BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

RECEIVED
CLERK'S OFFICE
JAN 10 2006
STATE OF ILLINOIS
Pollution Control Board

IN THE MATTER OF:	)	
	)	R06-10
PROPOSED AMENDMENTS TO	)	(Rulemaking-Land)
TIERED APPROACH TO CORRECTIVE	)	
ACTION OBJECTIVES	)	
(35 Ill. Adm. Code 742)	)	
	)	

NOTICE

Dorothy Gunn, Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 W. Randolph, Suite 11-500
Chicago, Illinois 60601

General Counsel
Illinois Dept. of Natural Resources
One Natural Resources Way
Springfield, Illinois 62702-1271

Matt Dunn
Environmental Bureau Chief
Office of the Attorney General
James R. Thompson Center
100 W. Randolph, 12th Floor
Chicago, Illinois 60601

Richard R. McGill, Jr.
Ill. Pollution Control Board
James R. Thompson Center
100 W. Randolph, Suite 11-500
Chicago, Illinois 60601

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board the written testimony of Gary P. King, Gregory W. Dunn, Lawrence W. Eastep, and Thomas C. Hornshaw as well as **ERRATA SHEET NUMBER 1**, a copy of each of which is herewith served upon you.

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY

By: Kimberly A. Geving
Kimberly A. Geving
Assistant Counsel
Division of Legal Counsel

DATE: January 9, 2006

1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276
(217)782-5544

THIS FILING SUBMITTED ON RECYCLED PAPER

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Pollution Control Board

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ACTION OBJECTIVES)
(35 Ill. Adm. Code 742))
)

R06-10
(Rulemaking-Land)

MOTION FOR ACCEPTANCE

NOW COMES the Illinois Environmental Protection Agency ("Illinois EPA") and, pursuant to 35 Ill Adm. Code 101.Subpart C and 35 Ill. Adm. Code 102.424, moves the Illinois Pollution Control Board ("Board") to accept the attached written testimony of Gary P. King, Gregory W. Dunn, Lawrence W. Eastep, and Thomas C. Hornshaw as well as **ERRATA SHEET NUMBER 1** for the above-captioned matter.

Respectfully submitted,

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY

By: ______________________
Kimberly A Geving
Assistant Counsel
Division of Legal Counsel

DATE: January 9, 2006

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P.O. Box 19276
Springfield, Illinois 62794-9276
(217)782-5544

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STATE OF ILLINOIS)
)
COUNTY OF SANGAMON)

PROOF OF SERVICE

I, the undersigned, on oath state that I have served the attached written testimony of Gary P. King, Gregory W. Dunn, Lawrence W. Eastep, and Thomas C. Hornshaw as well as **ERRATA SHEET NUMBER 1** upon the persons to whom they are directed, by placing a copy of each in an envelope addressed to:

Dorothy Gunn, Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 W. Randolph, Suite 11-500
Chicago, Illinois 60601

General Counsel
Illinois Dept. of Natural Resources
One Natural Resources Way
Springfield, Illinois 62702-1271

Matt Dunn
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James R. Thompson Center
100 W. Randolph, 12th Floor
Chicago, Illinois 60601

Richard McGill
Illinois Pollution Control Board
100 W. Randolph St.
Suite 11-500
Chicago, Illinois 60601

(Service List)

and mailing them (First Class Mail) from Springfield, Illinois on January 9, 2006, with sufficient postage affixed as indicated above.

SUBSCRIBED AND SWORN TO BEFORE ME
This 9th day of January, 2006.
Brenda Boehner
Notary Public

BRENDA BOEHNER
MY COMMISSION EXPIRES 11-3-2009

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ACTION OBJECTIVES)
(35 Ill. Adm. Code 742))

ERRATA SHEET NUMBER 1

NOW COMES the Illinois Environmental Protection Agency ("Agency") through one of its attorneys, Kimberly Geving, and submits this ERRATA SHEET NUMBER 1 to the Illinois Pollution Control Board ("Board") and the participants listed on the Service List. Thomas C. Hornshaw has provided testimony in support of these changes in his pre-filed written testimony, also served upon the Board and the Service List.

Section	
App. A, Table G	For some of the constituents, periods were used in the value rather than commas. Thus, for Aluminum, the value should be 9,500 ~~9.500~~ for Counties Within the Metropolitan Statistical Areas ("MSA") and 9,200 ~~9.200~~ for Counties Outside the MSA. For Calcium, 9,300 ~~9.300~~ and 5,525 ~~5.525~~, respectively. For Iron, 15,900 ~~15.900~~ and 15,000 ~~15.000~~, respectively. For Magnesium, 4,820 ~~4.820~~ and 2,700 ~~2.700~~, respectively. For Potassium, 1,268 ~~1.268~~ and 1,100 ~~1.100~~, respectively.
App. A, Table H	The first chemical, 2-Methylnaphthalene, does not have any value reflected in the Chicago column. Although there is no value for that cell, please add: ---.
App. A, Table I~~H~~	Please change the value for the 1 in 1,000,000 Cancer Risk Concentration column for the chemical 1,2 Dibromoethane as follows: 0.00002 ~~0.0000010~~. Additionally, there was a typographical error in the chemical name, and it should be capitalized as follows: 1,2 Dibromoethane ~~1,2 dibromoethane~~.

App. B, Table A	For the chemical 1,2 Dibromoethane (Ethylene dibromide), CAS No. 106-93-4, please delete the new reference to footnote x. The new value should only have footnote e next to it.
App. B, Table A	Beginning with the Inorganics and continuing through the rest of the table, all new (underlined) references to --- in the Class I and Class II columns, with the exception of the new ---[c] for Calcium, Magnesium, Phosphorus, Potassium, and Sodium, should be deleted. Only the existing values should be reflected in those columns. Where there are existing --- entries without underlining (for the two Chromium entries), those values are correct and should remain.
App. B, Table A	For the chemical Nitrate, CAS No. 14797-55-8, a second footnote in the Class I column should be added as follows: 10.0[q,m].
App. B, Table A	For the chemical Silver, CAS No. 7440-22-4, there is a typographical error in the Class II column. The new footnote added should be a footnote c, not footnote m. Please delete the m footnote and insert c in its place.
App. B, Table B	For the chemical Acetone, CAS No. 67-64-1, the new value of 1,000,000 that was added into the Ingestion columns for both the Industrial/Commercial and Construction Worker Exposure Routes is incorrect. Please delete the references to 1,000,000[b] and insert ---[g] into both those columns instead. No change to the stricken material is necessary.
App. B, Table B	For the chemical 1,2-Dibromoethane (Ethylene dibromide), CAS No. 106-93-4, an incorrect value was added for the Construction Worker Inhalation Exposure Route. Please delete the new reference to 0.03[b] and replace it with 0.16[e]. No change to the stricken material is necessary.
App. B, Table B	For each of the Ionizable Organics, a formatting error was noticed for the footnote I in the Class I column. Every one of those footnotes should be a lower case i rather than a capital I. Please make the following change for every Ionizable Organic in that column: i~~I~~. Additionally, the actual footnote at the end of the table should also be corrected the same way.
App. B, Table B	As with App. B, Table A, beginning with the Inorganics and continuing through the rest of the table, all new (underlined) references to --- in the Class I and Class II columns, with the exception of the new ---[c] for Calcium, Magnesium, Phosphorus, Potassium, and Sodium, should be deleted. Additionally, the existing values that were mistakenly stricken should be restored without strikethroughs. Where there are existing ---

	entries without underlining (for the two Chromium entries), those values are correct and should remain.
App. B, Table B	For the chemical Boron, CAS No. 7440-42-8, please make the following change in the Inhalation column of the Industrial/Commercial Exposure Route: ---[c] ~~1,000,000~~.
App. B, Table B	For the chemical Lead, CAS No. 7439-92-1, please make the following change in the Ingestion column of the Industrial/Commercial Exposure Route: 800[y] ~~400~~[k].
App. B, Table B	For the chemical Nitrate, CAS No. 14797-55-8, please make the following addition in the Class I column: 10.0[q,m].
App. B, Table B	In the footnote section, please strike the entire footnote k as follows: [k] ~~A preliminary remediation goal of 400 mg/kg has been set for lead based on Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, OSWER Directive #9355.4-12~~. Additionally, please strike the entire footnote v as follows: [v] ~~Calculated values correspond to soil concentrations that should not result in air concentrations that exceed criteria for workplace air.~~ The Agency has not re-lettered any of the existing footnotes to reflect these changes. If the Board would instead like to replace the deleted footnotes with one of the new footnotes (w, x, or y), that would be acceptable to the Agency.
App. B, Table F	For the chemical Acetone, CAS No. 67-64-1, please change both the Class I and Class II values as follows: 6.3 ~~4.0~~[b] and 6.3 ~~4.0~~.

Respectfully submitted,

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY

By: Kimberly A Geving
Kimberly A. Geving
Assistant Counsel
Division of Legal Counsel

Date: January 9, 2006

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ACTION OBJECTIVES	)	(Rulemaking-Land)
(35 Ill. Adm. Code 742)	)	
	)	

TESTIMONY OF GARY P. KING

My name is Gary King. I am the manager of the Division of Remediation Management within the Bureau of Land of the Illinois Environmental Protection Agency (Agency). I have been in my current title since May 1990. Within this Division are located three Sections: the Leaking Underground Storage Tank (LUST) Section, the Remedial Project Management (RPM) Section, and the Federal Sites Remediation (FSR) Section. The LUST section is responsible for administration of the corrective action portions of the LUST program. The RPM Section is responsible for administration of IEPA cleanup programs relative to voluntary cleanups, State-enforced cleanups, and State-funded cleanups. The FSR Section is responsible for federal Department of Defense cleanups, and National Priority List (NPL) cleanups.

Prior to assuming my current position I was the senior counsel for the Bureau of Land within the Agency's Division of Legal Counsel. I have been employed at the Agency since 1977. I received a B.S. in Civil Engineering in 1974 from Valparaiso University and a J.D. in 1977 from the same university.

I have testified before the Board in numerous rulemaking proceedings, including all of the Board's rulemakings under Title XVII of the Environmental Protection Act, which led to the adoption of 35 Ill. Adm. Code 740, Site Remediation Program, and 35 Ill. Adm. Code, Tiered Approach to Corrective Action Objectives. The Agency's proposal in this proceeding proposes amendments to Part 742.

A. REGULATORY DEVELOPMENT

The Agency has been implementing Part 742 since its adoption in 1997. It has proven to be a very effective methodology for developing remediation objectives. Other States have used TACO as a baseline for developing their own State programs. I have personally spoken with State environmental representatives from Indiana, Missouri, Wisconsin, New York, and Mississippi as they have developed their own State programs and have looked to the Illinois TACO rules to help guide their decision making.

As we have progressed with the implementation of TACO, we have found the need for updating and refinements, based on new information (such as studies on background levels of PNAs or changes to the federal Soil Screening Levels) or operational experience (such as model institutional control documents). This regulatory proceeding is the second time the Agency has proposed such amendments to Part 742 to the Board for adoption.

B. DISCUSSION OF PROPOSED REGULATIONS

In this testimony I will be discussing changes to Part 742 in the following areas:

Section 742.105 Applicability

The changes to Subsections (a) and (h) are proposed for purposes of making explicit considerations that were already implicit from the structure of TACO. These changes represent longstanding Agency practices in interpreting TACO. For instance, in the original TACO rulemaking in 1997 I testified that landfills were not an appropriate fit for use of TACO because of technical and regulatory issues.

Section 742.200 Definitions

The Agency has added a number of new definitions because of other changes being proposed in this proceeding.

Section 742.1000 Institutional Controls

Language has been added to subsection (c)(5) to clarify the use of highway authority agreements. In the Leaking Underground Storage Tank Program, the tank owner/operator is the responsible party and the person that receives the No Further Remediation Letter, but is not necessarily the property owner.

Language has been added to subsection (c)(6) to include a new instrument as an institutional control to address situations where the highway authority and the responsible party (the property owner or the leaking underground storage tank owner or operator) are the same entity. In that case, the institutional control would be an agreement between the highway authority and the Agency (Highway Authority Agreement Memorandum of Agreement) with respect to any contamination that remains under the highway.

Section 742.1010 Environmental Land Use Controls

The Agency is proposing changes to Section 742.1010 that clarify how ELUCs work and to make more transparent the procedures for how they can be changed in the future.

Section 742 1015 Ordinances

The Agency is proposing amendments to Section 742.1015 that are needed to support the short- and long-term effectiveness of ordinances used as environmental institutional controls by clarifying specific details of how ordinances are to be used and applied. Ordinances, like all other institutional controls, must remain in effect in perpetuity unless a responsible party demonstrates to the Agency that the ordinance (or other institutional control) is no longer necessary, and the Agency agrees with that demonstration.

Agency administration of ordinances as institutional controls includes: 1) The review of ordinances for suitability as institutional controls pursuant to Section 742.1015; 2) The application of approved ordinances to specific sites in accordance with all technical and legal requirements under TACO and the applicable programs; and 3) The long-term tracking of the ordinances themselves and of the compliance by sites that have used them to obtain closure. The Agency understands there is some uncertainty inherent in using ordinances as institutional controls. Ordinances, by their nature, may be amended. Section 742.1015(d) is designed to alert the Agency of such amendments (although the Agency has never been informed of any such amendment but knows of at least two cases where approved ordinances were used to close sites and subsequently amended or repealed with no notification to the Agency). However, minimizing the uncertainties to the extent practical is in the best interests of effective administration of these institutional controls.

