California's OEHHA Synthetic Turf Study: Assessment of Health Risks from Exposure to Chemicals in Crumb Rubber Infill

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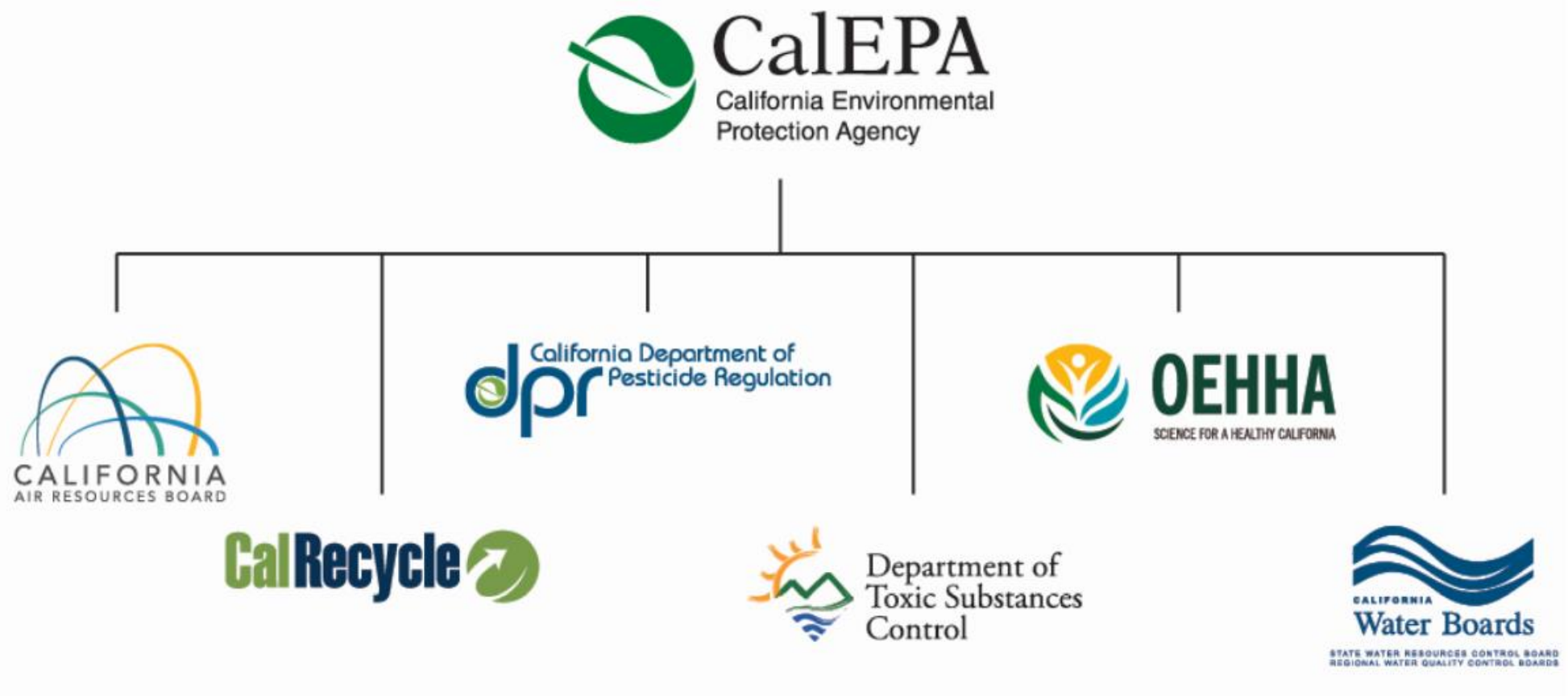
Who We Are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Who We Are

OEHHA
SCIENCE FOR A HEALTHY CALIFORNIA

Our mission is to protect and enhance the health of Californians and our state's environment through scientific evaluations that inform, support and guide regulatory and other actions.

