Green Chemistry
Education Webinar Series

Chemical Hazard Assessment: Informing Decisions for Safer Chemicals, Materials, and Products

November 10th, 2015

GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry

What is the GC3?

- Cross-sectoral, B2B network of over 70 companies and other organizations
- Formed in 2005
- Collaboratively advances green chemistry across sectors and supply chains

Today's Speakers

Lauren Heine

Interim Executive Director
Northwest Green Chemistry

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Managing Director and Chief Toxicologist
ToxServices, LLC

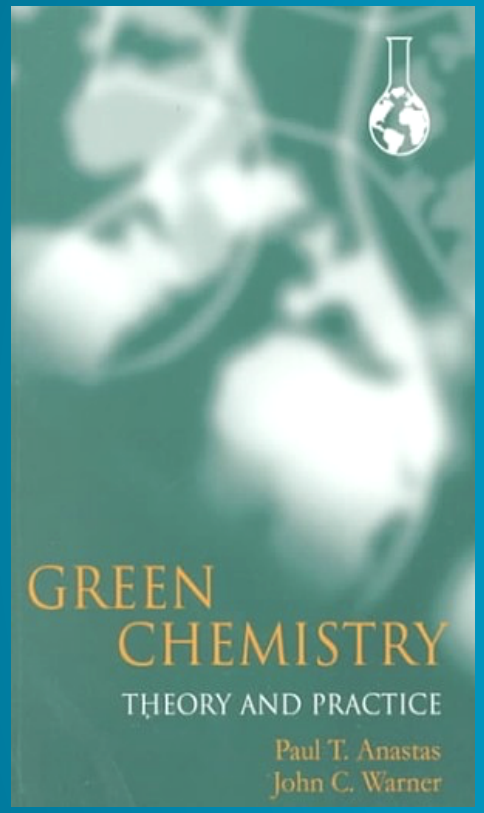
Ground Rules

- Due to the number of participants in the webinar, all lines will be muted
- If you have a question or comment, please type in the Q&A box located in the control panel at the right of your screen
- Questions will be answered at the end of the presentation

Webinar Agenda

- Provide an overview of Hazard and GHS
- How are CHAs performed?
- How do CHAs support informed decision making?
- How can I incorporate CHA into my company's decision making process?
- Examples and CHA-related resources

Key Concept to Selecting Safer Chemicals:
Reduce Risk by Reducing Inherent Hazard



Risk = f(Hazard, Exposure)

Green chemistry is defined as "the design of products and processes that reduce or eliminate the use or generation of hazardous substances."

*Anastas, P. T. and J.C. Warner. 1998. Green Chemistry: Theory and Practice, Oxford University Press

Key Concept to Selecting Safer Chemicals: Reduce Risk by Reducing Inherent Hazard

Green Chemistry Principles	
Number	**Hazard-based principles are BOLDED**
1	Prevent waste
2	Atom economy
3	**Less hazardous chemical syntheses***
4	**Design safer chemicals and products***
5	**Use safer solvents and auxiliaries***
6	Design for energy efficiency
7	Use of renewable raw materials/feedstocks
8	Reduce derivatives
9	Use catalytic reagents not stoichiometric reagents
10	**Design chemicals and products to degrade after use***
11	Analyze in real-time for pollution prevention
12	**Minimize the potential for accidents through safer process chemical selection***

What is Hazard?

Hazard = the *inherent property* of a substance having the potential to cause adverse effects when an organism, system, or (sub) population is exposed to that substance.

Risk = the *probability* of an adverse effect in an organism, system, or (sub) population under specified circumstances by exposure to a substance.

One pound lemon: Moderate hazard (from acetic acid and d-limonene), Low risk (in unpeeled form)

Risk = f(Hazard x Exposure)

What are Categories of Hazards?

- CMR
  - Carcinogen
  - Mutagen
  - Reproductive or Developmental toxins
- PBT
  - Persistent
  - Bioaccumulative
  - Toxic
- Endocrine disruption/activity
- Other human health endpoints
  - Acute toxicity
  - Systemic toxicity
  - Skin sensitization and irritation
  - Respiratory sensitization
- Aquatic toxicity
- Terrestrial toxicity
- Physical hazards
  - Reactivity
  - Flammability

What Are Chemical Hazard Assessments?

A Chemical Hazard Assessment is a critical component of a Chemical Alternatives Assessment (CAA)

- A CHA can be performed as part or independently of a full CAA

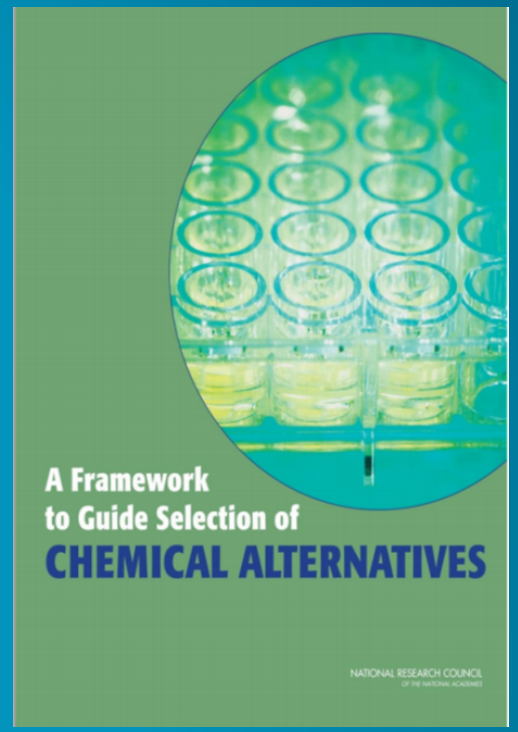
The Six Steps of a CAA are shown below:

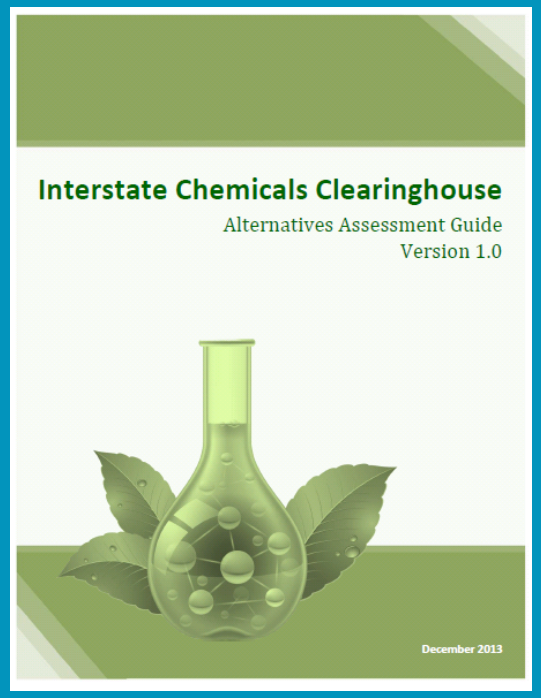
- **Chemical hazard assessment (CHA):** a systematic process of assessing and classifying hazards across an entire spectrum of endpoints and severity
- Life cycle thinking
- Exposure assessment
- Technical/functional assessment
- Economic assessment
- Social impact assessment

