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Timothy Downs
Instituto de Salud Ambiente y Trabajo

Carlos Santos-Burgoa
Instituto de Salud Ambiente y Trabajo

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TIMOTHY J. DOWNS, DENV, CARLOS SANTOS-BURGOA, MD, PHD

The dispersion of persistent, bioaccumulative toxic chemicals poses risks to human health and the integrity of the ecosystem on a continental scale. Mexico, the United States, and Canada sought to add two pollutants to an existing list of four subject to North American Regional Action Plans (chlordane, DDT, mercury, PCBs). Mexican negotiators used results from an internal selection process, applying 14 criteria in five categories—physicochemical, health-endpoint, data quality/quantity, exposure potential, and control feasibility—to a baseline group of over 4,700 substances. Using policy analysis by the multiattribute maximum-utility method, progressive application of criteria and weighting algorithms acted like successive filters to identify priority lists of 15 and 7 substances/substance groups for Mexico. The 15 are: 1) benzo-*a*-pyrene (+ other PAHs); 2) cadmium; 3) heptachlor; 4) hexachlorobenzene; 5) lead; 6) lindane (+ other HCH isomers); 7) 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (+ other PCDDs); 8) aldrin; 9) arsenic; 10) chromium; 11) carbon tetrachloride; 12) 3-3'-dichlorobenzidine; 13) dieldrin; 14) nickel; and 15) toxaphene. The first seven are the priority list of seven. *Key words:* chemical risk; policy analysis; tri-national; NAFTA; Mexico.

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North American Regional Action Plans (NARAPs) have been developed to cooperatively control substances that pose long-term risks to human health and the integrity of the ecosystem in all three countries of the region. The plans form a central part of the Sound Management of Chemicals (SMOC) initiative that originated under Resolution 95-5 of the Council of the Commission for Environmental Cooperation.[1] It was promulgated under the North American Agreement on Environmental Cooperation signed by Mexico, the United States, and Canada,[2] a side agreement of the North American Free Trade Agreement (NAFTA). SMOC is consistent with *Agenda 21*, the sustainable-development blueprint that was the result of the 1992 United Nations Conference on Environment and Development.[3]

The SMOC Working Group originally chose Hg, PCBs, chlordane, and DDT to be the first four tri-nationally controlled substances.[4] Later, the Substance Selection Task Force was created to analyze the appropriateness of new substances to be included in the SMOC initiative. The selection process was defined to include nomination, evaluation (substance evaluation and mutual-concern evaluation), discussion, and decision stages. Mexico reviewed its submission process to decide which substances to recommend for tri-national control, and we were asked to help the national authorities define Mexican priorities. Although the risk priorities of partner countries are unlikely to coincide under very different source-receptor conditions (especially Mexico compared with the other two), substance-selection criteria should be universal. The Task Force recently reviewed four additional substances[5]—hexachlorobenzene (HCB), dioxins/furans, lead, and lindane—with the first two approved for NARAP control.

Medium- and long-range transport of chemicals within and beyond the North American Continent occurs when substances resistant to physical, chemical, and biological degradation are dispersed by regional air and/or water circulation, and/or by migrating species. When the magnitudes, frequencies, and durations of the emissions of such substances are sufficient, significant environmental concentrations may occur. Combine persistence and source strength with high bioaccumulation potential, high human toxicity, and high non-human toxicity, and the substances pose *potential*

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Address correspondence and reprint requests to: Carlos Santos-Burgos, MD, PhD, Instituto de Salud Ambiente y Trabajo (ISAT), Cerrada del Convento 48A, Oficina H-D, Sta. Ursula Xitla, Tlalpan 14420, Mexico; telephone (52-5) 573-6929; fax: (52-2) 513-3151; e-mail <carlossb@mailbox.rtn.net.mx>.

risks to humans and other species in contact with polluted media on a continental scale. That is, even in places without local or national sources, chronic exposures to such substances may occur. Risks remain potential until we can estimate individual and population exposures.

The primary objective of the substance-selection and control process is to optimize protection of public health and ecosystem integrity in the region. Since health risk is a dependent-probability quantity, substance-selection criteria are identifiable by their governance of it:

1. Probability of substance *toxicity*—derives from limited toxicologic knowledge of target organisms, organs, and endpoints = function of toxicodynamics between substance and organism molecules, biotransformation, biostorage, and evacuation. This is generally the main source of uncertainty.
2. Probability of substance *presence/bioavailability* in the environment = function of source type (e.g., fixed vs moving combustion discharge to air, point vs non-point process discharges to water and soil), source strength, duration, frequency, and effectiveness of control. Once the substance is released, this probability becomes a function of the substance's physicochemical properties (e.g. vapor pressure, aqueous solubility, partition coefficients, degradation rate constants) and properties of the environment (e.g., wind, insulation and precipitation regimen, steam flow, groundwater flow, soil erosion, soil organic carbon content, vegetation type and cover).
3. Probability of *exposure*—contact between target organism(s) and substance = function of the combined probability of presence/bioavailability in the environment (2) and the probability of target-organism contact, the latter dependent on time-activity patterns and the effectiveness of multi-pathway exposure controls.

Probability 2 varies between environments and populations with geophysical, sociocultural and economic conditions, and probability 3 co-varies.

METHODS

Policy Analysis by Maximum Utility

The selection of substances for priority constitutes an exercise in policy analysis, "an analytical activity undertaken in direct support of specific public or private sector decision makers who are faced with a decision that must be made or a problem that must be resolved."[6] Its main objective is: "To evaluate, order and structure incomplete knowledge so as to allow decisions to be made with as complete an understanding as possible of the current state of knowledge, its limitations and its implications."[7]

A common and simple approach to analysis would be to establish a priori the group of criteria and the substances (options) to which they are to be applied. Such a group of criteria is that preestablished by the SMOC Task Force on Criteria[8]: toxicity, persistence, and bioaccumulation. A predetermined-options list would be any "favorite" list of substances or priority listing that has been arrived at without the policymaker's understanding the specific criteria applied (e.g., by blindly using the USEPA Top 20 Hazardous Substance List—why is it the top 20?). March[9] noted that "the prior specification of criteria and the prior specification of evaluation procedures that depend on such criteria are common presumptions in contemporary social policy making . . . [and] they are presumptions that inhibit the serendipitous discovery of new criteria." Consequently, the selection process described herein was not predetermined, but rather was tailored to Mexico's needs and applied in accordance with policy analysis that consists of "a set of

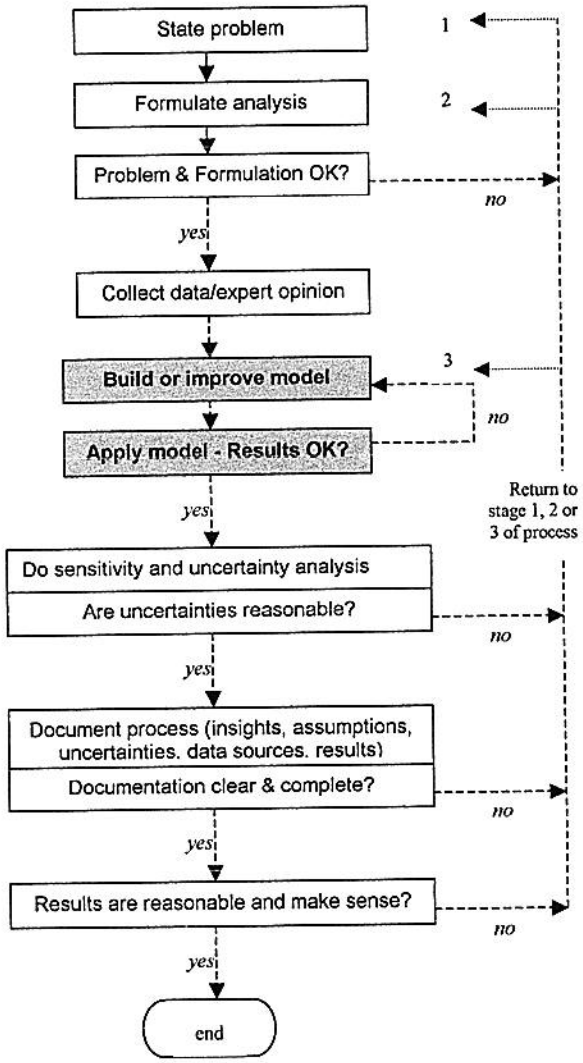

Figure 1—Good policy analysis (after Morgan and Henrion.)[6]