Section 742.1020 Highway Authority Agreements

Highway Authority Agreements ("HAAs") are one of the instruments that may be used as an institutional control under the Tiered Approach to Corrective Action Objectives ("TACO") regulations, 35 Ill. Adm. Code 742. An HAA is an agreement between the owner of the property from which a release occurred and the highway authority having jurisdiction over an adjacent right of way below which contamination has migrated.

In general, the HAA provisions of Section 742.1020 have worked effectively. The Agency, however, has noted legal difficulties in instances where the highway authority is also the property owner of the site. We concluded that a bilateral agreement with only one entity involved could not be binding. This problem was not foreseen or contemplated when the TACO regulations were adopted.

This oversight in the regulations can lead to unintended results. For example, contamination at a site located at an intersection may have migrated under two rights of way; one under the jurisdiction of the Illinois Department of Transportation ("IDOT") and one under the jurisdiction of the local government. If the local government owns the site, it can enter into an HAA with IDOT to address the contamination below IDOT's right of way. However, it cannot enter an HAA with itself to address the contamination under its own right of way.

As a result, in instances where the highway authority and the property owner are the same entity we have required the highway authority to enter an MOA with the Agency with terms similar to the HAA. The HAA MOA is substantially the same as any other HAA, except for the parties to the agreement. The HAA MOA allows a highway authority that is also a site owner to enter an agreement with the Agency (in lieu of itself) where it promises to restrict groundwater use and soil access to the extent required by the TACO regulations.

Section 742.1020 (b)(2) contains new language to clarify that a Highway Authority Agreement must limit access to soil contamination under the highway right of way above the residential Tier 1 remediation objective or the construction worker remediation objective, which ever is less. This is to address the situations where the construction worker objective is less that the Tier 1 objective.

Section 742.1020 (g) and (h) contains new language to address the situation where the highway authority and the responsible party (the property owner or leaking underground storage tank owner/operator) are one and the same. In this case, the highway authority would enter into a Highway Authority Agreement Memorandum of Agreement (HAA MOA) between the highway authority and the Agency. The HAA MOA provides that the responsible party shall agree to prohibit use of groundwater and limit access to soil under the highway right of way to protect human health and the environment The HAA MOA must match the form and contain the same substance as the model in new Appendix E.

The addition of subsections (g) through (i) and Appendix E will codify Agency practices concerning HAA MOAs.

Addendices D through I. Cross references to Section 742.1010(d), 742.1012(a), 742.1015(a) and (i), 742.1020(a).

Over the last seven years the Agency has developed model documents implementing the various institutional control options in Subpart J. We did this to make document preparation and Agency review more effective. We are now at a point where we think it is appropriate to codify these model documents in the Board regulations and require their use. The model documents are provided in Appendices D through I with appropriate cross references within Subpart J to those instruments.

Other changes found in these section are non-substantive typographical changes.

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STATE OF ILLINOIS
Pollution Control Board

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PROPOSED AMENDMENTS TO)
TIERED APPROACH TO CORRECTIVE) R06-10
ACTION OBJECTIVES) (Rulemaking - Land)
(35 Ill. Adm. Code 742))
)

PRE-FILED TESTIMONY OF GREGORY W. DUNN

My name is Gregory W. Dunn. I am currently manager of one of the Voluntary Site Remediation Units, in the Bureau of Land of the Illinois Environmental Protection Agency (Agency) that administers the Site Remediation Program (SRP). The SRP, as established under 35 Ill. Adm. Code 740, provides Remediation Applicants (property owners, developers, bankers, real estate agents, businesses, etc.) the opportunity to receive review and evaluation services, technical assistance, and no further remediation determinations from the Agency.

I graduated from Eastern Illinois University in 1986 with a B.S. in Geology and a B.S. in Earth Science. I have been employed with the Agency since September 1986. I was a project manager in the Site Assessment Unit from September 1986 until October 1992. From October 1992 until July 1997, I was a project manager in the Pre-Notice Program, which became the Site Remediation Program in June 1997. From July 1997 until December 1998, I was a project manager in the State Sites Unit, which uses State funds to remediate sites. Since December 1998, I have been manager of one of the

Voluntary Site Remediation Units. I am registered as a Licensed Professional Geologist in the State of Illinois and have almost 19 years of environmental experience.

Today I will testify in support of proposed rule changes in 35 Ill. Adm. Code 742 concerning the Incorporations by Reference (Section 742.210), Determination of Soil Attenuation Capacity (Section 742.215), Contaminant Source and Free Product Determination (742.305(e)), Groundwater Ingestion Exposure Route (742.320(d)), Tier 2 Groundwater Remediation Objectives (742.805(c)(1)), Ordinances (742.1015(b)(2)), Appendix C, Table D, and Appendix C, Table F.

<u>Incorporations by Reference:</u>
(Section 742.210)

Section 742.210 incorporates by reference several documents that are required for use elsewhere in Part 742. In order to keep current with the changes by the American Society for Testing and Materials (ASTM), the Agency proposes the following changes to Section 742.210(a): change the address and phone number of ASTM from 1916 Race Street, Philadelphia, PA 19103 (215) 299-5400 to the current address of 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 (610) 832-9585. Change "Standard Test Methods for Moisture, Ash and Organic Matter of Peat and Other Organic Soils" from ASTM D 2974-87 to ASTM D 2974-00, change the date approved from May 29, 1987 to August 10, 2000, and delete the reapproved 1995. Change "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)" from ASTM D 2488-93 to ASTM D 2488-00 and change the date approved from September 15, 1993 to February10, 2000. Change "Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method" from ASTM D 1556-90 to ASTM D 1556-00 and change the date approved from June 29, 1990 to March 10, 2000. Change "Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)" from ASTM D 2922-91 to ASTM D 2922-01 and change the date approved from December 23, 1991 to June 10, 2001. Change "Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method" from ASTM D 2937-94 to ASTM D 2937-00e1 and change the date approved from June 15, 1994 to June 10, 2000. Change "Standard Test Method for Specific Gravity of Soils" to "Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer" to reflect the correct name of the reference, change the ASTM D 854-92 to ASTM D 854-02 and change the date approved from November 15, 1992 to July 10, 2002. Change "Standard Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock" to "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass" to reflect the correct name of the reference, change ASTM D 2216-92 to ASTM D 2216-98 and change the date approved from June 15, 1992 to February 10, 1998. Change "Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method" to "Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating" to reflect the correct name of the reference, change ASTM D 4959-89 to ASTM D 4959-00, change the date approved from June 30, 1989 to March 10, 2000 and delete reapproved 1994. Change "Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method" from ASTM D 4643-93 to ASTM D 4643-00, and change the date approved from July 15, 1993 to February 10, 2000. Change "Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter" to "Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter" to reflect the correct name of the reference, change ASTM D 5084-90 to ASTM D 5084-03, and change the date approved from June 29, 1990 to November 1, 2003. Change "Standard Test Method for Particle-Size Analysis of Soils" from ASTM D 422-63 to ASTM D 422-63 (2002), change the date approved from November 21, 1963 to November 10, 2002, and delete the reapproved 1990. Change "Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75 *u*m) Sieve" to "Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75 *u*m) Sieve" to reflect the correct name of the reference, change ASTM D 1140-92 to ASTM D 1140-00, and change the date approved from November 15, 1992 to June 10, 2000. Change "Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)" from ASTM D 3017-88 to ASTM D 3017-01 and change the date approved from May 27, 1988 to June 10, 2001. Change "Standard Test Method for Permeability of Rocks by Flowing Air" from ASTM D 4525-90 to ASTM D 4525-90 (2001). Change "Standard Test Method for Classification of Soils for Engineering Purposes" to "Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)" to reflect the correct name of the reference, change ASTM D 2487-93 to ASTM D 2487-00, and change the date approved from September 15, 1993 to March 10, 2000. Change "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process" from ASTM E 1527-93 to ASTM E 1527-00 and change the date approved from March 15, 1993 to May 10, 2000. Change "Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites" from ASTM E 1739-95 to ASTM E 1739-95 (2002).

The Agency proposes to insert an addition into Section 742.210(a) to keep current with all available reference materials. "Methods for the Determination of Organic Compounds in Drinking Water Supplement I", EPA Publication No. EPA/600/4-90/020 (July 1990) will be added as additional reference material in support of EPA Publication No. EPA/600/4-88/039 dated December 1988 and revised July 1991 titled " Methods for the Determination of Organic Compounds in Drinking Water".

Determination of Soil Attenuation Capacity:
(Section 742.215)

Section 742.215(b) states the soil attenuation is not exceeded if the sum of the organic contaminant concentrations at a discrete sampling point is less than the natural organic carbon fraction of the soil. The natural organic carbon fraction (f_{oc}) of soil shall be either a default value as identified in Section 742.215(b)(1)(A) or measured by one of the methods identified in Section 742.215(b)(1)(B). The methods identified in Section 742.215(b)(1)(B) are ASTM Method D2974-87 (to be updated to D2974-00), SW 846 Method 9060 and Nelson and Sommers (1982).

TACO identifies two methods for determining the organic carbon content of soil, ASTM Method D-2974-87 (to be updated to D-2974-00) and SW-846 Method 9060 (now updated to 9060A), and one reference document, Nelson and Sommers (1982). The ASTM method measures the concentration of Total Organic Matter in a soil sample, and according to Nelson and Sommers, a conversion factor must estimate the organic carbon fraction in soil. SW-846 Method 9060A is used to determine the concentration of organic carbon of a liquid such as ground water, surface and saline waters, and domestic and industrial wastes. SW-846 Method 9060A is not for soil. Although this method can be modified for soil samples by individual laboratories, the Agency is not aware of any nationally recognized protocol to modify this method. Additionally, USEPA states on their web page that there is no SW-846 method for total organic carbon in soils since the USEPA Office of Solid Waste does not have a regulatory driver for total organic carbon.

The ASTM method measures the concentration of total organic matter; therefore, a conversion factor must be applied to this concentration to give an estimate of the organic carbon concentration. Nelson and Sommers states the total organic matter concentration should be multiplied by a conversion factor, typically between 0.50 and 0.58. Multiplying the total organic matter value derived from the ASTM test method by the conversion factor will result in an estimate of the organic carbon concentration that may be used to determine soil attenuation capacity. Therefore, the Agency proposes to make the following change to Section 742.215(b)(1)(B): A site-specific value as measured by the analytical method referenced in Appendix C, Table F, appropriately adjusted to estimate the fraction of organic carbon, as stated in ~~ASTM D2974-87,~~ Nelson and Sommers (1982); ~~or by SW-846 Method 9060: Total Organic Carbon, as~~

~~incorporated be reference in Section 742.210;~~

Contaminant Source and Free Product Determination:
(Section 742.305(e))

Section 742.305 identifies the requirements that must be met prior to excluding an exposure route. Pursuant to 742.305(e), an exposure route may not be excluded if any soil exhibits the characteristics of toxicity for hazardous waste as determined by 35 Illinois Administrative Code Section 721.124 or an alternative method approved by the Agency. However, Section 721.124 identifies the Toxicity Characteristic Leaching Procedure as the only test method used in determining the characteristics of toxicity. Since no alternative method exists to determine the characteristics of toxicity, the Agency proposes to strike the language stating "or an alternative method approved by the Agency".

Groundwater Ingestion Exposure Route:
(Section 742.320(d))

Section 742.320(d) identifies one of the requirements for excluding the groundwater ingestion exposure route. Current language indicates that an ordinance, effectively prohibiting the installation and use of potable water supply wells, is required for any area within 2,500 feet from the source of the release. The 2,500 feet was originally proposed by the Site Remediation Advisory Committee to correspond with the maximum setback zone for a community water supply well under Section 14.3 of the Environmental Protection Act. However, this requirement that an ordinance be adopted for any area within 2,500 feet excludes certain sites from using this Section of TACO. If a site lies within 2,500 feet of a municipal boundary and no ordinance exists beyond the municipal boundary, Section 742.320 cannot be used to exclude the pathway. This would include sites that may only have measured and modeled concentrations extending only a short distance off-site, but well within 2,500 feet of the boundary of the municipality with the groundwater ordinance. To resolve this issue, the Agency proposes the following language to 742.320(d): "As demonstrated in accordance with Section 742.1015, for any area within the measured and modeled extent of groundwater contamination above what would otherwise be the applicable Tier 1 groundwater remediation objectives, an ordinance adopted by a unit of local government is in place that effectively prohibits the installation of potable water supply wells (and the use of such wells)." The language change will allow a person to exclude the groundwater ingestion exposure route if the contamination is measured and modeled to be within the agency approved ordinance area of a municipality.

Tier 2 Groundwater Remediation Objectives: (Section 742.805(c)(1))

Section 742.805(c)(1) identifies an equation to be used to satisfy the mixtures of similar acting chemicals at the point of human exposure. In this equation, the parameter x_1 through x_2 is defined as the "Concentration of each individual contaminant at the location of concern. Note that depending on the target organ/mode of action, the actual number of contaminants will range from 2 to 14." Reviewing Appendix A, Table E and Appendix E, Table F, the range of contaminants should be from 2 to 33. Therefore, the Agency proposes the following language to 742.805(c)(1): "Concentration of each individual contaminant at the location of concern. Note that, depending on the target organ/mode of action, the actual number of contaminants will range from 2 to 33."

Ordinances:

(Section 742.1015(b)(2))

During the last rulemaking (R00-19), the Agency proposed language for Section 742.1015(b)(2). However, the word "modeled" was left off the proposed change in the final version of the docket. Therefore, the Agency proposes to add the following change to Section 742.1015(b)(2): "A scaled map(s) delineating the area and extent of groundwater contamination modeled above the applicable remediation objectives including any measured data showing concentrations of contaminants of concern in which the applicable remediation objectives are exceeded". The underlined "modeled" would be added to the proposed language.