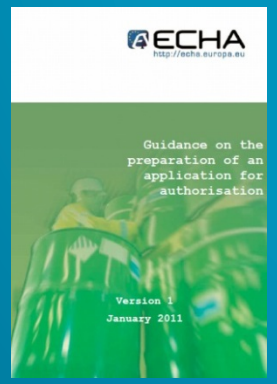
Chemical Alternatives Assessments

- Chemical Alternatives Assessments focus on finding alternative chemicals, materials and/or product designs to substitute for the use of hazardous chemicals

- When properly conducted, an alternatives assessment provides the means to avoid **regrettable substitution**, and promotes the selection of safer chemicals or materials







Design for the Environment
U.S. EPA

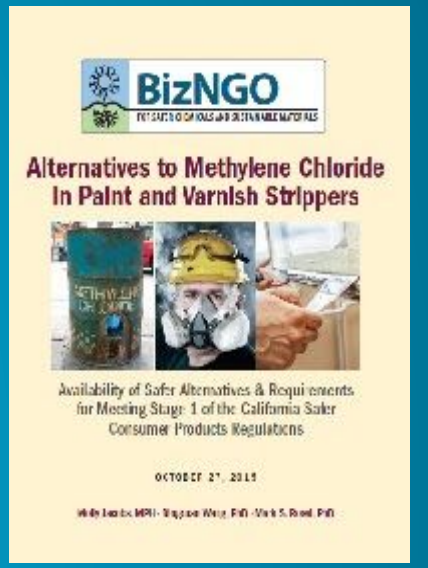
CalSAFER
SAFER CONSUMER PRODUCTS INFORMATION MANAGEMENT SYSTEM

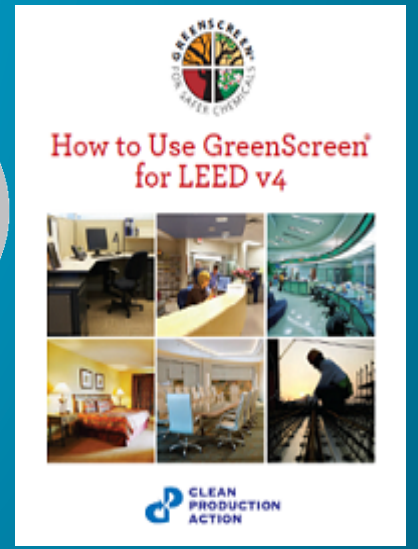
BizNGO
FOR SAFER CHEMICALS AND SUSTAINABLE MATERIALS

Lowell Center for Sustainable Production
UNIVERSITY OF MASSACHUSETTS LOWELL

Examples of Chemical Hazard Assessments

Alternatives Assessment	BizNGO's Alternatives to Methylene Chloride in Paint Strippers Report to meet Stage 1 of California Safer Consumer Products Regulations http://www.bizngo.org/news/article/methylene-alternatives-assessment-new-report-webinar State of Washington's Pilot Using the IC2 Alternatives Assessment Guide to Evaluate Alternatives to Copper-Based Boat Paint: http://theic2.org/
Materials Procurement	Identify chemicals of concern and safer alternatives • ZDHC members use chemical hazard assessments to select safer chemicals in textile formulations: www.roadmaptozero.com
Product Development	Inform development for new chemicals and formulations • GC3 project evaluated alternatives to known toxic phthalate plasticizers in wire & cable applications http://www.greenchemistryandcommerce.org/projects/business-and-academic-partnerships-for-safer-chemicals
Corporate Policies, Reporting and Management Systems	Track progress in managing chemical inventories. See sustainability reports by HP and Nike.
Standards, Scorecards and Ecolabels	USGBC LEED v4 Building Product Disclosure and Optimization awards credits to materials with GreenScreen or GreenScreen List Translator results http://www.greenscreenchemicals.org/news/article/how-to-leed-guide-press-release TCO Development Certified Displays 7.0 • TCO requires GreenScreen assessment of non-halogenated flame retardants http://tcodevelopment.com/news/criteria-review-non-halogenated-substances-pre-draft-open-for-comment/

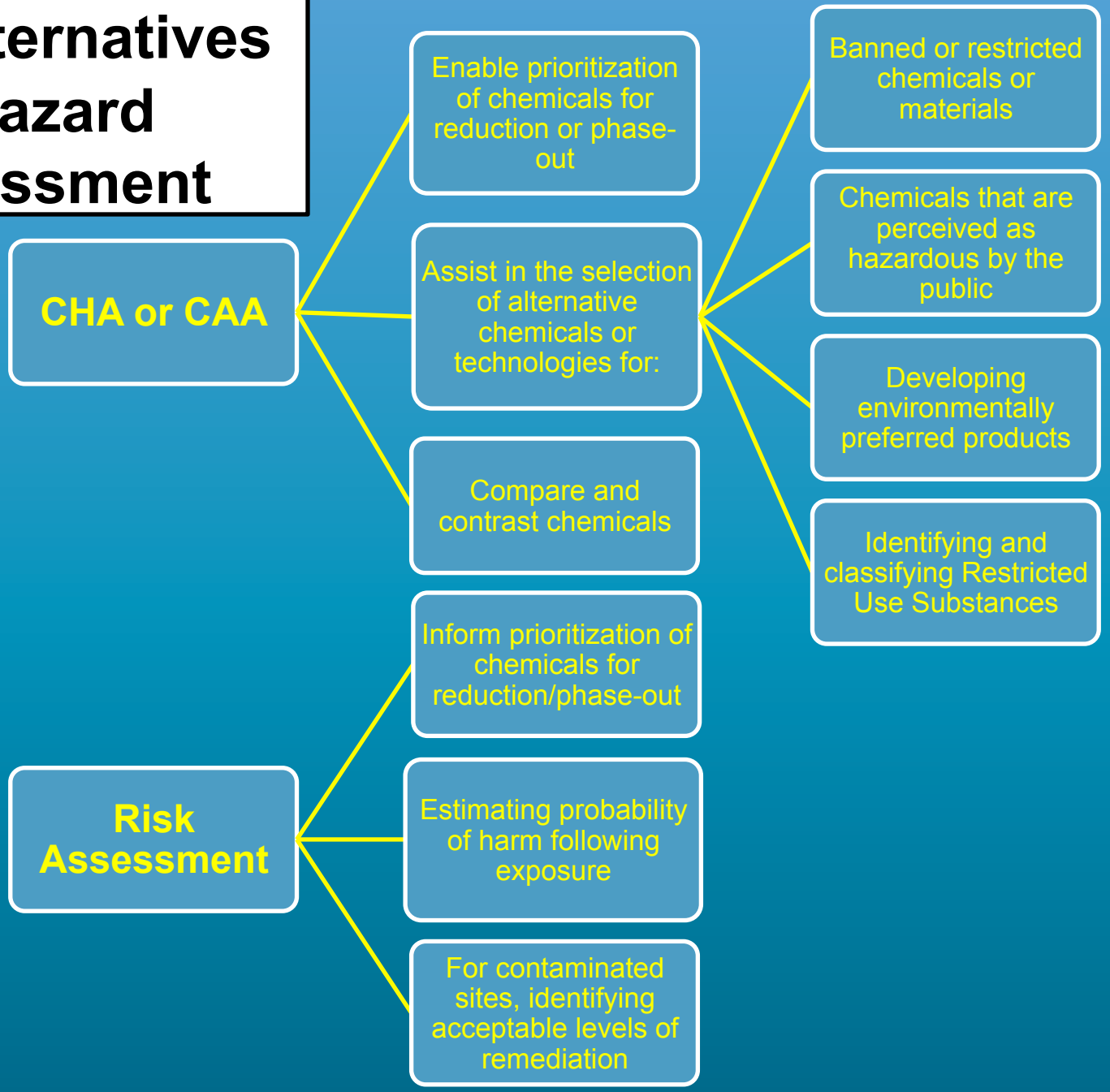




Decisions Empowered by Alternatives Assessment/Chemical Hazard Assessment vs. Risk Assessment

Alternatives assessments and chemical hazard assessments are intended to answer the question “Which chemical or product poses a lower hazard?”

