogenic risk under MTCA. Under this approach, Method B cleanup levels for PCB mixtures must be based on a cancer risk of one-in-one million (10^{-6}) (Option #2). Ecology's rationale for selecting this option includes the following:

- The proposed approach is consistent with the current MTCA rule requirements for PCB mixtures. Option 2 is consistent with the approach used for PCB mixtures in the current MTCA rule. PCB mixtures have been historically treated as a single hazardous substance when developing Method B and C cleanup levels or determining compliance with the Method A cleanup levels.
- The proposed approach is consistent with requirements established by other Ecology programs that are ARARs for MTCA sites. MTCA cleanup levels must be at least as stringent as legally applicable and relevant and appropriate requirements (ARARs) established under other state and federal environmental laws. Option 2 is consistent with approaches used by other Ecology programs to develop requirements that are applicable to MTCA cleanup sites. For example:
  - The Water Quality Program uses surface water human health criterion for marine and freshwaters identified in the National Toxics Rule for PCBs as a single numeric criterion for all PCBs. The EPA's National Recommended Water Quality Criteria for 2002 reaffirms the consideration of PCBs as a single hazardous substance stating: The polychlorinated biphenyl (PCB) numeric criterion for the protection of human health applies to total PCBs which is the sum of all homolog, all isomer, all congener, or all Aroclor analyses. Consequently, this option is consistent with the minimum cleanup standard for surface waters in Washington.
  - The Environmental Assessment Program calculated TEQs for dioxins/furans and PCBs in fish tissue and surface water in freshwater environments using the WHO-98 TEF values. Ecology identified impaired waterbodies by comparing the total TEQs for dioxins/furans and PCBs relative to the NTR criterion for TCDD and total PCBs (64 FRN 61195) with a designated 10^{-6} risk level (Ecology, 2004).
  - The Air Quality Program specifies risk-based acceptable source impact levels for Class A toxic air pollutants using unit risk factors published in EPA's Integrated Risk Information System (IRIS). When performing these evaluations, PCB mixtures are treated as a single hazardous substance in the same way as other toxic air pollutants such as arsenic or trichloroethylene.
- The proposed approach simplifies the procedures for establishing MTCA cleanup levels. The MTCA Cleanup Regulation specifies that Method B and C cleanup levels established for individual hazardous substances based on a particular pathway (e.g. soil ingestion) must be adjusted downward to take into account exposure to multiple hazardous substances and/or multiple exposure pathways in situation where total excess cancer risk would exceed 10^{-5}. Treating PCB mixtures as a single hazardous substance minimizes the need for such adjustments. This simplifies the process for establishing cleanup levels.
- The proposed approach is consistent with Ecology's initiatives on toxic chemicals. Public concerns about health threats posed toxic chemicals have grown over the last decade as new

information on toxicity and body burdens have become available. Ecology has undertaken several initiatives to reduce and cleanup sources of bioaccumulative chemicals in Puget Sound and other parts of the state. Selection of an option that relaxes cleanup requirements for chemical mixtures (Option 1) would be inconsistent with these Ecology initiatives.