Appendix C, Table D

Appendix C, Table D identifies the symbols, parameters, units, source, and parameter values to be used in the Risk Based Corrective Action (RBCA) equations. The Agency found an error in the tables for the soil bulk density symbol. The symbol for the soil bulk density is currently P_s, when the symbol should be P_b. The Agency proposes to change the symbol for the soil bulk density to P_b to reflect the correct symbol and to be consistent with the symbol for soil bulk density identified in Appendix C Table B and Appendix C Table F.

Appendix C, Table F

Pursuant to the discussion regarding the change to Section 742.215, the Agency proposes to modify Appendix C, Table F to reflect the Agency's proposed language in Section 742.215(b)(1)(B) by removing Nelson and Sommers (1982) and USEPA SW-846 Method 9060A Total Organic Content from the Method column, updating ASTM-D2974-87 to ASTM-D2974-00 Moisture, Ash and Organic Matter[b], adding "appropriately adjusted to estimate the fraction of organic carbon as stated in Nelson and Sommers (1982)" in the method column of the ASTM method, and add fraction in front of organic carbon in the parameter column for f_{oc}.

This concludes my testimony.

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STATE OF ILLINOIS
Pollution Control Board

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
)
TIERED APPROACH TO CORRECTIVE) R06-10
ACTION OBJECTIVES: AMENDMENTS) (Rulemaking-Land)
TO 35 Ill. Adm. Code 742)
)

PRE-FILED TESTIMONY OF LAWRENCE W. EASTEP, P.E.

My name is Lawrence W. Eastep. Until December 31, 2005, I was the manager of the Remedial Project Management Section of the Bureau of Land of the Illinois Environmental Protection Agency ("Agency"). The Remedial Project Management Section ("RPMS") is generally responsible for Bureau of Land remedial actions at sites that may pose environmental threats and that are not otherwise regulated by CERCLA, RCRA or LUST programs. The RPMS also is responsible for the voluntary Site Remediation Program ("SRP"), which encourages and administers many private party clean-ups.

I graduated from the University of Missouri at Rolla in 1969 with a B.S. in Civil Engineering. I received my M.S. in Civil Engineering (Sanitary/Environmental) in 1976 from the same institution. Except for a brief period from 1978 to early 1979 and my retirement on December 31, 2005, I was employed by the Agency since 1971 in a variety of positions including manager of the Bureau of Land Permit Section from 1983 through 1993. I assumed my most current responsibilities in January 1994. I am registered as a Professional Engineer in Illinois. I have thirty-three years experience in the environmental engineering field.

I will be testifying in support of the proposed amendments to 35 Ill. Adm. Code 742: Tiered Approach to Corrective Action Objectives. Specifically, my testimony will address the background table for polynuclear aromatic hydrocarbons, changes to Appendix B, Table A, and the inclusion of construction worker remediation objectives in Appendix B, Table A for residential scenarios.

I. Background Table For Polynuclear Aromatic Hydrocarbons And Changes To Appendix B, Table A

Introduction

Over the last several years, The Illinois Environmental Protection Agency ("IEPA") has become aware of significant "background" levels of polynuclear aromatic hydrocarbons, or PNAs, in Illinois soils. PNAs can occur as a result of the incomplete combustion of organic material and as a result of either natural or anthropogenic activities. Natural sources of PNAs are suspected to be forest fires or volcanic activity. Anthropogenic sources include operation of motor vehicles, coal burning power plants, burning refuse, outdoor grilling, and various industrial operations such as activities at manufactured gas plants. An obvious source in Illinois would be the great Chicago fire.

As a result of IEPA experience in reviewing contaminant investigations submitted pursuant to the SRP, it became evident that PNAs were somewhat ubiquitous. However, the IEPA did not have enough information to quantify the levels of PNAs, and it was determined that additional study was needed. In order to meet existing remedial objectives for certain PNAs, remedial applicants must remediate to below naturally occurring levels. This could mean removal of soils to excessive depths and then trying to find clean fill that might meet all the Tier 1 objectives. In many cases this was either technically infeasible or economically unreasonable.

In July 2000, a Brownfield Redevelopment Grant was approved for the City of Chicago to allow for the investigation of PNA levels in ambient soils in the City of Chicago. In 2001 and 2002, a study was subsequently conducted by the City in conjunction with the U.S. Geological Survey ("USGS"). The USGS assessed ambient soils, or "...those soils whose chemical composition is affected by ubiquitous natural and anthropogenic processes rather than site-specific disposal of waste materials." Results of the investigation and a statistical analysis are presented in Polynuclear Aromatic Hydrocarbon Background Study, City of Chicago, IL (Chicago Study) prepared by Tetra Tech Inc. for the City of Chicago.

In the same time period, the Electric Power Research Institute ("EPRI") conducted an investigation of PNAs in soils in the State outside of Chicago. The State of Illinois did not fund this study, nor was it an active partner, but the IEPA and EPRI were in consultation, and the IEPA did concur with the site selection and sampling protocols prior to commencement of the study. Results of the investigation and a statistical analysis are presented in Polycyclic Aromatic Hydrocarbons (PAHs) in Surface Soil in Illinois: Background PAHs ("EPRI Study"), incorporated by reference in Section 742.210.

Results of Background Studies

In the Chicago Study, results from fifty-seven randomly selected sampling locations across the City were used. Sixteen separate PNAs were analyzed for each sample. These locations represented properties owned by the City (such as police stations, fire stations, and libraries) and Commonwealth Edison. Sites were rejected from sampling if there was evidence of prior releases; the sites were close to industries that might have an impact on the sample; they were completely paved, etc. The resultant data were statistically evaluated and found to be lognormally distributed. The parametric 95th percentile was selected for use as the appropriate background value. It represents a number that 95% of any samples would be less than. The 95th percentile and median concentrations for the data are listed in Table 1. Where available, Tier 1 TACO limits are included for reference.

In the EPRI study, the State was divided into sixteen areas from which samples were selected. Areas selected were considered "populated areas" (with 1000 people/ sq. mile or 1.56 persons per acre), with a minimum population of 10,000 people. These were not necessarily within any municipal boundaries. Many of the sample locations were located in apparent unincorporated areas of their counties outside of municipal limits. In some cases, sample locations were 1-2 miles out from municipal limits, and in one case, Macomb, almost 3 miles out. Sample sites selected included parks, roadway medians, utility rights-of-way, commercial property, residential property, parking lot buffers and vacant lots. Most of the general areas around the actual sites sampled were residential, commercial, or rural. Contaminated sites were not sampled. For the actual sites sampled, only 1% of the sites were deemed to be "industrial". Results showing the 95th percentile are shown in Table 1.

In general, both studies showed that several PNA compounds were found to be present in almost every sample collected throughout the State. Not all of the specific PNA compound background levels exceeded TACO Tier 1 objectives, and the relationships of which PNAs exceeded particular Tier 1 objectives varied from Chicago, the metropolitan, and non-metropolitan areas. For the purposes of this testimony, when background is referenced, it means the 95th percentile value derived as a result of the studies. For example, the Benzo(a)Anthracene background levels found in Chicago (1.099mg/kg) and the downstate metropolitan areas (1.84 mg/kg) exceeded the TACO Tier 1 residential ingestion level of 0.9mg/kg, but not the industrial/commercial, migration to groundwater, or construction worker levels. However, benzo(a)pyrene in Chicago (1.302mg/kg), in the downstate metropolitan areas (2.14 mg/kg), and in the non-metropolitan areas (0.98mg/kg), all exceeded the TACO Tier 1 residential ingestion level of 0.09 mg/kg and the industrial commercial level of 0.8 mg/kg.

Development of Background Values

The IEPA proposes to allow PNA background levels to be used in the City of Chicago and in other populated areas. This change is similar to the amendments IEPA made for the background for arsenic. A new table has been added, the term "populated area" has been defined, and the Tier 1 tables have been changed. A new Table H (in Appendix A) is proposed that would show the background levels for the various PNAs in Chicago and in populated areas outside of Chicago, identified as either metropolitan or non-metropolitan. Additionally, the term "populated area" is newly defined and means any municipality with a population greater than 10,000 and the area within three miles of the municipal boundary. Finally, the Tier 1 tables have been modified. For the PNAs that have background levels exceeding a tier objective of any kind, the appropriate background level is incorporated into the Tier 1 table by virtue of a footnote. The footnote directs the reader to Appendix A, Table H.

New Table H has three columns. These columns have values for Chicago, Metropolitan Areas and Non-Metropolitan areas. The three separate areas were used because levels were statistically different in those areas. For benzo(a)anthracene, background levels exceeded Tier1 ingestion levels only in Chicago and the downstate metropolitan areas, but not non-metropolitan areas. Thus, the non-metropolitan areas would not use Table H since background in these areas was below Tier 1 levels. For benzo(a)pyrene ("BaP"), both the residential and industrial/commercial ingestion columns have a footnote telling the reader that any "populated" area in the state could use the background numbers in Table H.

The use of the term "metropolitan area" refers to counties in "standard metropolitan statistical areas" ("SMSA"). The term "non-metropolitan areas" refer to counties not in SMSAs. These counties are identified in Appendix A, Table G. The term "populated area" refers to any municipality with a population greater than 10,000 and the area within three miles of the municipal boundary boundary. There are many communities in the State that are somewhat urbanized far beyond their corporate limits and the EPRI study basically took this into account. This definition differs from the strict definition EPRI used (i.e., an "area" with 10,000 people and a density of 1000/sq.mile) because the IEPA felt that defining populated area without utilizing municipal boundaries would be much too cumbersome for all affected parties. The density factor (1,000 persons/square mile or 1.56 persons/acre) did not appear to make much of a difference, and areas meeting the populated area definition will likely have the appropriate density. Obviously, a city of 10,000 would clearly be identified as fitting within the definition. Without the reference of a boundary there would be a problem finding 10,000 people if they are not in an incorporated area. In making such a determination, the IEPA would have to consider such things as the proximity of the site to larger communities, and the nature of the surrounding area (e.g., whether it is a high traffic area, it is agricultural, it is an unincorporated "doughnut" located between larger communities, it is rural with only a history of residential use, etc). The IEPA feels that most sites will be easily categorized, one way or another, in a clear objective manner.

Conclusion

There were five PNAs that had background levels that exceeded at least one of the objectives listed in TACO. Of these, it is felt that the greatest impact will be for cleanups where Benzo(a)Pyrene is present. From personal experience, it appears that many Chicago area and downstate cleanups encounter Benzo(a)Pyrene at some level, generally above the Tier 1 residential level and near the background level. Allowing remedial applicants to utilize background will help hold costs down and allow them to focus on contaminants of concern, while still protecting human health and the environment.

TABLE 1

Chemical Name	Chicago study		EPRI study		TACO limits for reference			
	Chicago 95th percentile (mg/kg)	Chicago Median (mg/kg)	Metro mg/kg	Non-metro mg/kg	Resident Ingestion (mg/kg)	Industrial Commercial Ingestion (mg/kg)	Migration to ground-water (mg/kg)	Construction Worker - ingestion or inhalation (mg/kg)
2-methylnaphthalene			0.135	0.289				
Acenapthene		*0.085*						
Acenaphthylene	0.03	*0.016*	0.0685	0.044				
Anthracene	0.248	0.017	0.402	0.143	23000	610000	12000	610000
Benzo (a) Anthracene	1.099	0.855	1.84	0.719	0.9	8	2	170
Benzo (a) pyrene	1.302	0.975	2.14	0.98	0.09	0.8	8	17
Benzo (b) fluoranthene	1.484	1.05	2.05	0.704	0.9	8	5	170
Benzo (g,h,I) perylene	0.684	0.46	1.67	0.843				
Benzo (k) fluoranthene	0.992	0.77	1.68	0.634	9	78	49	1700
Chrysene	1.158	0.88	2.72	1.07	88	780	160	17000
Dibenzo (a,h,) anthracene	0.205	0.14	0.422	0.154	0.09	0.8	2	17
Fluoranthene	2.72	2.05	4.08	1.83	3100	82000	4300	82000
Fluorene	0.102	0.084	0.179	0.041	3100	82000	560	82000
Ideno (1,2,3-cd) pyrene	0.858	0.595	1.552	0.513	0.9	8	14	
Naphthalene	0.038	0.02	0.201	0.168	1600	41000	12	1.8
Phenanthrene	1.333	1.1	2.46	0.991				
Pyrene	1.9	1.65	3.03	1.23	2300	61000	4200	61000

Examples of some Benzo (a) Pyrene values from the EPRI study showing the range of values detected.