A **risk assessment** is designed to answer the question “Is this chemical or product safe enough for the intended use?”



Chemical Hazard Assessment

From Most Data/Resource/Expertise Intensive to Least

1. GreenScreen for Safer Chemicals® ("Full GreenScreen") and DfE Alternatives Assessment Criteria for Hazard Evaluation
   - Based significantly on Globally Harmonized System (GHS)
   - Includes evaluation of 18 hazard endpoints
   - Comprehensive review of all available data
   - Comprehensive assessments needed for identifying safer alternatives
2. Quick Chemical Assessment Tool (QCAT)
   - Includes evaluation of 9 hazard endpoints (GreenScreen subset)
   - Reviews all data sources in the GreenScreen® List Translator
   - Reviews a sub-set of measured and estimated data
3. GreenScreen List Translator™
   - Reviews list-based data sources only
   - Quickly identifies chemicals to avoid and why
   - Easily accessible tool that can be automated

Complexity

GHS: A Solid Base for CHA

GHS: The Purple Book of Hazard Classification

- GHS is the Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

What is GHS?

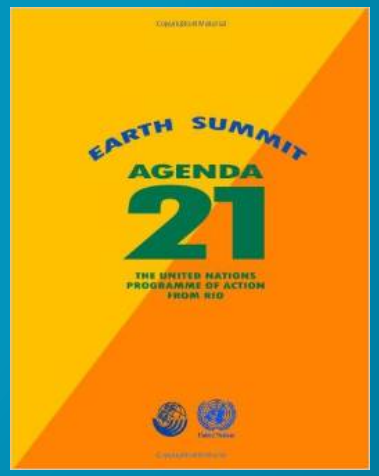
- GHS specifies criteria for the classification of health, physical and environmental hazards
- GHS specifies information to include on labels of hazardous chemicals and safety data sheets

Why was GHS developed?

- The UN developed GHS to promote a worldwide standard for hazard classification and communication
- GHS was born out of the UN's 1992 Earth Summit and was written up as Chapter 19 of the Earth Summit report: Agenda 21

Does every country in the world adhere to GHS?

- **No.** GHS is not required and participating countries are allowed to adopt only portions of it.
- 67 Countries have adopted GHS as of November, 2015



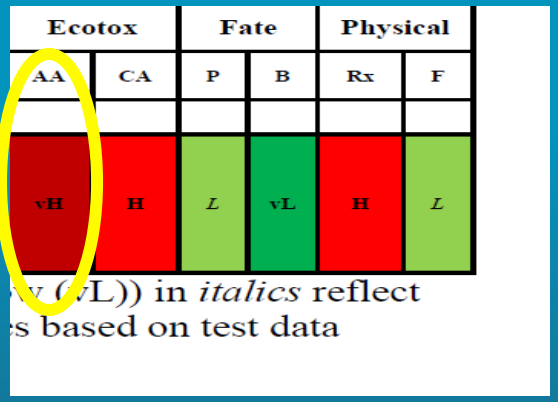
GHS: A Solid Base for CHA

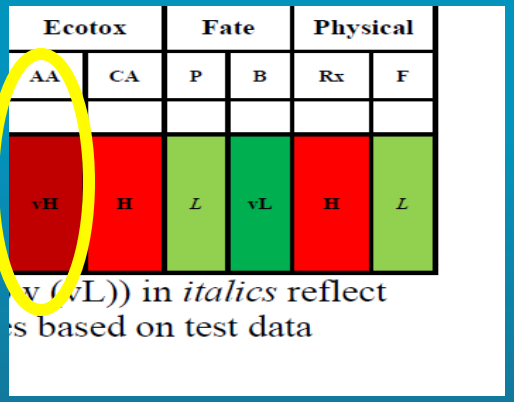
- GHS is built on 16 physical, 10 health and 3 environmental hazard classes
- GHS comprises the following communication elements
  - 9 Pictograms
  - 2 Signal words "Danger" or "Warning“
  - 72 individual and 17 combined Hazard statements
  - 116 individual and 33 combined Precautionary statements

Limitations of GHS

- GHS has no discrete hazard classification criteria for Persistence
- GHS has no discrete hazard classification criteria for Bioaccumulation
- GHS has no discrete hazard classification criteria for Endocrine Disruption
- GHS Category 1 toxicity for acute and chronic aquatic toxicity do not differentiate between very toxic and extremely toxic substances like biocides (pesticides, antimicrobials)
- GHS does not address additional species (e.g., birds, bees)

Chemical A





Chemical B

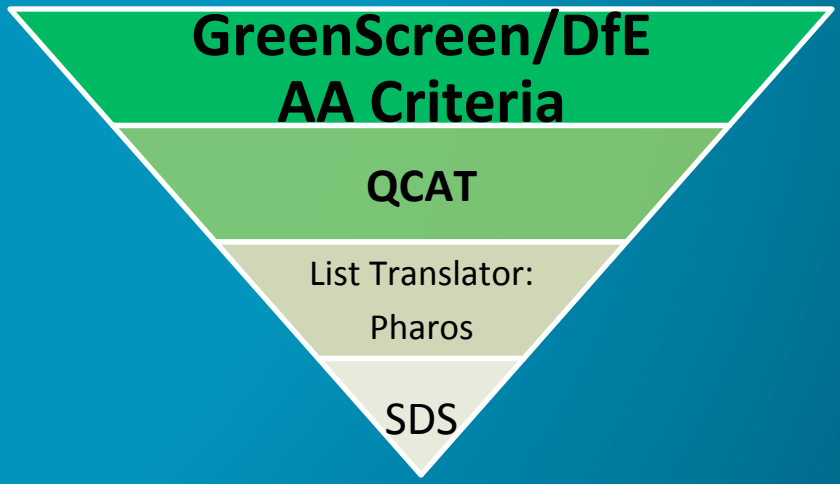
- The hazard tables appear the same for two different chemicals (A and B) but high acute aquatic (AA) toxicity could be orders of magnitude different at current highest toxicity classification level (GHS Category 1 for acute aquatic toxicity covers values less than 1 mg/L)
  - e.g., vH Fish or Daphia toxicity: LC_{50} or EC_{50} = 0.9 mg/L versus 0.0009 mg/L