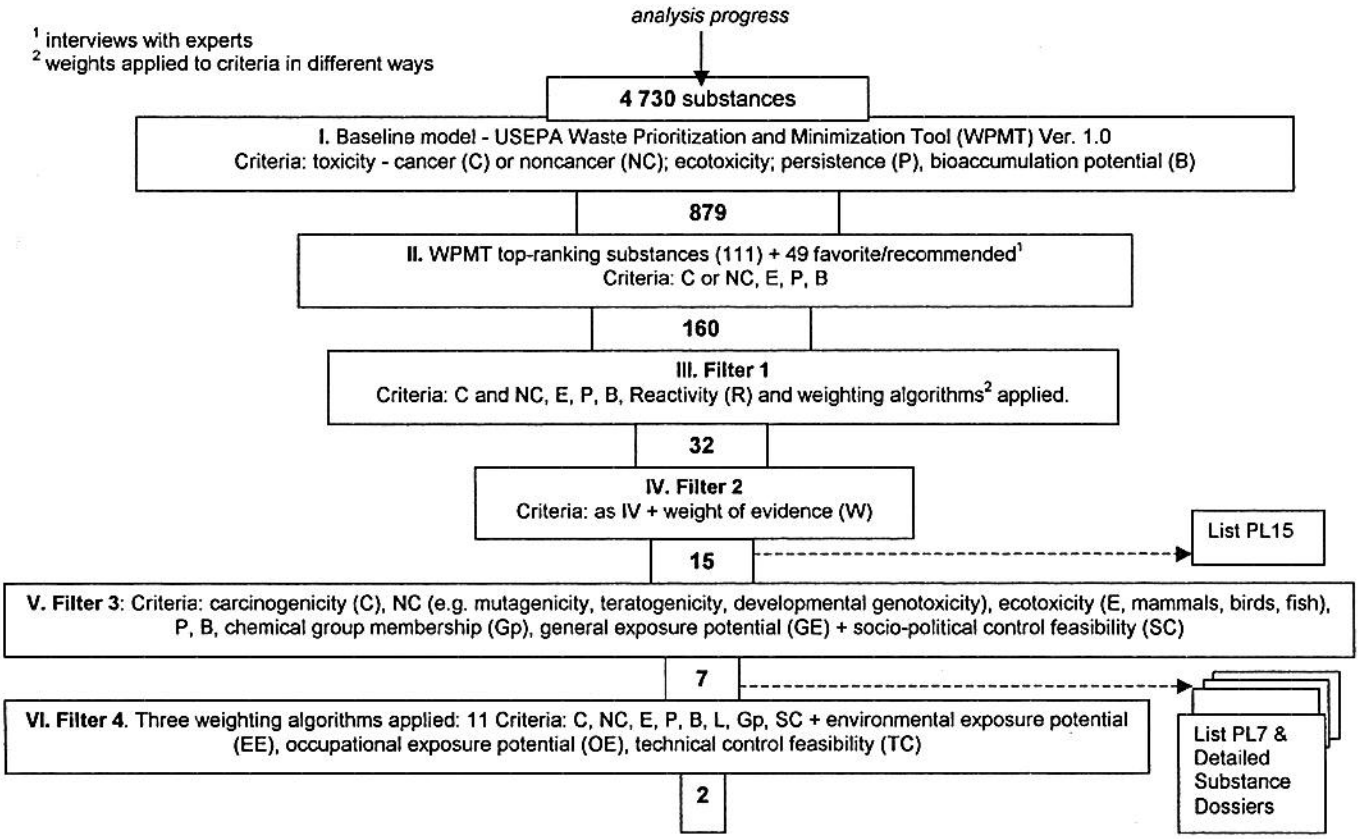

Figure 2—Multi-criteria selection process. As the number of candidate substances decreases, resolution of selectivity and data needs increase, affording efficiency.

procedures for inventing, exploring and comparing alternatives available for achieving certain social goals—and for inventing, exploring and comparing the alternative ends themselves—in a world limited in knowledge, in resources, and in rationality."[10]

For decision making based on the evaluation of outcomes, the most appropriate method uses utility-based criteria, with the decision algorithm consisting of the maximization of a multiattribute utility function (MAU)[6] of the following form:

$$\text{Maximize } MAU\,(w_1u_1 + w_2u_2 + w_3u_3 + \ldots w_{final}u_{final}) \quad (1)$$

where:

w_1 = weighting factor for attribute/criterion 1
w_2 = weighting for criterion 2, etc.
u_1 = utility value assigned to attribute/criterion 1
u_2 = utility of criterion 2, etc.

For example, for substance X, we may assign a utility value to the human cancer toxicity criterion: if X is not carcinogenic, utility is zero; if it is highly toxic utility would be scored high on an arbitrary relative scale. MAU handles noncommensurate quantities, and combines the ideas of *weight of evidence*—the quantity/totality of data—and *strength of evidence*—the quality/degree of certainty about data.

Substance Selection

We established an iterative selection process following the scheme proposed by Morgan and Henrion[6] for good policy analysis and the refinement of decision models (Figure 1). Literature sources, including prioritized substance lists from Mexico, Canada, the United States, and Europe, were used to obtain the following data: physico-chemical properties; toxicities; exposure potential; Mexican economic relevance, sources, uses and production; and technical pollution controls. The full process of selection of seven substances from 4,730 substances is described in Figure 2, which shows six stages and four criteria "filters." Each filter represents a modification of the preceding selection model to improve resolution, using more criteria to reduce the number of candidate substances while keeping data needs manageable. For example, application of Filter 3 criteria earlier than Stage V would overwhelm our resource capabilities: an implicit prioritization of the selection criteria operates. Table 1 describes the 14 criteria progressively applied to select seven substances from a domain of 4,730.

Relative criterion-utility values on semiquantitative scales (e.g., 0, 1, 2, and 3 for none, low, moderate, and high utility, respectively) are based on an objective evaluation of the totality of evidence consulted. For presence/absence in existing priority lists (weight of evidence), 1/0 values were used, and in later model Stages V and VI, where more resolution is needed, a 0–10 scale was used and normalized to 0–1.0 against the maximum possible utility value. Selection is made by total multi-criteria utility (e.g., by Excel® data sorting), but criteria on utilities are kept visible and flexible to weighting. We avoid a non-transparent grand index of risk priority composed of noncommensurable quantities.

The baseline database was the U.S. Environmental Protection Agency's Waste Minimization and Prioritization Tool (WMPT) version 1.0,[11] downloaded from the Internet. The database ranks 4,730 substances by four criteria: human toxicity (C, cancer *or* non-cancer), ecotoxicity (E), environmental persistence (P), and bioaccumulation potential (B). In Stage I of selection, the top 879 substances were isolated using the WMPT ranking. The Stage II cutoff was the top 111 by WPMT criteria, plus 49 additional substances not included in the WMPT ranking (Appendix A: 160 substances) but considered important by interviewed experts on hazardous substances. Six experts (in public health, ecology, and toxicology) were selected from professional and academic institutions in Mexico, presented with the 111 selections, and asked to add those substances they considered to be missing candidates.

