BEST PRACTICES FOR DEVELOPMENT AND USE OF DATA SCREENING VALUES AND CLEAN-UP OBJECTIVES

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- Over 13 years' experience in the environmental industry
- Registered civil/environmental engineer
- Manages the chemistry group at Trihydro
- Her primary responsibilities include:

  - Providing technical support for projects in data defensibility

  - Data quality

  - Managing complex site investigations and remediation projects

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Why are Screening Values and Clean-Up Levels Important?

Laboratory

- Client Expectations
- Choosing Methodology
- Repeat Work
- Forecasting Future Regulatory Requirements

Consultant/ Responsible Party

- Protection of Human Health and the Environment
- Property Reuse
- Meeting Project Objectives
- Risk Mitigation
- Spending Resources to Address Highest Risks

Regulatory Agencies

- Protection of Human Health and the Environment
- Public Scrutiny
- Public Protection
- Property Reuse
- Risk Mitigation
- Spending Resources to Address Highest Risks

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Common Questions

- What are the differences between a screening level and clean-up objective?
- How are screening levels developed?
- Who develops screening levels?
- Why are there so many screening value sources?
- Which of the multiple sources should I use?
- What if the laboratory cannot meet the screening levels?
- What if my existing data doesn't meet the screening levels?
- What happens if I exceed a screening level?

What is the Difference Between a Screening Level and Clean-up Objective?

SCREENING LEVEL

- Used in the first steps of an evaluation to determine pathways and develop a Chemical of Potential Concern and Chemical of Concern List.
- Very important part of Site Investigations, Sampling Plans, and Quality Assurance Plans.
- Developed with consideration for uncertainty.
- Designed to be overly protective of the media and receptors.

CLEAN-UP OBJECTIVE

- Used in the corrective action phase of an investigation.
- Developed as a Site Specific approved value that the site must meet to obtain closure or no further action.
- Site specific risk values are assumed or calculated.
- Typically are higher than screening levels.
- Used as final steps for clean-up.

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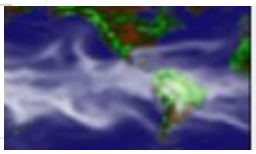
How are Screening Levels Developed?

Research to determine chemical toxicity

Each chemical is assigned a carcinogenic risk

Risk values go through nine steps of review and research

Integrated Risk Information System (IRIS)



RAIS
The Risk Assessment Information System

Key: I = IRIS; P = PPRTV; A = ATSDR; C = Cal EPA; X = APPENDIX PPRTV SCREEN (See FAQ #27); H = HEAST; J = New Jersey; O = EPA Office of Water; F = See FAQ;
RBA applied (See User Guide for Arsenic notice) ; c = cancer; * = where: n SL < 100X c SL; ** = where n SL < 10X c SL; n = noncancer; m = Concentration may e

Toxicity and Chemical-specific Information													Contaminant		
SFO $(mg/kg\text{-}day)^{-1}$	key	IUR $(ug/m^3)^{-1}$	key	RfD_o (mg/kg-day)	key	RfC_i (mg/m^3)	key	voc	muta-gen	GIABS	ABS	C_{sat} (mg/kg)	Analyte	CAS No.	F
1.8E-02	C	5.1E-06	C	1.5E-01	I					1	0.1		ALAR	1596-84-5	
8.7E-03	I			4.0E-03	I					1	0.1		Acephate	30560-19-1	
		2.2E-06	I			9.0E-03	I	V		1		1.1E+05	Acetaldehyde	75-07-0	
				2.0E-02	I					1	0.1		Acetochlor	34256-82-1	
				9.0E-01	I	3.1E+01	A	V		1		1.1E+05	Acetone	67-64-1	
						2.0E-03	X	V		1		1.1E+05	Acetone Cyanohydrin	75-86-5	
						6.0E-02	I	V		1		1.3E+05	Acetonitrile	75-05-8	
				1.0E-01	I			V		1		2.5E+03	Acetophenone	98-86-2	
3.8E+00	C	1.3E-03	C							1	0.1		Acetylaminofluorene, 2-	53-96-3	
				5.0E-04	I	2.0E-05	I	V		1		2.3E+04	Acrolein	107-02-8	
5.0E-01	I	1.0E-04	I	2.0E-03	I	6.0E-03	I		M	1	0.1		Acrylamide	79-06-1	
				5.0E-01	I	1.0E-03	I	V		1		1.1E+05	Acrylic Acid	79-10-7	
5.4E-01	I	6.8E-05	I	4.0E-02	A	2.0E-03	I	V		1		1.1E+04	Acrylonitrile	107-13-1	
						6.0E-03	P			1	0.1		Adiponitrile	111-69-3	
5.6E-02	C			1.0E-02	I					1	0.1		Alachlor	15972-60-8	
				1.0E-03	I					1	0.1		Aldicarb	116-06-3	
				1.0E-03	I					1	0.1		Aldicarb Sulfone	1646-88-4	
										1	0.1		Aldicarb sulfoxide	1646-87-3	
1.7E+01	I	4.9E-03	I	3.0E-05	I			V		1			Aldrin	309-00-2	
				2.5E-01	I					1	0.1		Ally	74223-64-6	
				5.0E-03	I	1.0E-04	X	V		1		1.1E+05	Allyl Alcohol	107-18-6	
2.1E-02	C	6.0E-06	C			1.0E-03	I	V		1		1.4E+03	Allyl Chloride	107-05-1	
				1.0E+00	P	5.0E-03	P			1			Aluminum	7429-90-5	
				4.0E-04	I					1			Aluminum Phosphide	20859-73-8	
				3.0E-04	I					1	0.1		Amdro	67485-29-4	
				9.0E-03	I					1	0.1		Ametryn	834-12-8	
2.1E+01	C	6.0E-03	C							1	0.1		Aminobiphenyl, 4-	92-67-1	