Sample No.	City	Site use	Area use	B(a)P -value ug/kg
BE-06	Bellville	Utility	Heavy Residential	3830
BE-06	Bellville	Right of Way	Light Industrial	1020
BE-10	Bellville *	Right of Way	Light Industrial	8.2
CA-08	Carbondale *	Right of Way	Commercial	2850
CA-05	Carbondale	Municipal	Light Industrial	5.03
DA-10	Danville	Right of Way	Heavy Residential	3260
DA-04	Danville	Recreational	Heavy Residential	42.9
DE-02	Decatur	Right of Way	Heavy Residential	1420
EF-08	Effingham *	Right of Way	Heavy Residential	1110
GL-01	Glenview	Municipal	Heavy Residential	5960
GL-02	Glenview	Municipal	Commercial	394
GL-07	Glenview	Municipal	Commercial	3360
LA-10	Lansing	Right of Way	Commercial	1150
QY-08	Quincy	Utility	Commercial	124
QY-09	Quincy	Utility	Heavy Industrial	1970
RF-06	Rockford	Right of Way	Light Industrial	1760
RF-07	Rockford	Right of Way	Heavy Residential	21

*areas outside of city limits

II. Inclusion of Construction Worker Objectives for Certain Chemicals in Appendix B, Table A for Residential Scenarios

Introduction

There are a number of chemicals (28) that have industrial commercial construction worker remedial inhalation objectives that are more stringent than the residential inhalation objectives. However, the manner in which TACO is used allows for construction activities on residential properties. For example, a site cleaned up to residential objectives might be expected to have construction of residential properties, repairs to those properties, etc. Additionally, many sites clean up to TACO residential objectives, even though the intended use of the property is industrial. Therefore, in order to protect the construction worker, the IEPA felt that it was still necessary to apply the industrial commercial construction worker remedial inhalation objectives to residential scenarios.

Revisions to TACO

In order to apply the industrial commercial construction worker remedial inhalation objectives that are more stringent than residential objectives, the chemicals in question have been footnoted. The footnotes require the applicant to consider the construction worker objectives when evaluating Tier 1 residential uses for inhalation. An option would have been to add another column to the residential tables, but since only 28 chemicals are involved, a footnote seemed sufficient. Another option would have been to simply replace the residential inhalation objective with the construction worker objective, but the basis for the residential objectives is a residential setting, not construction work. For example, if an applicant in the Site Remediation Program is evaluating naphthalene in a residential setting, the residential inhalation Tier 1 objective is 170mg/kg. The Tier 1 table (Appendix B, Table A) now has a footnote "x" for naphthalene that tells the applicant to go to Appendix B, Table B, where the naphthalene construction worker objective is 1.8mg/kg. Thus, the applicant in this case would also have to comply with the industrial commercial construction worker remedial inhalation objective.

The IEPA also considered adjusting the exposure period for construction workers in a residential setting, since construction worker exposures in a residential setting would normally be shorter than in an industrial/commercial setting. However, since many applicants remediate to residential levels in order to reduce encumbrances on their property, and actually intend on using the property for industrial uses, no changes were deemed necessary.

Conclusion

Since construction workers could be subjected to similar, if not identical, exposures in a residential setting as they would in an industrial setting, this change is necessary to be protective of human health.

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

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STATE OF ILLINOIS
Pollution Control Board

IN THE MATTER OF:	)	
	)	
PROPOSED AMENDMENTS TO	)	
TIERED APPROACH TO CORRECTIVE	)	R06-10
ACTION OBJECTIVES	)	(Rulemaking - Land)
(35 Ill. Adm. Code 742)	)	
	)	

PRE-FILED TESTIMONY OF THOMAS C. HORNSHAW, Ph.D.

Qualifications

My name is Thomas C. Hornshaw. I am a Senior Public Service Administrator and the Manager of the Toxicity Assessment Unit of the Illinois Environmental Protection Agency (Agency). I have been employed at the Agency since August of 1985, providing expertise to the Agency in the area of environmental toxicology. Major duties of my position include development and use of procedures for toxicity and risk assessments, review of toxicology and hazard information in support of Agency programs and actions, and critical review of risk assessments submitted to the Agency for various cleanup and permitting activities.

I was a member of the Agency's Cleanup Objectives Team until February of 1993, when that Team's responsibilities were assumed mainly by the Toxicity Assessment Unit. I was also a member of the Groundwater Standards Technical Team during the development of the Groundwater Quality Standards. These two teams have looked in depth at the problems involved with determining acceptable residual concentrations of chemicals in soil and/or groundwater. I have also participated in the development of the original 35 Ill. Adm. Code Part 742 rule, Tiered Approach to Corrective Action Objectives (TACO; R97-14) and the first amendment to this rule (R00-19).

I received Bachelor of Science (with honors) and Master of Science degrees in Fisheries Biology from Michigan State University, East Lansing, Michigan. I also received a dual Doctor of Philosophy degree from Michigan State University, in Animal Science and Environmental Toxicology. I am a member of the Society of Environmental Toxicology and Chemistry and Sigma Xi, the Scientific Research Society. I have authored or co-authored six papers published in peer-reviewed scientific journals, one report issued through the U.S. Environmental Protection Agency, and have written or co-written six articles which have appeared in trade journals. I have also presented fourteen posters and/or talks describing facets of my graduate work and my work at the Agency at various regional and national meetings. A more descriptive account of my work and educational background and a list of publications, posters, and talks is included in a Curriculum Vitae presented as Exhibit A to this testimony.

Testimonial Statement

My testimony today concerns several changes and updates needed to the text and tables of Part 742. I will describe changes necessary to remediation objectives for certain chemicals in Appendix B, Tables A, B, E, and F due to changes in the toxicity information for these chemicals. I will testify about the development of new remediation objectives for Lead for the Industrial/Commercial and Construction Worker Ingestion Route that are added to Appendix B, Table B, and pH-specific objectives for the Soil Component of the Groundwater Ingestion Route that are added to Appendix B, Tables C and D. I will also testify about the development of soil ingestion remediation objectives for the major nutrients Calcium, Magnesium, Phosphorus, Potassium, and Sodium. Finally, I will describe several minor changes or corrections that need to be made to the text and tables of TACO that have come to the attention of the Toxicity Assessment Unit.

TOXICITY INFORMATION CHANGES

As was the case in the first amendment of TACO, updating of the toxicity information for certain chemicals by USEPA necessitates the revision of remediation objectives for these chemicals in the associated Tier 1 remediation objective tables in Appendix B. Toxicity criteria have been updated since the R00-19 rulemaking for Acetone, Boron, 1,2-Dibromoethane, 1,1-Dichloroethylene, Phenol, and Xylene. The specific changes for these chemicals include: a new Reference Dose (RfD) for Acetone; a revised RfD and withdrawal of the Reference Concentration (RfC) for Boron; a new RfD and revised RfC, oral cancer Slope Factor (SFo), and inhalation cancer Unit Risk Factor (URF) for 1,2-Dibromoethane; a revised RfD and a new RfC for 1,1-Dichloroethylene; a revised RfD for Phenol; and a revised RfD and a new RfC for Xylene. These updated toxicity values were used in the appropriate SSL Equations in Appendix C, Table A to calculate updated soil objectives for these chemicals, and the updated objectives have been entered into Appendix B, Tables A and B. The procedures of 35 Ill. Adm. Code 620.Subpart F were also used to update the groundwater objectives to 6.3 mg/L in Appendix B, Tables E and F for Acetone. Note that since the Tier 1 Groundwater Remediation Objective for all chemicals except Acetone is also the Groundwater Standard under 35 Ill. Amd. Code 620 for these chemicals, only Acetone's objective is being changed in Appendix B, Tables E and F at this time. These updated objectives are proposed to be included in Appendix B, Tables A, B, E, and F (the change in Table F was inadvertently omitted from the original filing of this proposal and is now included in Errata Sheet Number 1).

In addition, the Toxicity Assessment Unit has become aware of a clarification from USEPA on the need for an adjustment to the RfD for Manganese for soil ingestion exposures to account for dietary intake of this element. Specifically, USEPA has determined that the RfD of 0.14 mg/kg/d, which corresponds to a daily intake of 10 mg/d (0.14 mg/kg/d times the assumed body weight of 70 kg) must be adjusted to account for the assumed 5 mg/d intake from the diet. Using the Modifying Factor of 3 contained in the USEPA's Integrated Risk Information System (IRIS) file for Manganese, the adjusted RfD is 0.02 mg/kg/d for non-dietary ingestion (5 mg/d divided by the Modifying Factor of 3 divided by 70 kg body weight). This adjusted RfD was used as above in the appropriate SSL equations to calculate replacement values for the Ingestion Route, which are being proposed for this chemical's Tier 1 remediation objectives.

NEW LEAD OBJECTIVES

In response to inquiries regarding the appropriateness of the existing 400 mg/kg soil objective (based on a child's exposure assumptions) for the worker exposures assumed for the Industrial/Commercial and Construction Worker Ingestion Route, the Toxicity Assessment Unit researched this issue in discussions with USEPA staff. After reviewing the USEPA Adult Blood Lead Model, it was decided that the default inputs for this model could be used to calculate new soil objectives of 800 and 700 mg/kg for the Industrial/Commercial and Construction Worker Ingestion Routes, respectively. These values are proposed to be added to Appendix B, Table B. The details of these calculations are contained in Memoranda from Les Morrow and Connie Sullinger to me, which are attached as Exhibits B and C to this testimony. Note that the 800 mg/kg value for the Industrial/Commercial worker was inadvertently left out of the original filing of this proposal and is now included in the Errata Sheet.

The Toxicity Assessment Unit also became aware of a USEPA publication (Understanding Variation in Partition Coefficient, Kd, Values. Volume II: Review of Geochemistry and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium, and Uranium. USEPA Office of Air and Radiation. EPA402-R-99-004B, August 1999) that could provide an approach to developing pH-specific objectives for the Soil Component of the Groundwater Ingestion Route for Lead. The section on Lead contains a review of the variations in the soil-water partition coefficient (Kd) under different soil pH conditions, and contains a table listing the minimum and maximum Kd for three different pH ranges and four different equilibrium Lead concentration ranges. From this table, the Toxicity Assessment Unit selected the most restrictive Kd values, corresponding to the minimum Kds for the three pH ranges at an equilibrium Lead concentration range of 100-200 ug/l (Kds of 150 L/kg for pH 4.0-6.3, 710 L/kg for pH 6.4-8.7, and 1,880 L/kg for pH 8.8-11.0), as the basis for calculating the soil objectives for the Soil Component of the Groundwater Ingestion Route. These Kds were used in SSL Equation S17 from Appendix C, Table A to calculate soil objectives for the three pH ranges. It is proposed to add objectives for lead of 23 mg/kg for pH 4.5 through 6.24, 107 mg/kg for pH 6.25 through 8.74, and 282 mg/kg for pH 8.75-9.0 in Appendix B, Table C, and values of 300, 1,420, and 3,760 mg/kg for these ranges, respectively, in Appendix B, Table D. A copy of the Lead section of the USEPA document is attached as Exhibit D to this testimony. Note that these Kd values are also added to the pH-specific table of Kds in Appendix C, Table J.

MAJOR NUTRIENTS

In response to several requests for and submissions of remediation objectives for essential nutrient minerals, I reviewed recent literature (*A Risk Assessment Model for Establishing Upper*

Intake Levels for Nutrients. Food and Nutrition Board, Institute of Medicine, National Academy of Sciences. June 1998; and *Recommended Dietary Allowances, 10th Edition.* Subcommittee on the Tenth Edition of the RDAs, Food and Nutrition Board, Commission on Life Sciences, National Research Council. 1989) pertaining to the normal, recommended, and tolerable upper intakes for Calcium (Ca), Magnesium (Mg), Phosphorus (P), Sodium (Na), and Potassium (K). Even when taking into account upper percentiles of the normal daily dietary intake of Ca, P, Na, and K, and assuming that the "soil" ingested by the receptors listed in TACO is 100% nutrient, there are no concerns for any soil concentration of these minerals for the Ingestion Route by any of the receptors. For Mg, there is no concern for ingestion by industrial/commercial receptors at any soil concentration, while the Residential receptor will be protected at concentrations up to 325,000 mg/kg and the Construction Worker receptor will be protected at concentrations up to 730,000 mg/kg. Therefore, the Agency proposes to add these nutrients to Appendix B, Tables A and B with the above listed values for Mn for the Residential and Construction Worker receptors, and footnote "g" (indicating no concern at any concentration) for all receptors for the other nutrients for the Ingestion Route. There are no appropriate criteria for evaluating the Inhalation Route, and these nutrients are not able to be analyzed by the leachate tests used for the Soil Component of the Groundwater Ingestion Route, so no soil objectives are proposed for these routes. Since these nutrients are all included in the analytical procedure for Total Dissolved Solids (TDS), it is proposed that they be added to the Appendix B, Table E groundwater objectives, with a new footnote citing the 35 Ill. Adm. Code 620 Groundwater Quality Standards for TDS of 1,200 mg/l for both classes of groundwater as the remediation objective. It should be noted that there may be ecological receptors, especially plant species, that could be impacted by high levels of essential nutrients in soil; therefore, it is also proposed to include footnote "n" (indicating that the Agency reserves the right to evaluate potential threats to crops, livestock, or wildlife) to the entries for these nutrients in Appendix B, Tables A and B.

MINOR CHANGES AND CORRECTIONS

As a result of its own review or because of questions from outside the Agency, the Toxicity Assessment Unit has become aware of several minor changes and corrections needed in TACO. Therefore, the following modifications are proposed:

Section 742.200 – The definition of "Volatile Organic Compounds (VOCs)" contains a list of USEPA SW-846 Methods that identify VOCs. The most recent update to the SW-846 Methods contains the following changes to this list: Method 8010 has been deleted; Method 8015 has been changed to Method 8015B; Method 8020 has been deleted; Method 8021 has been changed to Method 8021B; Method 8030 has been deleted; Method 8240 has been deleted; Method 8260 has been changed to Method 8260B; and Method 8315 has been changed to Method 8315A. These changes are proposed for this definition.