Stage III applied the first new criteria filter (Filter 1) to the 160 substances from Stage II, considering C and NC separately (WMPT combines them in its ranking). It also includes a sixth criterion, "reactivity" (R), to account for a parent substance's ability to form several products in reactions with other substances, an electrodynamic and thermodynamic criterion. The WMPT model tends to rank organic compounds above metals because by considering metal ions or compounds separately, each one may rank low, while collectively they represent a relatively high potential risk. Stage III reduction from 160 to 32 used four different weighting algorithms for the six criteria (Appendix A). For example, algorithm C used weights biased towards endpoints by giving criteria C, NC, and E twice the weight of physico-chemical/biochemical criteria, while algorithm B used equal weights for all. Substances consistently ranking top, insensitive to weightings, are considered

TABLE 1 Criteria for Selection of High-priority Hazardous Chemicals

	Code	Criterion name	Type	Description	Stage First Applied
1	T	Human toxicity	Health endpoints	Cancer or non-cancer effects	I
2	C	Cancer toxicity	Health endpoints	Cancer effects	I
3	NC	Non-cancer toxicity	Health endpoints	Non-cancer effects	I
4	E	Ecotoxicity	Health endpoints	Effects on animals	I
5	P	Persistence	Physico-chemical	Resistance to environmental degradation	I
6	B	Bioaccumulation potential	Biochemical	Potential for substance to accumulate in the organism, parameters include bio-concentration factor (BCF)	I
7	R	Reactivity	Chemical	Ability to form compounds with other substances—metals score high since they react with organic substances	III
8	W	Weight of evidence/ presence in priority lists	Data	Amount of published data available to support prioritization/number of priority lists substance appears in from national and international data sources	IV
9	GE	General exposure potential	Health endpoint	Subjective estimate of the level of an individual's contact, and population size in contact with substance in Mexico	V
10	Gp	Group membership	Chemical	Membership in a chemical group of substances together magnifying potential risk	V
11	EE	Environmental exposure potential	Exposure	Subjective estimate of the level of an individual's contact, and population size in contact with environmental media in Mexico	VI
12	OE	Occupational exposure potential	Exposure	Subjective estimate of the level of an individual's contact, and population size in contact with occupational media in Mexico	VI
13	SC	Socio-political control feasibility	Control	Estimate of relative feasibility of control methods considering the socio-political and economic implications of controlling the substance in Mexico	VI
14	TC	Technical control feasibility	Control	Estimate of relative feasibility of control methods considering the technical aspects of controlling the substance in Mexico	VI

priorities. Stage IV (Filter 2) reduced the 32 to 15 by using the utility of weight of evidence/presence in priority lists (W). This utility is the total utility of regulatory sub-criteria from 50 data sources from Mexico (14), the UN (1), the OECD (1), the European Union (2), Canada (1), and the United States (31). Although W is dominated by U.S. data, the data are related to toxicity independent of country, so they do not bias results. (Readers may contact us for a copy of the sub-criteria list and evaluation table.) The result of Stage IV is the first priority list of 15 substances (PL15, Appendix B).

Stage V reduction from 15 to seven substances (Appendix C) used eight criteria: general human exposure potential in Mexico (GE); human non-cancer toxicity (NC)—considering explicitly target organs, endocrine effects, skin effects, and reproductive effects; cancer toxicity (C); ecotoxicity (E)—considering effects on rats and target organs of mammals; P; B; and socio-political feasibility (SC). Membership in a chemical group of several isomers or compounds (Gp) potentiates utility and is used as a 1.2 multiplier for the total utility of the other seven. Scoring is normalized to the maximum utility possible. The result is the second priority list of seven substances (PL7, Appendix D). In Stage VL, PL7 was subjected to ten criteria and three weighting algorithms: T_i—all ten criteria equal; T_{ii}—only seven criteria; T_{iii}—SMOC original criteria plus E. In algorithm T_{ii} NC was given a relative weight of 2.0 compared with C, since it is a composite of several endpoints. New criteria are: technical feasibility (TC), occupational exposure potential (OE), and environmental exposure potential (EE). This stage seeks to compare PL7 with a view to recommending just two.

RESULTS

The final list of seven high-priority substances for Mexico consists of those substances with the highest combined rankings by all the above criteria. Among the seven are two metals, two secondary pollutants, and three organochlorine pesticides. In three cases, the process identified priority *groups* of substances: polychlorinated dibenzodioxins (PCDDs); polycyclic aromatic hydrocarbons (PAHs); and hexachlorocyclohexanes (HCHs), with principal examples of each group evaluated in detail.

TABLE 2 Summaries of Substance Evaluations (see Appendix D)

1. **Benzo-a-pyrene** ($C_{20}H_{12}$; group = polyaromatic hydrocarbons/PAHs; secondary pollutant)
   Human exposures to BaP are considered to be moderate, cancer toxicity high, and non-cancer toxicity moderate. Persistence and bioaccumulation potential are both considered high. Socio-political control feasibility is considered high but technical control feasibility moderate to low because of the secondary-pollutant nature of the substance.
2. **Cadmium** (Cd-X—ions and compounds; metal)
   Cancer effects, non-cancer effects, ecotoxicity, and persistence are all high, and bioaccumulation moderate to high. In addition, since Cd is a commercial metal with numerous uses, occupational exposure is expected to be high and environmental exposure moderate in Mexico relative to the other substances. Socio-political feasibility and technical feasibility for control are both considered moderate because of its commercial importance.
3. **Hexachlorobenzene** (C_6Cl_6; organochlorine pesticide)
   Human exposures to HCB are considered to be low since it has been a prohibited pesticide for several years; cancer toxicity moderate, and non-cancer toxicity moderate to high. Persistence and bioaccumulation potentials are both considered high. Socio-political control feasibility and technical control feasibility in Mexico are both high because of its prohibition.
4. **Heptachlor** ($C_{10}H_5Cl_7$; organochlorine pesticide)
   Human exposures to heptachlor are considered to be low since it has been a prohibited pesticide for several years in Mexico. Cancer toxicity is moderate and non-cancer toxicity high. Persistence and bioaccumulation potentials are both considered high. Socio-political control feasibility and technical control feasibility are both high because of its prior prohibition.
5. **Lead** (Pb-X—ions and compounds; metal)
   Cancer effects are moderate, non-cancer effects are high, ecotoxicity is high, persistence is high, and bioaccumulation moderate to high. In addition, since Pb is both a commercial metal and a low-temperature ceramic glaze additive and was formerly a gasoline additive, occupational exposure is expected to be high and environmental exposures moderate to high in Mexico relative to the other substances. However, as for Cd, socio-political feasibility and technical feasibility for control are both moderate because of its commercial importance.
6. **Lindane** ($C_6H_6Cl_6$; group: hexachlorocyclohexanes/HCHs; organochlorine pesticide)
   Human exposures to lindane are considered to be low to moderate because, although it is still used, there is a relatively smaller population considered at risk compared with ubiquitous substances such as Pb, BaP, and TCDD. Cancer toxicity is low and non-cancer toxicity high. Persistence and bioaccumulation potentials are both considered moderate compared with BAP, for example. Socio-political control feasibility is considered high and technical control feasibility high because of the previous success with the prohibition of other pesticides.
7. **2,3,7,8-Tetrachlorodibenzo-*p*-dioxin** ($C_{12}H_4Cl_4O_2$; group polychlorinated dibenzodioxins/PCDDs; secondary pollutant)
   Human occupational exposure to TCDD is considered to be moderate to low since it is not manufactured or used but is a byproduct, and environmental exposure moderate because of the ubiquitous nature of this secondary pollutant. Cancer toxicity is moderate and non-cancer toxicity moderate to high. Persistence and bioaccumulation potentials are both considered high. Socio-political control feasibility is considered moderate and technical control feasibility moderate to low because of the secondary-pollutant nature of the substance.

Appendix D utilities by algorithm T_i (all criteria) are: BaP (8.0), TCDD (8.0), lindane (7.9), Cd (7.5), Pb (7.4), heptachlor (7.2), and HCB (7.0). However, including only hazard criteria (T_{ii})—toxicities, exposures, bioaccumulation, and persistence—and weighting noncancer effects twice as important as cancer effects, the ranking changes: Cd (7.0), Pb (6.9), TCDD (6.4), BaP (6.2), heptachlor (6.2), lindane (5.9), and HCB (5.8). The final algorithm (T_{iii}) excludes exposures and includes the original SMOC hazard criteria that are more objective. The ranking is: heptachlor (4.7), Cd (4.6), HCB (4.5), TCDD (4.5), BaP (4.4), Pb (4.3), and lindane (3.9).

Two substances rank consistently high: Cd and TCDD, but the ranks are sensitive to control feasibility and exposure criteria, both of which require the collection of better data. Summary capsules of each substance evaluation in the Mexico context are given in Table 2; evaluations are relative to other substances in the list. PL7 dossiers supporting negotiations included the following information: names and structure; physicochemical properties; toxicity in humans; ecotoxicity; sources, uses and production in Mexico; fate and transport; presence in humans, other biota and environmental media; human exposure potential and pathways in Mexico; key classifications (e.g., IARC, ACGIH); risk management in Mexico; knowledge gaps in Mexico; and bibliography.

DISCUSSION

Different countries have differing risk sources, exposure regimens, feasible control methods, and resources (human, material, financial, and informational), so selection of substances for priority must be done efficiently, considering the utility values of multiple criteria in the national context. Gaps in knowledge mean environmental and occupational exposure criteria are often excluded from prioritization of substances even though these data are vital to estimate population risks and engage in strategic risk management.