HOW SCREENING LEVELS ARE DEVELOPED

How Screening Levels are Calculated

Human Health

- **Carcinogenic**
  - Ingestion

$$SL_{res\text{-}soil\text{-}ca\text{-}ing}\left(mg/kg\right)=\frac{TR\times AT_r\left(\frac{365\ days}{year}\times LT\ (70\ years)\right)}{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times IFS_{adj}\left(\frac{36750\ mg}{Kg}\right)\times\left(\frac{10^{-6}Kg}{mg}\right)}$$

where:

$$IFS_{adj}\left(\frac{36750\ mg}{Kg}\right)=\frac{EF_{ressc}\left(\frac{350\ days}{year}\right)\times ED_c\ (6\ years)\times IRS_c\left(\frac{200\ mg}{day}\right)}{BW_c\ (15\ Kg)}+\frac{EF_{ressa}\left(\frac{350\ days}{year}\right)\times ED_r\text{-}ED_c\ (20\ years)\times IRS_a\left(\frac{100\ mg}{day}\right)}{BW_a\ (80\ Kg)}$$

Note the duration

Note that both a child and adult are considered

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How Screening Levels are Calculated

Human Health

- **Noncarcinogenic-child**
  - Ingestion

$$SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}\left(mg/kg\right)=\frac{THQ\times AT_r\left(\frac{365\ days}{year}\times ED_c\left(6\ years\right)\right)\times BW_c\left(15\ Kg\right)}{EF_r\left(\frac{350\ days}{year}\right)\times ED_c\left(6\ year\right)\times\frac{1}{RfD_o\left(\frac{mg}{Kg\text{-}day}\right)}\times IRS_c\left(\frac{200\ mg}{day}\right)\times\frac{10^{-6}Kg}{1mg}}$$

  - Total

$$SL_{res\text{-}soil\text{-}nc\text{-}tot\text{-}c}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}}+\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}c}}+\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}c}}}$$

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Migration to Groundwater

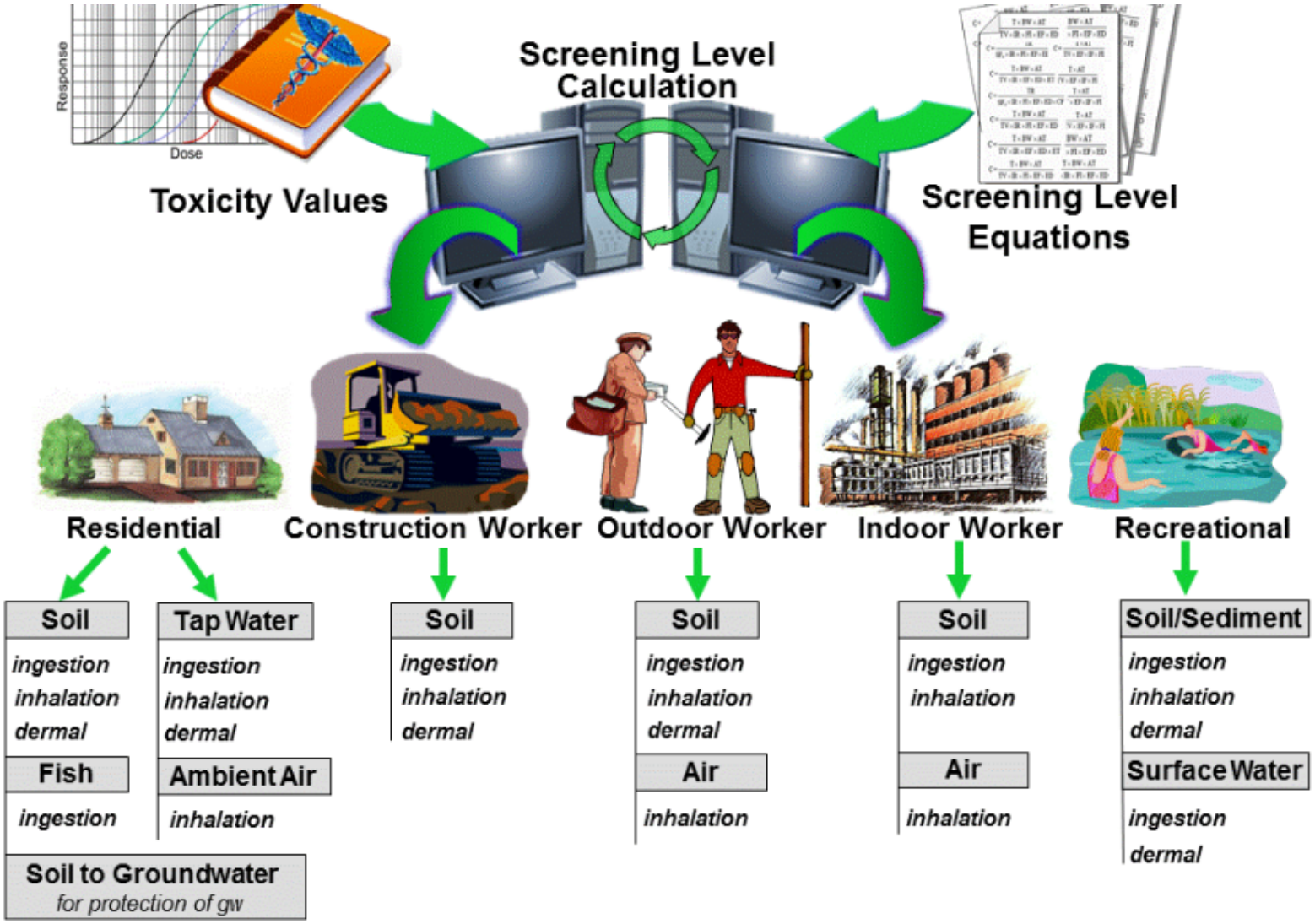
$$SSL(mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right)}\right]$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(\frac{0.3\ L_{water}}{L_{soil}}\right);$$