Endpoints Assessed in Chemical Hazard Assessment

Chemical Hazard Assessment (CHA) methods typically share common hazard endpoints relating to human toxicity, environmental toxicity, and environmental fate

- CHA tools have varying degrees of complexity

GreenScreen® Hazard Ratings																			
Group I Human					Group II and II* Human									Ecotox		Fate		Physical	
Carcinogenicity	Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity		Neurotoxicity		Skin Sensitization*	Respiratory Sensitization*	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability
						single	repeated *	single	repeated *	*	*								
L	L	L	M	*M*	L	L	L	vH	*H*	L	DG	L	L	H	H	vL	L	M	*L*



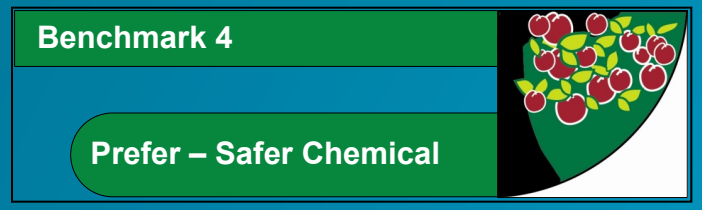
Endpoints Assessed in Chemical Hazard Assessment

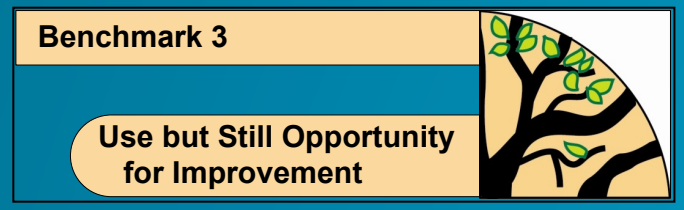
Ideally, A CHA should evaluate human health, ecotoxicity, fate, and physical hazards

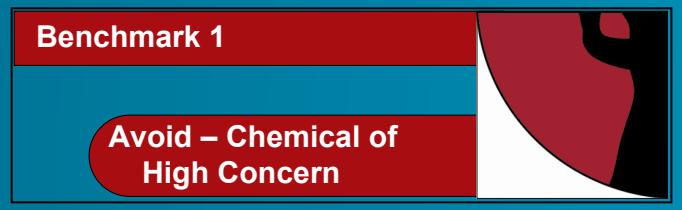
Hazard Summary Table Supplier A Chemicals [REDACTED]

				Group 1 Human Health					Group II and II* Human Health								Ecotoxicity		Fate		Physical		
Chemical	**CAS RN**	Functional use	% in Ingredient	Carcinogenicity	Mutagenicity	Reproductive	Developmental	Endocrine Activity	Acute Toxicity	Systemic Toxicity		Neurotoxicity		Skin Sensitization*	Respiratory Sensitization*	Skin Irritation	Eye Irritation	Acute Aquatic	Chronic Aquatic	Persistence	Bioaccumulation	Reactivity	Flammability	**GS Benchmark Score (Chemical)**
										s	r*	s	r*											
[REDACTED]	**[REDACTED]**	NS	30	**L**	**L**	**L**	**L**	DG	**L**	**L**	**L**	DG	DG	**L**	DG	**M**	**M**	**L**	*L*	**vL**	*L*	**L**	**L**	**3**
[REDACTED]	[REDACTED]	NS	15	*L*	*L*	*L*	**M**	**M**	*M*	DG	**L**	DG	DG	**M**	DG	**M**	**M**	*L*	*L*	*H*	*vL*	*M*	**L**	**2**
[REDACTED]	[REDACTED]	NS	3	**L**	**L**	**L**	**L**	*M*	**L**	DG	**L**	DG	*L*	**M**	**M**	*L*	*L*	DG	DG	*L*	*L*	*M*	*M*	**U**
[REDACTED]	[REDACTED]	NS	9	*L*	**L**	**L**	**L**	DG	**L**	M	**L**	M	**L**	**L**	DG	**L**	**L**	**L**	**L**	**vH**	***vL***	**L**	**L**	**3**
[REDACTED]	[REDACTED]	NS	7	*L*	**L**	**L**	**L**	DG	**L**	**M**	**L**	**M**	**L**	**L**	DG	**L**	**L**	**L**	**L**	**vH**	**vL**	**L**	**L**	**3**
[REDACTED]	[REDACTED]	NS	20	*L*	**L**	*L*	*L*	*L*	**M**	*vH*	*L*	*L*	*L*	*L*	DG	**vH**	**vH**	**M**	DG	*L*	*L*	*M*	L	**2**
[REDACTED]	[REDACTED]	NS	16	**L**	**L**	**L**	**L**	DG	**L**	DG	**L**	DG	DG	*L*	DG	**L**	**M**	**L**	*L*	**vL**	*vL*	**L**	**L**	**3**

CHA Tool #1: GreenScreen® for Safer Chemicals







GreenScreen® hazard-based continuum

A GreenScreen® can identify known "bad actor" chemicals

A GreenScreen® can rank chemicals

- To prioritize chemicals for further review and/or phase out
- To select more preferable chemicals

BENCHMARKS 1-4 = GreenScreen® Decision Logic

Benchmark U = Undetermined due to insufficient data

Aligned with Regulatory Drivers

Enhanced CHA Hazard Table: Route of Exposure

Nonstratified GreenScreen

Figure 1: GreenScreen™ Hazard Ratings for Terephthalic Acid

Group I Human					Group II and II* Human								Ecotox		Fate		Physical	
C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	B	Rx	F
						single	repeated*	single	repeated*										
M	L	L	M	DG	L	H	L	DG	L	L	DG	L	M	L	L	vL	vL	M	L

Note: Hazard levels in *italics* reflect estimated values and lower confidence. Hazard levels in **BOLD** font reflect

vs.