Policymakers in Mexico should resist international pressure to adopt risk standards or choices made in developed countries. Each country should consider its own needs and face the consequences of its own decisions. For example, the phasing out of DDT in Mexico should be done as alternative malaria controls are substituted. Players in international negotiations where a consensus about environmental health risk priorities is required should adopt both a national perspective and a regional perspective. Control plans should be evaluated with criteria that include: 1) technical feasibility; 2) cost–effectiveness (cost per unit risk reduction); and 3) socio-political and economic feasibility (especially for mined metals, for example).

Our exposure rankings are based not on measured population data in Mexico, but rather on a general knowledge of the sources and uses of the substances. Good exposure data are the main missing element in a characterization of substance risks in Mexico, and are considered a priority for future information resources. Information resources imply three key components: 1) comprehensive monitoring systems; 2) accredited laboratories capable of analyzing the indicator samples; and 3) information integration and dissemination. All three are weak in Mexico, and require regional NAFTA cost-sharing with public- and private-sector investment. For this reason, we recommend the development of a National or North American Regional Risk Characterization Program to strengthen information resources for effective environmental and occupational management.

In Mexico, poor socioeconomic conditions, environmental degradation, and deficient occupational conditions tend to favor higher-level population exposures to synthetic non-carcinogens than to synthetic carcinogens, i.e., it is likely that many non–cancer-related toxic effects in humans are more important than cancer-related effects (PL 15/7 substances have cancer *and* non-cancer "utilities"). Cancer tends to be the focus of developing-country chemical policy because public perception demands it.

Arguably, assumptions of zero threshold dose for cancer risk and a regulatory $<10^{-6}$ acceptable population risk are too stringent for countries with very limited resources and public health priorities that include controlling pathogens and vector-borne diseases. Downs et al.[12] applied comparative quantitative risk assessment at low cost to chemicals and pathogens in a wastewater-irrigation district of Mexico to identify priorities.

The recommendation of two substances from the final PL7 list depends necessarily upon the relative weights applied to the ten criteria in Appendix D. This subjective weighting was left to the decision makers, but it should be explicit, qualified, and defensible. Neither the exposure criteria nor weight-of-evidence criteria nor the two feasibility criteria were part of the a priori SMOC criterion group, and these are important considerations. Policymakers should beware of any bias towards organic substances, since risk policy should not exclude hazardous metals. The Mexican government subsequently used PL7 as a basis for its recommendations during tri-national negotiations. Recent SMOC talks resulted in the decision by the Council of the CEC[13] to make hexachlorobenzene and dioxins/furans subject to North American Regional Action Plans to be developed by the SMOC Working Group, while lead and lindane undergo further review. Notably, all four are PL7 substances.

Hot Spots

Independently of the tri-national actions, Mexico should invest in the sound management of all PL15 sub-

stances, starting with PL7. The criteria we applied to select these substances also allow a country to map potential risk "hot spots," a need Mexico is recognizing by initiating such a process. The selection of sites should proceed using the following criteria: 1) Sites with important risk-agent sources, e.g., high emission rates of PL7/15 priority substances; 2) Sites with large populations of potentially-exposed people from contact with occupational and/or environmental media; and 3) Sites where pollution is ecotoxic to sentinel/keystone species or complete habitats. The third criterion allows acute non-PL7/15 substance pollution by hydrocarbons or mining wastes to be prioritized, though sadly remediation is often impossible. Site selection by the MAU method should be used to reduce the number of potential hot spots to about 20–30. Judicial field sampling of media and quantitative risk screening[12] can then be used to identify priorities for strategic, cost-effective management and communication. Geographic information systems (GISs) are well suited to represent spatial data of this kind because their graphic output is readily interpretable by policymakers. The effort necessarily calls for much stronger intra- and interinstitutional collaboration within and between agencies responsible for public health and ecology in Mexico.

Sustainable Risk Management

While substance selection and regional plans are important steps toward risk management, the scope and integration required for sustainable improvements are far wider. Experience suggests partners must collaborate to integrate five components into a sustainable process in each country:

1. *Development of human resources.* Training scientists, technicians, and policy experts.
2. *Strengthening of information resources.* Integrated monitoring of risk agents and epidemiologic surveillance; state-level certified laboratories with regional data sharing and quality control; data integration by GISs; regional applied research networks; effective information transfer to decision makers and knowledge application.
3. *Regulatory development, enforcement, and compliance.* Regulations for Mexico should not be carbon copies of other countries' laws; rather, they should reflect national priorities and monitoring capacities (co-varies with 2 above), while successful enforcement/compliance experiences elsewhere can be adapted to Mexico.
4. *Stimulation of a market for environmental products and services* (driven by 3 above). Federal support for Mexican entrepreneurs, research and development, incentives for private sector investment, and the efficient, transparent application of financial resources earmarked for sustainable development projects.
5. *Multi-stakeholder participation.* Diagnosis of local needs, planning of activities, implementation, consolidation, and maintenance of risk interventions. Ideally includes the community/workforce at risk, scientists/academia, biodiversity conservationists, NGOs, public agencies/regulators, and private-sector risk sources and investors.

Such integrated processes are applicable to a wide range of issues from public health protection and biodiversity conservation through to natural resource stewardship, allowing positive synergies and economies of scale to emerge. Their success is governed much more by productive collaboration—how we work together—than by the limits of scientific knowledge.

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Stage II Candidates Subjected to Stage II Selection (160 to 32)

Weights applied to six criteria by algorithms A, B, C, and D:

		A	B	C	D
Persistence	P	1	1	1	1.5
Bioaccumulation potential	B	1	1	1	1.5
Cancer toxicity	C	1	1	2	1
Non-cancer toxicity	NC	1	1	2	1
Ecotoxicity	E	1	1	2	1.5
Reactivity	R	0	1	1	1

CAS#	Chemical Name	Stage III Criteria utilities [1]						[2]	Stage III Weighting algorithm utilities [3]				Utility Rankings WPMT baseline vs. algorithms [4]					Chemical Class
		P	B	C	NC	E	R	wpmt	A	B	C	D	wpmt #	A#	B#	C#	D#	
1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin	3	3	3	3	3	1	18	15	16	25	20.5	1	1	1	1	1	dioxin
56495	3-Methylcholanthrene	3	3	3	3	3	1	18	15	16	25	20.5	2	2	2	2	2	PAH
57976	7,12-Dimethylbenz(a)anthracene	3	3	3	3	3	1	18	15	16	25	20.5	3	3	3	3	3	PAH
309002	Aldrin (Octalene, HHDN)	3	3	3	3	3	1	18	15	16	25	20.5	4	4	4	4	4	cyclodiene
56553	Benzo(a)anthracene	3	3	3	3	3	1	18	15	16	25	20.5	5	5	5	5	5	PAH
50328	Benzo(a)pyrene	3	3	3	3	3	1	18	15	16	25	20.5	6	6	6	6	6	PAH
205992	Benzo(b)fluoranthene	3	3	3	3	3	1	18	15	16	25	20.5	7	7	7	7	7	PAH
189559	Benzo(rst)pentaphene	3	3	2	3	3	1	18	14	15	23	19	8	14	17	22	23	PAH
57749	*Chlordane (Toxychlor)*	3	3	3	3	3	1	18	15	16	25	20.5	9	8	9	9	9	cyclodiene
72548	*DDD, p,p'- (TDE)*	3	3	2	3	3	0	18	14	14	22	18	10	15	32	32	32	dichlorodiphenylethane
72559	*DDE, p,p'-*	3	3	2	3	3	0	18	14	14	22	18	11	16	33	33	33	dichlorodiphenylethane
50293	*DDT, p,p'-*	3	3	2	3	3	0	18	14	14	22	18	12	17	34	34	34	dichlorodiphenylethane
53703	Dibenz(a,h)anthracene	3	3	2	3	3	1	18	14	15	23	19	13	18	19	23	24	PAH
60571	Dieldrin (Alvit)	3	3	3	3	3	1	18	15	16	25	20.5	14	9	11	11	11	cyclodiene
72208	Endrin (Mendrin)	3	3	0	3	3	1	18	12	13	19	16	15	39	43	53	47	cyclodiene
76448	Heptachlor (Velsicol 104, Drinox, Heptagran)	3	3	3	3	3	1	18	15	16	25	20.5	16	10	12	12	12	cyclodiene
118741	Hexachlorobenzene	3	3	3	3	3	1	18	15	16	25	20.5	17	11	13	13	13	chlorinated aromatic
77474	Hexachlorocyclopentadiene	3	3	0	3	3	1	18	12	13	19	16	18	41	45	55	49	
143500	Kepone (Chlordecone)	3	3	2	3	3	1	18	14	15	23	19	20	23	24	25	25	
7439976	*Mercury*	*3*	*3*	*0*	*3*	*3*	*2*	*18*	*12*	*14*	*20*	*17*	*21*	*43*	*36*	*47*	*39*	*metal*
2385855	Mirex	3	3	2	3	3	1	18	14	15	23	19	22	24	25	26	26	Mirex