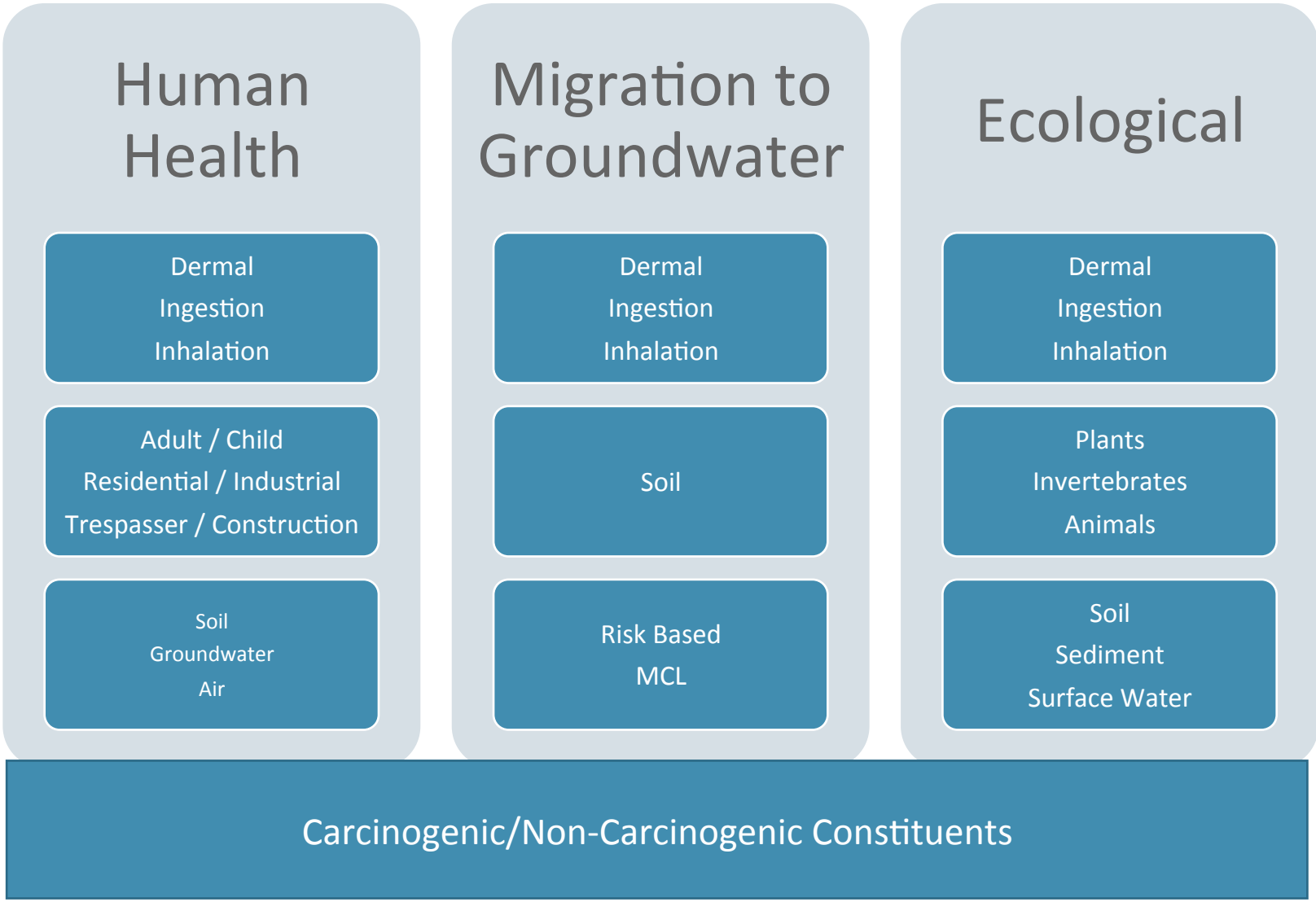
$$n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ kg}{L}\right)}{\rho_s\left(\frac{2.65\ kg}{L}\right)}\right) \text{ and}$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\ (0.002\ \text{unitless})$$



http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/images/chem_sl.gif

HOW SCREENING LEVELS ARE CALCULATED



DIFFERENT KINDS OF SCREENING LEVELS

Risk Level

- Carcinogens
- Combined risk < $1x10^{-6}$
- 1 in a million increased risk for developing cancer
- Lifetime average daily dose (weighted child/ adult)

