Soil Migration to Groundwater

Expanding Options for Developing Site-Specific SLs

Presented to:

Remediation Standards Stakeholders

November 12, 2014

Overview

- What's the Point?
- Health-Based Groundwater Quality Standards
- Accounting for Time
- Additional Option

What's the Point?

What's the Point?

New Jersey Department of Environmental Protection
Science Advisory Board

FINAL REPORT

RESPONSE TO CHARGE QUESTIONS ON THE IMPACT TO GROUND WATER SOIL REMEDIATION STANDARDS GUIDANCE

Prepared for:

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and
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October 20, 2011

What’s the Point?

> “The IGWSRS default values, and optional site-specific values generated by the user, appear to be overly conservative for a number of contaminants from a scientific perspective.”

NJDEP Science Advisory Board
October 20, 2011

What's the Point?

> …the entire IGWSRS process should be simplified …

NJDEP Science Advisory Board
October 20, 2011

What's the Point?

> "Evaluation of contaminant concentration without considering limits to the mass can overestimate potential impact to groundwater and thus generate overly conservative IGWSRS."

NJDEP Science Advisory Board
October 20, 2011

What's the Point?

> [In deriving IGWSSLs, NJDEP assumes] infinite mass with no allowance for mass-balance correction where warranted.

NJDEP Science Advisory Board
October 20, 2011

What's the Point?

- Generic screening levels can overestimate exposure
- Limited tools for site-specific MtGW screening level development
- Available options can be inefficient and prone to issues due to sampling complexities

Objective

Methods for developing site-specific MtGW screening levels should not be limited. At a minimum options should be expanded to include approaches developed by USEPA that account for mass conservation.

Health-Based GWQS

Health-Based GWQS

Health-Based GWQS

i. For constituents classified as carcinogens, the criteria shall be derived using the following equation:

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

Where the default values are:

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

Health-Based GWQS

ii. For constituents categorized as non-carcinogens and for constituents classified as carcinogens for which no carcinogenic slope factor is available, the criterion shall be derived using the following equation:

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

Where the default values are:

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

Health-Based GWQS (Cancer)

$$\boxed{GWQS = TCRL \cdot \frac{1}{SF} \cdot \frac{BW \cdot CF \cdot 365 \cdot ED}{IR \cdot EF \cdot ED}}$$

- IR = 2 L/day
- BW = 70 kg
- ED = 70 years
- EF = 365 days/year
- CF = 1000 ug/mg
- TRCL = $1x10^{-6}$
- SF = chemical-specific
- GWQS = chemical-specific

Health-Based GWQS (Noncancer)

$$GWQS = HQ \cdot \frac{RfD}{UF} \cdot \frac{BW \cdot CF \cdot RSC \cdot 365 \cdot ED}{IR \cdot EF \cdot ED}$$

- IR = 2 L/day
- BW = 70 kg
- ED = 70 years
- EF = 365 days/year
- RSC = 20%
- UF = 10 (*for Class C Carcinogens*)
- CF = 1000 ug/mg
- HQ = 1
- RfD = chemical-specific
- GWQS = chemical-specific

Health-Based GWQS

- Drinking water exposure scenario
- Consumption of 2 liter water, 365 days, for 70 years

Accounting for Time

Accounting for Time

INHALATION EXPOSURE PATHWAY
SOIL REMEDIATION STANDARDS

BASIS AND BACKGROUND

JUNE 2008

Accounting for Time

Equations for Calculating Inhalation Soil Remediation Standards for Volatile Organics:

Carcinogens

$$\mathrm{Inh_vSRS_c} = \frac{TR \times AT \times 365\, {}^{days}\!/_{year}}{URF \times 1000\, {}^{\mu g}\!/_{mg} \times EF \times ED \times \left(\frac{1}{VF}\right)}$$

Equation 1

Noncarcinogens

$$Inh_vSRS_n = \frac{THQ \times AT \times 365\, {}^{days}\!/_{year}}{EF \times ED \times \left(\frac{1}{RfC}\right) \times \left(\frac{1}{VF}\right)}$$

Equation 2

VF = Soil-to-air volatilization factor (m^3/kg)

Accounting for Time

Equation for Calculating Volatilization Factor (VF):

$$VF = Q/C_{vol} \times \frac{(3.14 \times D_A \times T)^{1/2}}{2 \times \rho b \times D_A} \times 10^{-4}\ {}^{m^2}\!/_{cm^2} \qquad \textbf{Equation 3}$$

VF = Soil-to-air volatilization factor (m^3/kg)

Q/C_{vol} = Inverse concentration at center of source (g/m^2-s per kg/m^3) (specific to volume)

D_A = Apparent diffusivity (cm^2/s)

T = Exposure interval (seconds)