1336363	*PCBs*	3	3	3	3	3	0	*18*	*15*	*15*	*24*	*19.5*	*23*	12	27	21	21	*PCB*
608935	Pentachlorobenzene	3	3	0	3	3	1	18	*12*	*13*	*19*	*16*	*24*	45	47	58	51	*chlorinated aromatic*
8001352	Toxaphene (Camphechlor)	3	3	3	3	3	1	18	*15*	*16*	*25*	*20.5*	*25*	13	15	14	14	*cyclodiene*
194592	7H-Dibenzo(c,g)carbazole	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*26*	51	54	77	72	*PAH*
191242	Benzo(ghi)perylene	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*27*	56	59	78	73	*PAH*
205823	Benzo(j)fluoranthene	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*28*	57	60	79	74	*PAH*
207089	Benzo(k)fluoranthene	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*29*	58	61	80	75	*PAH*
2104963	Bromophos	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*30*	59	62	81	76	
7440484	Cobalt (y compuestos)	3	3	0	2	3	2	17	*11*	*13*	*18*	*15.5*	*31*	61	40	67	54	*metal*
57349	Chlordene	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*32*	62	64	82	78	
226368	Dibenz(a,h)acridine	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*33*	65	67	84	81	*PAH*
224420	Dibenz(a,j)acridine	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*34*	66	68	85	82	*PAH*
192654	Dibenzo(a,e)pyrene	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*35*	67	69	86	83	*PAH*
189640	Dibenzo(a,h)pyrene	3	3	2	0	3	1	17	*11*	*12*	*17*	*14.5*	*36*	68	70	87	84	*PAH*
115322	Dicofol (DTMC)	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*37*	69	71	88	85	
206440	Fluoranthene	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*38*	74	76	90	87	
193395	Indeno(1,2,3-cd)pyrene	3	3	2	2	3	1	17	*13*	*14*	*21*	*17.5*	*39*	31	35	37	35	*PAH*
297789	Isobenzan	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*40*	78	80	91	88	
465736	Isodrin	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*41*	79	81	92	89	
21609905	Leptophos	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*42*	80	82	93	90	
72435	Methoxychlor (DMDT)	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*43*	81	83	94	91	*dichlorodiphenylethane*
40487421	Pendimethalin	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*44*	82	84	95	93	
87865	Pentachlorophenol (PCP)	3	3	2	2	3	1	17	*13*	*14*	*21*	*17.5*	*45*	33	37	38	36	*chlorinated phenol*
79947	Tetrabromobisphenol A	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*46*	83	85	97	94	
327980	Trichloronate	3	3	0	2	3	1	17	*11*	*12*	*17*	*14.5*	*47*	84	87	98	95	
1582098	Trifluralin	3	3	1	2	3	1	17	*12*	*13*	*19*	*16*	*48*	47	49	59	52	
7440622	Vanadium (y compuestos)	3	3	0	2	3	2	17	*11*	*13*	*18*	*15.5*	*49*	85	51	74	55	*metal*
95943	1,2,4,5-Tetrachlorobenzene	3	2	0	3	3	1	16	*11*	*12*	*18*	*15*	*50*	49	52	61	56	*chlorinated aromatic*
1836755	2,4-Dichloro-1-(4-nitrophenoxy)benzene	3	2	2	3	3	1	16	*13*	*14*	*22*	*18*	*51*	25	28	28	28	*chlorobenzene*
91941	3,3'-Dichlorobenzenezidine	3	2	2	3	3	1	16	*13*	*14*	*22*	*18*	*52*	26	29	29	29	
101144	4,4'-Methylenebis(2-chloraniline)	3	2	2	3	3	1	16	*13*	*14*	*22*	*18*	*53*	27	30	30	30	
101688	4,4'-Methylenediphenyl isocyanate (MDI)	2	3	0	3	3	1	16	*11*	*12*	*17*	*15*	*54*	50	53	76	57	
12674112	*Arochlor 1016*	*2*	*3*	*0*	*3*	*3*	*0*	*16*	*11*	*11*	*16*	*14*	*55*	52	93	103	98	*PCB*
1861401	Benefin (Benfluralin)	3	3	0	1	3	1	16	*10*	*11*	*15*	*13*	*56*	93	94	124	128	
510156	Chlorobenzenezilate	3	2	0	3	3	1	16	*11*	*12*	*18*	*15*	*57*	63	65	66	61	
21923239	Chlorthiophos	2	3	0	3	3	1	16	*11*	*12*	*17*	*15*	*58*	64	66	83	62	
218019	Chrysene	3	3	2	2	2	1	16	*12*	*13*	*20*	*16*	*59*	38	42	43	45	

56531	Diethylstilbestrol	2	3	3	3	3	1	16	14	15	23	19.5	60	19	20	24	17	
58902	Endosulfan (Thiodan)	3	2	0	3	3	1	16	11	12	18	15	61	71	73	68	63	
563122	Ethion (Nialate, Ethyl methylene)	2	3	0	3	3	1	16	11	12	17	15	62	72	74	89	64	
1024573	Heptachlor epoxide	3	2	3	3	3	1	16	14	15	24	19.5	63	20	21	17	18	cyclodiene
87821	Hexabromobenzenezene	3	3	0	2	2	1	16	10	11	16	13	64	107	108	110	129	
87683	Hexachlorobutadiene	3	2	1	3	3	1	16	12	13	20	16.5	65	40	44	46	41	
56531	Hexachlorocyclohexane	3	2	3	0	3	1	16	11	12	18	15	66	75	77	70	65	chlorinated hexane
319846	Hexachlorocyclohexane, alpha-	3	2	3	3	3	1	16	14	15	24	19.5	67	21	22	18	19	chlorinated cyclohexane
58899	Hexachlorocyclohexane, gamma- (Lindane)	3	2	3	3	3	1	16	14	15	24	19.5	68	22	23	19	20	chlorinated cyclohexane
26399360	Profluralin	3	3	0	2	2	1	16	10	11	16	13	69	116	117	115	131	
3118976	1-((2,4-Dimethylphenyl)azo)-2-napthalene	2	3	0	2	3	1	15	10	11	15	13.5	70	86	88	121	107	
4901513	2,3,4,5-Tetrachorophenol	3	2	2	0	3	1	15	10	11	16	13.5	71	87	89	99	108	
58902	2,3,4,6-Tetrachorophenol	3	2	2	2	3	1	15	12	13	20	16.5	72	34	38	40	40	chlorinated phenol
786196	Carbophenothion	2	3	0	2	3	1	15	10	11	15	13.5	73	95	96	126	110	
55285148	Carbosulfan	2	3	0	2	3	1	15	10	11	15	13.5	74	96	97	127	111	
470906	Chlorfenvinfos	3	2	0	2	3	1	15	10	11	16	13.5	75	97	98	104	112	
2921882	Chlorpyrifos	3	2	0	2	3	1	15	10	11	16	13.5	76	100	101	105	113	
5598130	Chlorpyrifos methyl	3	2	0	2	3	1	15	10	11	16	13.5	77	101	102	106	114	
1861321	Dacthal	3	2	0	2	3	1	15	10	11	16	13.5	78	102	103	107	115	
67721	Hexachloroethane	3	2	1	2	3	1	15	11	12	18	15	79	77	79	71	67	chlorinated ethane
33820530	Isopropalin	3	3	0	2	1	1	15	9	10	15	11.5	80	140	140	130	149	
2234131	Octachloronapthalene	3	3	0	2	1	1	15	9	10	15	11.5	81	142	142	132	151	
112903	Oleyl amine	2	3	0	2	3	1	15	10	11	15	13.5	82	111	112	133	116	amine
82688	Pentachloronitrobenzenezene	3	2	0	2	3	1	15	10	11	16	13.5	83	112	113	112	117	nitrobenzene
25154523	Phenol, nonyl-	2	3	0	2	3	1	15	10	11	15	13.5	84	113	114	135	118	phenol
4104147	Phosacetim	3	2	0	2	3	1	15	10	11	16	13.5	85	115	116	114	119	
3468631	Pigment orange 5	3	3	0	2	1	1	15	9	10	15	11.5	86	146	146	136	152	
129000	Pyrene	3	2	0	2	3	1	15	10	11	16	13.5	87	117	118	116	120	
3383968	Temephos	2	3	0	2	3	1	15	10	11	15	13.5	88	120	121	137	121	
961115	Tetrachlorvinphos	3	2	2	2	3	1	15	12	13	20	16.5	89	46	48	48	42	
2303175	Triallate	3	2	0	2	3	1	15	10	11	16	13.5	90	123	123	120	122	
78388	Tricresyl phosphate	2	3	0	2	3	1	15	10	11	15	13.5	91	124	124	138	123	
126727	Tris(2,3-dibromopropyl)phosphate	3	2	2	3	2	1	15	12	13	21	16.5	92	48	50	39	43	
3380345	2,4,4'-Trichloro-2'-hydroxidiphenyl	3	2	0	1	3	1	14	9	10	14	12	93	130	130	140	133	
118796	2,4,6-Tribromophenol	2	2	0	3	3	1	14	10	11	16	14	94	88	90	100	97	halophenol
140669	4-(1,1,3,3-Tetramethylbutyl)phenol	2	3	0	1	3	1	14	9	10	13	12	95	131	131	145	134	phenol