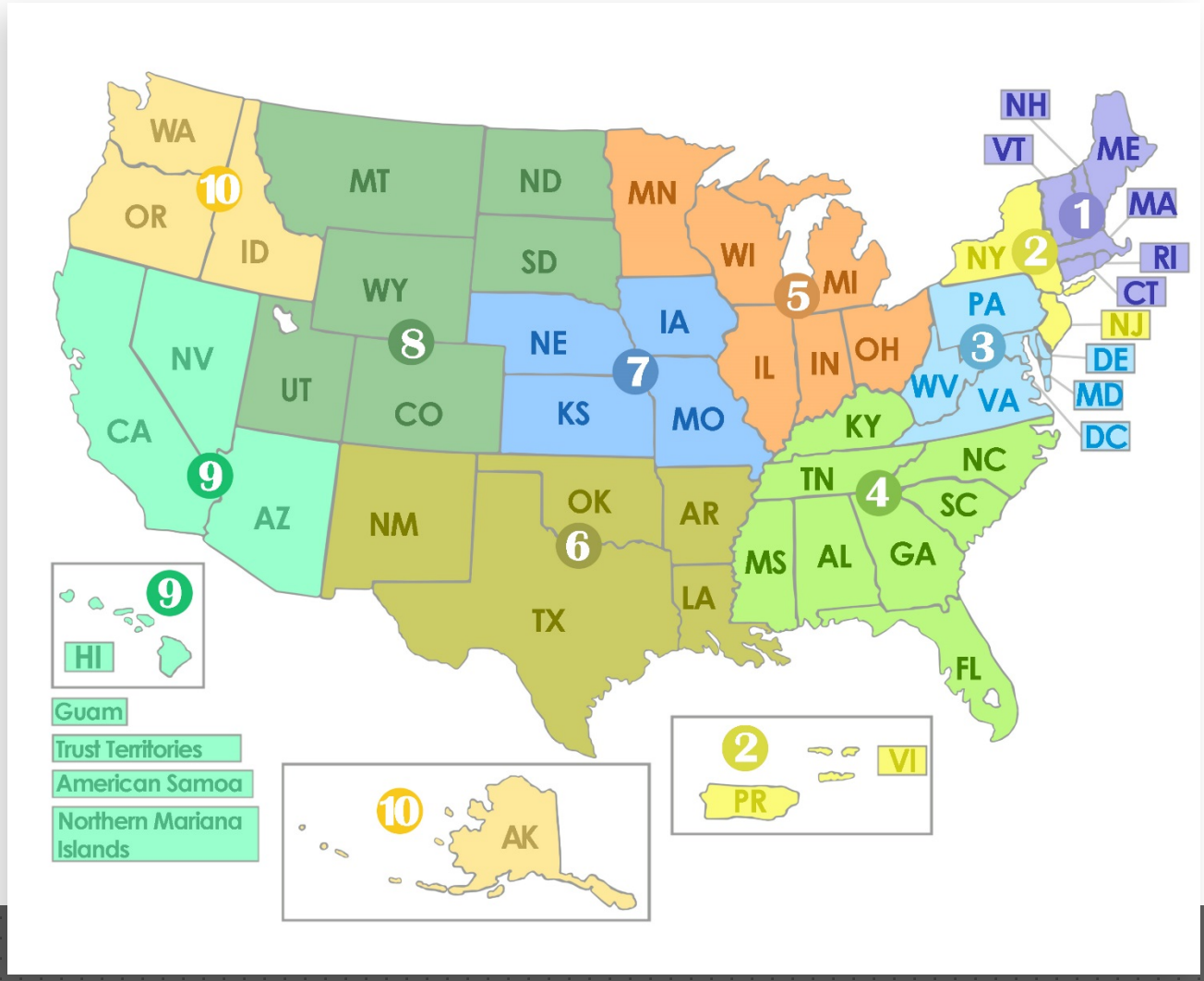
Hazard Quotient (HQ)

- Non-Carcinogens
- Combined Risk HQ < 1
- Average daily dose over time of exposure (i.e. child)

Some chemicals can have both cancer and non-cancer effects.

Who Develops Screening Levels?

- States
- Regions
- EPA
- Site Specific
- Regulatory Agencies



Regional Screening Levels

www.cleanuplevels.com

- Considered the Gold Standard
- Harmonized from EPA regions 3,6, and 9 in 2008
- Receptor Specific (residential/industrial)
- Soil and Groundwater do not consider Vapor Intrusion
- Not depth specific (surface/subsurface soils)
- Based on a “typical” Site Conceptual Model
- Provide information for Site Specific Calculations
- Are updated approximately every 6 months
- June 2015 is the most recent

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Regional Screening Levels – Summary Table

Regional Screening Level (RSL) Summary Table (TR=1E-6, HQ=0.1) June 2015 (revised)

See FAQ #27); H = HEAST; J = New Jersey; O = EPA Office of Water; F = See FAQ; E = Environmental Criteria and Assessment Office; S = see user guide Section 5; L = see user guide on lead; M = mutagen; V = volatile; R = SL < 100X c SL; ** = where n SL < 10X c SL; n = noncancer; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide); SSL values are based on DAF=1

Contaminant		Screening Levels											Protection of Ground Water SSLs		
Analyte	CAS No.	Resident Soil (mg/kg)	key	Industrial Soil (mg/kg)	key	Resident Air (ug/m^3)	key	Industrial Air (ug/m^3)	key	Tapwater (ug/L)	key	MCL (ug/L)	Risk-based SSL (mg/kg)	key	MCL-based SSL (mg/kg)
ALAR	1596-84-5	3.0E+01	c*	1.3E+02	c*	5.5E-01	c	2.4E+00	c	4.3E+00	c*		9.5E-04	c*	
Acephate	30560-19-1	2.5E+01	n	2.6E+02	c**					8.0E+00	n		1.8E-03	n	
Acetaldehyde	75-07-0	8.2E+00	n	3.4E+01	n	9.4E-01	n	3.9E+00	n	1.9E+00	n		3.8E-04	n	
Acetochlor	34256-82-1	1.3E+02	n	1.6E+03	n					3.5E+01	n		2.8E-02	n	
Acetone	67-64-1	6.1E+03	n	6.7E+04	n	3.2E+03	n	1.4E+04	n	1.4E+03	n		2.9E-01	n	
Acetone Cyanohydrin	75-86-5	5.0E+00	n	2.1E+01	n	2.1E-01	n	8.8E-01	n	4.2E-01	n		8.4E-05	n	
Acetonitrile	75-05-8	8.1E+01	n	3.4E+02	n	6.3E+00	n	2.6E+01	n	1.3E+01	n		2.6E-03	n	
Acetophenone	98-86-2	7.8E+02	n	1.2E+04	ns					1.9E+02	n		5.8E-02	n	
Acetylaminofluorene, 2-	53-96-3	1.4E-01	c	6.0E-01	c	2.2E-03	c	9.4E-03	c	1.6E-02	c		7.2E-05	c	
Acrolein	107-02-8	1.4E-02	n	6.0E-02	n	2.1E-03	n	8.8E-03	n	4.2E-03	n		8.4E-07	n	
Acrylamide	79-06-1	2.4E-01	c*	4.6E+00	c*	1.0E-02	c*	1.2E-01	c*	5.0E-02	c*		1.1E-05	c*	
Acrylic Acid	79-10-7	9.9E+00	n	4.2E+01	n	1.0E-01	n	4.4E-01	n	2.1E-01	n		4.2E-05	n	
Acrylonitrile	107-13-1	2.5E-01	c**	1.1E+00	c**	4.1E-02	c**	1.8E-01	c**	5.2E-02	c**		1.1E-05	c**	
Adiponitrile	111-69-3	8.5E+05	nm	3.6E+06	nm	6.3E-01	n	2.6E+00	n						
Alachlor	15972-60-8	9.7E+00	c**	4.1E+01	c*					1.0E+00	c*	2.0E+00	8.6E-04	c*	1.6E-03
Aldicarb	116-06-3	6.3E+00	n	8.2E+01	n					2.0E+00	n	3.0E+00	4.9E-04	n	7.5E-04
Aldicarb Sulfone	1646-88-4	6.3E+00	n	8.2E+01	n					2.0E+00	n	2.0E+00	4.4E-04	n	4.4E-04
Aldicarb sulfoxide	1646-87-3											4.0E+00			8.8E-04
Aldrin	309-00-2	3.9E-02	c**	1.8E-01	c*	5.7E-04	c	2.5E-03	c	9.2E-04	c*		1.5E-04	c*	
Ally	74223-64-6	1.6E+03	n	2.1E+04	n					4.9E+02	n		1.9E-01	n	
Allyl Alcohol	107-18-6														