Section 742.210(a) – As described above, the USEPA SW-846 methods have been updated since the last TACO amendment, necessitating a revision of this document's Incorporation by Reference citation under the Government Printing Office documents. However, a problem has arisen regarding this citation. In the past, the Agency has routinely been provided hard copies of SW-846 updates as they became available in draft, proposed, and final versions. Recently, however, USEPA has begun making these documents available to the public on line, and paper and CD copies must now be purchased. Due to budgetary constraints, the Agency does not intend to purchase either a paper or CD copy of the SW-846 methods since it is free on line. Therefore, the Agency is proposing a website citation for SW-846 instead of a date-certain document.

The Agency is aware that the Illinois Administrative Procedures Act (IAPA) requires that a date-certain document be used when incorporating documents by reference. However, at the time the IAPA was written, we were not in the on line information age that we are today. Additionally, with the advent of paperless office legislation, many businesses and governmental bodies do not keep paper copies of documents, especially those that are regularly updated such as SW-846. It is vitally important that current analytical procedures be used in conjunction with TACO-based cleanup projects, and the on line version of SW-846 will always contain these current procedures. Therefore, we request that the Board make special exception to the general rule regarding date-certain incorporations by reference and accept this citation via an on line web address. In support of this request, we contend that the latest updates are readily available to the public via the world wide web, and if a person does not have access to the web the Board could download the most current update for inspection. Thus, we propose that the current citation for SW-846 be replaced by: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", USEPA Publication number SW-846 (Third Edition, Final Update IIIA), as amended by Final Updates I, II, IIA, IIB, III, and IIIA (Document No. 955-001-00000-1). Available at www.epa.gov/epaoswer/hazwaste/test/main.htm.

There are also some outdated references in the National Technical Information Services documents in this section that need to be replaced. The Agency proposes to delete the 1992 "Dermal Exposure Assessment: Principles and Applications" citation and replace it with "Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim", EPA Publication No. EPA/540/R/99/005 (September 2001). Also, it is proposed to delete the 1989 "Exposure Factors Handbook" and replace it with the three-volume update, which will add: "Exposure Factors

Handbook, Vol. I: General Factors", EPA Publication No. EPA/600/P-95/002Fa (August 1997); "Exposure Factors Handbook, Vol. II: Food Ingestion Factors", EPA Publication No. EPA/600/P-95/002Fb (August 1997); and "Exposure Factors Handbook, Vol. III: Activity Factors", EPA Publication No. EPA/600/P-95/002Fc (August 1997). Note that only Volume I has been used in the development of TACO, but the other two Volumes are being cited because they could be used in Tier 3 assessments.

Finally, it is proposed to add to this section USEPA's update to the original Soil Screening Guidance, "Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites", OSWER Directive 9355.4-24 (December 2002). It is not proposed to delete the original Soil Screening Guidance references, as these documents contain information still used in TACO.

Section 742.220(b) – After discussion with USEPA, the Agency determined that it was intended that the requirement not to exceed the soil saturation limit only applies to liquid chemicals for the Soil Component of the Groundwater Ingestion Route, as is already the case for the Inhalation Route in Section 742.220(a). Therefore, the Agency proposes to add "that has a melting point below 30°C" after "For any organic contaminant" in the first line.

Section 742.225 – In order to clarify the acceptable procedures for compositing and averaging samples to demonstrate compliance with remediation objectives, the Agency proposes several changes for this Section: change Subsection (c)(1) to specify that if samples are composited for the Soil Component of the Groundwater Ingestion Exposure Route, the samples must be collected beginning at six inches below the ground surface for surface contamination and at the upper limit of contamination for subsurface contamination; add a new Subsection (c)(4) prohibiting the averaging of composite samples for this exposure route, since composite samples are already averages of soil concentrations, and allowing arithmetic averaging of samples collected at every two feet of depth as specified in Subsection (c)(1); add a new Subsection (d)(4) also prohibiting the averaging of composite samples for the Ingestion and Inhalation Exposure Routes, and specifying the use of USEPA's "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites", USEPA Office of Emergency and Remedial Response, OSWER 9285.6-10 (December 2002), or an alternative procedure approved by the Agency, as the method to be used to demonstrate compliance with remediation objectives for these routes of exposure (this document is proposed for addition to the incorporations by reference); and change Subsection (e) to reduce the limit on the number of non-detect samples allowed to be averaged from 50% to 15%, based on USEPA's "Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA00 Update", EPA/600/R-96/084 (July 2000), and specifying this guidance or an alternative procedure approved by the Agency as the method to be used to address non-detect values at greater than 15% when determining averages. This document is also proposed for addition to the incorporations by reference.

Section 742.510(a)(5) – When the Agency expanded the upper limit of pH values included in Appendix B, Tables C and D from 8.0 to 9.0 in the R00-19 amendment to TACO, we inadvertently neglected to change the text of this Section to reflect the change in the tables, and it is proposed to do so now.

Appendix A, Table G – Due to a typographical error, the values for Aluminum, Calcium, Iron, Magnesium, and Potassium include decimal points instead of commas (changes listed in Errata Sheet Number 1).

Appendix A, Table H – No data are available for Chicago for 2-Methylnaphthalene; therefore, the Agency proposes to add dashes instead of leaving this space blank (change listed in Errata Sheet Number 1).

Section 742.Appendix A, Table I – Since Beryllium is no longer thought to be carcinogenic by the oral route, it must be deleted from this table (this should have been done in the R00-19 amendment when the Ingestion Route soil objectives were updated). Also, the updated toxicity data for 1,2-Dibromoethane requires that the 1 in 1,000,000 Cancer Risk Concentration be changed from 0.0000010 to 0.00002 mg/L, and this chemical needs to be capitalized in the Chemical column (1,2-Dibromoethane changes listed in Errata Sheet Number 1).

Section 742.Appendix B, Tables A and B – In addition to the changes needed because of new toxicity data, several changes/corrections are necessary to these tables (Note: Changes marked by * are listed in Errata Sheet Number 1):

- Due to a typographical error, the value for the Soil Component of the Groundwater Ingestion Route for 1,2-Dibromo-3-chloropropane for Class II Groundwater should be changed from 0.002 mg/kg to 0.02 mg/kg in both tables.
- Due to an error in using the Toxicity Assessment Unit's computer program that calculates TACO remediation objectives, an incorrect value has been listed for 1,2-Dibromoethane for the Inhalation Exposure Route for the Construction Worker in Table B, requiring a change from 0.03 to 0.16 mg/kg; since the correct value is now greater than the value (0.06 mg/kg) for the Inhalation Route for Residential Exposures, Footnote x is no longer necessary for this chemical in Table A.*

- Due to an unknown problem, there are two entries listed for remediation objectives for the Soil Component of the Groundwater Ingestion Exposure Route for most of the Inorganics in both tables, --- and a numerical value. Where this occurs, the --- must be deleted, leaving only the numerical value. In addition, in Table B the numerical value has also been lined through; the lining through must be removed, leaving only the numerical value.*
- In both tables, the Footnote m has been inadvertently deleted from the values for Nitrate for the Soil Component of the Groundwater Ingestion Route, and must be added.*
- In Table A, the Footnote m has been inadvertently added to the --- listing for Silver for the Soil Component of the Groundwater Ingestion Route for Class II Groundwater, and must be deleted.*
- In Table B, the values for the Ingestion Exposure Route for Acetone for the Industrial/Commercial and Construction Workers were originally listed as 1,000,000 mg/kg, but the more correct Footnote g should have been entered.*
- Due to a typographical error, the value for the Ingestion Route for Chlordane for the Industrial/Commercial receptor should be changed from 1.6 mg/kg to 16 mg/kg.
- Due to a formatting error, the footnote i has been capitalized for all Ionizable Organics except 2,4,5-TP in Table B for the Soil Component of the Groundwater Ingestion Exposure Route for Class I Groundwater, and in the list of Footnotes to the table. This must be changed to lower case.*
- As noted above, the Reference Concentration for Boron has been withdrawn, but the previous value in Table B for the Inhalation Exposure Route for the

Industrial/Commercial Worker (1,000,000 mg/kg) has been inadvertently left in the table. This value should be replaced by ---[c] (as was done for the Construction Worker).*

- The Toxicity Assessment Unit has discovered that the computer program used to calculate TACO remediation objectives has incorrectly used equations for particulates instead of for vapors in calculating the Inhalation Exposure Route objectives for Mercury for the Industrial/Commercial and Construction Workers. These objectives were re-calculated using the appropriate equations, and the new values are proposed as replacement values. Since the objectives are to be used for the Inhalation Route, Footnote s in both tables has been changed to specify that the Inhalation objectives apply only at sites where elemental mercury is a contaminant of concern.
- As discussed above, new Ingestion Exposure Route objectives have been developed for Lead for the Industrial/Commercial and Construction Workers, and a new Reference Concentration for 1,1-Dichloroethylene has allowed calculation of new Inhalation Exposure Route objectives for these workers. These changes have rendered Footnotes k and v unnecessary, and they should be deleted and the footnotes re-numbered.

Section 742.Appendix B, Tables E and F – Since there is no reason to list Ionizable Organics separately for groundwater objectives, it is proposed to merge these chemicals alphabetically with the non-ionizable organics in these tables. The Toxicity Assessment Unit has also determined that there are three chemicals, 2-Chlorophenol, 2,4,5-Trichlorophenol, and 2,4,6-Trichlorophenol, whose organic carbon partition coefficient (Koc) values fall below the threshold Koc at which routine water treatment procedures (in this case, granular activated carbon) may not sufficiently remove a chemical from the water. Note that: Koc values for ionizable organics change with pH due to the relative proportions of ionized versus un-ionized species present at a particular pH; the Agency has testified in the original TACO rulemaking that we have used the Koc of Ethylbenzene as the threshold for determining whether a chemical may not be sufficiently removed by granular activated carbon; and we also testified that if a chemical is able to be removed by routine water treatment procedures, then the Class II groundwater objective will be five times the Class I objective. The Kocs for these three chemicals fall below the threshold Koc of 363 L/kg at pHs of 7.4, 7.9, and 6.9, respectively, which requires that we not use the five-fold increase above these pH values. Therefore, the Agency proposes that at and above these pH values the chemicals' Class II objectives be equal to the Class I objectives instead of five times the objectives as in the current version of TACO. Finally, due to a typographical error, the values for Class II Groundwater for 1,2-Dibromo-3-chloropropane should be changed from 0.0002 mg/l to 0.002 mg/l in these tables.

Appendix C, Table E – Due to a typographical error, an incorrect CAS No. has been listed for Chlorobenzene. The CAS No. should be corrected to 108-90-7.

Appendix C, Table I – When the above-mentioned expansion of the upper limit of pH values to pH 9.0 occurred in R00-19, the Agency also neglected to expand the pH range in this table to 9.0. The expanded table will be included in a second Errata Sheet.

Concluding Statement

I feel it is important to mention at this time that there are changes included in USEPA's 2002 update to the Soil Screening Guidance that will likely result in major changes to the calculation of some of the TACO Tier 1 remediation objectives, and, thus, changes to the values of these objectives. There is also new USEPA guidance about preferred sources for the toxicity data to be used in deriving risk-based concentrations, and newly-updated physical/chemical constants, all of which will result in additional changes to the Tier 1 values. There are other issues that the Toxicity Assessment Unit has brought up internally for discussion within the Agency regarding certain aspects of TACO that could also impact the development of remediation objectives. In light of these changes and issues, it is the Agency's intent to begin a dialog with the Site Remediation Advisory Committee to assess these items, and to eventually come before the Board with a separate docket that may contain major revisions to TACO.

This concludes my portion of the Agency's testimony for the proposed amendments to TACO.

EXHIBIT
A

CURRICULUM VITAE

THOMAS C. HORNSHAW

EDUCATION: Ph.D., Animal Science and Environmental Toxicology, 1985. M.S., 1981, and B.S., 1976, Fisheries Biology, Michigan State University.

EXPERIENCE: Senior Public Service Administrator, Illinois Environmental Protection Agency, 1985 - Present.

Graduate Research Assistant, Department of Animal Science, Michigan State University, 1981 - 1984.

Graduate Research Assistant, Department of Fisheries and Wildlife, Michigan State University, 1978 - 1981.

Student Aide, Water Quality Division, Biology Section, Michigan Department of Natural Resources, 1976 - 1977.

FIELDS OF EXPERIENCE: At the Illinois Environmental Protection Agency, Dr. Hornshaw's major duties include the management of the Toxicity Assessment Unit; development and use of procedures for human and environmental exposure assessments and risk assessments; review of toxicological data and hazard information in support of Agency programs and actions; and critical review of remedial investigation and risk assessment documents submitted to the Agency during hazardous waste site investigations and cleanups. Dr. Hornshaw was a member of the Agency's Cleanup Objectives Team until 1993, when that Team's functions were assumed by the Toxicity Assessment Unit. As a member of the Air Toxics Action Committee, he participated in the development of Illinois= Air Toxics rules. He is one of the Agency's representatives to the Great Lakes Toxic Substances Control Agreement (member of the Fish Advisory Task Force) and is the Chair of the multi-agency Illinois Fish Contaminant Monitoring Program. Dr. Hornshaw is also a member of the National Advisory Committee for Acute Exposure Guidance Levels, moderated by USEPA, whose task is the development of action levels for use in unplanned air releases of hazardous chemicals. In an earlier assignment at the Agency, Dr. Hornshaw assisted in the development of bioassay protocols and quality assurance procedures for the Biomonitoring Unit.

As part of his duties during his Ph.D. research at Michigan State University, Dr. Hornshaw conducted experiments to develop protocols for mammalian wildlife dietary LC_{50} and reproduction tests, using mink and European ferrets as representative mammalian carnivores. He has published four papers in scientific journals as a result of this research, and the protocols developed from these studies have been published by USEPA.