84852153	4-Nonyl phenol, branched	2	3	0	1	3	1	14	9	10	13	12	96	133	133	146	135	phenol
14351509	9-Octadecenylamine, N,N-dimethyl-,	2	3	0	1	3	1	14	9	10	13	12	97	134	134	147	136	amine
7440360	Antimony	3	1	0	3	3	2	14	10	12	18	15	98	91	55	64	58	metal
7440393	Barium	3	1	0	3	3	2	14	10	12	18	15	99	92	57	65	59	metal
225514	Benz(c)acridine	3	2	0	2	2	1	14	9	10	15	12	100	136	136	125	137	PAH
7440417	Beryllium	3	1	3	3	3	2	14	13	15	24	19.5	101	28	18	16	16	metal
7440439	Cadmium	3	1	3	3	3	3	14	13	16	25	20.5	102	29	8	8	8	metal
1937377	CI Direct Black 38	3	2	2	3	1	1	14	11	12	20	15	103	60	63	44	60	
494031	Chlornaphazin	2	2	3	2	3	1	14	12	13	20	17	104	37	41	42	38	
78488	DEF (S,S,S-Tributyltrithiophosphate)	1	3	0	3	3	1	14	10	11	15	14	105	103	104	128	99	
333415	Diazinon	2	2	0	3	3	1	14	10	11	16	14	106	104	105	108	100	
26761400	Diisodecyl phthalate	2	3	0	1	3	1	14	9	10	13	12	107	137	137	148	138	pthalate
28553120	Diisononyl pthalate	2	3	0	1	3	1	14	9	10	13	12	108	138	138	149	139	pthalate
298044	Disulfoton	2	2	0	3	3	1	14	10	11	16	14	109	105	106	109	101	
319857	Hexachlorocyclohexane, beta	3	2	2	2	2	1	14	11	12	19	15	110	76	78	54	66	chlorinated cyclohexane
319868	Hexachlorocyclohexane, delta	3	2	0	2	2	1	14	9	10	15	12	111	139	139	129	140	
	Additional 49 substances from expert opinion not ranked high by WPMT *(note metals and Furans appear)*																	
7440020	Nickel	3	1	3	2	3	3	14	12	15	23	19	112	44	26	27	27	metal
135886	N-phenyl-2-napthalenamine	2	2	0	3	3	1	14	10	11	16	14	113	110	111	111	102	amine
556672	Octamethyl cyclotetrasiloxane	2	3	0	1	3	1	14	9	10	13	12	114	143	143	151	141	
9036195	Octylphenoxy polyethoxyethanol	2	3	0	1	3	1	14	9	10	13	12	115	144	144	152	142	
434640	Perfluorotoluene	3	2	0	2	2	1	14	9	10	15	12	116	145	145	134	143	
298022	Phorate	2	2	0	3	3	1	14	10	11	16	14	117	114	115	113	103	
98511	p-tert-Butyltoluene	2	3	0	2	2	1	14	9	10	14	12	118	147	147	141	144	
50555	Reserpine	3	2	0	3	1	1	14	9	10	16	12	119	148	148	117	145	
57249	Strychnine	3	1	0	3	3	1	14	10	11	17	14	120	118	119	96	104	
3689245	Sulfotep	2	2	0	3	3	1	14	10	11	16	14	121	119	120	118	105	
13071799	Terbufos	2	2	0	3	3	1	14	10	11	16	14	122	121	122	119	106	
7440280	Thallium	3	1	0	3	3	2	14	10	12	18	15	123	122	86	73	69	metal
78308	Tri-o-cresyl phosphate	2	3	0	2	2	1	14	9	10	14	12	124	149	149	142	146	
101020	Triphenyl phosphite	2	3	0	1	3	1	14	9	10	13	12	125	150	150	153	147	
7440382	Arsenic	3	1	3	3	2	3	13	12	15	24	19	126	35	16	15	22	metal
56235	Carbon tetrachloride	3	1	3	3	2	1	13	12	13	22	17	127	36	39	31	37	chlorinated aliphatic
7440473	Chromium	3	1	3	3	3	3	13	13	16	25	20.5	128	30	10	10	10	metal
7439921	Lead	3	2	2	3	3	3	13	13	16	24	20	129	32	14	20	15	metal
120821	1,2,4-Trichlorobenzenezene	2	2	0	2	2	1	12	8	9	13	11	130	151	151	143	153	chlorbenzene
528290	1,2-Dinitrobenzenezene	2	1	0	3	3	1	12	9	10	15	13	131	126	126	122	124	nitrobenzene
99354	1,3,5-Trinitrobenzenezene	2	1	0	3	3	1	12	9	10	15	13	132	128	128	123	126	nitrobenzene

541731	1,3-Dichlorobenzenezene	2	2	0	2	3	1	12	9	10	14	12.5	133	129	129	139	132	chlorbenzene
71432	Benzene	2	1	2	3	3	3	12	11	14	21	18	134	54	31	36	31	aromatic
1464535	Diepoxybutane	2	1	2	3	3	1	12	11	12	19	16	135	70	72	52	46	
98953	Nitrobenzenezene	2	1	0	3	3	1	12	9	10	15	13	136	141	141	131	130	nitrobenzene
91598	2-Naphthylamine	2	1	2	3	2	1	11	10	11	18	14.5	137	89	91	62	70	amine
119937	3,3'-Dimethylbenzenezidine	2	1	2	3	2	1	11	10	11	18	14.5	138	90	92	63	71	methylbenzene
108429	3-Chloroaniline	2	1	2	0	3	1	11	8	9	13	11.5	139	152	152	144	148	
92875	Benzidine	2	1	3	3	2	1	11	11	12	20	16	140	55	58	41	44	
75218	Ethylene oxide	2	1	3	3	2	1	11	11	12	20	16	141	73	75	45	48	
96457	Ethylene thiourea	2	1	2	3	2	1	11	10	11	18	14.5	142	106	107	69	86	
121755	Malathion	2	1	0	2	3	1	11	8	9	13	11.5	143	153	153	150	150	
496720	1,2-Diamino-4-methylbenzenezene	2	1	0	2	2	1	10	7	8	12	10	144	154	154	154	156	methylbenzene
1120714	1,2-Oxathiolane, 2,2-dioxide	2	1	2	3	1	1	10	9	10	17	13	145	127	127	75	125	
106478	4-Chloraniline	2	1	2	2	2	1	10	9	10	16	13	146	132	132	101	127	
79447	Carbamic chloride, dimethyl-	2	1	3	3	1	1	10	10	11	19	14.5	147	94	95	49	77	
108907	Chlorobenzenezene	2	1	0	2	2	1	10	7	8	12	10	148	156	156	156	157	chlorobenzene
542881	Chloromethyl ether	2	1	3	3	1	1	10	10	11	19	14.5	149	98	99	50	79	methyl ether
107302	Chloromethyl methyl ether	2	1	3	3	1	1	10	10	11	19	14.5	150	99	100	51	80	methyl ether
1116547	N-Nitrosodiethanolamine	2	1	3	3	1	1	10	10	11	19	14.5	151	108	109	57	92	amine
75014	Vinyl chloride	2	1	3	3	1	1	10	10	11	19	14.5	152	125	125	60	96	
107131	Acrylonitrile	1	1	2	3	2	1	9	9	10	16	13.5	153	135	135	102	109	
353504	Carbonic difluoride	1	1	0	3	2	1	9	7	8	12	10.5	154	155	155	155	154	fluoride
924163	N-Nitrosodi-n-butylamine	1	1	3	3	2	1	9	10	11	18	15	155	109	110	72	68	amine
144490	Fluoroacetic acid	1	1	0	3	1	1	8	6	7	11	9	156	158	158	158	158	acid
110009	Furans	1	1	0	3	1	1	8	6	7	11	9	157	159	159	159	159	
75092	Methylene chloride	1	1	1	2	2	1	8	7	8	12	10.5	158	157	157	157	155	chloride
75150	Carbon disulfide	1	1	0	2	1	1	7	5	6	9	7.5	159	160	160	160	160	sulfide
1332214	Asbestos	3	1	3	3	1	1	3	11	12	21	15.5	160	53	56	35	53	