Regional Screening Levels

AST; J = New Jersey; O = EPA Office of Water; F = See FAQ; E = Environmental Criteria and Assessment Office; S = see user guide Section 5; L = see user guide on lead; M = mutagen; V = volatile; R = RBA applied where n SL < 10X c SL; n = noncancer; m = Concentration may exceed ceiling limit (See User Guide); s = Concentration may exceed Csat (See User Guide); SSL values are based on DAF=1

Contaminant		Carcinogenic Target Risk (TR) = 1E-06				Noncancer Child Hazard Index (HI) = 1			
Analyte	CAS No.	Ingestion SL TR=1.0E-6 (mg/kg)	Dermal SL TR=1.0E-6 (mg/kg)	Inhalation SL TR=1.0E-6 (mg/kg)	Carcinogenic SL TR=1.0E-6 (mg/kg)	Ingestion SL Child HQ=1 (mg/kg)	Dermal SL Child HQ=1 (mg/kg)	Inhalation SL Child HQ=1 (mg/kg)	Noncarcinogenic SL Child HI=1 (mg/kg)
ALAR	1596-84-5	3.9E+01	1.3E+02	7.5E+05	3.0E+01	1.2E+04	4.4E+04		9.2E+03
Acephate	30560-19-1	8.0E+01	2.6E+02		6.1E+01	3.1E+02	1.2E+03		2.5E+02
Acetaldehyde	75-07-0			1.1E+01	1.1E+01			8.2E+01	8.2E+01
Acetochlor	34256-82-1					1.6E+03	5.8E+03		1.2E+03
Acetone	67-64-1					7.0E+04		4.4E+05	6.1E+04
Acetone Cyanohydrin	75-86-5							5.0E+01	5.0E+01
Acetonitrile	75-05-8							8.1E+02	8.1E+02
Acetophenone	98-86-2					7.8E+03			7.8E+03
Acetylaminofluorene, 2-	53-96-3	1.8E-01	6.0E-01	2.9E+03	1.4E-01				
Acrolein	107-02-8					3.9E+01		1.4E-01	1.4E-01

Soil and Groundwater Screening Levels are a Combination of Ingestion, Dermal and Inhalation Pathways

- Total

$$SL_{res\text{-}soil\text{-}nc\text{-}tot\text{-}c}\ (mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}ing\text{-}c}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}der\text{-}c}} + \frac{1}{SL_{res\text{-}soil\text{-}nc\text{-}inh\text{-}c}}}$$

