OEHHA Synthetic Turf Study Summary of Revisions

Revision 1: Addition of a report subtitle to better reflect focus on chemicals in crumb rubber infill.

The report title was edited to include clarification that this study is focused specifically on the crumb rubber infill component of synthetic turf fields. The report title was changed to *Synthetic Turf Study: Assessment of Health Risks from Exposure to Chemicals in Crumb Rubber Infill*.

Revision 2: Discussion of chemicals that were dropped from the final analysis.

Section 3.6. Confirmation of Chemical Identity was added to discuss the chemicals that were not included in the final analysis and the reasons those chemicals were excluded from the study.

OEHHA tentatively identified over 400 organic chemicals in the combined targeted and non-targeted analyses of air and crumb rubber samples. The identities of a total of 179 organic chemicals were confirmed using reference standards by matching the chromatographic (GC retention time) and spectral (MS fragmentation pattern) data (Appendix D.3.6.1, Table D-14). Of these, 30 chemicals were not included in the targeted lists for sample analyses due to limitations in the availability of toxicity data or data showing low toxicity.

The tentative identifications for 260 organic chemicals were not confirmed due to several limitations:

- *79 chemicals (Appendix D.3.6.2, Table D-15), did not have high purity reference standards for a variety of reasons including their unavailability within a reasonable timeline and cost;*
- *14 chemicals were only detected in the blank samples (Appendix D.3.6.3, Table D-16);*
- *45 chemicals (Appendix D.3.6.4, Table D-17; Appendix D.3.6.5, Table D-18) had available data showing low order of toxicity or that the chemicals are relatively non-toxic such as those commonly found in food or plants (see Chapter 4 for details), or had no toxicity data available; and*
- *122 chemicals (Appendix D.3.6.6, Table D-19) could not be confirmed due to limitations of instrument sensitivity and peak resolution among many coeluting chemicals.*

Revision 3: Expanded discussion of ambient and surface temperature data to address heat hazard on fields.

The following text was added to Section 3.7.1. Temperature to discuss the ambient and surface temperature data collected on the study fields.

Higher surface temperatures were observed as the ambient temperature increased, with higher surface temperatures observed in the warmer sampling months. The maximum surface temperature was observed at midday for all fields. At the time the maximum surface temperature occurred, it was at least 20 degrees higher than ambient temperature observed at the same time for most of the fields. While ambient temperatures were similar on- and off-field, the off-field surface temperatures (on surfaces including grass, concrete, and dirt) were approximately 20 degrees lower than on-field surface temperatures. No significant differences in the average or maximum surface temperatures were observed based on field region (with the exception of Region 4/5 which had a sampling size of 2 fields) or field age alone.

Average temperatures at the deep, shallow and surface levels on the fields in the four regions studied followed a similar pattern of the deeper the probe, the cooler the temperature. In general, surface temperatures were the hottest and were more than 20 degrees higher than ambient temperatures. The highest surface temperature measured on a single field was 151 °F.

<u>Revision 4</u>: Clarification of the data spread on DART hazard across age groups.

The following text was added to Section 6.3.3. Hazard Index for DART in response to Scientific Advisory Panel (SAP) questions about the large spread between the calculated HI_{DART} values for those under 11 years and those above 11 years. *The calculated maximum value of HI_{DART} was greater than 1 for on field exposures of athlete groups aged 11 – 70 years, as detailed above in the section on inhalation exposure to DART chemicals (Section 6.3.1). The HI_{DART} for these age groups was based on a TC_{inh} value of 0.002 µg per cubic meter for BaP, while a value of 0.4 µg per cubic meter for BaP was used for children less than 11 years of age (Section 4.2.2).*

<u>Revision 5</u>: Discussion of biomonitoring feasibility study.

In Section 7.3. Study Boundaries and Limitations, the following text was added to address the biomonitoring of field users:

This study measured chemical concentrations in the air and in crumb rubber. No personal or biomonitoring measurements of chemicals in synthetic turf field users were performed. A study plan prepared by UCB presented the feasibility of using personal and/or biological monitoring to assess exposure to chemicals on synthetic turf fields (Appendix F.7). The report identified chemical targets that could be included in a biomonitoring study, and methods and metabolites to monitor and track their exposure. This preliminary study plan highlights the challenges and limitations of monitoring for a small number of VOCs, SVOCs, and metal/metalloids detected on synthetic turf fields. Certain chemicals identified as present on synthetic turf fields, even those designated as field-related, may have multiple uses and other exposure sources which make it

difficult to identify synthetic turf fields as the unique chemical exposure or to determine the fraction of measurable chemical biomarkers that are due to synthetic turf field use. In a pilot biomonitoring study on synthetic turf fields (USEPA and CDC/ATSDR, 2024), no differences in blood metal concentrations or urinary PAH levels were found between grass and synthetic turf field users.

Revision 6: Calculation of DART hazard on longer-than-average "tournament days".