ρb = Dry soil bulk density (g/cm^3)

Time Averaged Vapor Flux

Averaged Over Exposure Period

Accounting for Time

Table 2 Volatile Exposure Input Parameters			
Parameters		**Value**	**Source**
THQ	target hazard quotient	1	USEPA (1996a)
TR	target cancer risk	1×10^{-6}	USEPA (1996a); N.J.S.A. 58:10B-1 et seq.
AT	averaging time	Carcinogenic: 70 years	USEPA (1996a)
		Noncarc./Residential: 30 years	USEPA (1996a)
		Noncarc./Non-residential: 25 years	USEPA (2001)
EF	exposure frequency	Residential: 350 days/year	USEPA (1996a)
		Non-residential: 225 days/year	USEPA (2001)
ED	exposure duration	Residential: 30 years	USEPA (1996a)
		Non-residential: 25 years	USEPA (2001)
Q/C	inverse concentration at center of source	Residential: 90.4 $(g/m^2\text{-}s)/(kg/m^3)$ Non-residential: 138.7 $(g/m^2\text{-}s)/(kg/m^3)$	This document Section III.B
T	exposure interval	Residential: 9.5×10^8 seconds	USEPA (1996a)
		Non-residential: 7.9×10^8 seconds	USEPA (2001)
ρ_b	dry soil bulk density	1.5 g/cm^3	USEPA (1996a)

Accounting for Time

GUIDANCE DOCUMENT

INHALATION STANDARDS COMPLIANCE

DEVELOPMENT OF ALTERNATIVE REMEDIATION STANDARDS FOR THE INHALATION PATHWAY

June 2008

Accounting for Time

APPENDIX I: Methodology for developing Alternative Remediation Standards for the Inhalation Exposure Pathway Soil Remediation Standards

i. Depth Range of Contamination – The EPA SSG methodology (USEPA, 1996a) used to develop remediation standards assumes an infinite depth of contamination. If the depth of contamination is known, this may be incorporated into development of alternative remediation standards. An assumption of finite depth range will reduce the mass of contaminant in the soil, which will reduce the average volatilization flux. This in turn will result in a greater remediation standard. Use the following procedure:

(1) Determine the actual depth range of contamination by sampling conducted pursuant to the Technical Requirements for Site Remediation, N.J.A.C. 7:26E-4.

Accounting for Time

New Jersey Department of Environmental Protection

Site Remediation Program

Technical Guidance for the Attainment of Remediation Standards and Site-Specific Criteria

September 24, 2012
Version 1.0

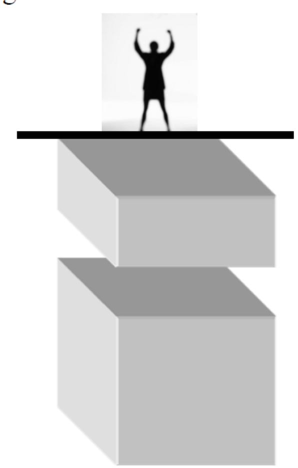
6.7.4.1 Direct contact exposure pathways

To determine whether a remedial action is required based upon the ingestion-dermal and the inhalation exposure pathways, use either single-point compliance or compliance averaging.

Any of the following compliance options can be used to determine if a remedial action is required for both the ingestion dermal and inhalation pathways:

- Single-point compliance
- Compliance averaging by calculating the arithmetic mean for the data set where there are two or fewer distinct sample values or nine or fewer total sample points
- Compliance averaging at the 95 percent upper confidence limit (UCL) of the mean
- Compliance averaging using a spatially weighted average (e.g., Thiessen polygons)

Figure 3: Vertical definition of functional area - ingestion-dermal and inhalation pathways



Accounting for Time

- Generic SRS for inhalation of volatiles accounts for average flux over the exposure period (e.g., 30 years, 25 years) assuming infinite depth of contamination
- Option available for ARS which accounts for finite depth of contamination
- Opportunity to calculate average soil concentrations to account for assumed movement of the residential and nonresidential receptors overtime within the “functional area” (a.k.a. exposure area) in evaluating direct contact

Accounting for Time

Time averaged exposure is utilized in evaluating inhalation and direct contact exposures.

Residential and Nonresidential Soil Remediation Standards

Time averaged exposure should be utilized in evaluating soil migration to groundwater exposure scenario.

Soil Migration to GW Screening Levels

Additional Option

Additional Option

Methods to Develop Site-Specific IGWSSLs

1 Soil-water partition equation

2 Synthetic precipitation leaching procedure (SPLP)

3 SESOIL Model ("clean or buffer zone")

4 SESOIL/AT123D Model

5 Mass-limited soil screening level for MtGW

Additional Option

United States Environmental Protection Agency | Office of Solid Waste and Emergency Response Washington, DC 20460 | Publication 9355.4-23 July 1996

Superfund

EPA

Soil Screening Guidance: User's Guide

Second Edition

Additional Option

> Use of infinite source models to estimate volatilization and migration to groundwater can violate mass balance considerations.