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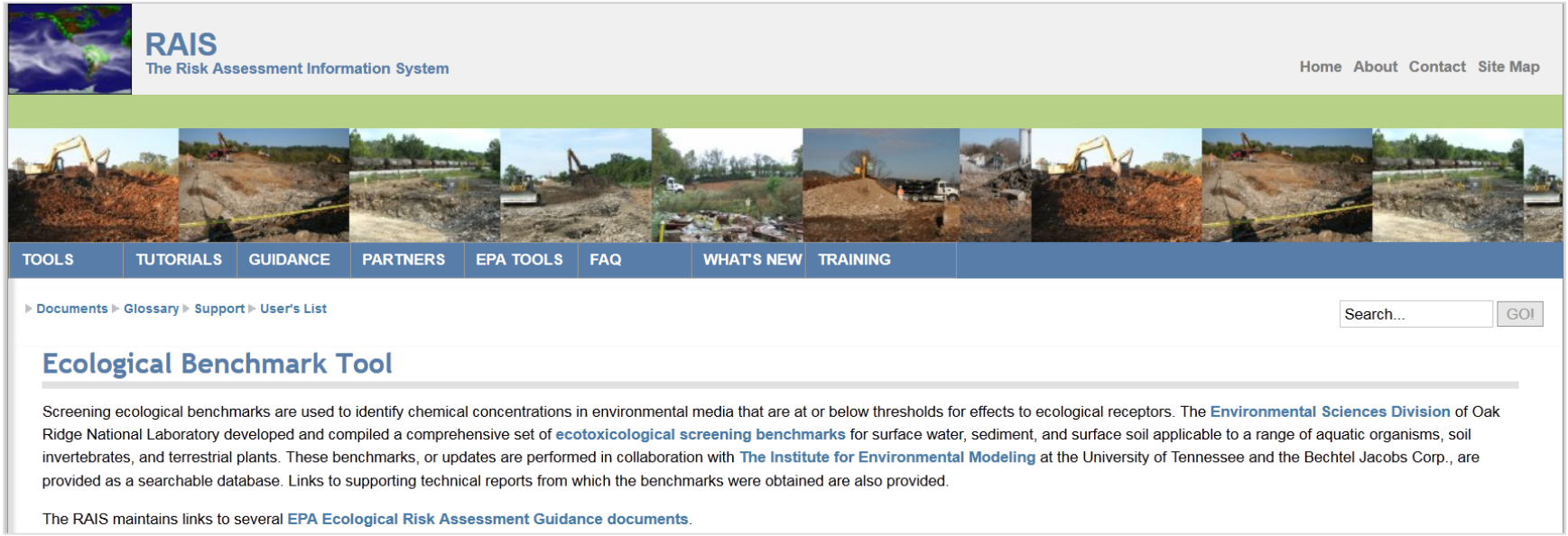
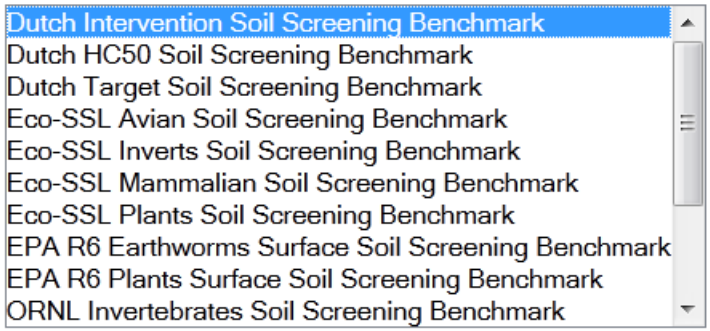
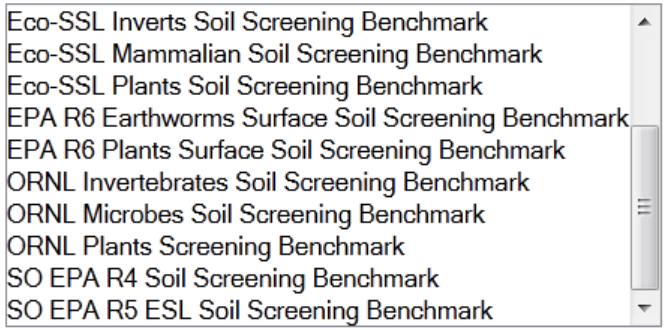
Ecological Screening



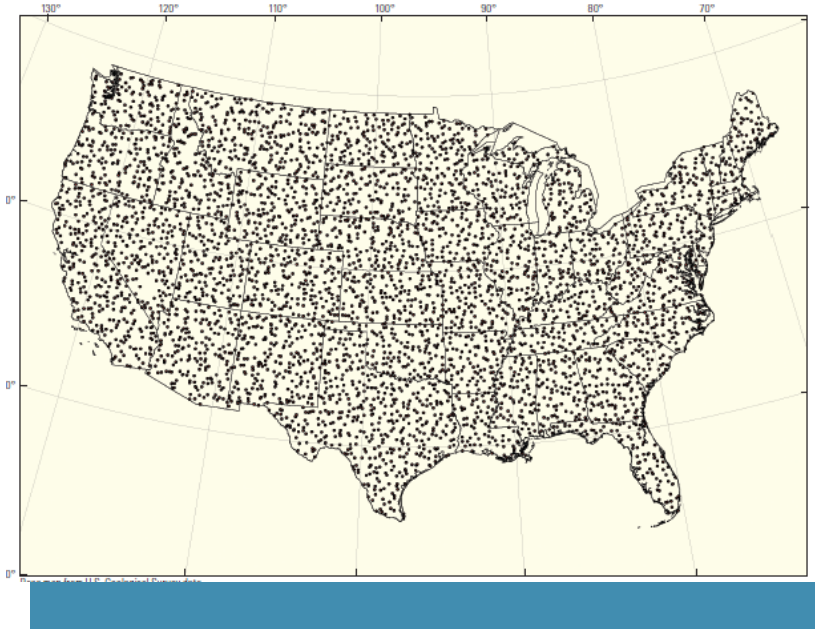
Soil Choices



Soil Choices



What About Background?