[1]Values: 1 = low value, 2 = moderate, 3 = high according to WPMT (USEPA waste prioritization and minimization tool) database.
[2]wpmt = EPA WPMT total score as it appears in database.
[3]Total criterion utility values using weightings from algorithms A–D.
[4]Substance utility ranking (1 = first, 2 = second, etc.) by wpmt vs algorithms A–D.

APPENDIX B

Result of Stage IV Selection (32 to 15)

PL15	CAS#	Chemical Name	Type	Total 1-50[1]
*	57749	*Chlordane (Toxychlor)*		*35*
*	50293	*DDT, p,p'-*		*28*
1	**309002**	**Aldrin** (Octalene, HHDN)	organochlorine pesticide	***27***
2	**76448**	**Heptachlor**	organochlorine pesticide	***27***
3	**118741**	**Hexachlorobenzene**	organochlorine pesticide	***27***
4	**7440439**	**Cadmium** (ions and compounds)	metal	***26***
5	**60571**	**Dieldrin (Alvit)**	organochlorine pesticide	***26***
6	**7440382**	**Arsenic** (ions and compounds)	metal	***25***
*	1336363	*PCBs*		*25*
7	**56235**	**Carbon tetrachloride**	solvent	***24***
8	**7440473**	**Chromium** (ions and compounds)	metal	***24***
9	**91941**	**3,3'-Dichlorobenzidine**	organochlorine pesticide	***23***
10	**7439921**	**Lead** (ions and compounds)	metal	***23***
11	**58899**	**Hexachlorocyclohexane, gamma- (Lindane)**	secondary organic pollutant	***22***
12	***8001352***	**Toxaphene** (Camphechlor)		***22***
13	**50328**	**Benzo(a)pyrene**	secondary organic pollutant	***21***
14	**7440020**	**Nickel** (ions and compounds)	metal	***21***
	101144	4,4'-Methylenebis(2-chloraniline)		*20*
	7440417	Beryllium (ions and compounds)		*20*
13	**53703**	**Dibenz(a,h)anthracene**	secondary organic pollutant	***19***
13	**56553**	**Benzo(a)anthracene**	secondary organic pollutant	***18***
15	**1746016**	**2,3,7,8-Tetrachlorodibenzo-p-dioxin**		***17***
	143500	Kepone (Chlordecone)		*17*
13	**205992**	**Benzo(b)fluoranthene**	secondary organic pollutant	***16***
13	**57976**	**7,12-Dimethylbenz(a)anthracene**	secondary organic pollutant	***15***
	56531	Diethylstilbestrol		*15*
13	**56495**	**3-Methylcholanthrene**	secondary organic pollutant	***14***
	1024573	Heptachlor epoxide		*14*
13	**189559**	**Benzo(rst)pentaphene**	secondary organic pollutant	***12***
	2385855	Mirex		*11*
	319846	Hexachlorocyclohexane, alpha-		*6*
	1836755	2,4-Dichloro-1-(4-nitrophenoxy)benzene		*5*

[1]Total 1–50 is the utility total for 50 data sources. Each appearance is 1 point; in the case of the Massachusetts Substance List sub-criterion 1 point for cancer effects, 2 points if cancer and non-cancer effects. * Substances already under tri-national agreement. Bolded substances with number in the PL15 column are fifteen priority substances selected.

APPENDIX C

Database for Stage V Selection (15 to 7)

PL15#	CAS#	Chemical Name	Exposure potential in Mexico					
			EE	v	OE	v	GE	GEn
1	7440439	Cadmium (ions and compounds)	medium	2	high	3	5	1.0
2	309002	Aldrin (Octalene, HHDN)	low (residual)	1	low (prohibited)	1	2	0.4
3	76448	Heptachlor (Velsicol 104, Drinox, Heptagran)	low (residual)	1	low (prohibited)	1	2	0.4
4	118741	Hexachlorobenzene	low (residual)	1	low (prohibited)	1	2	0.4
5	7440382	Arsenic (ions and compounds)	medium	2	low	1	3	0.6
6	7440473	Chromium (ions and compounds)	medium	2	high	3	5	1.0
7	60571	Dieldrin (Alvit)	low (residual)	1	low (prohibited)	1	2	0.4
8	56235	Carbon tetrachloride	low	1	high	3	4	0.8
9	7439921	Lead (ions and compounds)	medium	2	high	3	5	1.0
10	91941	3,3'-Dichlorobenzidine	low	1	high	3	4	0.8
11	7440020	Nickel (ions and compounds)	medium	2	high	3	5	1.0
12	58899	Hexachlorocyclohexane, gamma- (Lindane)	medium	2	medium	2	4	0.8
13	8001352	Toxaphene (Camphechlor)	low (residual)	1	low (prohibited)	1	2	0.4
14 Polycyclic aromatic hydrocarbons								
14	50328	Benzo(a)pyrene	*medium*	2	*medium*	2	4	0.8
14	56495	3-Methylcholanthrene						
14	57976	7,12-Dimethylbenz(a)anthracene						
14	56553	Benzo(a)anthracene						
14	205992	Benzo(b)fluoranthene						
14	189559	Benzo(rst)pentaphene						
14	53703	Dibenz(a,h)anthracene						
15 Dioxins								
15	1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin	medium	2	medium	2	4	0.8

CAS#	Carcinogenic effects in humans (C)												
	IARC	v	ACGIH	v	Cal	v	NTP	v	OSHA	v	EPA	C	Cn
7440439	1	3	A2	3	yes	1	suspect	1	suspect	1	med	6	**1.0**
309002	3	1	A3	2	yes	1	-	0	-	0	high	3	**0.5**
76448	2B	2	A3	2	yes	1	-	0	yes	1	high	4	**0.7**
118741	2B	2	A3	2	yes	1	suspect	1	suspect	1	med	4	**0.7**
7440382	1	3	A1	3	yes	1	-	0	-	0	high	6	**1.0**
7440473	3	1	A4	1	-	0	-	0	-	0	-	2	**0.3**
60571	3	1	A4	1	yes	1	-	0	-	0	high	2	**0.3**
56235	2B	2	A2	3	yes	1	suspect	1	suspect	1	med	5	**0.8**
7439921	2B	2	A3	2	yes	1	-	0	suspect	1	-	4	**0.7**
91941	2B	2	A3	2	yes	1	suspect	1	suspect	1	med	4	**0.7**
7440020	2B	2	A1	3	yes	1	suspect	1	suspect	1	low	5	**0.8**
58899	-	0	A3	2	yes	1	suspect	1	suspect	1	med	2	**0.5**
8001352	2B	2	A3	2	yes	1	suspect	1	suspect	1	med	4	**0.7**
PAHs													
50328	2A	2	A2	3	yes	1	suspect	1	suspect	1	high	5	**0.8**
56495													
57976													
56553													
205992													
189559													
53703													
Dioxins													
1746016	2B	2			yes	1	-		suspect	1	-	-	**0.7**