Stratified GreenScreen

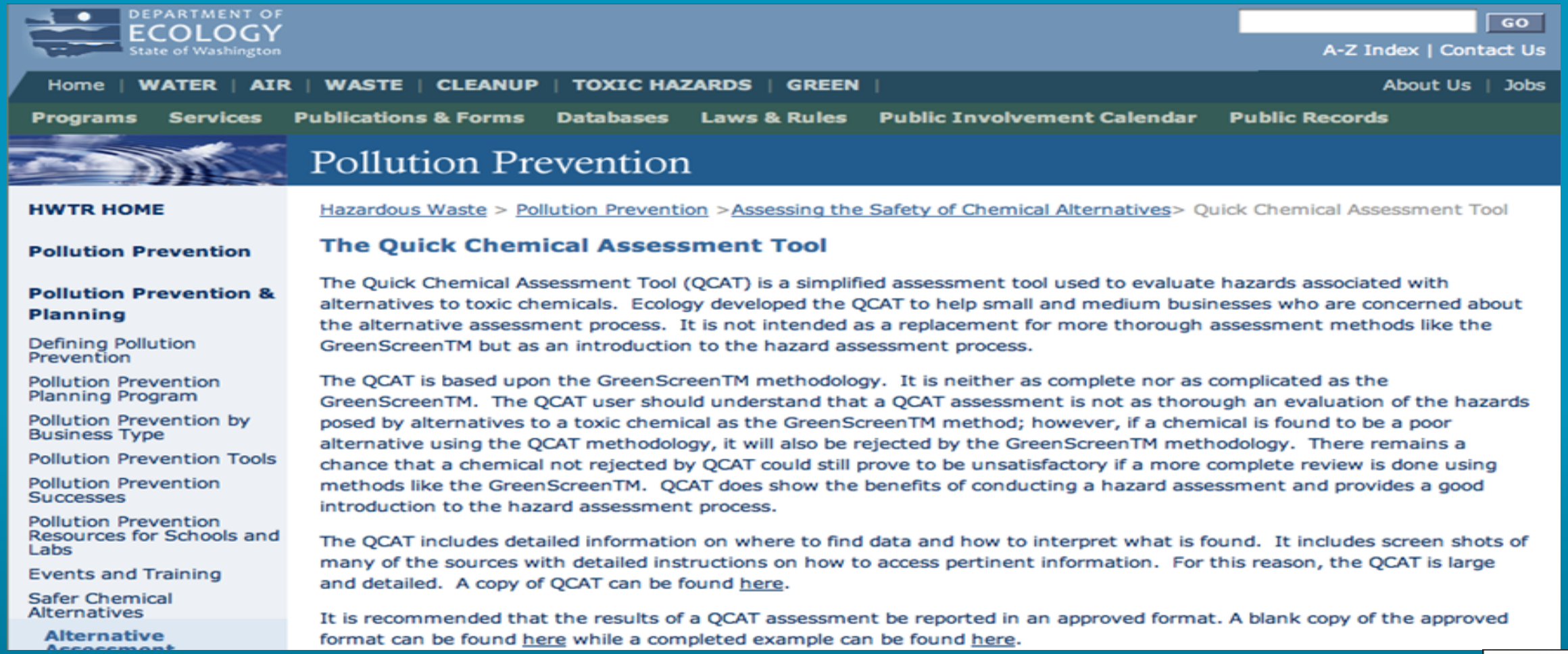
Figure 1: GreenScreen™ Hazard Ratings for Potassium Permanganate

Route of Exposure	Group I Human					Group II and II* Human								Ecotox		Fate		Physical	
	C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	B	Rx	F
							single	repeated*	single	repeated*										
Inhalation	*L*		M	M		DG	DG	M	DG	H										
Oral	*L*	L	M	H	M	M	vH	M	DG	H	L	DG	vH	vH	vH	H	*L*	vL	H	*L*
Dermal	*L*		*L*	*M*		L	H	M	DG	DG										

Note: Hazard levels (Very High (vH), High (H), Moderate (M), Low (L), Very Low (vL)) in *italics* reflect estimated values and lower confidence. Hazard levels in **BOLD** font reflect values based on test data (See Guidance). Please see Appendix A for a glossary of hazard acronyms.

By presenting only the lowest and/or ONLY score for a number of these hazards and fate properties, a nonstratified GreenScreen may masks relevant data gaps

CHA Tool #2: Quick Chemical Assessment Tool (QCAT)

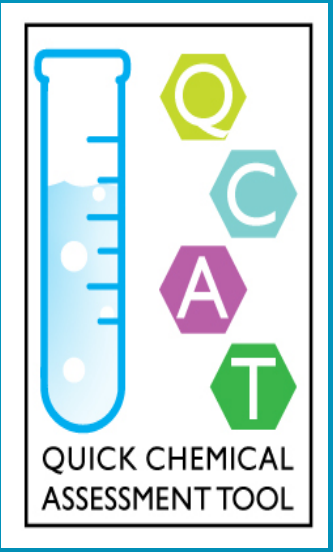


QCAT is available on web: http://www.ecy.wa.gov/GreenChemistry/QCAT.html

QUICK CHEMICAL ASSESSMENT TOOL

Quick Chemical Assessment Tool (QCAT), version 1.3

- QCAT was developed by the Washington State Dept. of Ecology as a tool for small/medium businesses with limited resources and expertise
- QCAT evaluates 9 hazard endpoints
- QCAT is a two step process
  - Step One: Hazard classification for each of nine hazard endpoints
    - List search (equal to GreenScreen List Translator™)
    - Check for experimental/modeling data if list-based hazard classification is not found for the endpoint assessed
  - Step Two: Chemical grading
    - Initial grade, ignoring data gaps (from A-F)
    - Data gap grade
    - Assigned a QCAT grade for the assessed chemical by selecting the lower of the Initial or Data gap grade



Grade Levels from the QCAT Assessment Process

Grade A	Few concerns, i.e., safer chemical	**Preferable**
Grade B	Slight concern	**Improvement possible**
Grade C	Moderate concern	**Use but search for safer**
Grade F	High concern	**Avoid**

Populate QCAT Matrix with Hazard Classifications for Chemical Being Evaluated

QCAT evaluates 9 hazard endpoints (shaded below) vs. 18 endpoints in a GreenScreen

QCAT Hazard Ratings

Group I Human					Group II and II* Human							Ecotox		Fate		Physical	
Carcinogenicity	Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity	Neurotoxicity	Skin Sensitization	Respiratory Sensitization	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability
L	L	L	M	DG	L	X	X	X	X	X	X	H	X	vL	vH	X	X

Level of Concern:

- vH = very High
- H = High
- M = Moderate
- L = Low
- vL = very Low
- DG = Data Gap
- X = GS® criteria not used in QCAT

QUICK CHEMICAL ASSESSMENT TOOL

QCAT Tool

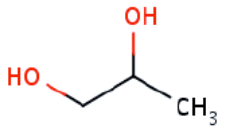
- Positives and negatives
  - Part of an alternatives assessment (AA)
  - Simpler and easier to implement than a full GreenScreen
  - Fewer regrettable substitutions
  - Not as complete as detailed AA/CHA
  - Less confidence that alternative is truly ‘green’
  - Introduces companies to the AA process

QUICK CHEMICAL ASSESSMENT TOOL

A QCAT for propylene glycol shows that data were found for all hazard endpoints except endocrine activity. An overall grade of B was assigned.

Propylene glycol QCAT is accessible at http://theic2.org/

Chemical Structure:



Hazard Summary Table:

Human - Group 1					Human - Group 2							Eco			Fate		Physical	
C	M	R	D	E	AT	ST	N	SnS	SnR	Irs	IrE	AA	CA	Eo	P	B	Ex	F
L	L	L	L	DG	M	X	X	X	X	X	X	L	X	X	L	vL	X	X

Note: Please see Appendix A for glossary of hazard endpoint acronyms. Grey boxes with an 'X' are criteria included in GreenScreen but not reviewed in QCAT.