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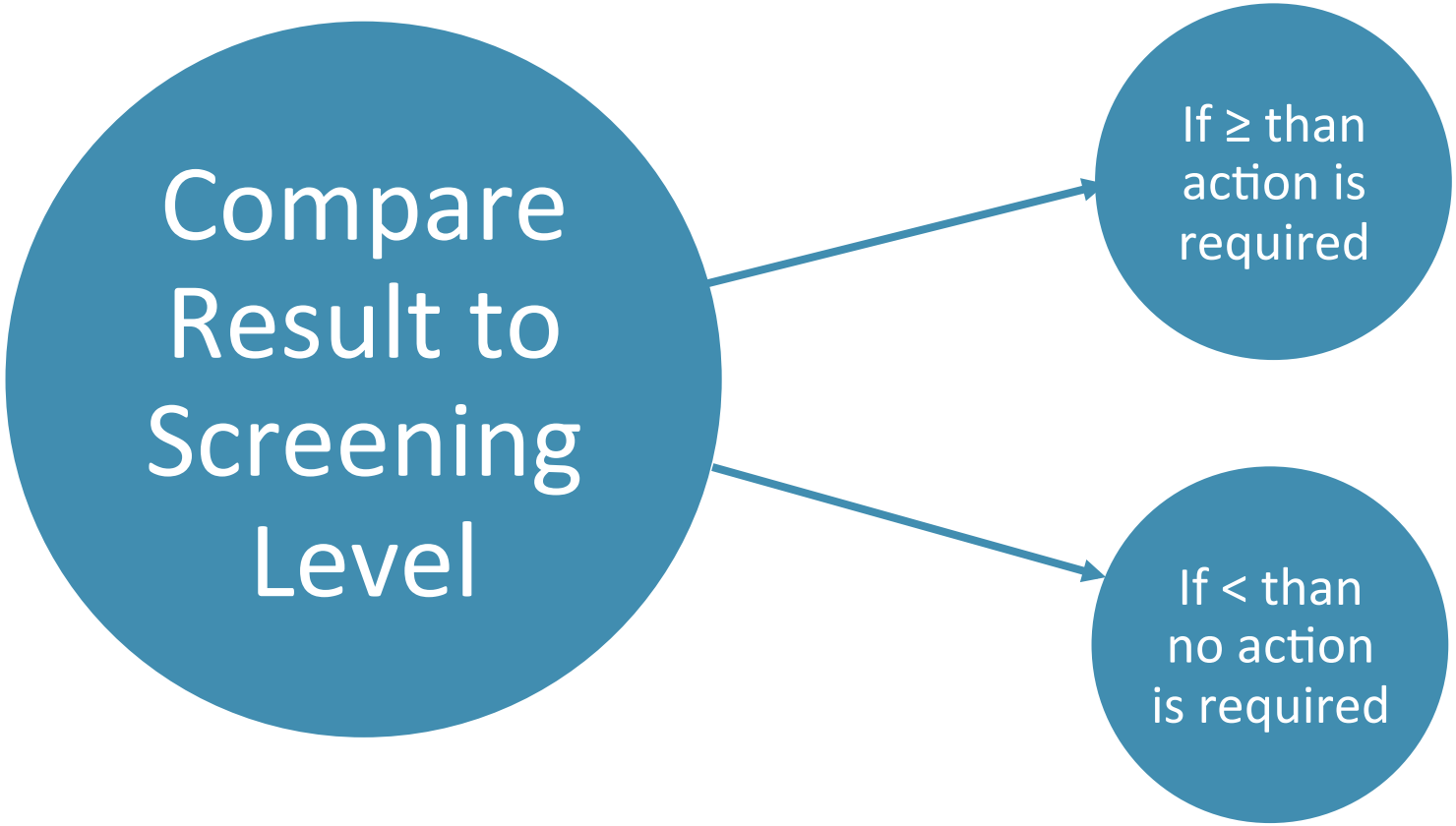
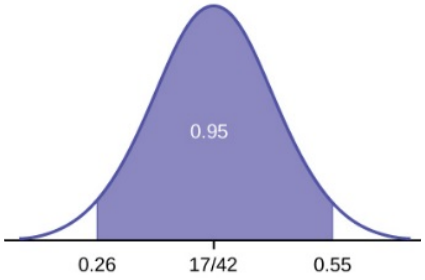
CHOOSING WHICH SCREENING LEVELS TO USE



HOW SCREENING LEVELS ARE COMPARED TO DATA

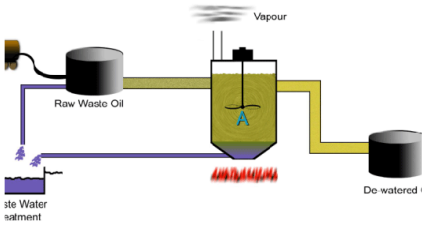


Statistical Design

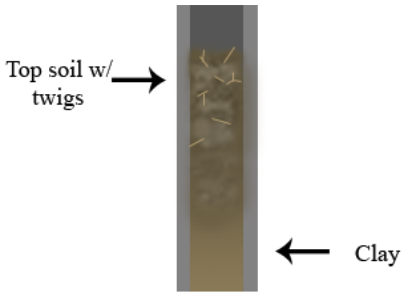
Risk Assessment

Calculate Clean-Up Objectives

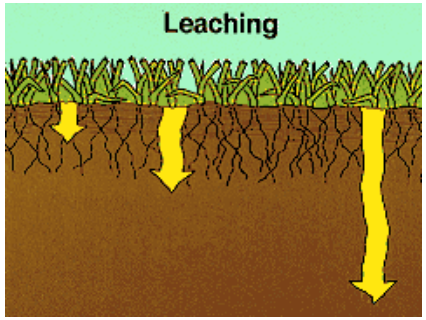
Re-analyze using Different Methods



Remediate and Resample



Establish Background



Eliminate Pathways

OPTIONS IF YOU CAN'T MEET THE SCREENING LEVEL

Lessons Learned

- Understand where the screening levels are coming from and what is needed to have a successful project
- Obtain established screening levels prior to starting work
- Compare screening levels to the laboratory's reporting limits and method detection limits prior to analyses
- Choose the best method for their matrix and data requirements
- Choose if reporting limits or method detection limits (MDL) are best for the site (are there concerns with using an MDL?)
- Explain/understand how dilutions, matrix interference, blank contamination, and other field and laboratory issues may effect their results (as appropriate)
- Explain/understand laboratory, regulatory agents, clients, and consultants about the variability in laboratory data results (as appropriate)