	Noncancer effects in humans (NC)										Effects on animals (E)		
CAS#	Repro-rh	v	ACGIHskin	v	III-endo	v	NIOS-orgs/h	v	NC	NCn	NIOS-orgs/a	NTPcan/a	E
7440439	A-	3	-	0	yes	1	lung, prostate, respiratory system, kidney, blood	3	7	0.9	-	-	1.0
309002	B+	2	yes	1	yes	1	CNS, liver, kidney, skin	3	7	0.9	tumors in lung, liver ,thyroid, adrenal gland	rats: m?, f? mice: m+, f-	1.0
76448	A-	3	yes	1	yes	1	CNS, liver	3	8	1.0	liver cancer	rats: m-, f? mice: m+, f+	1.0
118741	-	-	yes	1	yes	1	liver, kidney, skin, CNS, lung	3	-	0.8	-	-	1.0
7440382	A-	3	-	0	-	0	lung, lymph, liver, kidney, skin	3	6	0.8	-	-	1.0
7440473	B+	2	-	0	-	0	respiratory system, skin, eyes	3	5	0.6	-	-	1.0
60571	A-	3	yes	1	yes	1	CNS, liver, skin, kidney	3	8	1.0	lung, liver, thyroid, adrenal tumor	rats: m-, f- mice: m?, f-	1.0
56235	B+	2	yes	1	-		CNS, eyes, lung, liver, kidney, skin	3	6	0.8	liver cancer	-	1.0
7439921	A+	3	-	0	yes	1	GI tract, CNS, kidney, blood, gingival, eye	3	7	0.9	-	-	1.0
91941	nd	nd	yes	1	-	0	bladder, liver, lung, skin, GI tract	3	-	0.1	liver and bladder cancer	-	1.0
7440020	B	2	-	0	-	0	lung, skin, nasal,	3	5	0.6	-	-	1.0
58899	A-	3	yes	1	yes	1	eye, CNS, blood, liver, kidney, skin, respiratory system	3	8	1.0	-	rats: m-, f- mice: m-, f-	1.0
8001352	B+	2	yes	1	yes	1	CNS, skin	3	7	0.9	liver cancer	rats: m?, f? mice: m+, f+	1.0
PAHs													
50328	B+	2	-	0	-	0	eye, skin	3	5	0.6	-	-	1.0
56495													
57976													
56553													
205992													
189559													
53703													
Dioxins													
1746016	A-	3					liver, skin, CNS, eye	3	6	0.8	-	-	1.0

Bioaccumulation (B)				P	SC	TOT	Gp	Score	PL7
logKow	BCF	v	Bn						
na	1/2 life 10+yr	4	0.8	0.9	0.9	0.91	*1.0*	0.93	YES
6.5	100-10000	5	1.0	1.0	1.0	0.83	*1.0*	0.83	NO
5.5	100-10000	5	1.0	1.0	1.0	0.87	*1.0*	0.87	YES
5.5	log 3.7-4.5	5	1.0	1.0	1.0	0.86	*1.0*	0.86	YES
na	moderate	-	0.5	1.0	1.0	0.84	*1.0*	0.84	NO
na	100-100000	3	0.8	1.0	0.9	0.80	*1.0*	0.80	NO
-	100-10000	3	1.0	1.0	1.0	0.81	*1.0*	0.81	NO
2.83	14-18	1	0.5	1.0	1.0	0.84	*1.0*	0.84	NO
na	log 1.4-3.2	3	0.8	0.9	0.8	0.87	*1.0*	0.87	YES
3.02	114-940	2	0.6	1.0	1.0	0.74	*1.0*	0.74	NO
na	moderate	-	0.5	1.0	0.9	0.83	*1.0*	0.83	NO
3.6	100-1000	2	0.8	0.7	1.0	0.83	*1.2*	0.99	YES
3.3	100-10000	3	1.0	1.0	1.0	0.86	*1.0*	0.86	NO
PAHs									
6.04	100-10000	3	1.0	0.9	0.9	0.83	*1.2*	0.99	YES
Dioxins									
-	1000	3	0.9	1.0	0.9	0.9	*1.1*	0.96	YES

EE Environmental exposure potential in Mexico
OE Occupational exposure potential in Mexico
GE Exposure potential in Mexico
C Human toxicity—cancer
NC Human toxicity—non-cancer
E Ecotoxicity
B Bioaccumulation potential
P Persistence
SC Socio-political feasibility
v Utility value assigned to sub-criterion
Gen, Cn, NCn, En, SCn, and Bn are normalized utility values in the range 0–1.0
TOT Total utility value of above criteria normalized against maximum (7.0)
Gp Presence in a chemical substance group (multiplier of TOT)
SCORE Final utility (TOT − Gp)
PL7 Qualifies for top seven list PL7

Cancer effects
IARC = IARC group designation
ACGIH = ACGIH group: A1 = confirmed human carcinogen; A2 = suspected human carcinogen; A3 = confirmed animal carcinogen; A4 = suspected animal carcinogen
Cal = included in California's list of carcinogens
NTP = cancer designation of National Toxicology Program
OSHA = cancer designation of Occupational Safety and Health Agency
EPA = EPA cancer risk level from exposure to substance

Non-cancer effects
Repro-rh = Reprotox® System classification in TOMES CPS® System compact-disk database
ACGIHskin = toxic to skin according to ACGIH
III-endo = endocrine disruptor according to the Illinois Proposed List: probable effects in animals
NIOS-orgs/h = target human organs according to U.S. National Institute of Occupational Safety and Health (NIOSH)

Effects on animals ("ecotoxicity")
NIOS-orgs/a = target animal organs according to NIOSH
NTPcan/a = tumorgenesis in rats and mice: m+ male positive; f+ female positive; m− male negative; f− female negative.

Bioaccumulation potential
Log Kow = $\log\text{arithm}_{10}$ of octanol/water partition coefficient
BCF = bioaccumulation factor range of value

Note: Contact authors for complete data sources.

APPENDIX D

Final Stage VI Comparison between PL7 Substances

Chemical Name	Criteria										Totals by algorithms			Ranking by algorithms		
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	1-10	3-9	3-5,8,9			
	SC	TC	C*	NC*	E	OE	EE	B*	P*	Gp						
Ti weights	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	Ti	Tii	Tiii	Ri	Rii	Riii
Tii	*0*	*0*	*1*	*2*	*1*	*1*	*1*	*1*	*1*	*0*						
Tiii	*0*	*0*	*1*	*1*	*1*	*0*	*0*	*1*	*1*	*0*						
BaP + PAHs	0.9	0.5	0.8	0.6	1.0	0.6	0.6	1.0	1.0	1.0	8.0	6.2	4.4	=1st	=4th	4th
Cadmium	**0.7**	**0.7**	**1.0**	**0.9**	**1.0**	**0.9**	**0.6**	**0.8**	**0.9**	**0.0**	**7.5**	**7.0**	**4.6**	**3rd**	**1st**	**2nd**
HCB	1.0	1.0	0.7	0.8	1.0	0.3	0.2	1.0	1.0	0.0	7.0	5.8	4.5	6th	6th	=3rd
Heptachlor	1.0	1.0	0.7	1.0	1.0	0.3	0.2	1.0	1.0	0.0	7.2	6.2	4.7	5th	=4th	1st
Lead	0.7	0.7	0.7	0.9	1.0	1.0	0.7	0.8	0.9	0.0	7.4	6.9	4.3	4th	2nd	5th
Lindane	1.0	1.0	0.5	1.0	1.0	0.5	0.5	0.7	0.7	1.0	7.9	5.9	3.9	2nd	5th	6th
2,3,7,8-TCDD + PCDDs	**0.9**	**0.5**	**0.7**	**0.8**	**1.0**	**0.5**	**0.6**	**1.0**	**1.0**	**1.0**	**8.0**	**6.4**	**4.5**	**=1st**	**3rd**	**=3rd**

See Appendix C or Table 1 for criterion codes.
Scores are normalized values with 1.0 maximum. Bolded substances have consistently high priority.
*Original criterion in SMOC preliminary documents and guidelines (C and NC combined).

TC Technical control feasibility
Ti Total score by algorithm i (sum of all criteria 1–10)
Tii Total score by algorithm ii (sum of hazard criteria 3–9, giving weight of 2.0 to non-cancer effects)
Tiii Total score by algorithm iii (sum of original hazard criteria 3–5, 8, 9)
Ri-iii Ranking by algorithms i, ii, iii