B	Initial Grade
B	Final Grade (data gaps)

Grade Levels from the QCAT Assessment Process

Grade A	Few concerns, i.e., safer chemical	Preferable
Grade B	Slight concern	Improvement possible
Grade C	Moderate concern	Use but search for safer
Grade F	High concern	Avoid

CHA Tool #3: The GreenScreen® List Translator

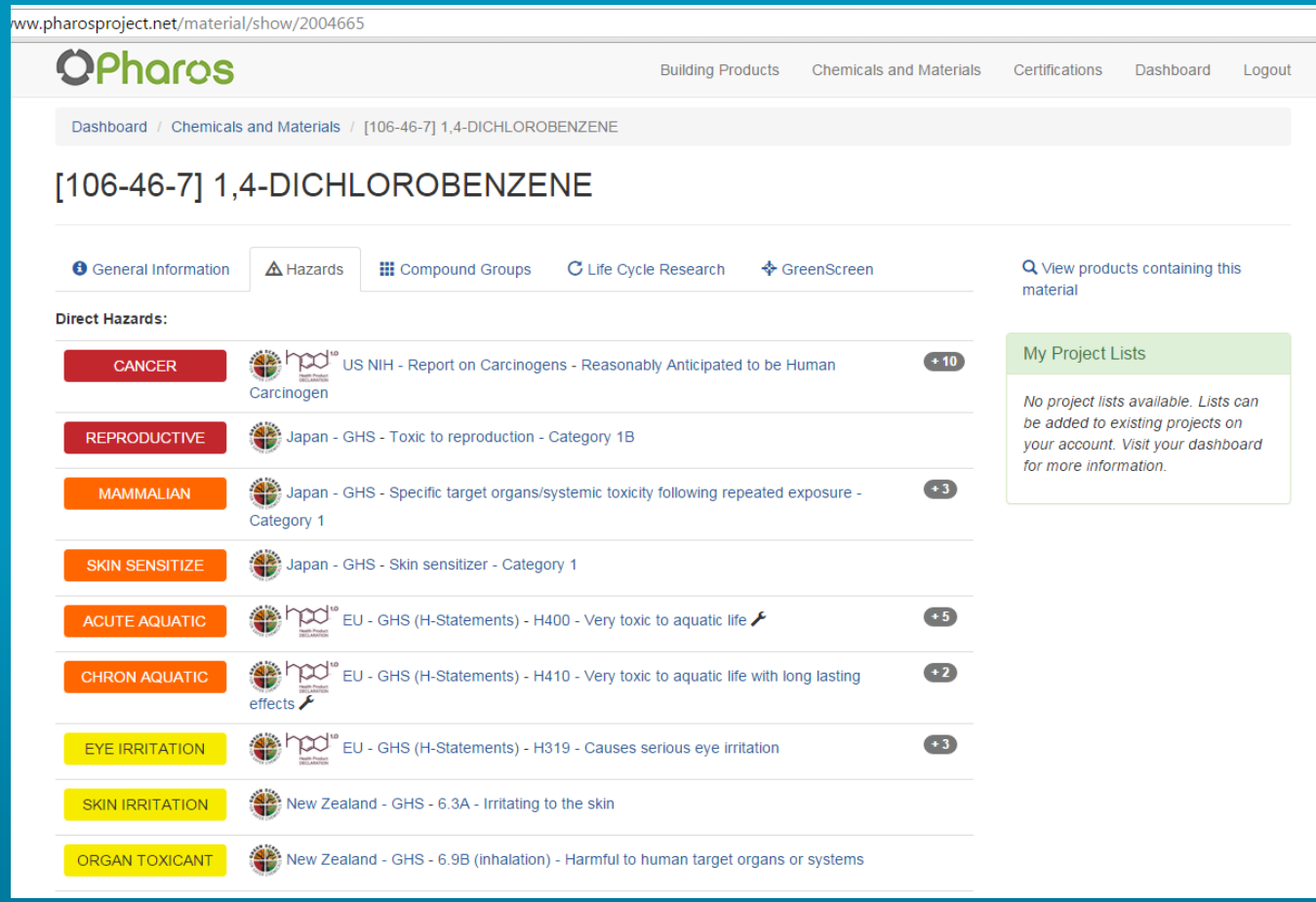
GreenScreen® List Translator

- Readily identifies chemicals of concern
- Based on authoritative lists
- Doesn't require toxicology expertise
- Used to identify GreenScreen® Benchmark 1 Chemicals
  - LT-1 chemicals are Benchmark 1 chemicals (unless proven otherwise)
  - LT-P1 chemicals may be Benchmark 1 chemicals
  - LT-U chemicals are not known to be Benchmark 1 need further assessment to determine Benchmark score

Obtaining GreenScreen® List Translator

Manual Version: http://http://www.greenscreenchemicals.org/method/greenscreen-list-translator

Automated Tool: Incorporated into Pharos http://www.pharosproject.net/



1,4-Dichlorobenzene is a List Translator-1 (LT-1) Chemical

Pharos

Making Informed Decisions

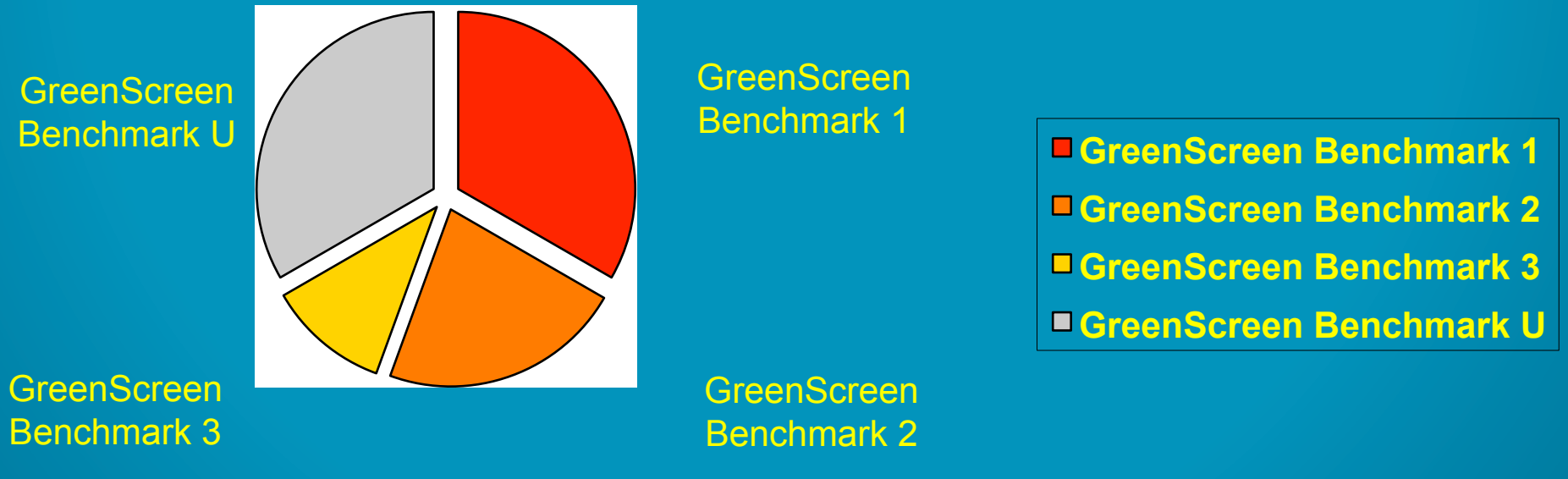
- Consider the chemical's specific application & use
- Use the full GreenScreen® hazard table, not just the Benchmark score
  - e.g., a BM 3 chemical (a very good CHA score) having moderate or high eye irritation would not be a good choice for an eye wash!!
- Apply Risk Management
  - Risk management can be defined as the process of identifying, selecting and implementing actions to reduce risk to human health and ecosystems