As part of his duties during his M.S. research at Michigan State, Dr. Hornshaw conducted experiments to assess the suitability of several species of Great Lakes fish for animal feed, testing the fish in reproduction trials with mink. He quantitated levels of polychlorinated biphenyls in fish, mink fat, and mink milk as a portion of this research, and published the results of these studies in a scientific journal. These results were also published in several trade journals serving the fur industry. He has authored or co-authored articles detailing the results of several other studies sponsored by the fur industry in these trade journals.

After receiving his Bachelor's degree from Michigan State, Dr. Hornshaw worked as a student aide in the Biology Section of the Water Quality Division of Michigan's Department of Natural Resources. His duties included assisting staff aquatic biologists in the collection of fish, water, sediment, and benthos samples, in laboratory work, in data handling, and in reporting requirements. His field experience included sample collection and identification from inland lakes, Great Lakes, and rivers and streams.

HONORS: Bachelor of Science, with honors; Member, Sigma Xi, the Scientific Research Society.

AFFILIATIONS: Member, Society of Environmental Toxicology and Chemistry.

THESES:

Hornshaw, T. C. 1984. Development of Dietary LC_{50} and Reproduction Test Protocols Using Mink and Ferrets as Representative Mammalian Carnivores. Ph.D. Thesis, Michigan State University, East Lansing, MI. 212pp.

Hornshaw, T. C. 1981. Renewed Use of Underutilized Species of Great Lakes Fish for Animal Feed. M.S. Thesis, Michigan State University, East Lansing, MI. 45pp.

PUBLICATIONS (Peer Reviewed):

Ringer, R. K., Hornshaw, T. C., and Aulerich, R. J. Mammalian Wildlife (Mink and Ferret) Toxicity Test Protocols (LC_{50}, Reproduction, and Secondary Toxicity). U.S. Environmental Protection Agency Report No. EPA/600/3-91/043. July 1991. NTIS Document # PB91-216507.

Hornshaw, T. C., Aulerich, R. J., and Ringer, R. K. 1987. Toxicity of thiram (tetramethylthiuram disulfide) to mink and European ferrets. Bull. Environ. Contam. Toxicol. 38: 618 - 626.

Hornshaw, T. C., Ringer, R. K., Aulerich, R. J., and Casper, H. H. 1986. Toxicity of sodium monofluoroacetate (Compound 1080) to mink and European ferrets. Environ. Toxicol. Chem. 5: 213 - 223.

Hornshaw, T. C., Aulerich, R. J., and Ringer, R. K. 1986. Toxicity of o-cresol to mink and European ferrets. Environ. Toxicol. Chem. 5: 713 - 720.

Hornshaw, T. C., Safronoff, J., Ringer, R. K., and Aulerich, R. J. 1986. LC_{50} test results in polychlorinated biphenyl-fed mink: age, season, and diet comparisons. Arch. Environ. Contam. Toxicol. 15: 717 - 723.

Bleavins, M. R., Aulerich, R. J., Hochstein, J. R., Hornshaw, T. C., and Napolitano, A. C. 1983. Effects of excessive dietary zinc on the intra- uterine and postnatal development of mink. J. Nutr. 113: 2360 - 2367.

Hornshaw, T. C., Aulerich, R. J., and Johnson, H. E. 1983. Feeding Great Lakes fish to mink: effects on mink and accumulation and elimination of PCBs by mink. J. Toxicol. Environ. Health 11: 933 - 946.

PUBLICATIONS (Trade Journals):

Hornshaw, T. 1992. Illinois' Air Toxics selection process described. National Air Toxics Information Clearinghouse (NATICH) Newsletter. USEPA Office of Air Quality Planning and Standards, Research Triangle Park, NC. January, 1992.

Aulerich, R. J., Napolitano, A. C., and Hornshaw, T. C. 1986. How supplemental copper affects mink kit hemoglobin concentration. In The Fur Rancher Blue Book of Fur Farming. Communications Marketing, Inc., Eden Prairie, MN. pp. 42 - 46.

Hornshaw, T. C., Aulerich, R. J., and Ringer, R. K. 1985. Mineral concentrations in the hair of natural dark and pastel mink. Scientifur 9(3): 216 - 219.

Aulerich, R. J., Napolitano, A. C., and Hornshaw, T. C. 1985. Effect of supplemental copper on mink kit hemoglobin concentration. Fur Farmer's Gazette of the United Kingdom 35(4): 8 - 11.

Hornshaw, T. C., Aulerich, R. J., Johnson, H. E., and Ringer, R. K. 1982. How suitable are today's Great Lakes fish for use in feeding mink? Fur Rancher 62(9): 21 - 23.

Hornshaw, T. C., and Aulerich, R. J. 1980. Can Great Lakes fish again be fed safely to mink? In The Fur Rancher Blue Book of Fur Farming. Communications Marketing, Inc., Eden Prairie, MN. pp. 48 - 49.

PRESENTATIONS:

Hornshaw, T.C. "Background Metals and PAHs – Panel Discussion." Session Chair and Panel Member at the Midwestern States Risk Assessment Symposium, August 25-27, 2004, Indianapolis, IN.

Hornshaw, T.C. "Vapor Intrusion Action Levels – Panel Discussion." Panel Member at the Midwestern States Risk Assessment Symposium, July 24-26, 2002, Indianapolis, IN.

Hornshaw, T. C. AThe Illinois Strategy for Endocrine Disruptors.@ Talk presented at The Endocrine Disruptor Debate: Environmental Chemicals and Reproductive and Developmental Health, October 17, 1997, St. Paul, MN.

Hornshaw, T. C. ARisk Pathways and Exposure Potential as Critical Factors in the Determination of Remedial Objectives.@ Talk presented at the Science for Environmental Professionals and Attorneys Conference, January 8, 1997, Chicago, IL.

Hornshaw, T. C. APotential Health Effects of Triazine Herbicides and Their Metabolites in Community Water Supplies.@ Talk presented at the 1996 Illinois Agricultural Pesticides Conference, January 3-4, 1996, Champaign, IL.

Hornshaw, T. C. "The Illinois Fish Contaminant Monitoring Program." Talk presented at the Biannual Meeting of the Federal-State Toxicology and Risk Assessment Committee (FSTRAC), November 6-8, 1991, Chicago, IL.

Hornshaw, T. C. "Assessing Exposure to Toxic Air Releases from a Chemical Facility: Illinois Acrylonitrile Exposure Assessment." Talk presented at the National Governors' Association Conference on Assessing Exposure to Toxic Contaminants: Issues and Problems Facing State Government, March 29, 1989, Salt Lake City, UT.

Hornshaw, T. C. "Risk Assessment from State Point of View." Talk presented at the 1st Annual Hazardous Materials Management Conference/Central, March 16, 1988, Chicago, IL.

Perino, J. V., Whitaker, J. B., and Hornshaw, T. C. Technical aspects of an aquatic toxicological testing program at a state regulatory agency. Poster presented at the 1st Annual Meeting of the Ozark-Prairie Chapter of the Society of Environmental Toxicology and Chemistry, April 24-26, 1986, Columbia, MO.

Hornshaw, T. C. "Illinois EPA's Aquatic Toxicity Testing Program." Talk presented to the Illinois Environmental Consensus Forum. December 12, 1985. Springfield, IL.

Aulerich, R. J., Bursian, S. J., Nachreiner, R. F., Olson, B. A., Hochstein, J. R., Hornshaw, T. C., and Koudele, K. A. Toxicological manifestations of dietary exposure to 3,4,5,3', 4', 5'- hexachlorobiphenyl in mink. Poster presented at the 24th Annual Meeting of the Society of Toxicology, March 18-22, 1985, San Diego, CA.

Hornshaw, T. C. "Effects of Feeding Great Lakes Fish to Mink." Talk presented at the Great Lakes Commercial Fisheries Workshop, March 12, 1985, Mackinaw City, MI.

Hornshaw, T. C., Safronoff, J., Aulerich, R. J., and Ringer, R. K. Development and validation of dietary LC_{50} test protocols for wildlife mammalian carnivores using mink and ferrets. Poster presented at the 5th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 4-7, 1984, Arlington, VA.

Hornshaw, T. C., Ringer, R. K., and Aulerich, R. J. Toxicity of thiram to mink and European ferrets. Poster presented at the 23rd Annual Meeting of the Society of Toxicology, March 12-16, 1984, Atlanta, GA.

Hornshaw, T. C., Ringer, R. K., and Aulerich, R. J. Toxicity of sodium monofluoroacetate (Compound 1080) to mink. Poster presented at the 22nd Annual Meeting of the Society of Toxicology, March 6-11, 1983, Las Vegas, NV.

Hornshaw, T. C., Aulerich, R. J., Johnson, H. E., and Ringer, R. K. Suitability of today's Great Lakes fish for animal feed. Poster presented at the International Symposium on PCBs in the Great Lakes, March 15-17, 1982, East Lansing, MI.

EXHIBIT

B

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

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ROD R. BLAGOJEVICH, GOVERNOR RENEE CIPRIANO, DIRECTOR

MEMORANDUM

DATE: February 25, 2005

TO: Tom Hornshaw

FROM: Les Morrow

SUBJECT: Default Assumptions for Adult Lead Model
Industrial/Commercial Worker Scenario

The following are the default assumptions recommended by the Toxicity Assessment Unit for developing a Tier 3 soil remediation objective for lead for the industrial/commercial worker scenario. The assumptions are to be used in the USEPA Adult Lead Model and result in a default soil remediation goal of 800 mg/kg for the industrial/commercial worker receptor. A copy of the output page of the spreadsheet model including the final PRG of 794 mg/kg (rounded to 800 mg/kg to be consistent with the USEPA recommendation) is attached.

Exposure Parameter	Description of Exposure Variable	Units	Default Values for Industrial/Commercial Worker Scenario
$PbB_{fetal,0.95}$	95th percentile blood lead in fetus	µg/dl	10
$R_{fetal/maternal}$	Fetal/maternal blood lead ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dl per µg/day	0.4
IR_s	Soil ingestion rate	g/day	0.05
AF_S	Absorption fraction for soil	--	0.12
GSD_i	Geometric standard deviation blood lead [1]	--	2.29
PbB_0	Baseline blood lead [2]	µg/dl	1.70
EF_s	Exposure Frequency	days/yr	219
AT_s	Averaging Time	days/yr	365

Notes

1 Site-specific information on race/ethnicity for the industrial/commercial worker population may be used to alter the GSD_i. Only those values based upon "All Regions" and stratified by race/ethnicity from the following reference may be used in place of the default value: USEPA. March 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). EPA 9285.7-52.

2 Site-specific information on race/ethnicity for the industrial/commercial worker population may be used to alter the PbB_0. Only those values based upon "All Regions" and stratified by race/ethnicity from the following reference may be used in place of the default value: USEPA. March 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). EPA 9285.7-52.

Calculations of Preliminary Remediation Goals (PRGs)

Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
		Using Equation 1		~~Using Equation 2~~	
		~~GSDi = Hom~~	GSDi = Het	~~GSDi = Hom~~	~~GSDi = Het~~
$PbB_{fetal, 0.95}$	ug/dL	~~10~~	10	~~10~~	~~10~~
$R_{fetal/maternal}$	--	~~0.9~~	0.9	~~0.9~~	~~0.9~~
BKSF	ug/dL per ug/day	~~0.4~~	0.4	~~0.4~~	~~0.4~~
GSD_i	--	~~2.1~~	2.29	~~2.1~~	~~2.3~~
PbB_0	ug/dL	~~1.5~~	1.70	~~1.5~~	~~1.7~~
IR_S	g/day	~~0.050~~	0.050	~~--~~	~~--~~
IR_{S+D}	g/day	~~--~~	--	~~0.050~~	~~0.050~~
W_S	--	~~--~~	--	~~1.0~~	~~1.0~~
K_{SD}	--	~~--~~	--	~~0.7~~	~~0.7~~
$AF_{S, D}$	--	~~0.12~~	0.12	~~0.12~~	~~0.12~~
$EF_{S, D}$	days/yr	~~219~~	219	~~219~~	~~219~~
$AT_{S, D}$	days/yr	~~365~~	365	~~365~~	~~365~~
PRG	ppm	[redacted]	794	[redacted]	[redacted]

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

EXHIBIT

C

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

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ROD R. BLAGOJEVICH, GOVERNOR RENEE CIPRIANO, DIRECTOR

MEMORANDUM

DATE: May 29, 2003

TO: Tom Hornshaw

FROM: Connie Sullinger

SUBJECT: Default Assumptions for Adult Lead Model Construction Worker Scenario

The following are the default assumptions recommended by the Toxicity Assessment Unit for developing Tier 3 soil remediation objectives for lead for the construction worker scenario. The assumptions are to be used in the USEPA Adult Lead Model and result in a default soil remediation goal of 700 mg/kg for the construction worker.

Exposure Parameter	Description of Exposure Variable	Units	Default Values for Construction Worker Scenario
$PbB_{fetal,0.95}$	95th percentile blood lead in fetus	µg/dl	10
$R_{fetal/maternal}$	Fetal/maternal blood lead ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dl per µg/day	0.4
IR_s	Soil ingestion rate	g/day	0.1
AF_S	Absorption fraction for soil	--	0.12
GSD_i	Geometric standard deviation blood lead [1]	--	2.3
PbB_0	Baseline blood lead [2]	µg/dl	1.7
EF_s	Exposure Frequency	days/yr	30
AT_s	Averaging Time	days/yr	90

Notes

1 Site-specific information on race/ethnicity for the construction worker population may be used to alter the GSD_i. Only those values based upon "All Regions" and stratified by race/ethnicity from the following reference may be used in place of the default value: USEPA. March 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). EPA 9285.7-52.