- The proposed approach is consistent with approaches being used by other environmental programs. Ecology has reviewed the methods and procedures used by other environmental programs to characterize PCB mixtures. These programs differ in terms of analytical parameters (e.g. total PCB analysis vs dioxin-like PCB congener analysis), regulatory focus (e.g. site cleanup, water quality, etc.) and risk policies. However, the vast majority of programs reviewed by Ecology treat PCB mixtures as a single hazardous substance when establishing regulatory requirements. For example:
  - EPA has established a maximum contaminant level for PCBs under the Safe Drinking Water Act. The MCL establishes a single numeric standard (0.0005 mg/L) for total PCBs. The Washington Board of Health has adopted an identical drinking water standard for PCBs (WAC 246-290-310).
  - The EPA Superfund Program uses the methods and procedures described in IRIS for evaluating mixtures of PCBs. PCB mixtures are treated as a single hazardous substance.
  - The Agency for Toxic Substances and Disease Registry (ATSDR) uses the TEF methodology to evaluate the toxicity and assess the risks of PCB mixtures. For example, ATSDR evaluated the health risks associated with eating PCB contaminated fish in Eunice City Lake in Louisiana. In that evaluation, ATSDR calculated TEQs using the WHO-98 TEFs for the 12 dioxin-like PCB congeners. The TEQs for each fish species were then compared to the EPA Region III risk-based concentration (RBC) for TCDD levels in fish tissue. The Region III RBC for TCDD in fish tissue is based on an excess cancer risk of one-in-one million (10^{-6}).
  - The Food & Drug Administration (FDA) uses the TEF methodology and toxicity equivalent factors to monitor food and animal feed with the goal of reducing dietary exposure to dioxin-like compounds (FDA, 2005).
  - Ecology reviewed the methods and procedures used by several other state environmental programs. Most states have established cleanup levels for total PCBs that treat the mixture as a single hazardous substance. Several states also use the WHO-98 TEF values and methodology to evaluate dioxin-like PCBs. Many of these states treat mixtures of dioxin-like PCBs as if the mixture (characterized by the TEQ) was a single hazardous substance. Some states (e.g. Texas) calculate TEQs that reflect the sum of dioxins, furans and dioxin-like PCBs.

Consideration of Non-Dioxin Health Effects Associated With PCB Mixtures

Issue #9

How should Ecology take into account non-dioxin-like health effects when using the TEF methodology to assess the potential carcinogenic risk of PCB mixtures under MTCA?

Background

Under the MTCA Cleanup Regulation, excess cancer risks, cleanup levels and remediation for PCB mixtures are currently established using information on the total PCB concentrations at a site and the cancer slope factor for PCBs published in the Integrated Risk Information System (IRIS) database.

However, there is a sizable body of scientific information supporting the use of a TEF methodology to characterize PCB mixtures. EPA (1991)[76] concluded that selected PCBs may share a common mode of action with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Ahlborg et al. (1994)[77] toxicity equivalency factors (TEFs) are considered to be applicable to PCBs for the health endpoint of cancer through the common mode of action shared with TCDD.

In 1998, the WHO generated a database consisting of approximately 1,200 peer-reviewed publications evaluating the toxicity of PCBs. The WHO proposed TEF values for 12 dioxin-like PCBs based on their evaluation of this database. The proposed WHO-98 TEF values for polychlorinated biphenyls were published by Van den Berg et al. (1998)[78] and have been recognized by national and international regulatory agencies (Cal EPA, 2005).

MTCA Rulemaking Options

Ecology has considered three options for resolving this rulemaking issue:

1. Limit evaluation of PCB congeners to those with dioxin-like effects: Under this option, the 12 dioxin-like congeners identified by the World Health Organization would be used to characterize the health risks for the whole mixture;
2. Separately evaluate dioxin-like health effects and non-dioxin health effects: Under this option, Method B cleanup levels would be based on the endpoint resulting in the most stringent cleanup level.

[76] U.S. EPA. 1991. Workshop report on toxicity equivalency factors for polychlorinated biphenyl congeners. Risk Assessment Forum. EPA/625/3-91/020. The purpose of the 1991 EPA workshop was to examine the existing toxicity and exposure database on PCBs to ascertain the feasibility of developing toxicity equivalency factors for dioxin-like PCB congeners.
[77] Ahlborg UG, Becking GC, Birnbaum LS, Brouwer A, Derks HJGM, Feeley M, Golor G, Hanberg A, Larsen JC, Liem AKD, et al. 1994. Toxic equivalency factors for dioxin-like PCBs; report on a WHO-ECEH and IPCS consultation. Chemosphere 28 (6): 1049-1067. The results of the 1991 EPA workshop were published in this peer-reviewed technical publication.
[78] Van den Berg M, Birnbaum L, Bosveld, ATC, Brunstrom B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, et al. (1998). Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environmental Health Perspectives 106(12):775-792. This peer-reviewed publication is the technical standard for using WHO-recommended TEFs for polychlorinated dibenzo-*p*-dioxins and dibenzofurans and dioxin-like PCBs.

3. Perform an integrated evaluation of dioxin-like health effects and non-dioxin-like health effects: Under this option, Method B cleanup levels would be established at concentrations where the cancer risk from all congeners does not exceed an incremental cancer risk of one-in-one million (10^{-6}).

