3. Initial Evaluation and Screening of Alternative Replacement Chemicals

3.1 GreenScreen® Evaluation

The initial evaluation and screening of alternative replacement chemicals used GreenScreen® version 1.2 hazard assessment tool. GreenScreen® includes threshold values or criteria to determine a hazard classification for each hazard endpoint. These classifications include a 3-point, 4-point, or 5-point ranking scheme—e.g., "very high," "high," "moderate," "low" or "very low" (a 5-point ranking scheme). Criteria used for the hazard classifications are derived from authoritative lists of chemicals of concern as well as criteria from the Globally Harmonized System for the Classification and Labeling of Chemicals (GHS) and the U.S. EPA Design for the Environment (DfE) Program Alternatives Assessment Criteria for Hazard Evaluation.

Hazard classifications include notations reflecting the level of confidence in the evidence used. Where no evidence was available, data gaps are also noted. Once the hazards are classified, GreenScreen® includes a decision framework that weights hazard endpoints and classifications to establish Benchmark scores.[21] The Benchmark scoring process applies greater weight to human health endpoints versus ecotoxicity and physicochemical characteristics, and among the human health endpoints, applies greater weight to carcinogenicity, mutagenicity, reproductive toxicity, developmental toxicity, and endocrine activity. A chemical with a score of Benchmark 1 is considered a chemical of high concern and should be avoided. More preferable alternatives are given Benchmark scores of 2-4. Benchmark 2 chemicals are categorized as usable, but efforts should

TABLE 3
GreenScreen® Hazard Assessment Results

Chemical Name	CASRN	Group I Human					Group II & II Human									Ecotox		Fate		Physical	
								ST		N											
		C	M	R	D	E	AT	Single	repeated	Single	repeated	SnS	SnR	IrS	IrE	AA	CA	P	B	RX	F
Methylene chloride	75-09-2	H	NE	DG	DG	M	*M*	vH	H	*vH*	*vH*	L	DG	H	H	M	*L*	*vH*	vL	L	L
Benzyl alcohol	100-51-6	L	L	*L*	M	DG	M	L	L	*M*	*H*	H	*L*	L	H	L	L	vL	vL	*L*	L
2-(2-butoxyethoxy) ethanol	112-34-5	*L*	L	L	L	DG	L	L	H	DG	L	L	DG	*M*	H	L	L	vL	vL	*L*	M
Dimethyl sulfoxide	67-68-5	*L*	L	L	L	DG	L	L	L	L	L	L	L	*M*	*M*	L	*L*	*L*	vL	*L*	M
1,3-dioxolane	646-06-0	L	*M*	*M*	M	DG	L	M	M	M	L	L	DG	*M*	*H*	L	L	*M*	vL	*L*	H
Estasol (dibasic esters mixture)	95481-62-2	*L*	L	L	*M*	*M*	L	M	*M*	M	DG	L	DG	L	*M*	M	L	vL	vL	*M*	L
d-Limonene	5989-27-5	L	L	DG	L	DG	L	L	L	DG	DG	H	DG	H	*H*	vH	H	vL	M	*L*	M
Acetone	67-64-1	*L*	L	*M*	M	DG	L	*M*	M	M	*M*	L	DG	L	H	L	L	vL	vL	L	H
Methanol	67-56-1	NA	NA	NA	H	NA	H	vH	NA	NA	NA	NA	NA	NA	NA	L	*L*	vL	*vL*	NA	H
Toluene	108-88-3	DG	L	H	H	M	L	M	H	M	H	L	DG	H	L	H	*H*	*H*	vL	L	H
Formic acid	64-18-6	L	L	L	*L*	DG	H	vH	*H*	vH	DG	L	DG	vH	vH	M	M	vL	vL	L	M
Caustic soda	1310-73-2	*L*	L	*L*	*L*	*L*	H	vH	*L*	*L*	*L*	L	DG	vH	vH	M	DG	*L*	*vL*	*M*	L

Abbreviations
C = Carcinogenicity
M = Mutagenicity
R = Reproductive Toxicity
D = Developmental Toxicity
E = Endocrine Activity
AT = Acute Toxicity
ST = Systemic Organ Toxicity
N = Neurotoxicity
SnS = Skin Sensitization
SnR = Respiratory Sensitization
IrS = Skin Irritation
IrE = Eye Irritation
AA = Aquatic Toxicity
CA = Chronic Aquatic Toxicity
P = Persistence
B = Bioaccumulation
RX = Reactivity
F = Flammability

Note
Hazard levels (Very High (vH), High (H), Moderate (M), Low (L), Very Low (VL) in italics reflect estimated (modeled values, authoritative B lists, screening lists, weak analogues, and lower confidence. Hazard levels in BOLD are used with good quality data, authoritative A lists, or strong analogues. Group II Human Health endpoints differ from Group II Human Health endpoints in that they have four hazard scores (i.e., vH, H, M and L) instead of three (i.e., H, M and L), and are based on single exposures instead of repeated exposures. DG indicates insufficient data for assigning hazard level. NE indicates no determination was made (conflicting data).

be taken to find safer alternatives. Benchmark 3 chemicals are those with an improved environmental health and safety profile but could still be improved. Chemicals that reach Benchmark 4 are considered safer chemicals and are therefore the most preferred. For a full description of GreenScreen® version 1.2 method see the GreenScreen® website.[22]

GreenScreen® evaluations for all but one of the candidate alternatives, toluene, were conducted by ToxServices. The hazard assessment for toluene—also using GreenScreen® —was publicly available through the Interstate Chemicals Clearinghouse (IC2) hazard assessment database.[23] The GreenScreen® for methylene chloride was also retrieved from IC2 hazard assessment database. Both sources included quality control evaluations. Appendix 2 provides the results from the GreenScreen® hazard assessments. The GreenScreen® evaluations conducted by ToxServices are proprietary. The public version of this report only contains executive summaries (although full reports would be provided to DTSC for review). Table 3 lists the summary results from the GreenScreen® hazard assessments.

The GreenScreen® Benchmarks™ for methylene chloride and each of the candidate alternatives are described in Table 4 along with the hazard endpoints that are the primary drivers of the Benchmark scores.

Methanol and toluene received a Benchmark 1 score: "Avoid—Chemical of High Concern."[24] Methanol was classified as having "high" developmental toxicity while toluene similarly demonstrated "high" developmental toxicity as well as "high" reproductive toxicity based on authoritative lists. Methanol is the most frequently used co-solvent in current methylene chloride paint stripping formulations, highlighting the need for a broader "formulation perspective" with regards to hazard. As stated earlier, feasible formulations identified in Stage 2 will be subsequently

TABLE 4
GreenScreen® Hazard Assessment Benchmarks

Chemical	CASRN	Benchmark	Benchmark Explanation	Benchmark Reason (Primary Hazard Endpoints of Concern)
Methylene chloride	75-09-2	1	Avoid Chemical of High Concern	"High" carcinogenicity
Benzyl alcohol	100-51-6	2	Use but Search for Safer Substitutes	"Moderate" developmental toxicity; "High" neurotoxicity (repeated dose) and skin sensitization
2-(2-butoxyethoxy) ethanol	112-34-5	2	Use but Search for Safer Substitutes	"High" systemic toxicity (repeated dose)
Dimethyl sulfoxide (DMSO)	67-68-5	3	Use but Still Opportunity for Improvement	"Moderate" toxicity associated with skin irritation & eye irritation; "Moderate" flammability
1,3-dioxolane	646-06-0	2	Use but Search for Safer Substitutes	"Moderate" mutagenicity, reproductive toxicity and developmental toxicity; "High" flammability
Estasol (dibasic esters mixture)	95481-62-2	2	Use but Search for Safer Substitutes	"Moderate" developmental toxicity and endocrine activity
d-Limonene	5989-27-5	2	Use but Search for Safer Substitutes	"Very high" acute ecotoxicity and "high" toxicity associated with skin sensitization
Acetone	67-64-1	2	Use but Search for Safer Substitutes	"Moderate" developmental toxicity & reproductive toxicity and "high" flammability
Methanol	67-56-1	1	Avoid Chemical of High Concern	"High" reproductive and developmental toxicity
Toluene	108-88-3	1	Avoid Chemical of High Concern	"High" developmental toxicity
Formic acid	64-18-6	2	Use but Search for Safer Substitutes	"Very High" toxicity associated with skin irritation, eye irritation & systemic toxicity (single dose) & neurotoxicity (single dose); "High" systemic toxicity (repeated dose)
Caustic soda	1310-73-2	2	Use but Search for Safer Substitutes	"Very High" toxicity associated with skin irritation, eye irritation & systemic toxicity (single dose)

CASRN = Chemical Abstracts Service Registration Number

■ GreenScreen Benchmark 1: Chemical of High Concern—Avoid.