2 Site-specific information on race/ethnicity for the construction worker population may be used to alter the PbB_0. Only those values based upon "All Regions" and stratified by race/ethnicity from the following reference may be used in place of the default value: USEPA. March 2002. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). EPA 9285.7-52.

EXHIBIT
D

United States
Environmental Protection
Agency

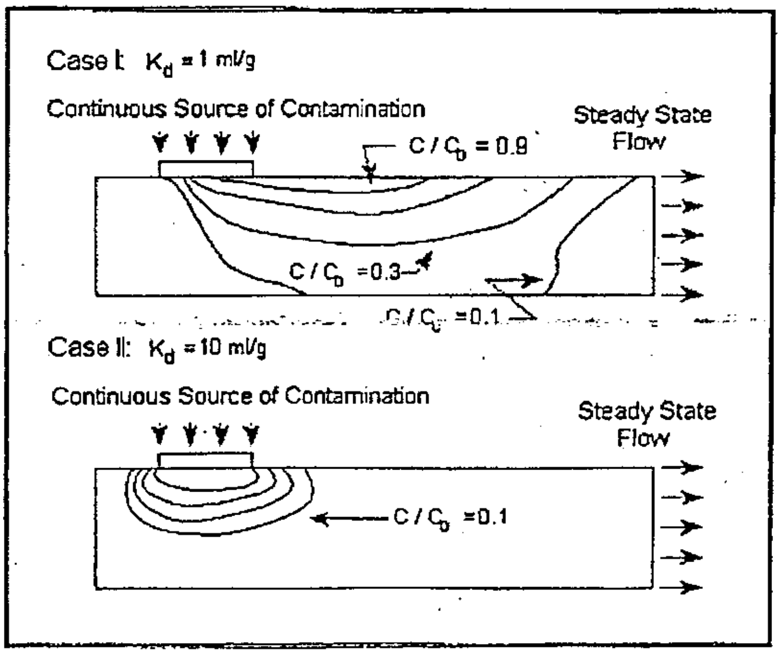
Office of
Air and Radiation
6602J

EPA402-R-99-004B
August 1999

EPA

Understanding Variation In Partition Coefficient, K_d, Values

Volume II: Review Of Geochemistry And Available K_d Values For Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (^3H), And Uranium



5.5 Lead Geochemistry and K_d Values

5.5.1 Overview: Important Aqueous- and Solid-Phase Parameters Controlling Retardation

Lead has 3 known oxidation states, 0, +2, and +4, and the most common redox state encountered in the environment is the divalent form. Total dissolved lead concentrations in natural waters are very low ($\sim 10^{-8}$ M). Dissolved lead in natural systems may exist in free ionic form and also as hydrolytic and complex species. Speciation calculations show that at pH values exceeding 7, aqueous lead exists mainly as carbonate complexes [$PbCO_3^0(aq)$, and $Pb(CO_3)_2^{2-}$]. Important factors that control aqueous speciation of lead include pH, the types and concentrations of complexing ligands and major cationic constituents, and the magnitude of stability constants for lead-ligand aqueous complexes.

A number of studies and calculations show that under oxidizing conditions depending on pH and ligand concentrations, pure-phase lead solids, such as $PbCO_3$, $Pb_3(OH)_2(CO_3)_2$, $PbSO_4$, $Pb_5(PO_4)_3(Cl)$, and $Pb_4SO_4(CO_3)_2(OH)_2$, may control aqueous lead concentrations. Under reducing conditions, galena (PbS) may regulate the concentrations of dissolved lead. It is also possible that lead concentrations in some natural systems are being controlled by solid solution phases such as barite ($Ba_{(1-x)}Pb_xSO_4$), apatite [$Ca_{(1-x)}Pb_x(PO_4)_3OH$], calcite ($Ca_{(1-x)}Pb_xCO_3$), and iron sulfides ($Fe_{(1-x)}Pb_xS$).

Lead is known to adsorb onto soil constituent surfaces such as clay, oxides, hydroxides, oxyhydroxides, and organic matter. In the absence of a distinct lead solid phase, natural lead concentrations would be controlled by adsorption/desorption reactions. Adsorption data show that lead has very strong adsorption affinity for soils as compared to a number of first transition metals. Lead adsorption studies on bulk soils indicate that the adsorption is strongly correlated with pH and the CEC values of soils. Properties that affect CEC of soils, such as organic matter content, clay content, and surface area, have greater affect on lead adsorption than soil pH.

5.5.2 General Geochemistry

Lead is an ubiquitous heavy metal and its concentration in uncontaminated soil ranges from 2 to 200 mg/kg and averages 16 mg/kg (Bowen, 1979). Annual anthropogenic lead input into soils has been estimated to be from 0.04 to 4 µg/kg (Ter Haar *et al.*, 1967). In contaminated soils, lead concentrations may be as high as 18 percent by weight (Mattigod and Page, 1983; Ruby *et al.*, 1994). Lead in nature occurs in 4 stable isotopic forms (^{204}Pb, ^{206}Pb, ^{207}Pb, and ^{208}Pb). The isotopes, ^{206}Pb, ^{207}Pb, and ^{208}Pb are the stable end products of the ^{238}U, ^{235}U, and ^{232}Th thorium decay series, respectively (Robbins, 1980). Additionally, heavier isotopes of lead (^{210}Pb, ^{211}Pb, ^{212}Pb, and ^{214}Pb) are known to occur in nature as intermediate products of uranium and thorium decay (Robbins, 1978). The most common valence state of lead encountered in the environment is the divalent form (Baes and Mesmer, 1976). Extensive studies of lead biogeochemistry have been conducted due to its known adverse effects on organisms (Hammond, 1977). Comprehensive descriptions of environmental chemistry of lead have been published by Boggess and Wixson (1977) and Nriagu (1978).

5.5.3 Aqueous Speciation

Lead exhibits typical amphoteric[1] metal ion behavior by forming hydrolytic species (Baes and Mesmer, 1976). Formation of monomeric hydrolytic species, such as $PbOH^+$, $Pb(OH)_2^\circ(aq)$ and $Pb(OH)_3^-$, is well established. Although several polymeric hydrolytic species such as Pb_2OH^{3+}, $Pb_3(OH)_4^{2+}$, $Pb_4(OH)_4^{4+}$, and $Pb_6(OH)_8^{4+}$ are known to form at high lead concentrations, calculations show that these types of species are unlikely to form at concentrations of dissolved lead ($\sim 10^{-9}$ M) typically encountered even in contaminated environments (Rickard and Nriagu, 1978). These investigators also showed that computation models of speciation of dissolved lead in fresh- or seawater predicted that at pH values exceeding about 6.5, the dominant species are lead-carbonate complexes. Lead is known to form aqueous complexes with inorganic ligands such as carbonate, chloride, fluoride, nitrate, and sulfate.

To examine the distribution of dissolved lead species in natural waters, MINTEQA2 model calculations were completed using the water composition described in Table 5.1. The total lead concentration was assumed to be 1 *µg/l* based on the data for *natural waters* tabulated by Duram *et al.* (1971) and Hem (1985). A total of 21 aqueous species (uncomplexed Pb^{2+}, and 20 complex species, listed in Table 5.8) were used in the computation. Results of the computation are plotted as a species distribution diagram (Figure 5.2). The data show that, under low pH (<6) conditions, free ionic Pb^{2+} appears to be the dominant species, and the neutral species, $PbSO_4^\circ(aq)$, accounts for about 5 percent of the total dissolved lead. Within the pH range of 6.5 to 7.5, the main species of lead appear to be free ionic species, Pb^{2+}, and the neutral complex species, $PbCO_3^\circ(aq)$ with minor percentage of the species consisting of $PbHCO_3^+$ (about 15 percent), $PbSO_4^\circ(aq)$ (<5 percent), and $PbOH^+$ (<5 percent). Between the pH range 7 to 9, the neutral complex species $PbCO_3^\circ(aq)$ dominates dissolved lead speciation. At pH values exceeding 9, in addition to $PbCO_3^\circ(aq)$, a significant fraction of soluble lead is present as the anionic carbonate complex, $Pb(CO_3)_2^{2-}$. These calculations also confirm Rickard and Nriagu's (1978) observation that polymeric species are not significant in the chemistry of lead in natural waters. The species distribution illustrated in Figure 5.2 does not change if the concentration of total dissolved lead is increased from 1 to 1,000 µg/l.

This speciation calculation demonstrates that the important factors that control aqueous speciation of lead include pH and the types of complexing ligands. Aqueous speciation of lead has a direct bearing on dissolution/precipitation of lead-solid phases and the adsorption/desorption

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[1] Amphoteric behavior is the ability of an aqueous complex or solid material to have a negative, neutral, or positive charge.

reactions. Complexation enhances the solubility of lead-bearing solid phases. This enhancement in solubility is dependent on the strength of complexation [indicated by the magnitude of stability constant] and the total concentrations of complexing ligands. Also, as will be discussed shortly, adsorption of lead is affected by the type, charge, and the concentration of lead complexes present in solution. Cationic lead species, especially Pb^{2+} and its hydrolysis species, adsorb more commonly than anionic lead complexes.

5.5.4 Dissolution/Precipitation/Coprecipitation

Lead solids in the environment may occur in a number of mineral forms (Rickard and Nriagu 1978; Mattigod *et al.*, 1986; Zimdahl and Hassett, 1977). However, these authors have identified a limited number of secondary lead minerals that may control the concentrations of dissolved lead in soil/water environments. If the concentration of dissolved lead in a pore water or groundwater exceeds the solubility of any of these phases, the lead-containing solid phase will precipitate and thus control the maximum concentration of lead that could occur in the aqueous phase. According to Rickard and Nriagu (1978), under oxidizing conditions, depending on pH and ligand concentrations, cerussite ($PbCO_3$), hydrocerussite [$Pb_3(OH)_2(CO_3)_2$], anglesite ($PbSO_4$), or chloropyromorphite [$Pb_5(PO_4)_3Cl$] may control aqueous lead concentrations. A review paper by McLean and Bledsoe (1992) included data which showed that lead concentrations in a calcareous soil was controlled by lead-phosphate compounds at lower pH and by mixed mineral phases at pH values exceeding 7.5. A study conducted by Mattigod *et al.* (1986) indicated that the mineral leadhillite [$Pb_4SO_4(CO_3)_2(OH)_2$] may be the solubility controlling solid for lead in a mine-waste contaminated soil.

Table 5.8. Lead aqueous species included in the speciation calculations.

Aqueous Species
Pb^{2+}
$PbOH^+$, $Pb(OH)_2^\circ(aq)$, $Pb(OH)_3^-$, $Pb(OH)_4^{2-}$ $Pb_2(OH)_3^+$, $Pb_3(OH)_4^{2+}$
$PbCO_3^\circ(aq)$, $Pb(CO_3)_2^{2-}$, $PbHCO_3^+$
$PbSO_4^\circ(aq)$, $Pb(SO_4)_2^{2-}$
$PbNO_3^+$
$PbCl^+$, $PbCl_2^\circ(aq)$, $PbCl_3^-$, $PbCl_4^{2-}$
PbF^+, $PbF_2^\circ(aq)$, PbF_3^-, PbF_4^{2-}

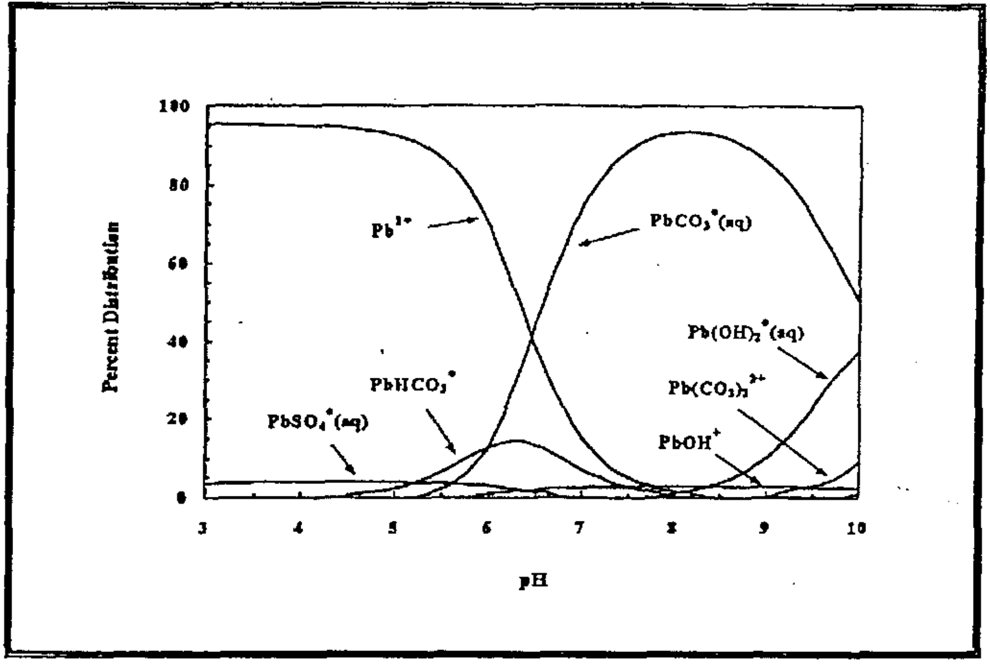

Figure 5.2. Calculated distribution of lead aqueous species as a function of pH for the water composition in Table 5.1. [The species distribution is based on a concentration of 1 µg/l total dissolved lead.]