USEPA's (1996) Soil Screening Guidance: Technical Background Document

Additional Option

Option 1: Equilibrium Partitioning

Option 2: Leach Testing (e.g., SPLP)

Option 3: Mass-Limited SSL

Additional Option

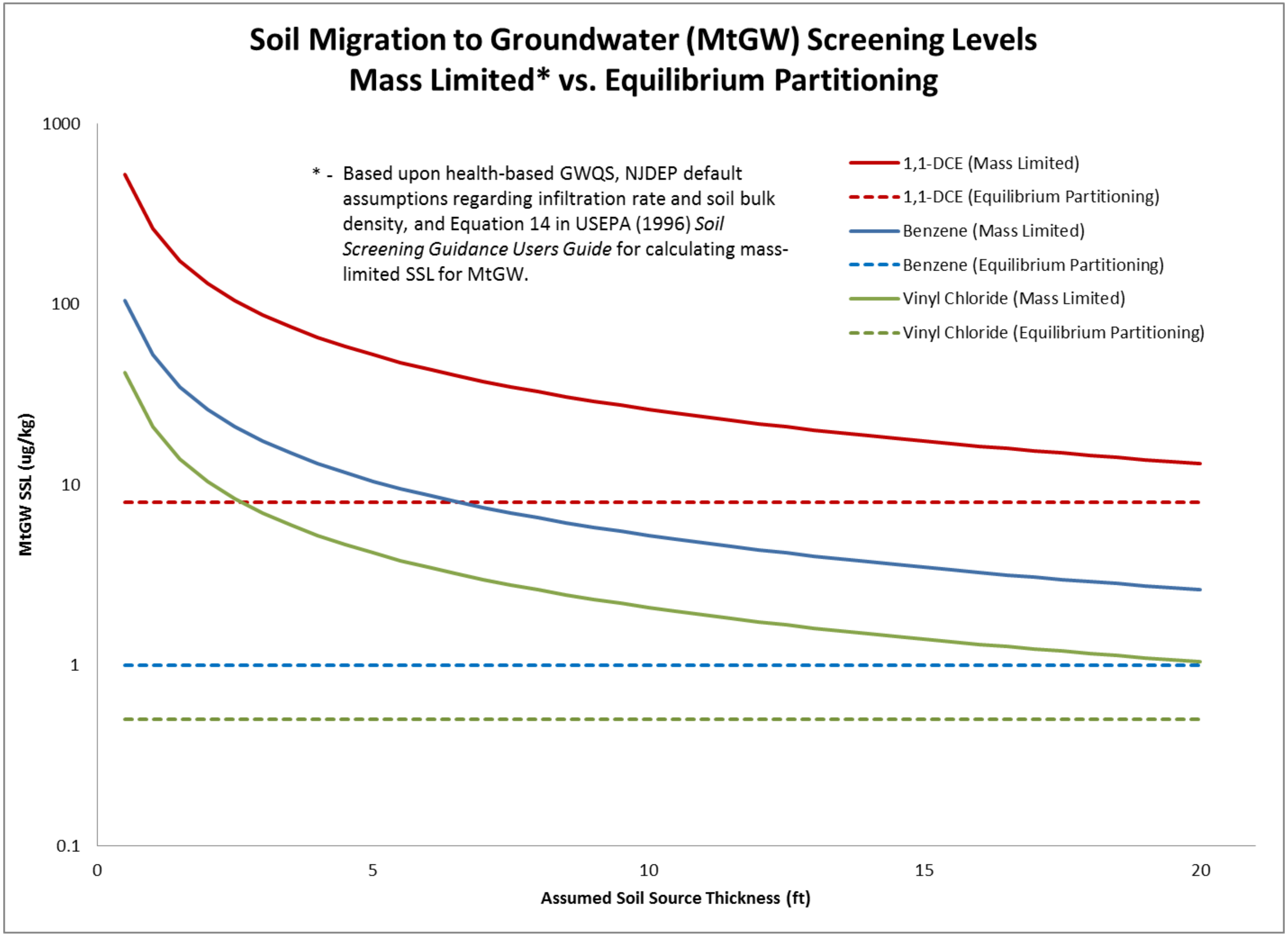
Use of infinite source models to estimates volatilization and migration to groundwater can violate mass balance considerations.

To address this concern, the USEPA Soil Screening Guidance includes models for calculating mass-limited SSLs for each of these pathways.