In Section 7.4.2. Time-Activity and Exposure Parameters, the following text was added to address the hazard on days where field users may spend extended time on/at the field which is representative of a hypothetical "tournament day".

With particular focus on DART endpoint, the time spent on field (exposure time, ET) on tournament days relative to practice days is greater, and there is wide variability in ET among field users. The mean ET varied from 1.5 to 3.1 hours during practice compared to mean ET of 2.1 to 4.3 hours on game days. However, the 95th percentile ET values varied from 2 to 8 hours during practice compared with 4 to 9.2 hours during game days (Appendix B.2.4). As detailed in the preceding paragraph, OEHHA risk assessment is based on mean ET values. Considering the impact of 95th percentile ET values, it will have a direct influence on the resulting exposure calculations and HI_{DART}. Thus, for a hypothetical scenario of tournament day exposure based on the 95th percentile ET values (ET = 4 to 9.2 hours), the resulting HI_{DART} can be greater than the mean values calculated in this study because of greater ET values (ranging from 1.7 to 4.6).

Revision 7: Comparison of the study findings with those of other studies on synthetic turf.

Section 7.7. Comparison to Other Studies was added to discuss how the results of this study compare to other published studies. The following text was added:

OEHHA's study of 35 synthetic turf fields with crumb rubber infill adds to the growing literature about exposure to chemicals that may be released from crumb rubber. The OEHHA study is a risk assessment based on detected chemicals with TC values for which exposure assessment was conducted, and it is not a health impact study or an epidemiological evaluation. The non-cancer hazard and cancer risks to turf field users obtained in this study are comparable to earlier studies summarized in Tables A-1 and A-2 (Beausoleil et al., 2009; Connecticut Academy of Science and Engineering, 2010; Denly et al., 2008; Dye et al., 2006; European Chemical Agency, 2017; European Chemical Agency, 2021; Ginsberg and Toal, 2010; Ginsberg et al., 2011; Li et al., 2010a; Li et al., 2010b; Lim and Walker, 2009; Lioy and Weisel, 2011; Mattina et al., 2007; Menichini et al., 2011; National Institute for Public Health and the Environment, 2017a; National Institute for Public Health and the Environment, 2017b; Pavilonis et al.,

2014; Ruffino et al., 2013; Simcox et al., 2010; Simcox et al., 2011; USEPA, 2009; Vetrano, 2009; Zhang et al., 2008). Further, the conclusions of the NTP Toxicology studies on crumb rubber and the ECHA risk assessment are in line with the present study (Appendix A.2). As seen in other studies (Simcox et al., 2010; Simcox et al., 2011; USEPA, 2009; Vetrano, 2009), OEHHA's particle analysis also found that on- and off-field particle levels were similar.

Whereas previous studies used standard or theoretical exposure parameters in their assessments (Denly et al., 2008; Vetrano, 2009), this study estimated exposure to chemicals based on survey and video studies of soccer players in California. Collected data was used to estimate relevant exposure scenarios and characterize variability associated with risk estimates.

Additionally, elevated surface temperatures on synthetic turf fields found in the present study were consistent with the temperature evaluations reported in earlier studies. For example, Lim and Walker (2009) reported that synthetic turf fields had surface temperatures that were on average 26- to 42-degrees Fahrenheit higher than grass and other surfaces. Denly et al. (2008) measured surface temperatures ranging from 80 to almost 180 degrees Fahrenheit while the ambient temperatures ranged from around 70 to 100 degrees Fahrenheit.

Apart from the studies included in Appendix Tables A-1 and A.2, a report from the Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds (FRAP) study was released (USEPA, 2016; USEPA and CDC/ATSDR, 2024)(US EPA 2024). While the FRAP study is not a risk assessment, it focused on assessing potential human exposure for six chemicals (pyrene, benzo(a)pyrene, benzothioazole, methyl isobutyl ketone, lead and zinc), while the OEHHA study conducted exposure and risk assessments for 148 chemicals associated with crumb rubber infills. Furthermore, in the FRAP study, only 78 of the targeted analytes were found to have any TC values, while the OEHHA study found or developed TC values for 148 chemicals to facilitate a health risk assessment.

Regarding the number of chemicals, OEHHA's study tentatively identified more than 400 organic chemicals initially, and then focused on 149 organic chemicals plus 30 metals and metalloids for targeted analysis. The risk assessment was based on 57 VOCs, 71 SVOCs, and 20 metals and metalloids for which OEHHA had found or developed TCs. These chemicals are comparable to those focused by earlier studies summarized in Tables A-1 and A-2. The US EPA's FRAP study, in its targeted analysis, identified 31 VOCs, 49 SVOCs and 21 metals (USEPA, 2016). In addition, a literature review of 20 studies on crumb rubber across 6 countries compiled a list of 302 chemicals (from analysis of crumb rubber, air, and leachate), without assigning or

identifying chemicals associated with each specific location, study or exposure medium (Perkins et al., 2019).