Lead may also exist in soils as solid-solution phases. Solid solutions are defined as solid phases in which a minor element will substitute for a major element in the mineral structure. Depending on the degree of substitution and the overall solubility of the solid-solution phase, the equilibrium solubility of the minor element in the solid solution phase will be less than the solubility of the solid phase containing only the minor element (pure phase). For instance, lead may occur as a minor replacement in barite [$Ba_{(1-x)}Pb_xSO_4$], apatite [$Ca_{(1-x)}Pb_x(PO_4)_3OH$], calcite [$Ca_{(1-x)}Pb_xCO_3$], and iron sulfides, [$Fe_{(1-x)}Pb_xS$] (Driesens, 1986; Goldschmidt, 1954; Nriagu and Moore, 1984; Rickard and Nriagu, 1978). Consequently, the equilibrium solubility of lead controlled by these phases will be less than the concentrations controlled by corresponding pure phases, namely $PbSO_4$, $Pb_5(PO_4)_3OH$, $PbCO_3$, and PbS, respectively.

Under reducing conditions, galena (PbS) may control the lead concentrations in the environment. Rickard and Nriagu (1978) calculated that, within the pH range of 6-9, the equilibrium solubility of galena would control total lead concentrations at levels less than approximately 10^{-10} M (<21 ng/l). Therefore, if galena is present in a soil under reducing conditions, the aqueous concentrations of lead will be controlled at extremely low concentrations.

5.5.5 Sorption/Desorption

Lead is known to adsorb onto soil constituent surfaces such as clays, oxides, hydroxides, oxyhydroxides, and organic matter. Ion exchange reactions of lead on a number of clay minerals such as montmorillonite, kaolinite, illite, and vermiculite have been studied by a number of investigators. These studies showed, that lead was preferentially adsorbed by exchange on clays, readily replacing calcium and potassium (Bittel and Miller, 1974; Overstreet and Krishnamurthy, 1950). Studies conducted by Lagerwerff and Brower (1973) on montmorillonitic, illitic, and kaolinitic soils confirmed that lead would preferentially exchange for calcium. Another clay mineral, vermiculite, is also known to exhibit very high ion exchange selectivity for lead (Rickard and Nriagu, 1978). Based on a number of studies Rickard and Nriagu (1978) also concluded that beyond neutral pH, precipitation reactions may control lead concentrations in solution rather than ion exchange and adsorption reactions involving clay mineral surfaces.

Experimental data show that only hydrogen ions and unhydrolyzed aluminum ions are capable of displacing lead from exchange sites on clay minerals (Lagerwerff and Brower, 1974; Zimdahl and Hassett, 1977). Clay minerals also differ in their exchange preference for lead. Bittel and Miller (1974) showed that the exchange preference for lead varies in the sequence,

kaolinite > illite > montmorillonite.

These studies also showed that, in neutral to high pH conditions, lead can preferentially exchange for calcium, potassium, and cadmium. Under low pH conditions, hydrogen ions and aluminum ions would displace lead from mineral exchange sites.

Studies of lead adsorption on oxide, hydroxide, and oxyhydroxide minerals show that the substrate properties, such as the specific surface and degree of crystallinity, control the degree of adsorption (Rickard and Nriagu, 1978). *Experimental data* by Forbes *et al.* (1976) showed that goethite (FeOOH) has higher adsorption affinity for lead than zinc, cobalt, and cadmium. Data show that manganese-oxide minerals also adsorb lead ions (Rickard and Nriagu, 1978). These investigators concluded that the high specificity of lead adsorption on oxide and hydroxide surfaces and the relative lack of desorbability (<10 percent) of adsorbed lead indicated that lead upon adsorption forms solid solutions with oxide or hydroxide surfaces. Therefore, this lack of reversibility indicated that the reaction is not a true adsorption phenomenon.

A number of studies have confirmed that many natural and synthetic organic materials adsorb lead. Data showing significant correlations between concentrations of organic matter and lead in soils indicate that soil organic matter has a higher affinity for lead adsorption as compared soil minerals.

A number of lead adsorption studies on bulk soils indicate that the adsorption is strongly correlated with pH and the CEC values of soils (Zimdahl and Hassett, 1977). A multiple regression analysis by Hassett (1974) of lead adsorption data indicated that properties that affect CEC of soils, such as organic matter content, clay content, and surface area, have a greater effect on lead adsorption than soil pH. The results of a number of studies of lead adsorption on a variety of soil and mineral surfaces were summarized by McLean and Bledsoe (1992). These data show that lead has very strong adsorption affinity as compared to a number of first row transition metals (cobalt, nickel, copper, and zinc). According to a recent study (Peters and Shem, 1992), the presence of very strong chelating organic ligands dissolved in solution will reduce adsorption of lead onto soils. These data show that the adsorption of lead in the environment is influenced by a number of factors such as the type and properties of adsorbing substrate, pH, the concentrations of lead, and the type and concentrations of other competing cations and complex forming inorganic and organic ligands.

5.5.6 Partition Coefficient, K_d, Values

5.5.6.1 General Availability of K_d Data

The review of lead K_d data reported in the literature for a number of soils (Appendix F) led to the following important conclusions regarding the factors which influence lead adsorption on minerals and soils.[1] These principles were used to evaluate available quantitative data and generate a look-up table. These conclusions are:

- Lead may precipitate in soils if soluble concentrations exceed about 4 mg/l at pH 4 and about 0.2 mg/l at pH 8. In the presence of phosphate and chloride, these solubility limits may be as low as 0.3 mg/l at pH 4 and 0.001 mg/l at pH 8. Therefore, in experiments in which concentrations of lead exceed these values, the calculated K_d values may reflect precipitation reactions rather than adsorption reactions.

- Anionic constituents such as phosphate, chloride, and carbonate are known to influence lead reactions in soils either by precipitation of minerals of limited solubility or by reducing adsorption through complex formation.

- A number of adsorption studies indicate that within the pH range of soils (4 to 11), lead adsorption increases (as does precipitation) with increasing pH.

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[1] Since the completion of our review and analysis of K_d data for the selected contaminants and radionuclides, the studies by Azizian and Nelson (1998) and Yong and MacDonald (1998) were identified and may be of interest to the reader.

- Adsorption of lead increases with increasing organic matter content of soils.
- Increasing equilibrium solution concentrations correlates with decreasing lead adsorption (decrease in K_d).

The factors which influence lead adsorption were identified from the following sources of data. A description and assessment of these data are provided in Appendix F. Lead adsorption behavior on soils and soil constituents (clays, oxides, hydroxides, oxyhydroxides, and organic matter) has been studied extensively. However, calculations by Rickard and Nriagu (1978) show that the solution lead concentrations used in a number of adsorption studies may be high enough to induce precipitation. For instance, their calculations show that lead may precipitate in soils if soluble concentrations exceed about 4 mg/l at pH 4 and about 0.2 mg/l at pH 8. In the presence of phosphate and chloride, these solubility limits may be as low as 0.3 mg/l at pH 4 and 0.001 mg/l at pH 8. Therefore, in experiments in which concentrations of lead exceed these values, the calculated K_d values may reflect precipitation reactions rather than adsorption reactions.

Lead adsorption studies on manganese and iron oxides and oxyhydroxides indicate irreversible adsorption which was attributed to the formation of solid solution phases (*i.e.*, coprecipitation) (Forbes *et al.*, 1976; Grasselly and Hetenyi, 1971; Rickard and Nriagu, 1978). No correlations however have been established between the type and content of oxides in soil and the lead adsorption characteristics of soil.

Anionic constituents such as phosphate, chloride, and carbonate are known to influence lead reactions in soils either by precipitation of minerals of limited solubility or by reducing adsorption through complex formation (Rickard and Nriagu, 1978). Presence of synthetic chelating ligands, such as EDTA, has been shown to reduce lead adsorption on soils (Peters and Shem, 1992). These investigators showed that the presence of strongly chelating EDTA in concentrations as low as 0.01 M reduced K_d for lead by about 3 orders of magnitude. By comparison quantitative data is lacking on the effects of more common inorganic ligands (phosphate, chloride, and carbonate) on lead adsorption on soils.

A number of adsorption studies indicate that within the pH range of soils (4 to 11), lead adsorption increases with increasing pH (Braids *et al.*, 1972; Bittel and Miller, 1974; Griffin and Shimp, 1976; Haji-Djafari *et al.*, 1981; Hildebrand and Blum, 1974; Overstreet and Krishamurthy, 1950; Scrudato and Estes, 1975; Zimdahl and Hassett, 1977). Griffin and Shimp (1976) also noted that clay minerals adsorbing increasing amounts of lead with increasing pH may also be attributed to the formation of lead carbonate precipitates which was observed when the solution pH values exceeded 5 or 6.

Solid organic matter such as humic material in soils is known to adsorb lead (Rickard and Nriagu, 1978; Zimdahl and Hassett, 1977). Additionally, soluble organic matter such as fulvates and amino acids are known to chelate soluble lead and affect its adsorption on soils (Rickard and Nriagu, 1978). Correlative relationships between the organic matter content of soils and its effect on lead adsorption have been established by Gerritse *et al.* (1982) and Soldatini *et al.* (1976).

Lead adsorption by a subsurface soil sample from Hanford, Washington was investigated by Rhoads *et al.* (1992). Adsorption data from these experiments showed that K_d values increased with decreasing lead concentrations in solution (from 0.2 mg/l to 0.0062 mg/l).

5.5.6.2 K_d Look-Up Tables

Among all available data, Gerritse et al (1982) obtained adsorption data at lead concentrations (0.0001 - 0.01 mg/l) which apparently precluded precipitation reactions. Also, these concentrations are within the range of lead concentrations most frequently encountered in ground waters (Chow, 1978). Additionally, data obtained by Rhoads *et al.* (1992) indicated that K_d values vary log-linearly as a function of equilibrium lead concentrations within the range of 0.00001 to 0.2 mg/l. The data generated by Gerritse *et al.* (1982) and Rhoads *et al.* (1992) were used to develop a look-up table (Table 5.9) of K_d as a function of soil pH and equilibrium lead concentrations.

5.5.6.2.1 Limits of K_d Values with Respect to pH

The pH ranges in the look-up table (Table 5.9) were selected from the rate of change that we noted in the K_d data as a function of pH. The K_d values within this pH range increase with increasing pH, and are greatest at the maximum pH limit (pH 11) of soils.

Table 5.9. Estimated range of K_d values for lead as a function of soil pH, and equilibrium lead concentrations.

Equilibrium Lead Concentration (µg/l)	**K_d (ml/g)**	**Soil pH**		
		4.0 - 6.3	**6.4 - 8.7**	**8.8 - 11.0**
0.1 - 0.9	Minimum	940	4,360	11,520
	Maximum	8,650	23,270	44,580
1.0 - 9.9	Minimum	420	1,950	5,160
	Maximum	4,030	10,760	20,620
10 - 99.9	Minimum	190	900	2,380
	Maximum	1,850	4,970	9,530
100 - 200	Minimum	150	710	1,880
	Maximum	860	2,300	4,410

5.5.6.2.2 Limits of K_d Values with Respect to Equilibrium Lead Concentrations

The limits of equilibrium lead concentrations (0.0001 mg/l to about 0.2 mg/l) were selected based on the experimental data generated by Gerritse *et al.* (1982) and Rhoads *et al.* (1992). These investigators showed that within the range of initial lead concentrations used in their experiments the principal lead removal reaction from solution was adsorption and not precipitation. Four concentration ranges were selected to develop the K_d values.

5.6 Plutonium Geochemistry and K_d Values

5.6.1 Overview: Important Aqueous- and Solid-Phase Parameters Controlling Retardation

In the ranges of pH and conditions typically encountered in the environment, plutonium can exist in all 4 oxidation states, namely +3, 4, +5, and +6. Under oxidizing conditions, Pu(IV), Pu(V), and Pu(VI) are common, whereas, under reducing conditions, Pu(III) and Pu(IV) would exist. Dissolved plutonium forms very strong hydroxy-carbonate mixed ligand complexes, therefore, its adsorption and mobility is strongly affected by these complex species. Under conditions of low pH and high concentrations of dissolved organic carbon, it appears that plutonium-organic complexes may be control adsorption and mobility of plutonium in the environment.

If plutonium is present as a distinct solid phase (amorphous or partly crystalline $PuO_2 xH_2O$) or as a solid solution, the upper limits of aqueous plutonium concentrations would be in the 10^{-12} to 10^{-9} M range. Dissolved plutonium in the environment is typically present at $\leq 10^{-15}$ M levels indicating that adsorption may be the principal phenomenon that regulates the mobility of this actinide.

Plutonium can adsorb on geologic material from low to extremely high affinities with K_d values ranging from 11 to 300,000 ml/g. Plutonium in the higher oxidation state adsorbed on iron oxide surfaces may be reduced to the tetravalent state by Fe(II) present in the iron oxides.

Two factors that influence the mobilization of adsorbed plutonium under environmental pH conditions (>7) are the concentrations of dissolved carbonate and hydroxyl ions. Both these ligands form very strong mixed ligand complexes with plutonium, resulting in desorption and increased mobility in the environment.

5.6.2 General Geochemistry

Plutonium is produced by fissioning uranium fuel and is used in the construction of nuclear weapons. Plutonium has entered the environment either through accidental releases or through disposal of wastes generated during fuel processing and the production and detonation of nuclear weapons. Plutonium has 15 isotopes, but only 4 of these isotopes namely, ^{238}Pu [$t_{½}$ (half life) =

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