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to specify that an integrated evaluation of dioxin-like and non-dioxin-like health effects may be required by Ecology on a site-specific basis when using toxicity equivalency factors to evaluate dioxin-like PCBs. Ecology's rationale for selecting this option includes the following:

- PCB toxicity includes both dioxin-like and non-dioxin-like modes of action that contribute to the overall toxicity of PCB mixtures. The TEF methodology considers the toxicity of only the dioxin-like PCB portion of the PCB mixtures. Non-dioxin-like toxicity includes both cancer and non-cancer effects due to different modes of action. Although evaluation methods of PCB effects continue to evolve, dioxin-like toxicity (as evaluated with TEF methodology) is an important component of PCB toxicity that requires consideration.
- An integrated evaluation is consistent with current EPA Guidance . An integrated evaluation of dioxin-like and non-dioxin-like health effects for PCBs would follow the general guidance provided by EPA's Integrated Risk Information System:

  > When congener concentrations are available, the slope-factor approach can be supplemented by analysis of dioxin TEQs to evaluate dioxin-like toxicity. Risks from dioxin-like congeners (evaluated using dioxin TEQs) would be added to risks from the rest of the mixture (evaluated using slope factors applied to total PCBs reduced by the amount of dioxin-like congeners).

- Specific procedures for performing an integrated evaluation are not available: Specific procedures for an integrated evaluation of dioxin-like and non dioxin-like health effects have not been developed beyond that provided in EPA's Integrated Risk Information System. Additional experience needs to be accumulated before establishing a specific approach in rule.

Use of TEF Values When Evaluating Cross-Media Transfer

Issue #10

How should Ecology apply the TEF methodology when evaluating cross-media impacts?

Background

Mixtures of polychlorinated dibenzo-p-dioxins and dibenzofurans, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons exist in the environment as complex chemical mixtures. The Department of Ecology has determined these mixtures are persistent, bioaccumulative toxins (WAC 173-333-100). This means these complex environmental mixtures remain in the environment for long periods of time with the potential to transfer from one medium to another and accumulate in the food chain.

Models are typically used to predict how these chemical mixtures migrate from one medium to another (such as leaching from soil to groundwater) and bioaccumulate (concentrate in fish from water or sediment). The transport and partitioning of these complex environmental mixtures are determined, in part, by physicochemical properties such as water solubility, vapor pressure, Henry's law constant, and octanol-water partition coefficient. This "cross media" transport of these mixtures is complicated by the fact that these mixtures are made up of congeners or different PAHs each with different physicochemical properties. And the composition of the mixtures changes over time (weathering) through partitioning, chemical transformation, and preferential bioaccumulation. Environmental partitioning of a chemical refers to the processes by which mixtures, or components of the mixture, separate into air, water, sediment, and soil.

MTCA Rulemaking Options

Ecology has considered two options for resolving this rulemaking issue:

1. Index Chemical: Under this option, cleanup proponents would use the chemical properties of the index chemical (that is, TCDD, BaP) when modeling the fate and transport of dioxin/furan, PAH and PCB mixtures.
2. Congener-Specific Analysis: Under this option, cleanup proponents would use congener- and PAH-specific properties, when available, when modeling the fate and transport of dioxin/furan, PAH and PCB mixtures.

Ecology's Rulemaking Proposal and Rationale

Ecology is proposing to revise WAC 173-340-708(8) to require that congener- and PAH-specific properties be used when modeling the fate and transport of mixtures of dioxin/furans, PCBs and PAHs. Ecology's rationale for selecting this option includes the following:

- Technical Basis. The fate and transport of dioxins, furans, PCBs and PAHs are not necessarily not related to their TEFs. A wide range of other physical and chemical characteristics influence the persistence, mobility and transport of contaminants in the environment.

- Scientific Review. NAS (2003) has reviewed the application of the TEF methodology to dioxin/furan mixtures and concluded "…[a]lthough the TEF system is useful for determining toxicity in mixtures of DLC congeners, it cannot be used to simplify environmental fate and transport analyses of DLCs because individual congeners differ in their physical and chemical properties, an important consideration in fate modeling…" (p. 20). NRC (2001) reached similar conclusions in its review of PCB contamination.

- Approaches Used By Other Agencies. EPA Region V has developed a Total Equivalency Approach that is designed to allow variations in bioaccumulation potential to be considered when establishing water quality criteria for dioxin/furan mixtures. This approach involves multiplying each TEF value for each congener by a corresponding bioconcentration equivalency factor (BEFs) to calculate a Total Equivalency for the mixture. This approach is being used by the water quality programs in New York and several other Great Lakes states. The Oregon DEQ is considering adopting a similar approach.

- Practical Considerations. Congener-specific information is available for the physical and chemical characteristics that influence the environmental fate and transport of dioxin, furans, PCBs and PAHs. Site-specific evaluations of fate and transport can be streamlined through the use of spreadsheet models. For example, Ecology has developed a spreadsheet model to estimate the fate and transport of petroleum contaminants (including PAHs) that have been released into soils.

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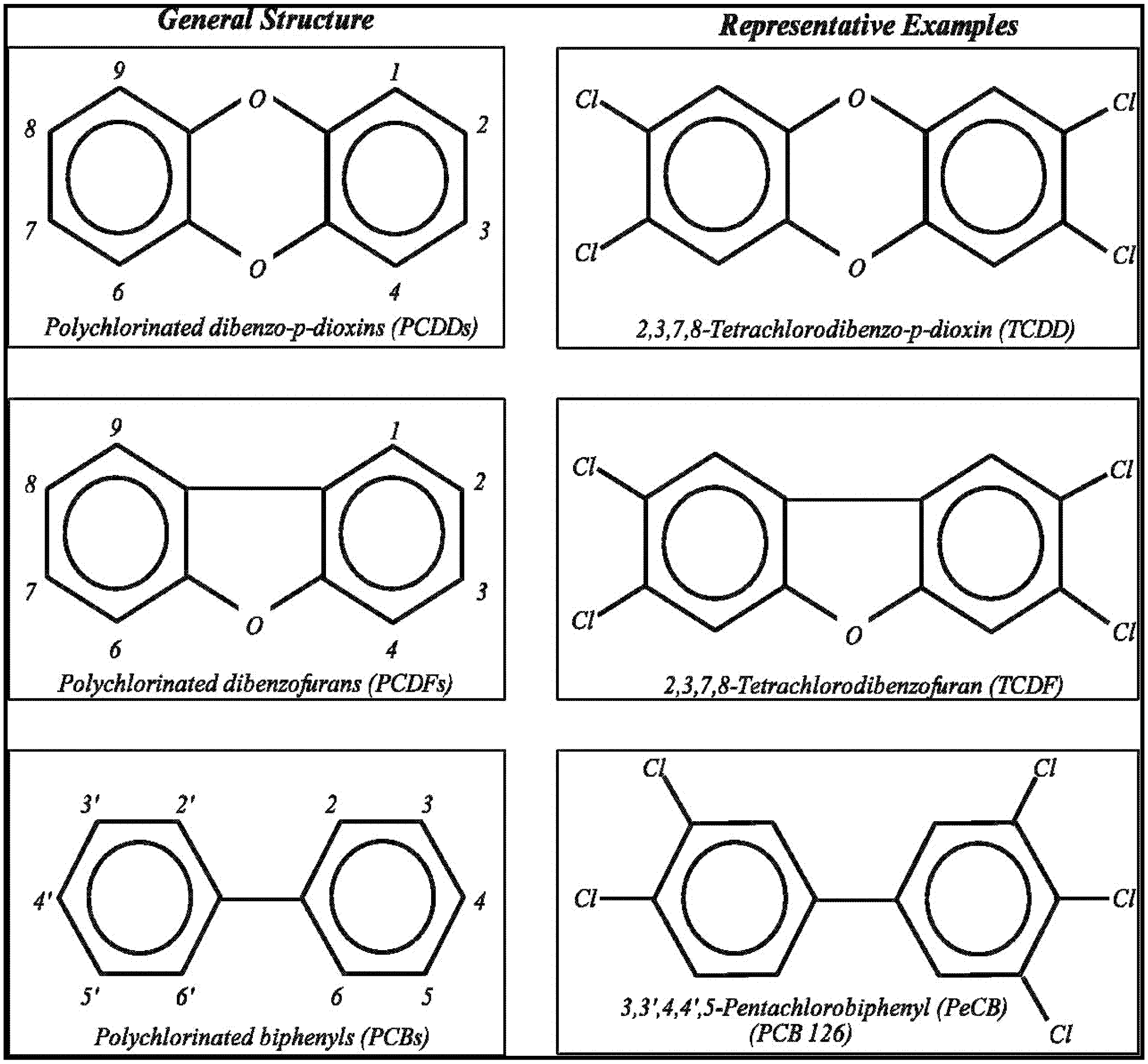
Representative Structural Formulas

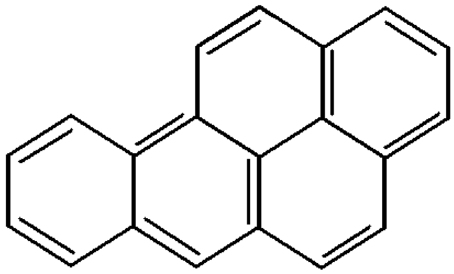
Polychlorinated dibenzo-p-dioxins and dibenzofurans
Polychlorinated biphenyls



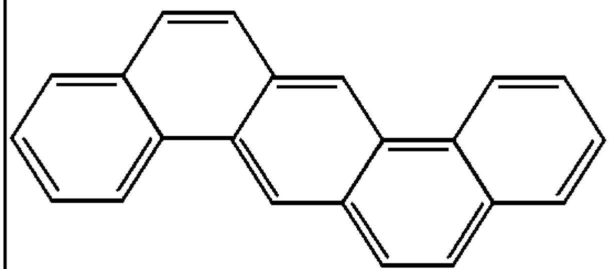
Chemical structures of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and polychlorinated biphenyls. Numbers by aromatic ring carbons of general structures represent potential chlorine substitutions.

Polycyclic Aromatic Hydrocarbons

Representative Examples



Benzo[a]pyrene



Dibenzo[a,h]anthracene

Appendix – Information on Bioavailability of Soil-Bound Dioxin

Consolidation of the Dioxin Bioavailability Data			
As Measured by Liver Content (%)		As Measured by AHH Induction (%)	As Measured by P-450 Induction (%)
48		54	117
19		112	91
62		49	90
70		92	76
67		56	105
60		121	65
67		113	71
52		81	84
57		103	
14		60	
22		61	
45		106	
32			
71			
56			
66			
44			
0.25			
24			
30			
# of Studies	20	12	8
Average %	45	84	87
Wittsiepe et. al., 2007 not included, bioavailability determine from various organs & tissues in minipigs			

Summary Tables of Technical Studies –Absorption/Bioavailability Mean Estimates of Relative Oral Bioavailability of TCDD from Soil (Based on liver concentrations, unless otherwise noted)

	Author	Animal	Relative Bioavailability	Notes
Times Beach				
	McConnell	Guinea Pig	<48%	1 µg/kg dose
	McConnell	Guinea Pig	19%	3 µg/kg dose (dead animals only)
	Shu	Rat	63% (reported as 43%)	43% from inappropriate adjustment (real range 52-70%)
	Wendling	Guinea Pig	30%	Liver concentration at high 10 µg/kg dose
	Wendling	Guinea Pig	7%	Liver concentration at low 3 µg/kg dose
Minker Stout				
	McConnell	Guinea Pig	<57%	1 µg/kg dose
	McConnell	Guinea Pig	14%	3 µg/kg dose (dead animals only)
	McConnell	Rat	45%	5 µg/kg dose
	McConnell	Rat	49 – 112%	Based on AHH induction
	Lucier	Rat	22 – 45%	Dose range 0.015 – 5.5 µg/kg
	Lucier	Rat	56 - 121%	Based on AHH induction
	Lucier	Rat	65 - 117%	Cytochrome P450 induction
Seveso				
	Bonaccorsi	Rabbit	32%	
Seveso (recontam)				
	Bonaccorsi	Rabbit	56 – 71%	
	Poiger	Rat	44 – 66%	
Newark (manufact.)				
	Umbreit	Guinea Pig	~0.25%	
	Wendling	Guinea Pig	1.6%	Liver concentration at high 10 µg/kg dose
	Wendling	Guinea Pig	1.6%	Liver concentration at low 5 µg/kg dose
Newark salvage				
	Umbreit	Guinea Pig	24%	
Arable land/ from Hamburg	Wittsiepe	Minipigs	0.6 to 21.9%	I-TEQ bioavailability is 13.8%; liver, adipose, muscle, brain & blood analyzed Rel. bioavail. estimated by comparison of organ/tissue concent. with mixt. Extracted from same soils by solvent

Soil From	Reference	Relative Bioavailability	Endpoint Measured	Animal	Gavage Dose (µg TCDD/kg body weight)	Soil Concentration (µg TCDD/kg soil)	Particle Size	Notes
Times Beach, MO								
	McConnell	<48%	Liver content	Guinea Pig	1.3	770 µg/kg	< 250 µm	Dead animals
		19%	Liver content	Guinea Pig	3.8			
	Shu	62%	Liver content	Rat	0.0032			
		70%	Liver content	Rat	0.007			
		67%	Liver content	Rat	0.04			
		60%	Liver content	Rat	0.037			
		67%	Liver content	Rat	0.175			
		52%	Liver content	Rat	1.45			
	Wendling	30%	Liver content	Guinea Pig	10	510		
		7%	Liver content	Guinea Pig	3	510		
Minker Stout, MO								
	McConnell	<57%	Liver content	Guinea Pig	1.1	880 µg/kg	< 250 µm	
		14%	Liver content	Guinea Pig	3.3			Dead animals
		54%	AHH induction	Rat	0.22			
		112%	AHH induction	Rat	0.44			
		49%	AHH induction	Rat	1.1			
		92%	AHH induction	Rat	5.5			
	Lucier	22%	Liver content	Rat	1.1	880 µg/kg	< 250 µm	
		45%	Liver content	Rat	5.5			
		56%	AHH induction	Rat	0.015			
		121%	AHH induction	Rat	0.044			
		113%	AHH induction	Rat	0.1			
		81%	AHH induction	Rat	0.22			
		103%	AHH induction	Rat	0.5			
		60%	AHH induction	Rat	1.1			
		61%	AHH induction	Rat	2.0			
		106%	AHH induction	Rat	5.5			
		117%	P450 induction	Rat	0.015			
		91%	P450 induction	Rat	0.044			

		90%	P450 induction	Rat	0.1			
		76%	P450 induction	Rat	0.22			
		105%	P450 induction	Rat	0.5			
		65%	P450 induction	Rat	1.1			
		71%	P450 induction	Rat	2.0			
		84%	P450 induction	Rat	5.5			
Seveso, Italy								
	Bonaccorsi	32%	Liver content	Rabbit	0.56	81 µg/kg	30-74 µm	7 x 80 ng/kg doses
Seveso								
(recontaminated)	Bonaccorsi	71%	Liver content	Rabbit	0.28	30 day soil contact		7 x 40 ng/kg doses
		56%	Liver content	Rabbit	0.56	30 day soil contact		7 x 80 ng/kg doses
	Poiger	66%	Liver content	Rat	0.11	15 hour soil contact		
		44%	Liver content	Rat	0.11	8 hour soil contact		
Arable land/								
from Hamburg Germany	Wittsiepe	10%	Various tissues	Minipigs	2.63 ng I-TEQ/kg bw-day	0.5 g/kg bw/d of PCDD/F mixture	30.6% sand 36.5% silt 32/9% clay 6.83% organic carbon Particle size < 1mm	
Newark mfg site								
	Wendling	1.6%	Liver content	Guinea Pig	10	1400		
		1.6%	Liver content	Guinea Pig	5	1400		
	Umbreit	~0.25%	Liver content	Guinea Pig	12	Mghing site:1500 to 2500 ppb; Salvage yard: ~180 ppb	For both sites: medium dense, black, coarse to fine-grained sand fill with some medium to fine gravel, traces of silt, organic matter & cinders	
Newark salvage site								
	Umbreit	24%	Liver content	Guinea Pig	0.32			