All Chemicals Need Risk Management, but it's a lot easier with inherently safer chemicals…

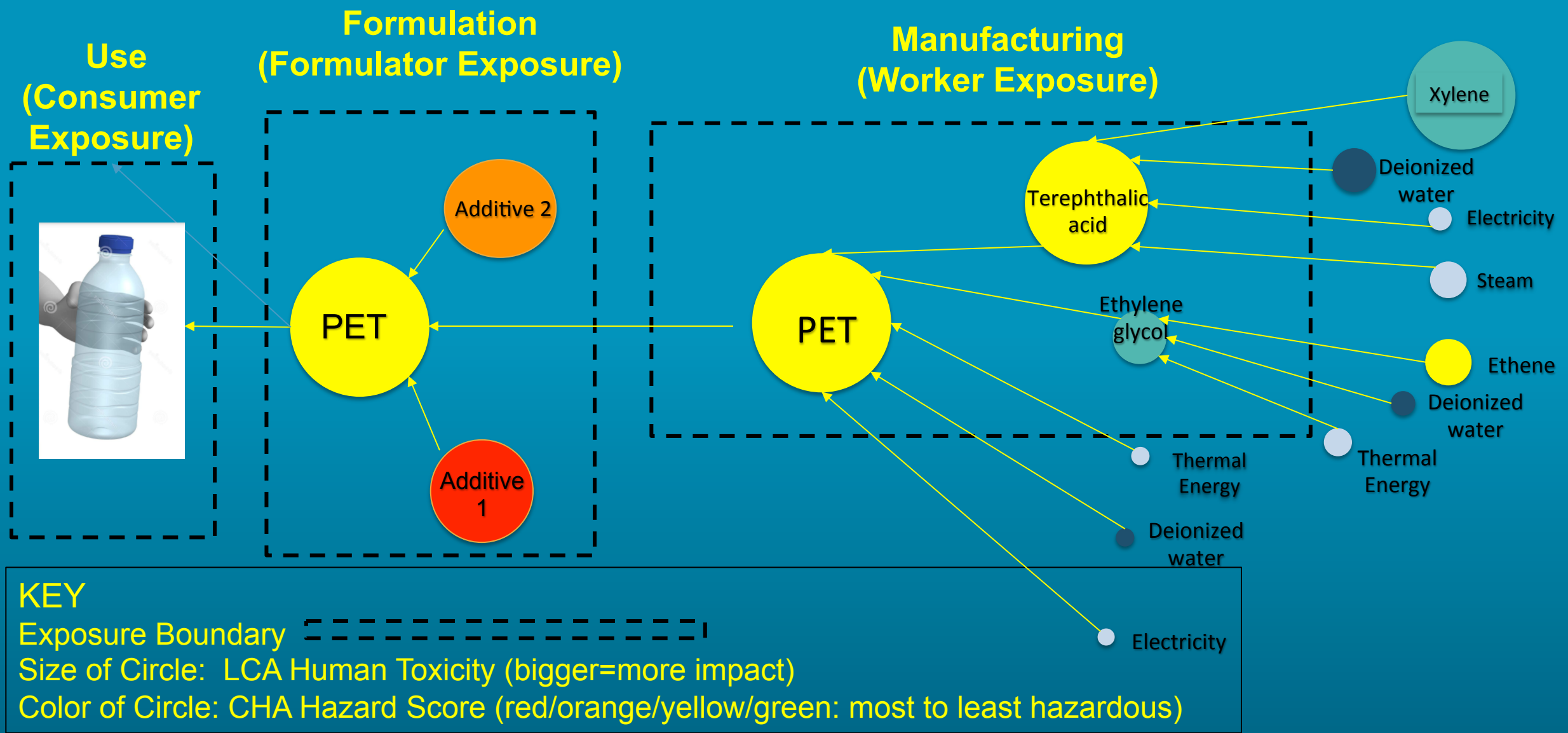
Making Informed Decisions

- **CHA Empowers Informed Decisions (Replace, Substitute, Redesign)**
  Below is an example of a GreenScreen benchmark score distribution in a finished textile treatment formulation

  This formulation contains a number of BM1 ingredients that are flagged for substitution because individual chemicals are CMRs and/or PBT, as well as BM U (Hazards Unassignable) chemicals



Challenge #1: Assessing Upstream Impacts by Assessing CHA and Life Cycle Impacts Simultaneously



Challenge #2: Assessing Hazards of Mixtures

Northwest Green Chemistry: Choosing Safer Products
Scorecard: Alternatives to Copper-based Antifouling Paints Compares 10 products across 8 variables

- Ingredients were assessed using GreenScreen®
- Scorecard & criteria available on NGC website

Product	How it Works [1]	Apparent Attributes [1]	Use/ Versatility	Unit Cost for Coverage [2]	Longevity (months)	Applic Meth
UltraSonic Anti-Fouling	Physical - Sonic technology that prevents attachment	Effective on soft fouling when idle; No chemicals; Solar attachment available	All substrates except wood/ saltwater	$2.60/sf (up to 32 ft) $2.35/sf (each add'l 20 ft)	36 +	Inter installa no penetra
Aurora VS 721 Bottom Coat	Release Coating - Bottom wax	Wipe and buff application; Clear barrier coat	All substrates/ all waters	$0.15/sf	12	Wet sp 2 co
Seahawk	Biocide - Econea; and a proprietary slick anti-	Metal free; Soft growth	All substrates/			Spray, b

http://www.northwestgreenchemistry.org/choosing-safer-products.html

Ingredient Information for Anti-foulant Options: Mixtures

Product	Active Ingredients[1]	CAS	GS Status	Benchmark Score	Inert Ingredients[2]	CAS
UltraSonic Anti-Fouling	N/A - mechanical process, no chemicals	NA	NA	NA	N/A - mechanical process, no chemicals	NA
Aurora VS 721 Bottom Coat	Distillates (petroleum), hydrotreated light	64742-47-8	6/30/15	BM2	None	NA
Seahawk Smart Solution (Black)	Tralopyril (ECONEA)	122454-29-9	1/1/15	BM2	Aromatic hydocarbon[3]	64742-95-6
					Ethylbenzene	100-41-4
					Ceramic microspheres	66402-68-4
					Carbon black	1333-86-4
West Marine CFA Eco Copper-free Antifouling Paint (Red)	Tralopyril (ECONEA)	122454-29-9	1/1/15	BM2	Barium sulfate	7727-43-7
	Zinc pyrithione	13463-41-7	6/30/15	BM1tp(BM2)	Ethylene glycol monobutyl ester	111-76-2
					Iron Oxide Red	1332-37-2
					Polytetrafluoroethylene	9002-84-0
					Zinc oxide	1314-13-2
					Crystalline silica, quartz	14808-60-7
Interlux Pacifica Plus	Zinc pyrithione	013463-41-7	6/30/15	BM1tp(BM2)	Napthalene	000091-20-3
					Xylenes	001330-20-7
	Tralopyril (ECONEA)	122454-29-9	1/4/15	BM2	Carbon black powder	001333-86-4
					Barium sulfate	007727-43-7
					Calcium sulfate dihydrate	010101-41-4
					Zinc oxide	001314-13-2
					Naptha (petroleum), heavy aromatic	064742-94-5

Challenges with Mixtures: Example Zn-Free Marine Bumper

Strategies for Testing:

- Whole product testing – “fail fast”
- Assess individual ingredients:
  - No SVHCs?
  - Weighted average?
  - GHS/CLP mixture rules?
  - Other?