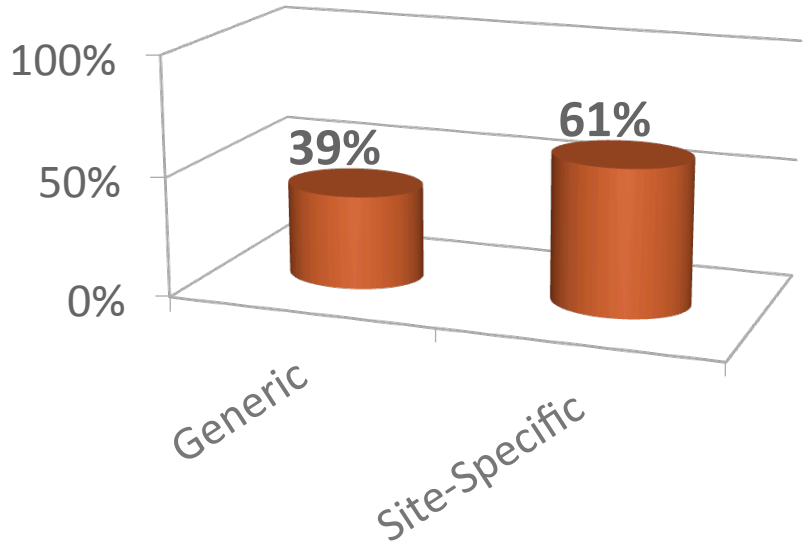
Example Comparison Table

Analyte	CAS Number	Residential Screening Level (mg/kg)	Industrial Screening Level (mg/kg)	Migration to GW Screening Level (mg/kg)	Achievable Laboratory Limits		Residential Soil Limit Determination	Industrial Soil Limit Determination	Soil Limit Determination (Migration to GW)
					RL (mg/kg)	MDL (mg/kg)			
1,4-Dioxane	123-91-1	4.9	17	0.00014	0.5	0.0561	RL below RSL	RL below RSL	RSL below MDL
2,2-Dichloropropane	594-20-7	NL	NL	NL	0.005	0.00044	--	--	--
2-Chlorotoluene	95-49-8	1600	20000	0.17	0.005	0.00051	RL below RSL	RL below RSL	RL below RSL
4-Chlorotoluene	106-43-4	1600	20000	0.18	0.005	0.00078	RL below RSL	RL below RSL	RL below RSL
4-Methyl-2-pentanone (MIBK)	108-10-1	5300	53000	0.23	0.02	0.00436	RL below RSL	RL below RSL	RL below RSL
Acetone	67-64-1	61000	630000	2.4	0.02	0.00538	RL below RSL	RL below RSL	RL below RSL
Benzene	71-43-2	1.1	5.4	0.0002	0.005	0.00047	RL below RSL	RL below RSL	RSL below MDL
Bromobenzene	108-86-1	300	1800	0.036	0.005	0.00049	RL below RSL	RL below RSL	RL below RSL
Bromochloromethane	74-97-5	160	680	0.021	0.005	0.0003	RL below RSL	RL below RSL	RL below RSL
Bromodichloromethane	75-27-4	0.27	1.4	0.000032	0.005	0.00022	RL below RSL	RL below RSL	RSL below MDL
Bromoform	75-25-2	62	220	0.0021	0.005	0.00023	RL below RSL	RL below RSL	MDL below RSL
Bromomethane	74-83-9	7.3	32	0.0018	0.01	0.0005	RL below RSL	RL below RSL	MDL below RSL
Carbon Disulfide	75-15-0	820	3700	0.21	0.005	0.00042	RL below RSL	RL below RSL	RL below RSL
Carbon Tetrachloride	56-23-5	0.61	3.0	0.00015	0.005	0.00063	RL below RSL	RL below RSL	RSL below MDL
Chlorobenzene	108-90-7	290	1400	0.049	0.005	0.00054	RL below RSL	RL below RSL	RL below RSL
Chloroethane	75-00-3	15000	61000	5.9	0.01	0.00089	RL below RSL	RL below RSL	RL below RSL
Chloroform	67-66-3	0.29	1.5	0.000053	0.01	0.00029	RL below RSL	RL below RSL	RSL below MDL
Chloromethane	74-87-3	120	500	0.049	0.01	0.00077	RL below RSL	RL below RSL	RL below RSL
cis-1,2-Dichloroethene	156-59-2	160	2000	0.0082	0.0025	0.00056	RL below RSL	RL below RSL	RL below RSL

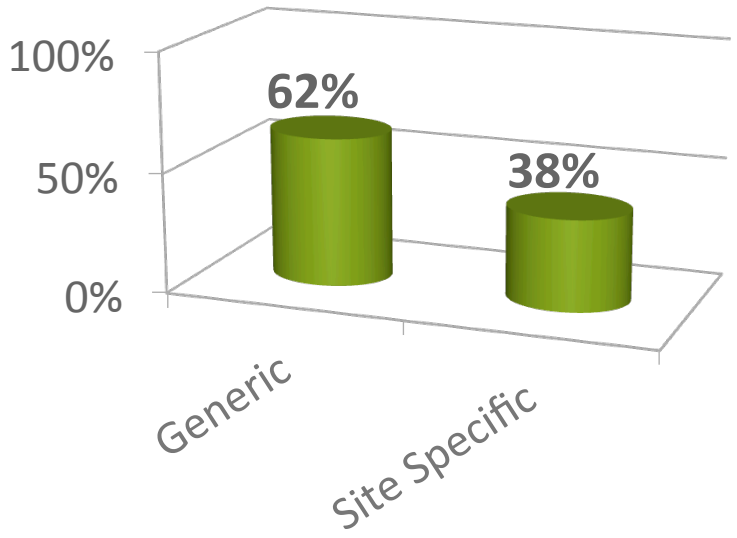
Trihydro

Risk-based Standards Lead to Closure

Closed Sites



Open Sites



RESULT: PREMISE VERIFIED

Invest in site-specific data to calculate site-specific standards rather than adopting generic screening standards as cleanup objectives.

Summary

- The laboratory cannot always meet screening levels since they are established using toxicological results not actual instrumentation.
- Regulatory agencies develop screening levels to be extremely conservative.
- Failure of a screening level is cut and dry at the exact number and may trigger additional investigation and remediation if above the limit.
- Be realistic if a screening level cannot be met.
- Look at multiple screening levels and options to determine what is best for the site and where to get the most benefit for the time and money spent.

References and Acknowledgements

Dr. Charlie DeWolf, PHD, Trihydro Corporation

Shannon Thompson, P.E., Trihydro Corporation

Allison Riffel, P.E., Trihydro Corporation

Integrated Risk Information System (IRIS), EPA, http://www.epa.gov/iris/

Risk Assessment Information System, US Department of Energy (DOE), http://rais.ornl.gov/