Additional Option

Equation 14: Mass-Limit Soil Screening Level for Migration to Ground Water	
$$\text{Screening Level in Soil (mg/kg)} = \frac{(C_w \times I \times ED)}{\rho_b \times d_s}$$	
Parameter/Definition (units)	**Default**
C_w/target soil leachate concentration (mg/L)	(nonzero MCLG, MCL, or HBL)[a] × dilution factor
d_s/depth of source (m)	**site-specific**
I/infiltration rate (m/yr)	**0.18**
ED/exposure duration (yr)	70
ρ_b/dry soil bulk density (kg/L)	**1.5**

Additional Option



Additional Option

State of New Jersey
Department of Environmental Protection and Energy
Site Remediation Program
CN 028
Trenton, NJ 08625-0028
Tel. # 609-292-1250
Fax. # 609-633-2360

Scott A. Weiner
Commissioner

Lance R. Miller
Assistant Commissioner

Dear Interested Party:

Re: Proposed New Rule - Cleanup Standards for Contaminated Sites

Enclosed is a copy of a proposed new rule that the New Jersey Department of Environmental Protection and Energy has developed for use during remediation of contaminated surface soils, subsurface soils, building interior surfaces, and ground water. This is a pre-register copy and may not be identical to the regulation contained in the New Jersey Register. The rule is expected to appear in the February 3, 1992 register, and will allow for a 90 day comment period. To ensure the broadest and earliest possible public input into these proposed regulations, we are distributing a copy to individuals and organizations who have expressed an interest or contributed in some way to the development of the proposal.

In signing the proposed cleanup standard rules, Commissioner Weiner has determined the direction the Department will take concerning both the substantive and procedural issues in the identification of cleanup standards for contaminated sites. While these regulations cannot be enforced until the adoption of the final cleanup standards, they may be used as guidance to determine: what concentration of contaminants need to exist at a site in order for the site to be considered contaminated; which areas of environmental concern need additional investigation, and the concentration of a contaminant allowed for a site to be considered "clean".

Therefore, when the person responsible for conducting the cleanup agrees to remediate a contaminated site consistent with the proposed cleanup standards, no further discussion of the identification of cleanup standards will be necessary. It must be remembered, however, that if upon adoption, or at any time thereafter, the concentration of a given contaminant goes down, then remediation to the lower adopted concentration would be required.

NJDEPE
CSCS92

Additional Option

The subsurface soil cleanup standards are intended for the protection of ground water, surface water and structures which may be affected by contaminants in subsurface soil. The subsurface soil cleanup standards are based on the potential mobility of contaminants to ground water and protection of ground water uses. The subsurface soil cleanup standards presented in the regulations were developed to protect ground water quality in areas where ground water is used as a potable drinking water source. Subsurface soil cleanup standards for volatile organic compounds were developed using a model to predict the percentage of total contamination that may leach to ground water over 70 years. Cleanup standards for the semivolatile organic contaminants and the pesticides were developed using a ranking system which considers solubility, biodegradation and toxicity.

....

1. To calculate the subsurface soil standard for volatile organic compounds as controlled by the soil-to-ground water pathway, the applicable ground water standard shall be interpreted as the maximum 70-year averaged ground water concentration of the contaminant.

Additional Option

1. To calculate the subsurface soil standard for volatile organic compounds as controlled by the soil-to-ground water pathway, the applicable ground water standard shall be interpreted as the maximum 70-year averaged ground water concentration of the contaminant. The amount of ground water flowing underneath the waste site over 70 years shall be estimated as follows:

$$L_{70} = V_{gw} \times D_{gw} \times W \times 365 \times 70 \times 28$$

Additional Option

2. The allowed amount of any contaminant leaching into the ground water shall be calculated as follows:

$$Q = L_{70} \times GW_{std},$$

Where: GW_{std} = the ground water standards (ug/L or ppb); and

Q = the allowed amount of leached contaminant (ug).

3. The weight of contaminated soil shall be calculated as follows:

$$G = D_L \times L \times W \times 28 \times 10^3 \times 1.3$$

Where: D_L = the depth of contamination (feet);

L = the length of the site parallel to ground water flow (feet);

W = width of the site perpendicular to ground water flow (feet);

28 = 28 L/cubic foot;

$10^3 = 10^3$ cc/L; and

1.3 = the dry soil bulk density (g/cc).

Additional Option

- Simple and conservative approach
- Technical basis and protectiveness of this approach can be supported and documented
- Accounts for limited mass available for leaching
- Concentration in groundwater would not be greater than the GWQS over the assumed exposure period (i.e., 70 years)
- Consistent with inhalation-based SRS
- Does not suffer the same limitations as other available options
- Consistent with NJDEP's proposed approach circa 1992

Discussion