Resources for CHA: Lists, Databases, and Software

Databases that Identify Safer Chemicals or CHA/AA Methods

U.S. EPA Safer Chemical Ingredients List (SCIL), CleanGredients, Pharos Material Health Library (37,000+ chemicals), IC2 Chemical Hazards database, CPA's GreenScreen store, TechStreet for GreenScreens, OECD Substitution and Alternatives Assessment Toolbox

Databases that Identify Regulatory, Hazard, Risk, or Exposure-Related Information About a Chemical

- U.S. EPA ChemView database, IC2 Chemical Hazards Database, ChemAdvisor LOLI, OECD e-ChemPortal

Software to Assess Hazards for Human Health and Environmental Endpoints

- U.S. EPA Expo-Box, ECOSAR, T.E.S.T., EPI SUITE, VEGA, QSAR Toolbox, Oncologic, ToxTree

Resources: Organizations Involved in CAA/CHA Activities

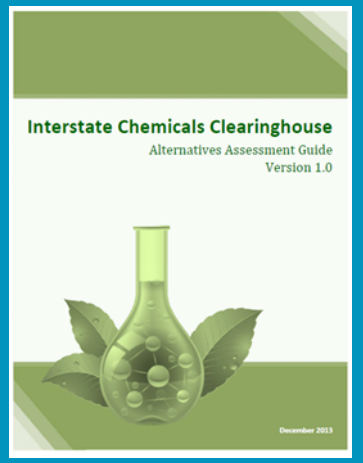
- **Green Chemistry and Commerce Council (GC3)**
  - Founded in 2005 as part of the Lowell Center for Sustainable Production
  - GC3's annual meeting is scheduled May 24-26, 2016 in Burlington, VT
  - **http://greenchemistryandcommerce.org/**
- **Northwest Green Chemistry**
  - Founded in 2013 by U.S. EPA National Estuary Program
  - Identifying safer alternatives and integrating green chemistry and green engineering into new products
  - Scorecards, alternatives assessments, QCAT Training
    http://www.northwestgreenchemistry.org
- **BizNGO**
  - Founded in 2006 by Clean Production Action (CPA)
  - BizNGO's annual meeting is December 8-9, 2015 in Boston
  - Developed BizNGO CAA Protocol and piloted AA to meet Step 1 of California SCP Regulations
  - CPA holds GreenScreen training courses (http://www.greenscreenchemicals.org/)
  - **http://www.bizngo.org/index.php**

Resources: Finding Completed AA and CHAs

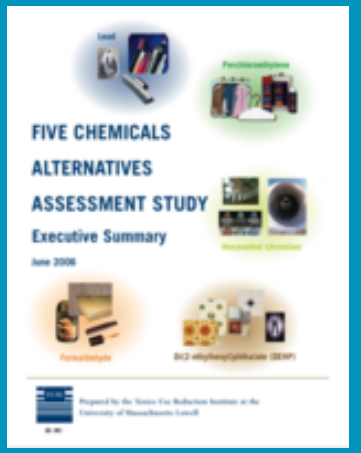
Completed AAs and CHAs are available on-line:

U.S. EPA Alternatives Assessments: Flame Retardants Used in Flexible Polyurethane Foam: An Alternatives Assessment Update **and** Flame Retardants in Printed Circuit Boards **http://www2.epa.gov/saferchoice/design-environment-alternatives-assessments**

ToxServices LLC. Assessing Alternatives to Copper Antifouling Paint: Piloting the Interstate Chemicals Clearinghouse (IC2) Alternatives Assessment Guide **http://theic2.org/alternatives_assessment_guide**



Toxic Use Reduction Institute (TURI). 2006. Five Chemicals Alternatives Assessment Study **http://www.turi.org/TURI_Publications/TURI_Methods_Policy_Reports/Five_Chemicals_Alternatives_Assessment_Study._2006**



The IC2 has GreenScreens and QCAT assessments available: **http://theic2.org/**

Conclusion

Chemical hazard assessment is a critical component of intelligent material design and formulation

- Hazard reduction promotes the design (or re-design) of materials and products that reduce or eliminate the use or generation of hazardous substances
- This is the literal definition of Green Chemistry and benefits the user of the material and the world at large!

Contact Information

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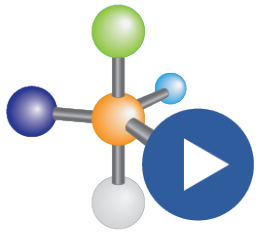
New from GC3: Safer Chemistry Training

GREEN CHEMISTRY & COMMERCE COUNCIL

Safer Chemistry Training for Businesses



Webinar Title and Description	Presenters	Chemistry Rating
Foundations for Green Chemistry and Green Engineering		
Green Chemistry: Benign by Design One of the fathers of green chemistry, Dr. John Warner, provides an introduction to green chemistry, as well as ideas for how to build this concept into education and practice.	**John Warner** Warner Babcock Institute for Green Chemistry	
Introduction to Green Engineering Green engineering applies principles similar to those of green chemistry to process and product design. In this webinar, experts in green engineering introduce principles, tools, and examples of this practice.	**Julie Zimmerman** Yale University	
	Matthew Eckelman Northeastern University	
	Julie Schoenung University of California Davis	
The Role of Policy in Green Chemistry Research and Adoption This webinar provides an overview of the range of policies that can affect chemical design and product development and adoption, with examples from a major chemical manufacturer.	**Robert Giraud** DuPont Company	
	Joel Tickner Green Chemistry & Commerce Council	
Green Chemistry in Business		
The Value of Green Chemistry	**Helen Holder**	

- Free, customizable online curriculum
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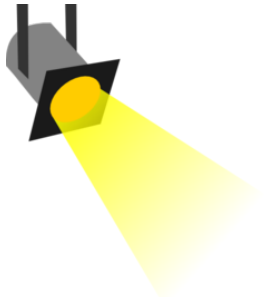
- Can be tailored to specific job needs

www.greenchemistryandcommerce.org/safer-chemistry-training

Upcoming Events



Ask the Innovators: Spotlight on Berkeley's Greener Solutions Program

Nov. 10th, 2015 3:00-4:30 PM ET (12:00-1:30 PT)

www.acs.org/gcforum

11th Annual GC3 Innovators Roundtable Sponsored by Seventh Generation

May 24th-26th, 2016, Burlington, VT

ACS Green Chemistry Institute®

Thanks for joining us!
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GC3 GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry