Staff Responses to State Government Query on Chemicals for Biomonitoring

A Report of the California Environmental Contaminant Biomonitoring Program

February 2009

Preface

The California Environmental Contaminant Biomonitoring Program (CECBP or "the Program") is a new initiative that will measure levels of environmental chemicals in California residents. Three departments are involved in implementing the Program: the California Department of Public Health (CDPH), the Office of Environmental Health Hazard Assessment (OEHHA), and the Department of Toxic Substances Control (DTSC), . The CECBP was authorized by the State Legislature and signed into law by Governor Schwarzenegger in 2006. The law calls for the Program to systematically collect biological specimens, such as blood and urine, from California residents and to analyze them for the presence of designated environmental chemicals.

The primary goals of the Program are to:

- Determine levels of environmental chemicals in a representative sample of Californians;
- Establish trends in the levels of these chemicals over time;
- Assess the effectiveness of public health efforts and regulatory programs to reduce exposures of Californians to specific chemicals; and
- Provide opportunities for meaningful public participation through activities and materials that are understandable and sensitive to the diverse needs of Californians.

This report summarizes state staff responses to CECBP's State Government Query on chemicals to be considered for biomonitoring. OEHHA staff administered the Query and prepared the report by distilling and organizing the responses.

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INTRODUCTION

This report summarizes responses to the California Environmental Contaminant Biomonitoring Program (CECBP) State Government Query (see Appendix). The Query consisted of eight questions, which were designed to elicit information from state staff on chemicals considered to be good candidates for biomonitoring.

The Office of Environmental Health Hazard Assessment (OEHHA) identified state staff based on their programmatic responsibilities, knowledge and experience in their particular fields, and by referral. OEHHA contacted staff from a variety of state programs in several different agencies and departments, as shown below. In some cases, several programs within a department were contacted.

- California Environmental Protection Agency
    - California Air Resources Board (CARB)
    - California Integrated Waste Management Board
    - Department of Pesticide Regulation (DPR)
    - Department of Toxic Substances Control
    - State Water Resources Control Board
    - OEHHA
- California Department of Public Health (CDPH)
    - Birth Defects Monitoring Program
    - Division of Drinking Water and Environmental Management
    - Environmental Health Investigations Branch
    - Food, Drug and Radiation Safety Division
    - Occupational Health Branch
- California Department of Industrial Relations, Division of Occupational Safety and Health
- California Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation
- Regional Air Quality Management Districts (Bay Area, South Coast)
- Air Pollution Control District (San Joaquin Valley Unified)
- Regional Water Quality Control Boards (Central Valley, San Francisco Bay)

Each staff person identified by OEHHA was sent the State Government Query, as well as the list of chemicals biomonitored by the Centers for Disease Control and Prevention (CDC) in the National Health and Nutrition Examination Survey (NHANES) 2003-2004 (available at: http://www.cdc.gov/ExposureReport/pdf/NHANES03-04List_03_2007.pdf). The CECBP enabling legislation (California Health and Safety Code, Section 105440 *et seq.*) identified chemicals biomonitored by the CDC as the initial set of designated chemicals, from which the Program can select priority chemicals to biomonitor.

Interviews with state staff were generally conducted by telephone. Most individuals contacted offered their own comments or suggestions. Some staff discussed the questions with colleagues and provided pooled comments of various staff members. In several cases the contacted staff member invited other staff to the telephone interview so that more than one person participated. Some individuals responded by email or sent comments by email instead of or in addition to the telephone interview. Some staff also passed the questions to colleagues who sent emails of their own with comments or suggestions.

The report is divided into three sections. Section I summarizes general chemical categories and specific chemicals in these categories that were suggested by state staff for biomonitoring or otherwise considered to be of concern. These categories include: classes of chemicals already biomonitored by CDC in 2003-2004 (e.g., metals, phthalates, polybrominated diphenyl ethers [PBDEs], volatile organic compounds); other chemical classes not currently biomonitored by CDC (e.g., nanoparticles); chemicals associated with specific biological effects (e.g., endocrine disruptors); and chemical categories associated with specific exposures (e.g., via chemicals in consumer products). Many of these categories overlap. Section II summarizes input from state staff on specific criteria for selecting chemicals to biomonitor. Section III provides other general comments and suggestions from staff about chemical selection.

Throughout the report, chemical classes/families and specific chemicals (or their metabolites) that were biomonitored by CDC for the NHANEs 2003-2004 are labeled with the symbol " ♦ ".

SECTION I: General Categories and Specific Chemicals Suggested for Biomonitoring

Section I summarizes general categories and specific chemicals in each category that were suggested by state staff for biomonitoring and/or otherwise were considered to be a concern in California because of exposures and/or known or potential adverse effects. The categories include: chemicals and classes of chemicals biomonitored by CDC in 2003-2004; other chemical classes not already biomonitored by CDC; chemicals or chemical categories associated with specific biological effects; and chemical categories associated with specific exposures. Many of these categories overlap. All suggestions made by state staff are included below, without regard to whether or not biomonitoring would be practical.

Air contaminants

Many staff considered the general category "air contaminants" to be of concern. Some staff specified particular categories of air contaminants, including: traffic-related air pollutants, tobacco smoke♦, particulate matter, polycyclic aromatic hydrocarbons (PAHs)♦, solvents, volatile organic compounds (VOCs)♦, chemicals used in cleaning and maintenance, air pollutants related to wood burning, asbestos, crystalline silica and, as a category, those chemicals identified as Toxic Air Contaminants by the State of California. Staff comments on traffic-related pollutants and tobacco smoke are provided in the following paragraphs, while PAHs, solvents, VOCs, and chemicals used in cleaning and maintenance are discussed as separate categories below.

Traffic-related air pollutants: Staff from several programs stated that exposure to traffic-related air contaminants was likely greater in California because of the heavy traffic in certain parts of the state. Specifically named traffic-related contaminants included: acetaldehyde (see VOCs), benzene♦ (see VOCs), 1,3-butadiene (see VOCs), carbon monoxide, diesel exhaust, diesel exhaust particulate matter, formaldehyde (see VOCs), gasoline exhaust and vapors, nitroaromatics (including nitro-PAHs and nitrobenzene♦), nitrogen oxides, ozone, polycyclic aromatic hydrocarbons (PAHs)♦ (discussed as a class below), styrene♦ (see VOCs) and sulfur oxides. Air contaminants resulting from the use of biodiesel and biofuels were mentioned as emerging concerns.

> *Diesel engine exhaust and/or diesel particulate matter*: Staff from several programs mentioned by-products of diesel fuel combustion as appropriate for biomonitoring. Diesel engine exhaust is listed as known to cause cancer under Proposition 65. Another identified concern was an association between diesel exhaust particles and immune system effects. Staff discussed the absence of a suitable biomarker for diesel exposure, though 1-nitropyrene was suggested as a potential candidate.

Nitroaromatic compounds: Nitroaromatics (including nitrobenzene♦ and nitro-PAHs) were suggested as important traffic-related air contaminants because of potentially increased formation from heavy-duty diesel vehicles (e.g., trucks, buses, motor homes) when new selective catalytic reduction (SCR) technology is introduced for the 2010 model year. This technology will probably also be introduced at a later date in diesel passenger cars as well. The new SCR technology will inject urea into the exhaust stream to control oxides of nitrogen. Staff commented that since urea is a nitrogen-containing compound, there is a very good chance that many organo-nitrogen compounds will form. Nitrobenzene is listed as causing cancer under Proposition 65.

Tobacco smoke♦: Staff from a number of programs suggested biomonitoring cotinine♦ as a measure of cigarette smoking or environmental tobacco smoke [ETS]. Staff noted that ETS exposure may increase the effects of other contaminant exposures and needs to be considered as a covariate. For example, hypothyroidism associated with perchlorate may be exacerbated by cigarette smoke.

Chemicals in consumer products

This general category was suggested by state staff for biomonitoring because of concern that certain chemicals commonly used in consumer products, including personal care products, have been shown to have endocrine-disrupting abilities or other toxic effects, or to have been insufficiently studied. Widespread exposures to consumer products were also cited as a consideration.

Antimicrobial agents in personal care products

Triclosan♦: Staff from several programs suggested triclosan for biomonitoring. Triclosan is widely used in personal care products (e.g., liquid hand soaps, face cleaners, toothpaste, mouth rinse, cosmetics) and also in fabrics, plastics, carpets and plastic kitchenware. It is stable and likely to bioaccumulate. Staff commented that triclosan's toxicity has not been well studied but that research findings provide evidence for a number of biological effects, including endocrine disruption and inhibition of the metabolism of other environmental phenols. Staff were also concerned that widespread use of triclosan would encourage the growth of bacteria resistant to triclosan as well as potentially conferring resistance to other antimicrobials.

Triclocarban: Triclocarban was suggested for biomonitoring because it is a common ingredient in personal care products such as bar soaps and deodorants and has been found to have endocrine-disrupting properties. Staff commented that one study found approximately 75 percent of triclocarban persists during

wastewater treatment and that it accumulates in municipal sludge, some of which may later be used as fertilizer for crops.

Environmental phenols♦

Bisphenol A♦: There was widespread concern about the endocrine-disruptive potential of bisphenol A, which is used in the production of polycarbonate plastics (used in many food and drink containers) and in the production of epoxy resins (used to coat metal products such as the interiors of food cans). Staff reported that bisphenol A may potentially affect nervous and immune system development, cause other reproductive effects and promote obesity. The prenatal period and early childhood were identified as critical exposure windows.

Nonylphenol: Nonylphenol was suggested for biomonitoring because of its wide use in consumer products and industrial applications. Recent research suggests that nonylphenol has estrogenic activity, and may affect development of the nervous and immune systems, and promote obesity. It has been detected in water/sediments and/or macrovertebrates in San Francisco Bay. Nonylphenol and nonylphenol ethoxylates are used in laundry and cleaning products, in cosmetics and perfumes, as well as in industrial applications. While the nonylphenol ethoxylates degrade to nonylphenol, the latter compound degrades very slowly. Nonylphenol and nonylphenol ethoxylates have been identified as "reproductive hazards" in the European Union and banned from consumer and industrial products.

Oxybenzone (Benzophenone-3)♦: Oxybenzone was suggested for biomonitoring because it is an active ingredient in sunscreen and is also widely used in other products, and because Californians are likely to have heavier use of sunscreen compared to the national average. Staff were concerned that oxybenzone had reportedly been linked to endocrine disruption and reported that a new CDC study had found oxybenzone in nearly all people tested.

Parabens: Parabens, widely used as preservatives in cosmetics and toiletries, were suggested for biomonitoring because of concern that they are endocrine-disrupting chemicals. (Parabens as a class include methylparaben, ethylparaben, propylparaben, butylparaben, isobutylparaben, isopropylparaben, and benzylparaben). Staff commented that screening tests of individual parabens have found weak estrogenic activity. Staff also relayed that parabens have been detected in a small number of breast tumor tissue samples and that studies with butylparaben have found effects on the male reproductive system.

Methylsiloxanes: Methylsiloxanes were suggested for biomonitoring because of their widespread usage in consumer and personal care products (hair care and skin care

products, antiperspirants/deodorants), their use in dry cleaning, and their physical and chemical properties, which suggest that these chemicals may be persistent and bioaccumulative. Although, for the most part, these chemicals have not been well studied, some toxicity data are available for two methylsiloxanes.

> *Octamethyl cyclotetrasiloxane (D4)*: D4 is widely used in industry, in household products and in cosmetics. In cosmetics, it is often in mixtures with other methylsiloxanes, D5 and D6. Animal studies have found that D4 is estrogenic and that it has been found in human adipose tissue samples.
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> *Decamethylcyclopentasiloxane (D5)*: D5 is also used widely in personal care products. D5 is being used as an alternative to perchloroethylene in dry cleaning. Evidence suggests that D5 is persistence and bioaccumulative, and that it has been associated with uterine tumors in animal studies.

Artificial or synthetic musks: Synthetic musks were suggested for biomonitoring because of their wide use as fragrance ingredients in perfumes, soaps, and household cleaning products, and because of their persistence and bioaccumulation. Synthetic musks are used to mask chemical odors in products labeled "unscented," but they are not used in products labeled "fragrance-free." Staff suggested both nitro-musks and polycyclic musks as candidates for biomonitoring and relayed that both classes of musks have been found in breast milk. The production of polycyclic musks has increased in recent years as toxicity concerns have led to decreased production of nitromusks. Staff relayed that few toxicity data are available for polycyclic musks even though these chemicals are in widespread use. There is concern that both of the suggested polycyclic musks (below) disrupt endocrine function.

> *Musk ketone and musk xylene*: These nitro-musks are decreasing in use in recent years because of concerns about toxicity.
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> *1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-gamma-2-benzopyran (HHCB or galaxolide)*: High concentrations of HHCB were found in breast milk and levels of HHCB in U.S. breast milk samples were higher than those found in Europe. Staff commented that HHCB has been identified as an endocrine disruptor, including evidence that HHCB has anti-estrogenic activity.
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> *6-Acetyl-1,1,2,4,4,7-hexamethyltetraline (AHTN or tonalide)*: Staff noted that AHTN has also been found in U.S. breast milk and that levels were higher than those found in Europe. Research findings provide evidence that AHTN is an estrogen receptor antagonist.

Sunscreens: The following sunscreens were suggested for biomonitoring because of widespread consumer exposure and findings of estrogenic activity: 3-benzylidene camphor, 2-ethylhexyl 4-dimethylaminobenzoate (octyl-dimethyl-*para*-amino benzoic

acid [PABA]), 4-methylbenzylidene camphor and oxybenzone♦ (also listed above as an environmental phenol).

Chemicals used in cleaning and maintenance

Chemicals used in cleaning and maintenance were suggested as a general category for biomonitoring because of the extent of exposure to these chemicals. Some cleaning and degreasing solvents were also suggested (listed under VOCs).

Glycol ethers: Glycol ethers are commonly found in cleaning products. Ethylene glycol monobutyl ether (EGBE) was specifically suggested for biomonitoring because it is present in household cleaning products and adverse reproductive effects have been observed in animal studies. Consumers are exposed via dermal absorption and inhalation.

Terpenes: *d*-Limonene and *a*-pinene are degreasers that give cleaning products a citrus or pine smell, respectively. These compounds were of concern to staff because they react with indoor ozone (*e.g.*, ozone emitted from printers, copiers, air cleaners, and other devices) to form formaldehyde and ultrafine particles. Biomonitoring for *d*-limonene and *a*-pinene would provide information on exposures to formaldehyde and ultrafine particle from these sources.

Dioxins♦ and furans♦

Polychlorinated dibenzodioxins♦ and polychlorinated dibenzofurans♦ (dioxins/furans) were suggested for biomonitoring because they are persistent, bioaccumulative, carcinogenic and have been found to cause other adverse health effects and because of exposures from dietary intake (predominantly from meat and dairy products). Staff also relayed that dioxins have been identified in San Francisco Bay fish tissues. Polychlorinated dibenzodioxins and furans are listed as known to cause cancer under Proposition 65. Tetrachlorodibenzodioxin (TCDD♦), the most carcinogenic dioxin, is listed under Proposition 65 as known to cause cancer and developmental toxicity.

Endocrine-disrupting chemicals

Chemicals that disrupt endocrine function were suggested as a category for biomonitoring by staff from a number of programs. Specific endocrine-disrupting chemicals and categories of chemicals that were separately suggested include: bisphenol A♦, perchlorate♦, triclosan♦, PBDEs♦, perfluorinated compounds (PFCs)♦, polychlorinated biphenyls (PCBs)♦, phytoestrogens♦, dioxins/furans♦, methylsiloxanes, and synthetic musks. Perchlorate♦ and phytoestrogens♦ are discussed below. The other categories and specific chemicals named above are discussed elsewhere in this section (see specific

chemical categories, such as PBDEs and PFCs, and the general category on consumer products).

Perchlorate♦: Perchlorate was one of the most frequently suggested chemicals for biomonitoring. It is a component of rocket fuel, used in the manufacture of explosives, fireworks and flares. It is now a ubiquitous contaminant, high in water-accumulating crops (e.g., lettuce, fruits, vegetables); it is also found in cow's milk. Perchlorate blocks uptake of iodine by the thyroid gland and leads to decreased synthesis of thyroid hormones, which (among other things) are critical determinants of growth and development in fetuses, infants and young children. Staff reported that perchlorate is concentrated in breast milk as well as infant formula and that recent epidemiologic studies have found an association with thyroid function at current U.S. exposure levels, in women with low iodide consumption, particularly among those who are smokers.

Phytoestrogens♦*:* Phytoestrogens in general and genistein♦ specifically were suggested for biomonitoring because these chemicals are weakly estrogenic and dietary exposures are increasing. The long-term effects of these exposures (e.g., to infants receiving soy formula) are unknown.

Metals♦ and other inorganics

Many staff suggested metals as an important category to biomonitor.

Aluminum: Aluminum was suggested because of its potential to cause neurotoxicity. Aluminum bioavailability from drinking water depends on drinking water composition; and bioavailability from food depends on trace element content. Populations with compromised kidney function are known to bioaccumulate aluminum. This includes kidney failure and dialysis patients as well as premature infants. Staff suggested that biomonitoring data would help us understand the range of aluminum exposures across these conditions and the extent to which aluminum neurotoxicity may be a public health issue.

Antimony♦: Antimony is used in lead storage batteries, solder, sheet and pipe metal, bearings, castings, and pewter; antimony oxide is added to textiles and plastics as a flame retardant. Antimony is also used in paints, ceramics, and fireworks, and in enamels for plastics, metal, and glass. Antimony oxide (antimony trioxide) is listed under Proposition 65 as known to cause cancer.

Arsenic and arsenic compounds♦: Arsenic was suggested because of its toxicity and prevalence in California soils, and in ground, surface and well water. Staff relayed that an assessment of chemicals at California school sites or potential school sites found arsenic at 29 percent of the 320 sites evaluated. Arsenic is listed under Proposition 65 as known to cause cancer.

Boron: Boron was suggested because of widespread commercial and household use of boron compounds in pesticides, flame retardants, and laundry bleaches. Exposure is primarily via ingestion in food and drinking water. Although boron is considered beneficial at low doses, animal studies report associations with male reproductive tract and developmental toxicity.

Cadmium♦: Cadmium is listed under Proposition 65 as known to cause cancer, developmental and reproductive toxicity. Most cadmium exposure occurs by inhalation; airborne levels are a concern in populations near smelters. Tobacco smoke is also an important source of cadmium exposure. Cadmium can enter the food supply by the addition of cadmium-containing sewage sludge to agricultural applications. Staff reported that an assessment of chemicals at California school sites or potential school sites (320 total sites) found cadmium at 8 percent of school sites.

Chromium VI: Chromium VI was suggested for biomonitoring because of groundwater contamination from various sources, including wood treatment and chrome plating. Chromium VI is a carcinogen and is listed under Proposition 65 as known to cause cancer and reproductive toxicity. Other staff noted that biomonitoring of chromium VI may not be possible because of rapid conversion in the body to chromium III, a beneficial trace mineral.

Copper: Copper, an essential trace mineral, is widely used as a pesticide for many food crops. It is also used to treat lumber, as a fumigant and as an algaecide for swimming pools. Staff who suggested copper mentioned aquatic toxicity concerns. Exposure at high levels causes liver, kidney and immune system toxicity. It is not known whether any human health effects occur from long-term environmental exposures to copper. Individuals with Wilson's disease, who have a genetic inability to transport copper, may be more susceptible to long-term environmental exposures.

Fluoride: Fluoride was suggested for biomonitoring because of studies suggesting a link between fluoride exposure in drinking water and cancer.

Lead♦: In suggesting lead for biomonitoring, staff commented that lead can cause diminished IQ and neurobehavioral effects in the developing brain. Lead is listed under Proposition 65 as known to cause cancer, as well as developmental and reproductive toxicity. Staff reported that an assessment of chemicals at California school sites or potential school sites (320 total sites) found lead at 42 percent of sites, due mainly to past uses in paint and gasoline.

Manganese: Manganese was recommended because of its neurotoxicity. High nervous system concentrations are associated with hyperactivity in children and Parkinson's disease in adults. Staff reported that manganese supplementation of soy-based infant formula about 25-30 years ago resulted in high infant exposures. [Manganese

accumulates in plants such as soy and rice, resulting in high concentrations in soy-based versus other infant formulas, even before supplementation]. The manganese-containing fuel additive methylcyclopentadienyl manganese tricarbonyl (MMT) is banned for use in California, but manganese and manganese compounds are used in a wide variety of industrial applications. CARB will submit a report to the Legislature in January 2010 on ambient manganese exposure.

Mercury♦: Staff expected mercury exposures in California to be higher than in other parts of the U.S. because of past mining activity, which has resulted in high levels of inorganic mercury in sediment. Staff also commented that exposure to mercury from eating locally caught fish is likely higher in California than in other parts of the country because: 1) interest in fishing is relatively high; 2) there is relatively easy access to rivers, reservoirs, and the coast; and 3) California has significant populations of ethnic groups for whom fish is an important part of their diet.

Nickel: Staff reported that an assessment of chemicals at California school sites or potential school sites (320 sites total) found nickel at 8 percent of sites. Nickel and nickel compounds are listed as known to cause cancer under Proposition 65.

Nitrate: Nitrate was suggested for biomonitoring because of concern about levels in drinking water, due to runoff and leaching from fertilizer use. Staff indicated that high levels of nitrate in drinking water can cause methemoglobinemia in infants. Staff also reported that some epidemiological studies have found an association between nitrate levels in maternal drinking water and neural tube birth defects. The greatest source of nitrate exposure is via ingestion of nitrate-containing foods (e.g., leafy vegetables, cured meat), and the International Agency for Research on Cancer (IARC) has recently concluded that ingested nitrate under conditions that result in endogenous nitrosation is probably carcinogenic to humans.

Radium: Naturally occurring radionuclides radium-228 and radium-226 were suggested for biomonitoring because of concern about their presence in drinking water. Radium levels are higher in areas where uranium mining has occurred, and elevated radium levels are found in soil in certain areas of California. Both radionuclides have been detected in some water sources. Radium accumulates in bone tissue, and both radium-226 and radium 228 are associated with an increased incidence of osteogenic sarcoma. Exposure to radium-226 is also associated with an increased incidence of head carcinoma.

Selenium: Selenium is an essential trace element. High levels cause gastrointestinal and neurological effects, and selenium sulfide is listed as known to cause cancer under Proposition 65. Selenium is used in a variety of industrial and commercial processes. Combustion of fossil fuels also contributes to atmospheric selenium. Selenium sulfide is used in shampoo as an anti-dandruff agent.

Uranium♦ *(depleted and naturally occurring in water)*: Uranium was suggested for biomonitoring because of concerns about drinking water exposures to individuals who obtain their water from private wells. Uranium exposure is linked to a number of cancers, including stomach and kidney cancer and leukemia. Uranium has also been found to disrupt endocrine function and may be associated with an increased risk of fertility problems and reproductive cancers.

Vanadium and vanadium compounds: Vanadium was suggested for biomonitoring because of the possible use of vanadium pentoxide (which is listed under Proposition 65 as causing cancer) as a catalyst in selective catalytic reduction (SCR) in diesel emission control technology. Vanadium is also found in some California drinking water. Laboratory research has suggested potential benefits from very low levels of vanadium but vanadium pentoxide has been found to cause a range of adverse effects, including cancer.

*Zinc***:** Zinc was mentioned because of its aquatic toxicity.

Nanoparticles

Nanoparticles were mentioned as a concern by nearly everyone who provided input. Staff were concerned about their widespread use, the potential for toxicity and the absence of any labeling requirement for nanomaterials. One suggestion was to biomonitor silver oxide and titanium dioxide as indicators of nanoparticles.

Perfluorinated compounds (PFCs)♦

PFCs were suggested as a chemical class by staff from a wide number of programs based on widespread exposure, persistence, bioaccumulation and toxicity. Perfluorooctanoic acid♦ and perfluorooctane sulfonic acid♦ were specifically named in this regard.

Pesticides♦, herbicides♦ and fungicides♦

Pesticides were named as a general category of high concern for most staff providing input. A wide variety of pesticides were suggested, including those that are endocrine disruptors or neurotoxic. Exposures from area-wide spraying (e.g., mosquito control) and pesticide drift from agricultural applications were of concern. There was concern expressed about the toxicity of pesticides used in California vineyards and the extent to which pesticide residues are present in wine. Staff from a number of programs commented on California's high pesticide use compared to other parts of the U.S. Another comment was that the profile of pesticide use may be different in California. Staff commented that certain populations that preferentially consume a significant amount of food from particular areas of the world (e.g., Asia or Latin America) may have

exposures that reflect pesticide usage in other countries. Pesticides used in households or home gardens were also of concern.

Organochlorine pesticides♦: Organochlorine pesticides were raised as a general category, including both those no longer registered for use in the U.S. and those in current use.

Organochlorine pesticides not currently registered for use in U.S.:

DDT♦, *DDD*♦, *DDE*♦: DDT, DDD and DDE were suggested for biomonitoring because they are persistent, bioaccumulative and toxic. DDT, DDD (a structural analogue of DDT) and DDE (the primary breakdown product of DDT and DDD) are persistent, bioaccumulative and toxic. DDT and DDE build up in plants and in fatty tissues of fish, birds, and other animals. Although banned since the early 1970's, staff still cited them as important in California. Staff named DDT/DDE as one of four main contaminants in Southern California fish, and stressed the importance of these chemicals in terms of subsistence fishing exposures. Staff reported that an assessment of chemicals at California school sites or potential school sites, found DDT and DDE at 33 percent of school sites (320 total sites). DDD was found at 17 percent of sites. DDT, DDE and DDD are listed as known to cause cancer under Proposition 65 and have been shown to have estrogenic activity. There is also evidence that DDT causes neurodevelopmental and reproductive toxicity.

Chlordane♦: Although this cyclodiene pesticide was banned in 1988, it was suggested for biomonitoring because it is persistent and exposure still occurs. Chlordane is listed as known to cause cancer under Proposition 65. Staff reported that an assessment of chemicals at California school sites or potential school sites found chlordane at 8 percent of sites. Exposure occurs from fish consumption in certain areas (e.g., San Francisco Bay).

Dieldrin♦: Dieldrin is another legacy cyclodiene pesticide that staff suggested for biomonitoring. Staff reported that an assessment of chemicals at California school sites or potential school sites (320 total sites) found dieldrin at 9 percent of sites. It is also found in fish from the S.F. Bay. Dieldrin is listed as known to cause cancer under Proposition 65.

Toxaphene: Toxaphene was suggested because it was once one of the most widely used pesticides in the U.S. and in California. Although banned for 25 years, toxaphene is persistent and bioaccumulative. It is listed as known to cause cancer under Proposition 65. Staff relayed that exposure from contaminated fish is still a concern and that an assessment of chemicals at California school sites or potential school sites (320 total sites) found toxaphene at 10 percent of sites.

Organochlorine pesticides registered for use in California:

Dicofol: Dicofol was suggested for biomonitoring because it was linked to autism spectrum disorders (ASD) in a study evaluating a possible association between maternal residence near agricultural pesticide applications during key periods of gestation and development of ASD in children. Dicofol is structurally similar to DDT and has been reported to disrupt thyroid hormone activity. DPR's 2006 Pesticide Use Report states that dicofol is being replaced due to resistance issues; there was a 90 percent decrease in reported use from 2005 to 2006.

Endosulfan♦: Endosulfan was suggested for biomonitoring because it was linked to autism spectrum disorders (ASD) in a study evaluating a possible association between maternal residence near agricultural pesticide applications during key periods of gestation and development of ASD in children. Endosulfan is persistent and bioaccumulative and there is laboratory evidence that endosulfan is an endocrine disruptor with anti-androgenic activity. Endosulfan is also a neurotoxicant. Animal studies have found male reproductive harm and birth defects. Endosulfan residues have been detected in human blood, in fetal tissue, in breast milk and in mammary adipose tissue. Staff reported that an assessment of chemicals at California school sites or potential school sites (320 total sites) found endosulfan or its metabolites at 7 percent of evaluated sites. Staff noted that endosulfan is banned in the European Union. DPR's 2006 Pesticide Use Report indicates that over 92,000 pounds of endosulfan were applied in California in 2006. While the use of endosulfan decreased in some areas, endosulfan use increased by 89 percent in the San Joaquin Valley from 2005 to 2006.

Lindane♦: Lindane was suggested for biomonitoring because of groundwater contamination from past uses. DPR's Pesticide Use Report indicated some use in 2006, but very little lindane is currently used in the U.S. Lindane is listed as known to cause cancer under Proposition 65. It is available for use for treatment of scabies and head lice and there are also reports of lindane-induced neurotoxicity in infants and young children.

Pyrethroid pesticides♦: Pyrethroid pesticides were suggested for biomonitoring predominantly because of their widespread use in consumer products. Home use of these pesticides is increasing due to U.S. EPA restrictions on organophosphate and carbamate pesticides. Staff reported that pyrethroid pesticides used in household or yard settings, unlike those used in agriculture, would not be expected to change much over time. Pyrethroids are also used in the treatment of head lice and scabies. Research findings for some pyrethroids report endocrine disruption and immunotoxicity. Some pyrethroids have been identified as causing cancer (e.g., resmethrin is listed as known to cause cancer

under Proposition 65 and permethrin has been identified by U.S. EPA as "likely to be carcinogenic to humans"). Specific pyrethroid pesticides were not suggested by staff.

Organophosphate pesticides♦:

Chlorpyrifos♦: Chlorpyrifos was suggested for biomonitoring because of findings of developmental and reproductive toxicity in animals and epidemiological evidence suggesting a link between chlorpyrifos exposure and increased risks of adverse developmental and reproductive effects. Staff reported that, until recently, chlorpyrifos had wide home and garden use. Although residential use is now banned, there is still high agricultural use.

Diazinon♦: Diazinon was suggested for biomonitoring because of findings of adverse effects in animal studies, including neurodevelopmental and immunological toxicity. Staff reported that, until recently, this insecticide was widely used in residential settings. A U.S. EPA agreement with manufacturers resulted in the phase-out of residential uses. Agricultural use has also decreased somewhat in recent years.

Malathion♦: Malathion was suggested for biomonitoring because it is widely used in California (e.g., strawberries, head lettuce, walnuts, celery). Findings from a number of studies suggest that malathion may cause chromosomal damage. Surface water contamination is a concern.

Fumigant pesticides: Fumigant pesticides were suggested for biomonitoring primarily because of their wide use in California. Staff commented that California and Florida use the great majority of fumigant pesticides nationwide. According to DPR's 2006 Pesticide Use Report, fumigants are applied at higher rates than other pesticides because they are injected into soil (to sterilize a field before planting) and thus treat a volume of space rather than the surface area of plants. Staff also mentioned that fumigants are used at food processing facilities and factories processing products for export.

Fumigant pesticides registered for use in California

1,3-Dichloropropene: 1,3-Dichloropropene is the second most highly used fumigant in California and is also one of the most highly used pesticides in the State. It is listed as known to cause cancer under Proposition 65.

Chloropicrin: Chloropicrin is the third most highly used fumigant in California, with use steadily increasing over the last 10 years. Chloropicrin is also used as a fungicide and was used as a chemical warfare agent during World War I. Degradation products include nitrate and nitrite, nitromethane and phosgene.

Methyl bromide: Methyl bromide use in California has decreased by 60 percent in the last 10 years because of the U.S. EPA mandated phase-out (due to ozone depletion), but over six million pounds were still used in California in 2006. Methyl bromide is listed under Proposition 65 as known to cause reproductive toxicity.

Methyl isothiocyanate [MITC]: MITC, the active agent of metam sodium and metam potassium, was suggested for biomonitoring because of cancer and developmental toxicity concerns. Metam sodium is listed as both a carcinogen and developmental toxicant under Proposition 65. Metam potassium is identified as a probable human carcinogen (Group B2), along with metam sodium, by U.S. EPA. Despite a recent decline in use, metam sodium is still the most highly used fumigant in California (11 million pounds in California in 2006); metam potassium use has markedly increased (none in 1999 and over 3 million pounds in 2006).

Fumigant pesticides not currently registered for use in the U.S.

1,2-Dibromo-3-chloropropane (DBCP)♦: DBCP is a fumigant that was banned in the late 1970s. It was suggested for biomonitoring because it is still found in groundwater in the southern part of the Sacramento Valley, in the San Joaquin Valley and probably in other parts of the state as well. DBCP is listed under Proposition 65 as known to cause cancer and male reproductive toxicity.

Ethylene dibromide: The fumigant ethylene dibromide was suggested for biomonitoring because of concerns about groundwater contamination. It is no longer used in California. Ethylene dibromide is listed under Proposition 65 as known to cause cancer and male reproductive toxicity.

Other pesticides♦:

N,N-Diethyl-3-methylbenzamide (DEET)♦: DEET was suggested for biomonitoring because of its widespread use. It is the active ingredient of most commercial insect repellents and is sprayed directly onto skin and clothing. DEET is absorbed through the skin, and staff reported that animal studies have found that combined use of DEET and the sunscreen oxybenzone (listed as an environmental phenol) increase the absorption of both compounds. DEET has been found in umbilical cord blood samples.

Avermectin B1: Avermectin B1, a miticide used predominantly on almond trees and on cotton, was suggested for biomonitoring because animal studies provide evidence of developmental toxicity.

Fiprols: Fipronil was identified as a member of the emerging pesticide class of fiprols. Staff reported that it is used in flea and tick treatment and for structural pest control. Fipronil has been classified as possibly carcinogenic to humans by U.S. EPA based on thyroid tumors in male and female rats. Staff reported that fipronil has been implicated in the colony collapse disorder of honeybees.

Neonicotinoids: Imidacloprid was identified as a member of the emerging class of neonicotinoid pesticides. Imidacloprid is widely used in products to control fleas in cats and dogs, and is used on a variety of crops in California (e.g., raisins and table grapes, tomatoes, oranges, strawberries). Imidacloprid is one of the most widely used pesticides in the European Union. There is some concern that neurotoxic actions of imidacloprid could occur in humans.

Sulfur dioxide: Sulfur dioxide was suggested for biomonitoring because animal studies have found evidence of embryotoxicity and some indication of male and female reproductive effects; epidemiological studies suggest effects on pre-term delivery and birth weight. Sulfur dioxide is used on wine grapes and added to wine. The sulfate used to treat dried fruit also forms sulfur dioxide.

Fungicides♦:

Imazalil: Imazalil, a post-harvest fungicide used on citrus fruits, was suggested for biomonitoring because animal studies provide evidence of both fetotoxicity and carcinogenicity. Imazalil residues have been found in fruit juice.

Thiabendazole and salts: Thiabendazole, another post-harvest fungicide, was suggested for biomonitoring because animal studies suggest fetotoxicity.

Vinclozolin: Vinclozolin was suggested for biomonitoring because animal studies found developmental toxicity. Vinclozolin is listed as known to cause both cancer and developmental toxicity under Proposition 65. It is an androgen antagonist. DPR's 2006 Pesticide Use Report indicates that usage has markedly declined (from 83,000 lbs in 1996 to 400 lbs in 2006).

Herbicides♦:

Atrazine♦: The herbicide atrazine was suggested for biomonitoring because of findings that it causes sexual abnormalities in frogs. Atrazine is banned in the EU.

2,4-Dichlorophenoxyacetic acid (2,4-D)♦: 2,4-D and its salts are used as growth regulators on fruits, to manipulate the amount of time the fruit stays on the tree and to extend the shelf life of fruit. Staff commented that there are questions

about how much gets into and remains in fruit. 2,4-D was suggested for biomonitoring because of findings of endocrine disruption and developmental toxicity in animals.

Paraquat: Paraquat was suggested for biomonitoring because it is still used in high volumes. It is one of the herbicides used most (by acres treated) on wine grapes, table grapes and almonds. Staff commented that paraquat is poorly absorbed by the gastrointestinal tract, which would likely limit bioavailability. Staff reported that recent mechanistic studies suggest that paraquat may trigger oxidative stress-related neurodegeneration.

Simazine♦: Simazine was suggested for biomonitoring because it is a widely used herbicide and because animal studies suggest that it causes both mammary gland tumors and fetotoxicity. Simazine is one of the herbicides most used on wine and table grapes (by acres treated). Staff reported that soil leaching and surface run-off are concerns and that simazine use is regulated to protect groundwater.

2,4,5 Trichlorophenoxyacetic acid (2,4,5-T)♦: 2,4,5-T was suggested for biomonitoring because animal studies found long-term behavioral effects after pre-natal exposure and because the herbicide is always contaminated with TCDD. 2,4,5-T has been banned in the U.S. and elsewhere in the world.

Pharmaceuticals and hormones

Pharmaceuticals used in humans and/or animals were suggested for biomonitoring. Hormones used in animals were also suggested. Staff noted the absence of any meaningful monitoring of pharmaceuticals and hormones in food from animal sources. There was concern that the widespread use of pharmaceuticals in animals has increased antibiotic resistance. Staff also cited recent studies that detected pharmaceuticals in effluent from sewage treatment and in source waters for drinking water supplies.

Phthalates♦, other plasticizers and plastic additives

Phthalates♦: There was widespread concern among staff about phthalates as a class. Staff noted that phthalates are present in a wide variety of products (e.g., consumer and household products, automobiles, electrical wires and cables, medical tubing, and blood storage bags).

Butyl benzyl phthalate (BBP)♦: BBP is one of six phthalates now banned from children's toys and childcare articles in California. Staff reported that BBP is has been detected in indoor air, especially in automobile interiors. BBP is listed under Proposition 65 as known to cause developmental toxicity.

Diethylhexyl phthalate (DEHP)♦: DEHP was the phthalate mentioned most frequently and was suggested for biomonitoring because of widespread use, high exposure and toxicity. Staff relayed that DEHP is prominent in indoor air, especially inside automobiles, and that it can leach out of plastics into liquid that comes in contact with the plastic. DEHP is one of the six phthalates banned from children's toys and childcare articles in California. Further, in addition to DEHP's known toxic effects (it is listed under Proposition 65 as known to cause cancer and developmental and male reproductive toxicity), staff reported that recent data suggest that DEHP may promote obesity, and affect neurological and immunological development.

Diethyl phthalate (DEP)♦: DEP was suggested because it has been found in indoor air, especially in automobile interiors.

Diisobutyl phthalate (DiBP)♦: DiBP was suggested because it has been found in indoor air, especially in automobile interiors.

Diisodecyl phthalate (DIDP): DIDP is listed under Proposition 65 as known to cause developmental toxicity. It is one of six phthalates banned from children's toys and childcare articles in California. It is also widely used in consumer products and as a replacement for DEHP.

Diisononyl phthalate (DINP)♦: DINP is one of six phthalates banned from children's toys and childcare articles in California. It was suggested for biomonitoring because of its use in consumer products and as a replacement for DEHP. Staff recommended that an additional metabolite of DINP be biomonitored.

Di-n-butyl phthalate (DBP)♦: DBP is one of six phthalates banned from children's toys and childcare articles in California. Staff reported that DBP has been found in indoor air, especially in automobile interiors. DBP is listed under Proposition 65 as known to cause developmental and male and female reproductive toxicity.

Di-n-hexyl phthalate (DnHP): DnHP is listed under Proposition 65 as known to cause male and female reproductive toxicity.

Di-n-octyl phthalate (DnOP)♦: DnOP is one of six phthalates banned from children's toys and childcare articles in California.

Dipropyl phthalate: Dipropyl phthalate was suggested because it has been found in indoor air, especially in automobile interiors.

Other plasticizers and plastic additives: Staff from several programs expressed concern about plastic additives, nonphthalate plasticizers and phthalate replacements. Staff were particularly concerned that little information is available on the identity (and/or toxicity) of phthalate replacement chemicals.

> *Adipates*: Di-2-ethylhexyl adipate (DEHA) is used in food-contact films and can migrate into certain foodstuffs.
>
> *Di-isononyl cyclohexane-1,2-dicarboxylate (DINCH)*: DINCH was suggested because it was recently approved for use in the European Union and will likely be widely used. However, OEHHA could not locate any DINCH toxicity studies in the published scientific literature.

PBDEs♦ and other flame retardants

Flame retardants, and specifically brominated and/or chlorinated flame retardants, were a concern of nearly all staff who provided input. All staff who mentioned flame retardants recommended PBDEs as chemicals important to biomonitor. There was also concern about other flame retardants that are increasing in use, many of which are replacing penta- and octa-BDEs. Staff expressed concern about the high levels of PBDEs already measured in California residents and noted that exposure to other brominated and chlorinated flame retardants would likely be higher in California than in other parts of the country because of California's strict furniture flammability regulations.

PBDEs♦: PBDEs were suggested for biomonitoring by nearly all individuals who provided input. Although the manufacture and sale of two of the three commercial PBDE mixtures (octa- and pentaBDEs) are now banned in California and the mixtures have been phased-out nationally, exposures to these PBDEs continues. PentaBDE, for example, was used for 20 years as a flame retardant in polyurethane foam to satisfy California's flammability regulations. Levels of PBDEs in house dust in California are markedly higher than in house dust in other parts of the country. Staff reported that bioaccumulation of PBDEs in California sea lions in the San Francisco Bay has recently been documented. Staff also reported that the U.S. Mussel Watch program has found PBDE levels in Southern California bivalves to be 100 times the national average. Staff cited animal studies that have found that PBDEs can cause permanent changes in learning, behavior and memory, alter thyroid hormone function, and affect brain development and noted that only one PBDE, decaBDE (BDE 209), has been studied for possible carcinogenic effects. Staff relayed that the following BDE congeners were identified as having been found indoors by laboratories conducting analyses of dust and air samples: BDE 47♦, BDE 99♦, BDE 100♦, BDE 153♦, BDE 154♦, BDE 181, BDE 183♦, BDE 190, and BDE 209.

Other brominated flame retardants (BFRs): There was also concern about other BFRs now on the market, many of which are replacing penta- and octa-BDEs. These include:

> *Bis(2-ethylhexyl)tetrabromophthalate (TBPH)*: Staff suggested TBPH because it is expected to be used in large quantities in California. TBPH is a component of Firemaster 550, the primary pentaBDE replacement in polyurethane foam. Staff also noted that no chronic toxicity information is available for this chemical. TBPH is the brominated analogue of bis(2-ethylhexyl)phthalate (DEHP).
>
> *1,2-Bis(2,4,6-tribromophenoxy)ethane*: Staff suggested this flame retardant because it is being marketed as an alternative to PBDEs. Staff reported that little is known about current usage volume or toxicity. It was recently found in ambient air samples in the United States.
>
> *Decabromodiphenylethane*: This flame retardant was suggested because it is another PBDE alternative, with little known about current usage volumes, toxicity, or fate and transport. It is structurally similar to decaBDE.
>
> *1,2-Dibromo-4-(1,2-dibromoethyl)cyclohexane*: This BFR was suggested for biomonitoring because it is a PBDE alternative that has recently been found to interfere with male sex hormones and because it was recently identified in blubber of Beluga whales from the Canadian Arctic. Staff reported that U.S. EPA issued a Decision Not to Test in 1985 due to the determination of insufficient exposure. Staff commented that little is known about current usage volumes.
>
> *Hexabromocyclododecane (HBCD)*: Staff suggested HBCD because it is a widely used flame retardant, with little toxicological information.
>
> *Tetrabromobisphenol A (TBBPA)*: Staff recommended TBBPA for biomonitoring because it is the most widely used BFR worldwide. Staff cited toxicity concerns including interference with thyroid hormone activity.

Chlorinated flame retardants (CFRs): The following CFRs were suggested because of use, exposure and potential toxicity:

> *Chlorinated paraffins*: Chlorinated paraffins were suggested for biomonitoring because they are widely used and because of concerns about persistence, bioaccumulation and toxicity. Chlorinated paraffins consisting of, on average, chains of twelve carbon atoms and containing approximately 60 percent chlorine (by weight) are listed as known to cause cancer under Proposition 65.
>
> *Declorane Plus*: Staff commented that Dechlorane Plus has been in use for 40 years but is poorly studied. It was suggested for biomonitoring because of its use and persistence, while its toxicity remains unknown.

Tris(1,3-dichloro-2-propyl)phosphate (TDCPP): TDCPP was suggested for biomonitoring because it is one of two primary pentaBDE replacements in polyurethane foam and because of cancer findings in laboratory animals. The U.S. Consumer Product Safety Commission has concluded that TDCPP is a probable human carcinogen. Because of California's unique furniture flammability requirements, staff expected that exposure here would be higher than in other parts of the U.S.

Non-halogenated organophosphate flame retardants:

Triphenyl phosphate: Triphenyl phosphate was suggested because it has been found in bivalves in the San Francisco Bay. It is a widely used flame retardant and a component of several formulations replacing PBDEs in polyurethane foam.

Polychlorinated biphenyls (PCBs)♦

PCBs were suggested for biomonitoring primarily because of dietary exposures (meat, fish, poultry, dairy products, oils and fats). Staff commented that although PCBs are banned from current use, these compounds, along with mercury/methyl mercury, are among the most important chemical contaminants in California fish. Staff reported that an assessment of chemicals at California school sites or potential school sites (320 total sites), found PCBs at over 6 percent of sites. Other current sources of exposure include PCB leaching from landfills, incineration of municipal refuse and sewage sludge, and breakdown and/or improper disposal of PCB-containing products. PCBs have been extensively studied and are listed under Proposition 65 as known to cause cancer and developmental toxicity.

Polycyclic aromatic hydrocarbons (PAHs)♦

PAHs as a class were considered important to biomonitor by staff from a wide variety of programs. Staff commented that exposure to PAHs may be greater in Californians because of dense traffic and greater urbanization. Concerns about PAH-associated carcinogenicity and immunotoxicity were raised. Occupational exposures (e.g., roofers) were of concern; food sources of PAHs were also noted. In addition to the PAHs listed and discussed below, staff also mentioned acenaphthylene, anthracene, benzo[a]anthracene, benzo[e]pyrene, benzofluoranthenes, benzo[ghi]perylene, chrysene, coronene, fluoranthene, indeno[1,2,3-cd]pyrene, and phenanthrene.

Benzo(a)pyrene♦: Benzo(a)pyrene was suggested for biomonitoring because of air exposures. Benzo(a)pyrene is listed under Proposition 65 as known to cause cancer. Staff commented that a major source of benzo(a)pyrene exposure had been from motor vehicle emissions and that current catalytic converter technology has resulted in

decreased emissions. The other major source of benzo(a)pyrene in California is burning of vegetative materials. Major sources of indoor benzo[a]pyrene in California include tobacco smoke and wood burning in fireplaces and woodstoves.

1-Hydroxypyrene♦: 1-Hydroxypyrene was suggested for biomonitoring because it correlates well with other PAHs and can be biomonitored as a surrogate for total PAHs.

Naphthalene♦: Staff commented that naphthalene is likely the PAH formed in the highest concentration from diesel and gasoline combustion. Staff suggested that exposures may be higher in California, because of high fossil fuel use in transportation. Naphthalene was also suggested for biomonitoring because it is a significant component of paving and sealing materials for parking lots. Naphthalene exposures from these sources occur because, over time, naphthalene is released into the air. Naphthalene is listed as known to cause cancer under Proposition 65. Polychlorinated naphthalenes were suggested as an emerging concern.

Solvents

Solvents were suggested as a general class for biomonitoring by staff from a number of programs. Staff raised concerns regarding wide use and potential for exposure because of the typical kinds of applications (both industrial and consumer) that solvents are used for. Respirable solvents were singled out as a concern. Several solvents are discussed in the section on volatile organic compounds (VOCs) below.

Volatile organic compounds (VOCs)♦

Volatile organic compounds (VOCs) were suggested as a class of chemicals for biomonitoring. The VOC category here includes chemicals identified and biomonitored by CDC as VOCs, as well as chemicals that meet the criterion for being a VOC (i.e., vapor pressure greater than 10 pascals (Pa). Some VOCs were of concern as air contaminants, while others were of concern as groundwater contaminants. Certain VOCs are discussed in other categories in this report (e.g., trihalomethanes in water disinfection by-products).

Acetaldehyde: Acetaldehyde was suggested because it is a concern in both indoor and outdoor air. Acetaldehyde is listed as known to cause cancer under Proposition 65. Staff reported that levels of acetaldehyde measured in indoor air samples have increased in recent years. Staff also suggested that acetaldehyde emissions from motor vehicles may increase due to the potential increased use of ethanol in gasoline. Staff commented that there is currently no apparent biomarker for acetaldehyde exposure.

Acrylonitrile: Acrylonitrile was suggested because of relatively high levels in California's ambient air. Acrylonitrile is listed as known to cause cancer under

Proposition 65. Staff reported that the cancer risk from ambient air levels appears to be high. Acrylonitrile is primarily used as the raw material for the manufacture of acrylic and modacrylic fibers. Other major uses include the production of plastics, such as acrylonitrile-butadiene-styrene (ABS). Staff reported that CARB is trying to identify the major sources that contribute to indoor and outdoor air levels. Preliminary information suggests that sources include car interior materials, possibly hoses and other products under the hood, and some household products and building materials.

Aniline: Aniline was suggested because it is the organic chemical released in highest amounts in recycled tires that are used on playground surfaces. The use of recycled tire rubber in various applications is increasing, and OEHHA will be studying its use in the new generation of athletic fields made of synthetic turf. Aniline is listed under Proposition 65 as known to cause cancer. Staff expected that aniline would not be detected in people other than occupationally exposed workers.

Benzene♦: Benzene was suggested because of exposure in ambient air (from motor vehicle exhaust, gas stations, industrial emissions and tobacco smoke). Benzene is leukemogenic and is listed as known to cause cancer under Proposition 65. Staff reported that an assessment of chemicals of concern at California school sites or potential school sites (320 total sites), found benzene at 11 percent of sites.

1,3-Butadiene: 1,3-Butadiene was suggested for biomonitoring because of concerns about levels in air. 1,3-Butadiene is listed as known to cause cancer and developmental and male and female reproductive toxicity under Proposition 65.

Carbon tetrachloride♦: Carbon tetrachloride was suggested for biomonitoring because of groundwater and soil contamination as a result of high usage in industrial facilities and military bases. In the past, indoor air levels had been very high but carbon tetrachloride is now prohibited from common household products, and indoor and outdoor levels are similar.

1,4-Dichlorobenzene♦: 1,4-Dichlorobenzene was suggested because it is ubiquitous in the environment. It is listed as known to cause cancer under Proposition 65. It is a chemical intermediate and has been used as a fumigant used to control moths, molds and mildew and as a deodorant for toilets and refuse containers.

Dichloroethane♦: Dichloroethane can refer to either 1,1-dichloroethane♦ or 1,2-dichloroethane (ethylene dichloride)♦. Both are listed as known to cause cancer under Proposition 65.

1,2-Dichloroethene (cis-DCE)♦: *cis*-DCE is an industrial solvent suggested for biomonitoring because it is a major breakdown product of perchloroethylene and trichloroethylene and is found in contaminated soil and groundwater.

1,2-Dichloropropane♦: 1,2-Dichloropropane was suggested for biomonitoring because it is a groundwater concern. It is used as a chemical intermediate and more than 100 – 500 million pounds were produced in and/or imported into the U.S. in 2002. 1,2-Dichloropropane was once widely used as a soil fumigant, but in 2006, its combined use with other related fumigants was only 182 pounds in California. It is listed as known to cause cancer under Proposition 65.

1,4-Dioxane: 1,4-Dioxane was suggested for biomonitoring because it is a groundwater and soil contaminant. Staff reported that 1,4-dioxane, a solvent stabilizer, has become concentrated in soil at solvent-contaminated sites as VOCs such as perchloroethylene and trichloroethylene are cleaned up. 1,4-Dioxane has also been found in a variety of personal care products (such as shampoos and conditioners) and is formed as a by-product during the manufacture of alkyl ether sulfates and other ethoxylated substances used in these products. 1,4-Dioxane is listed under Proposition 65 as known to cause cancer.

Formaldehyde: Formaldehyde was suggested for biomonitoring because levels in both indoor and outdoor air are a concern. Formaldehyde is listed as known to cause cancer under Proposition 65. Staff reported that it is found at elevated levels (above Reference Exposure Levels, RELs) and at levels posing high cancer risks in most indoor environments. Staff reported that exposure to formaldehyde is expected to decrease in the next few years in California, as composite wood regulations take effect and as construction using green building guidelines increases. Staff discussed the lack of a biomarker for formaldehyde. One suggestion was to measure formaldehyde DNA-protein crosslinks in peripheral blood lymphocytes.

Methyl-tert-butyl ether (MTBE)♦: The fuel oxygenate MTBE, although now banned in California, was suggested for biomonitoring because of groundwater contamination. Studies in animals have found both cancer and adverse effects on development.

Methylene chloride♦: Methylene chloride was suggested for biomonitoring because of concerns about levels in air. Methylene chloride is primarily used as a paint remover, but is also used as a solvent in chemical processing and in formulated products. It is listed as known to cause cancer under Proposition 65.

Styrene♦: Styrene was suggested for biomonitoring because of both inhalation exposures (from emissions from industrial processes, gasoline exhaust and cigarette smoke) and exposures via food (from polystyrene food packaging materials, from which residual styrene monomers can migrate into food). Styrene is extensively metabolized to styrene oxide, which is listed under Proposition 65 as known to cause cancer. The International Agency for Research on Cancer (IARC) has concluded that styrene is a probable human carcinogen.

Perchloroethylene (tetrachloroethylene)♦: Perchloroethylene was suggested for biomonitoring because of concerns about levels in air and groundwater. Perchloroethylene, a degreasing agent and a chemical intermediate, has been used extensively as a dry cleaning agent (but is being phased out for this use in California). It is listed under Proposition 65 as known to cause cancer.

Toluene♦: Toluene is a component of gasoline, petroleum fuels, solvents and thinners, and motor vehicle exhaust. It was suggested as an indicator of BTEX (benzene, toluene, ethylbenzene, xylene) exposures. Toluene exposure has also been a potential concern for nail salon workers.

Trichloroethylene (TCE)♦: TCE, a common industrial degreasing agent with some household use as well (e.g., glues, adhesives, paint remover, spot removers), was suggested for biomonitoring because of concerns about groundwater contamination (from industrial sites, rail yards, military bases) and also because of exposures from inhalation and dermal absorption from TCE-containing products. TCE is listed under Proposition 65 as known to cause cancer.

1,1,1-Trichloroethane♦: 1,1,1-Trichloroethane has been used as a solvent.

1,2,3-Trichloropropane (TCP): TCP is used as a paint and varnish remover, a cleaning and degreasing agent, and as a maintenance solvent. It was suggested for biomonitoring because it is a contaminant of concern in drinking water. It is listed as causing cancer under Proposition 65.

Vinyl chloride: Vinyl chloride, a known human carcinogen, was suggested for biomonitoring because it is an anaerobic biodegradation product of TCE and perchloroethylene and there is concern about groundwater contamination (e.g., at or around industrial sites, rail yards, military bases).

Xylene♦: Xylene is used as a solvent and also is found in petroleum products such as gasoline.

Water disinfectants and disinfectant by-products

Water disinfectants and disinfection by-products were suggested as generally important for biomonitoring. Epidemiological studies have reported increased cancer risk among individuals who consume chlorinated water. Disinfection by-products have been associated with cancer and reproductive and developmental effects in animals.

Chloramine: Staff suggested chloramine for biomonitoring because of concern about the effects of replacing chlorine as a water disinfectant with chloramine by many utility

districts throughout California. Staff noted that replacement with chloramine has decreased some of the known carcinogenic by-products of chlorine water disinfection (e.g., trihalomethanes), but may have introduced new health risks: Less than 20 percent of the by-products of chloramination have been identified. The switch to chloramine appears to increase the formation of N-nitrosodimethylamine (NDMA) (also suggested for biomonitoring) and highly toxic haloacetamides and haloacetonitriles.

Haloacetic acids: Haloacetic acids were suggested for biomonitoring because of concerns of adverse health effects with chronic exposures. Of the haloacetic acids, dichloroacetic acid (DCA) and dibromoacetic acid (DBA) are listed under Proposition 65 as known to cause cancer. Trichloroacetic acid (TCA) has been found to cause liver tumors in animals. DBA, DCA, and TCA have been reported to cause reproductive toxicity.

N-Nitrosodimethylamine (NDMA): The carcinogen NDMA was suggested for biomonitoring because it is a water disinfectant by-product. It is formed predominantly when chloramine is used as a water disinfectant but can also be formed to a much smaller degree when chlorine is used as a disinfectant. There was a substantial concern about drinking water contamination. Staff also reported that NDMA is currently on the U.S. Department of Defense Emerging Contaminant Watch List.

Trihalomethanes: The trihalomethanes were suggested for biomonitoring because they are by-products of water chlorination. With the exception of dibromochloromethane, the trihalomethanes (shown below) are listed as known to cause cancer under Proposition 65. One staff suggestion was to biomonitor for total trihalomethanes.

> *Bromodichloromethane*♦: Bromodichloromethane was suggested because it is a disinfectant by-product of water chlorination and, as such, is a drinking water concern. It is listed as known to cause cancer under Proposition 65. Staff noted that developmental and reproductive toxicity are also of concern.
>
> *Bromoform*♦: Bromoform was suggested because it is by-product of water chlorination and, as such, is a drinking water concern. It is listed as known to cause cancer under Proposition 65.
>
> *Chloroform*♦: Chloroform was suggested because it is a by-product of water chlorination. Staff commented that, in addition to drinking water, indoor air levels are also of concern because of vaporization during a number of hot water uses, including showering, bathing, dishwashing, and so forth. Chloroform is listed as known to cause cancer under Proposition 65.

Dibromochloromethane♦: Dibromochloromethane was suggested because it is a by-product of water chlorination and, as such, is a concern in chlorinated drinking water.

Other chemicals

Acrylamide♦: Acrylamide was suggested for biomonitoring because of the high levels in certain cooked foods. Staff also reported that it was found in studies of indoor air quality. Another concern was the possibility that over time acrylamide might be released from acrylamide-based polymers used in water treatment processes. Acrylamide is listed as known to cause cancer under Proposition 65.

Caffeine: Caffeine was suggested because of possible reproductive harm. Staff noted that, for some time, epidemiological evidence has linked caffeine exposure over 300 mg/day to increased risk of miscarriage. More recent evidence from larger studies found a link with exposures over 200 mg/day. Urinary caffeine was suggested as a biomarker for caffeine.

Caprolactam: Caprolactam was suggested based on its use in building products. It is used primarily as a monomer in the production of nylon-6 fibers and resins for textile, carpet and industrial yarns.

Microcystins: Microcystins, cyclic heptapeptides produced by blue-green algae, were suggested for biomonitoring because of concern for potential liver toxicity and results of epidemiological studies that link exposure in drinking water to liver and colorectal cancer.

Sodium benzoate: Sodium benzoate was suggested for biomonitoring because, as an ingredient in soft drinks, it can react with Vitamin C (either in the soft drink or in the body) to form benzene.

SECTION II: Staff input on criteria for selecting chemicals to biomonitor

Question #8 of the Query asked staff to consider 10 possible criteria for selecting chemicals to biomonitor and, given the CECBP's initial resource limitations, to provide input on the importance of these criteria in selecting chemicals to biomonitor. The criteria were as follows:

- *Chemicals widely used in California;*
- *New or emerging chemicals whose use is expected to increase;*
- *Chemicals on the CDC list, to compare California levels with the national levels;*
- *Chemicals not biomonitored by CDC, to capture what is not being assessed by the federal program;*
- *Chemicals where exposures are higher in California than national levels (e.g., due to mining, regulations on flame retardancy);*
- *Chemicals in the workplace where exposure may be the highest;*
- *Chemicals that pose the most risk for pregnant women, fetuses, and young children;*
- *Chemicals regulated by current state programs, to assess program effectiveness;*
- *Biomonitoring for chemicals that are likely to be higher in people in close proximity to polluting sources (e.g., near factories, ports, oil refineries or farms); and*
- *Chemicals that are persistent and bioaccumulative.*

Staff were asked to rank the four criteria that they viewed as most important. Criteria were generally ranked in responses by individual staff members, interviewed by telephone. However, some staff provided responses in consultation with colleagues; in at least two programs, staff jointly decided on a single response. Not all staff ranked four important criteria (some ranked five; several ranked fewer than four). Some staff responded to this question by offering general comments on chemical selection without ranking the proposed criteria. Because of all of these factors, responses to this question are reported qualitatively, and comments attributed to a "respondent" may refer to either an individual or group responding to this question.

Ranking of four most important criteria

"Chemicals widely used in California" was the criterion that respondents ranked first most frequently. One respondent noted that the Query should more appropriately have referred to the presence of chemicals in California as opposed to their usage. Another commented that "*Chemicals widely used in California"* may be difficult to measure and that volume is not necessarily a good surrogate for exposure via consumer products. One respondent cautioned that some chemicals can be a high health risk at low levels.

"Chemicals that pose the most risk for pregnant women, fetuses and young children" was also viewed as an important criterion. It was second to "*Chemicals widely used in California"* when only the first ranked criteria were tallied, but when respondents selected their top four criteria, it was the most frequently selected criterion (combining 1st, 2nd, 3rd and 4th). Over 70 percent of staff respondents ranked selecting "*Chemicals that pose the most risk for pregnant women, fetuses and young children"* as one of the four most important criteria.

The other top criteria receiving a ranking of 1st, 2nd, 3rd or 4th most frequently were *"New or emerging chemicals whose use is expected to increase"* and *"Chemicals that are persistent and bioaccumulative."*

General comments on criteria for selecting chemicals

Each of the proposed criteria listed in the Query was considered important by at least some staff members. For most respondents, "*Chemicals on the CDC list, to compare California levels with the national levels"* was not considered a high priority compared to the other proposed criteria. Some respondents felt it would be a missed opportunity to simply replicate the CDC list. One respondent suggested that biomonitoring for these chemicals should be a high priority: it would enable CECBP to identify chemicals where California biomonitoring could be dropped because the distribution of exposures is no different than the national distribution.

"Chemicals not biomonitored by CDC, to capture what is not being assessed by the federal program" was a high priority for many respondents. One wrote: "This will enable us to fill gaps in existing data, and gather early data on chemicals of emerging concern."

Selecting "*Chemicals where exposures are higher in California than national levels"* was also considered important by a number of respondents. A couple of respondents, however, felt it was ill-advised to focus on comparisons with the rest of the country.

As noted above, selecting "*New and emerging chemicals"* was considered a priority by a number of respondents. One respondent specifically cited nanomaterials and flame retardants in this category. The difficulty in tracking down emerging chemicals was also noted, which is compounded by the fact that the identities of many chemicals are proprietary.

"Chemicals in the workplace where exposure may be the highest" and "*Biomonitoring for chemicals that are likely to be higher in people in close proximity to polluting sources (e.g., near factories, ports, oil refineries or farms)"* were also given a high priority by a number of respondents.

Respondents considered the biomonitoring of "*Chemicals regulated by current state programs, to assess program effectiveness"* to be a laudable goal, but thought it would be difficult to accomplish. One respondent commented that it would be most meaningful if biomonitoring could be conducted before and after exposure controls were changed. Some respondents commented that it would take time before biomonitoring results could inform decision-making. One respondent concluded that it might take 10 years or five cycles of biomonitoring to assess effectiveness. With regard to mercury in fish, one respondent wrote: "Because we expect that it will take many years to see significant reductions in concentrations of mercury in fish, monitoring effectiveness of the control programs is a very long-term goal." There were other comments that suggested that this approach might only work when chemicals are banned or discontinued.

As noted above, respondents ranked "*Chemicals that are persistent and bioaccumulative"* as one of the most important criteria for selecting chemicals. One respondent noted, however, that sometimes data demonstrate that a chemical is persistent and bioaccumulative, but its toxicity might be inadequately studied and thus unknown.

Another suggestion was to use multiple criteria in selecting chemicals. One respondent suggested using a combined approach to selecting chemicals: select a few chemicals that are currently being biomonitored by the CDC list to compare levels in Californians with those nationwide; select a few chemicals where exposures are likely higher in California; select a few chemicals that are not being monitored by the CDC, and so forth.

SECTION III: Other staff comments on selecting chemicals to biomonitor

Section III captures other comments that staff made on selecting chemicals for biomonitoring.

Weigh the potential to evaluate markers of effect when selecting chemicals

One respondent wrote that, when available, markers of effect can contribute to the seriousness with which exposure data are viewed. As an example, with perchlorate, exposure data are now taken with additional seriousness since NHANES data showed an association between current exposure levels and decrements in thyroid hormones. The respondent suggested that when deciding between several deserving chemicals, CECBP should consider the potential for biomonitoring to provide this type of information.

Focus on biological effects

Several respondents suggested biomonitoring chemicals based on their mechanism of toxicity or biological effects. Examples cited by staff include:

- Chemicals that disrupt endocrine function
- Chemicals known to disrupt signaling pathways that have important functions during development
- Chemicals that affect thyroid hormone function
- Chemicals that trigger auto-immune responses.

Look for biomarkers of effect

Staff suggested biomonitoring for biomarkers of effect for specific chemicals as well as conditions or disease states (biomarkers of auto-immune disease) by looking for specific DNA or protein adducts, induced proteins, and so forth.

Consider interrelationships between chemicals

Staff suggested biomonitoring for chemicals that interact, citing some examples:

- Perchlorate hypothyroidism is exacerbated by cigarette smoke.
- Certain chemicals may affect the fate and/or toxicity of other environmental chemicals because they increase levels of certain cytochrome P-450 drug metabolizing enzymes.

Select representative chemicals

Staff suggested that:

- Certain chemicals are markers for other chemicals or groups of chemicals (e.g., cotinine for tobacco smoke).
- Certain chemicals co-occur, and biomonitoring for only one will provide sufficient information (e.g., one of the BTEX [benzene, toluene, ethylbenzene, xylene] chemicals).
- The most common chemical of a chemical class might be selected (e.g., the most common phthalate).
- Chemicals should be selected to be broadly representative, without omitting any media: include chemicals in food, packaging, consumer products, drinking water, outdoor air, indoor air, and so forth.

Address difficulty in determining identity of important chemicals

Staff raised the following issues:

- Are current biomonitoring programs capturing the majority of environmental contaminants in our bodies or only a small fraction of them?
- Trade secret issues are a problem: the identities of many products are proprietary.
- CECBP should investigate the possibility of undertaking preliminary open scans, to assess whether important chemicals are being missed.

CECBP should tie in with green chemistry issues

Staff commented that:

- Lack of data on replacements for phthalates and PBDEs is a specific green chemistry concern.
- Replacement of toxic chemicals with ones that have not been adequately studied is a general green chemistry concern.
- Biomonitoring for alternatives to well-known problem chemicals (e.g., bisphenol A) may provide early evidence that the supposedly safer alternative may also be a problem.
- Biomonitoring a "new" chemical coming from an industry will establish real time baselines even before a chemical becomes a public health issue.
- Biomonitoring for chemicals that might potentially be phased out would provide critical information for evaluating the efficacy of the regulatory action.

Weigh the priority of chemicals in current use versus banned chemicals

Some staff questioned whether it is useful to biomonitor for banned chemicals such as organochlorine pesticides such as DDT. Staff commented that it was important to:

- Select chemicals where it would be possible to take public health interventions or environmental actions.
- Understand the biological actions of certain contaminants, whether or not they are in current use. In the case of DDT, staff reported that developmental effects associated with maternal body burdens of DDT are still being worked out and biomonitoring could provide important information.

Conduct community studies

Staff commented that a statewide study should be accompanied by community studies, and provided the following input on such studies:

- Staff noted that CDC's national study provides a snapshot of the U.S. population and that CECBP can provide a statewide snapshot. Community studies would complement statewide and CDC studies because some exposures can be tracked to sources geographically. Specific methods such as geocoding/relationship to source (or in the case of traffic, roads) can add to these studies.

    - Examples of possible community studies cited by staff included:
        1. Individuals living near farms (look at chemicals important geographically)
        2. Individuals living in close proximity to traffic
        3. Individuals living near lead smelters

- Staff suggested conducting focused workplace studies.
    - One respondent specifically mentioned biomonitoring heavy metals (*e.g.*, nickel, cadmium) in workers in the metal finishing industry.

- Staff recommended considering studying sensitive subpopulations:

    - Study individuals with specific disease states: For example, look at manganese, dieldrin and paraquat in people with Parkinson's disease or people with neurodegenerative diseases.
    - Study populations with respiratory disorders (such as people with asthma and allergies) with respect to pesticides released aerially by vector control.
    - Study pregnant women and children to look at specific chemicals, such as BPA, DEHP, and nonylphenol, for which there are concerns about developmental toxicity and new data suggesting effects on obesity and

neural and immune development with critical exposure periods being prenatal and early childhood.

Look at demographics and how people are exposed differently

Staff noted the following:

- In some ethnic groups, there is significant exposure from imported food (e.g., Chinese imports).
- For methylmercury exposure, look at fish consumption, as there is greater fish consumption among the affluent and in certain ethnic populations.

Consider environmental justice issues

Staff stressed the importance of considering environmental justice issues:

- Staff mentioned issues such as disproportionate exposures because of geographic location and dietary exposures due to subsistence fishing.

Use all available information

Staff suggested leveraging other available data:

- Staff suggested possible resources both in terms of available data (from established state monitoring programs) and future collaborations.
- Staff suggested closely watching the actions of the European Union (EU) and chemicals banned under the new EU-wide chemicals policy known as Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).

Plan what to do with the results

Staff commented that it was important to:

- Know what to do with the data and have the resources to take action.
- Recognize that mitigating risks is not only a regulatory issue – other actions have to be taken as well, such as legislation, education, tracking.
    - With respect to biomonitoring mercury levels, one staff member wrote that biomonitoring plus follow-up fish consumption advice could be very useful in reducing the risks of adverse effects from mercury to children whose mothers eat locally caught fish.

Comments on methods

- General staff comments on methods:
    - Chemical panels may be easier than individual chemicals.
    - Be informed as to what the University of California system is working on and what type of analyses are available for chemicals and metabolites.
    - Analysis of urinary metabolites is a simple non-invasive method for collecting samples from participants.
    - New assays can be developed but they require time, effort and money and may cause program delays.

- Specific staff comments on methods:
    - Methylmercury: staff suggested that methylmercury may be so well correlated with total mercury that the added cost of measuring methylmercury is not worthwhile. "It might make most sense as a follow-up test for individuals with 'high' total mercury who claim they don't eat fish."
    - Traffic-related contaminants: GIS-based tools have been developed to assess exposure to traffic related pollutants.

Concerns about false negatives

One respondent expressed concern about the danger of false negatives with biomonitoring due to differences in pharmacokinetics and pharmacodynamics effects.

Concluding general staff comments

Staff commented that:

- CECBP needs to be visionary – the program should look forward two decades.
- CECBP should consider all media: look at food, packaging, consumer products, air, water.
- CECBP should select chemicals for which it is possible to have a positive impact on public health.

APPENDIX

California Environmental Contaminant Biomonitoring Program
State Government Query

California Environmental Contaminant Biomonitoring Program
State Government Query

Background

The California Environmental Contaminant Biomonitoring Program was authorized by Senate Bill No. 1379 and signed into law in 2006 (Health and Safety Code Sections 105440-105444). The Program will determine baseline levels of environmental contaminants in a representative sample of Californians, establish time trends in chemical levels, and assess the effectiveness of current regulatory programs.

The Program is being administered as a collaborative effort between the Office of Environmental Health Hazard Assessment (OEHHA), the Department of Toxic Substances Control (DTSC), and the California Department of Public Health (CDPH). A nine-member Scientific Guidance Panel will provide scientific peer review and make recommendations on program design and on selection of specific chemicals for biomonitoring. More details about the program are can be found at http://www.oehha.org/multimedia/biomon/index.html.

Selecting chemicals for biomonitoring will take place via a two-step process, with "priority chemicals" for biomonitoring chosen from a list of chemicals identified as "designated chemicals". Designated chemicals are defined as those chemicals known to or strongly suspected of adversely impacting human health or development. At present, the designated chemicals consist of chemicals or their metabolites that are included in the CDC biomonitoring program (the CDC list is attached). The Scientific Guidance Panel can recommend that additional chemicals be added to the list of designated chemicals.

Criteria for adding a chemical to the list of designated chemicals were specified in the legislation and includes: exposure or potential exposure to the public or to specific subgroups; known or suspected health effects based on peer-reviewed studies; the need to assess the efficacy of existing regulatory programs to reduce exposures; the availability of an adequate analytical method for biomonitoring, and the incremental analytic cost of performing the analyses.

The Scientific Guidance Panel will recommend that chemicals be identified as *priority chemicals* based on: 1) the degree of potential exposure to the public or specific subgroups, including, but not limited to occupational, 2) the likelihood of a chemical being a carcinogen or toxicant based on peer-reviewed health data, the chemical structure, or the toxicology of chemically related compounds, and 3) the limits of laboratory detection for the chemical, including the ability to detect the chemical at low enough levels that could be expected in the general population.

The first meeting of the Scientific Guidance Panel was held in December 2007. At that meeting, the Program committed to various efforts to gather input on chemical selection from a wide range of stakeholders. These included workshops, teleconferences and development of a survey geared to the lay public (which is available on the Program

website). The survey asks about specific categories of chemical exposures and provides an opportunity to propose specific chemicals to be considered for biomonitoring. We are interested in your specific input in these areas as well.

Query to State Government Agencies

The Program has also committed to contacting boards and departments throughout State government. We want to know:

1. What chemicals, categories of chemicals or chemical exposures are currently of most concern to your program?

2. Are there any chemicals, categories of chemicals or chemical exposures that your program sees as an emerging concern because of exposure, potential toxicity, bioaccumulation or persistence?

3. Are there chemicals or categories of chemicals addressed by your program where exposures in California would be expected to differ significantly from typical national exposure levels?

4. Are there chemicals, categories of chemicals or chemical exposures that should be biomonitored to assess the effectiveness of your program?

5. As a public health scientist, what chemicals, categories of chemicals, or chemical exposures, whether or not they are chemicals of concern for your program, do you think should be biomonitored in California?

6. Do you have any information on the extent of exposure in California or in subgroups in California of chemicals you have identified?

7. For purposes of analysis, can you recommend the best chemical markers (e.g., the chemical itself, metabolite, hemoglobin adduct) for any of the chemicals, categories of chemicals or chemical exposures you have identified that you think should be biomonitored?

8. The initial number of priority chemicals biomonitored in the California program will, of necessity, be limited. As laboratory capability is increased, the number of priority chemicals biomonitored will be expanded.

   Given the current limits, we would like your input on whether the program should put particular weight on any of the following focus areas:

   i. Chemicals widely used in California;
   ii. New or emerging chemicals whose use is expected increase;
   iii. Chemicals on the CDC list, to compare California levels with the national levels;

iv. Chemicals not biomonitored by CDC, to capture what is not being assessed by the federal program;
v. Chemicals where exposures are higher in California than national levels (e.g., due to mining, regulations on flame retardancy);
vi. Chemicals in the workplace where exposure may be the highest;
vii. Chemicals that pose the most risk for pregnant women, fetuses, and young children;
viii. Chemicals regulated by current state programs, to assess program effectiveness;
ix. Biomonitoring for chemicals that are likely to be higher in people in close proximity to polluting sources (e.g., near factories, ports, oil refineries or farms);
x. Chemicals that are persistent and bioaccumulative.

a. From the above list, would you choose and rank the top four areas of focus in terms of the importance they should have in selecting priority chemicals to biomonitor?

b. Do you recommend other areas of focus?