■ GreenScreen Benchmark 2: Use but search for something safer.

■ Use but Still Opportunity for Improvement.

screened using authoritative lists (rather than a complete GreenScreen® evaluation on all chemicals given the sheer number of chemicals and associated costs).

With the exception of dimethyl sulfoxide (DMSO), all other candidate alternatives received a Benchmark 2 score: "Use but Search for Safer Substitutes." The majority of these Benchmark 2 chemicals are associated with eye irritation and nearly half are associated with skin irritation, with two of the chemicals associated with skin sensitization. Other concerns for Benchmark 2 chemicals included: developmental and reproductive toxicity associated with acetone, systemic toxicity (kidney and respiratory toxicity) associated with formic acid and caustic soda, neurotoxicity associated with acetone, benzyl alcohol and formic acid, aquatic toxicity associated with d-limonene, and high flammability concerns related to acetone and 1,3-dioxolane.

While the hazard severity of DMSO associated with the range of endpoints examined was deemed lower than other candidate alternatives, DMSO has the capacity to potentiate the toxicity of other chemicals that are included in the final product formulation or other chemicals that users are in contact with while using a DMSO-containing product. It is well established that DMSO is a penetration enhancer of dermally applied/exposed substances.[25] Should DMSO be further considered as a potential alternative given Stage 2 analysis results, a deeper examination of the hazards of other formulation chemicals is *essential* since DMSO will increase the toxicity potency of chemicals contained in the formulation.

3.2 Chemicals De-Selected for Stage 2

Table 5 lists chemicals that have been de-selected for further consideration. Methanol was classified as having "high" developmental toxicity while toluene similarly demonstrated "high" developmental toxicity as well as "high" reproductive toxicity. As in the case of NMP (described in Section 2.1), both methanol and toluene are considered reproductive/developmental toxicants under California's Proposition 65 and are included on DTSC's list of candidate chemicals. Given that these decision rules guided the de-selection of NMP, they should also guide the de-selection of methanol and toluene.

TABLE 5
Chemicals De-Selected for Further Assessment in California SCP Stage 2 Alternatives Analysis

De-selected alternative	CASRN	Reason for De-selection
Methanol	67-56-1	Developmental toxicant—Listed on CA Prop 65 and DTSC's Candidate List of Chemicals
Toluene	108-88-3	Developmental & reproductive toxicant—Listed on CA Prop 65 and DTSC's Candidate List of Chemicals

TABLE 6
Chemicals Selected for Further Assessment in California SCP Stage 2 Alternatives Analysis

Chemical	CASRN
Benzyl alcohol	100-51-6
2-(2-butoxyethoxy) ethanol	112-34-5
Dimethyl sulfoxide (DMSO)	67-68-5
1,3-dioxolane	646-06-0
Estasol (dibasic esters mixture)	95481-62-2
d-Limonene	5989-27-5
Acetone	67-64-1
Formic acid	64-18-6
Caustic soda	1310-73-2

All chemicals in Table 3 were cross-referenced with DTSC's Candidate Chemical List. In addition to those identified in Table 5, caustic soda is also included on DTSC's Candidate Chemical List due to ocular, respiratory and dermal toxicity as identified by reference exposure levels (RELs) established by the California Office of Environmental Health Hazard Assessment under Health and Safety Code section 44360(b)(2).

Table 6 includes the nine chemicals that BizNGO will advance to the Stage 2 analysis of the SCP regulations. Stage 2 will focus, depending on the availability of data, on the evaluation of additional hazards not considered in the GreenScreen® assessment and additional environmental impacts. Stage 2 will also focus on preventing the shifting of negative impacts from one environmental or human heath endpoint to another by reviewing available multi-media life cycle information. Product performance and economic impacts will be assessed in Stage 2 as well.

4. Consideration of Additional Information

The U.S. EPA is currently examining alternatives for methylene chloride paint strippers. This screening analysis should be reexamined in light of new or different information that emerges in the U.S. EPA report, which is expected to be released as a draft in spring 2016. In addition, the literature will be monitored as outlined in Section 5 for substantive changes in the evidence (e.g., updated review by authoritative sources that increases the severity classification of a chemical on an authoritative list) used for classifying candidate alternatives. If substantive changes are identified that alter the hazard assessment, the assessment will be updated to aid in decision making during the Stage 2 analysis.