BIOMONITORING CALIFORNIA

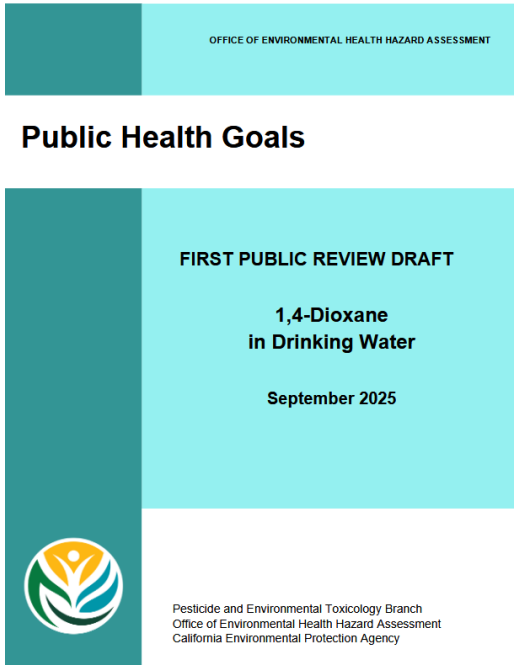
PROPOSITION 65
Your right to know!

GOOD CATCH CALIFORNIA
Your Fish Advisor

CalHeatScore

CalHeatScore shows daily rankings of forecasted heat impacts across California ZIP codes.

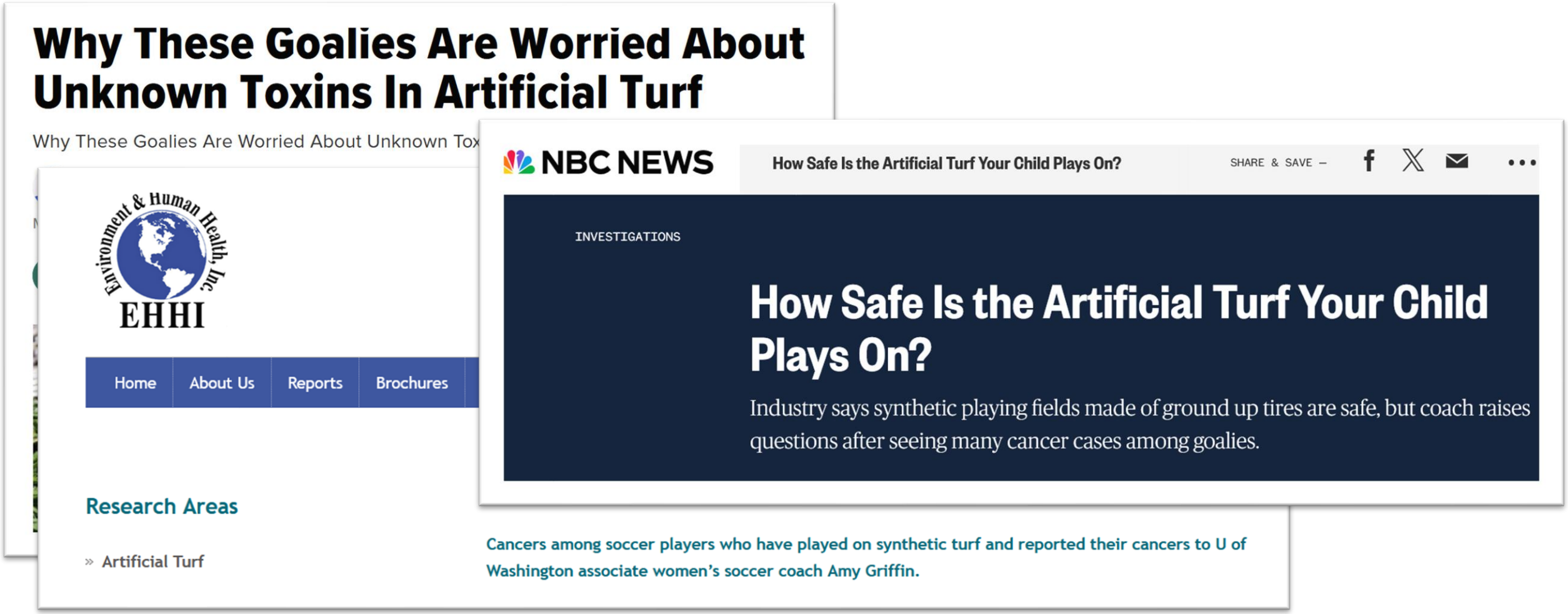
CalEnviroScreen



Outline

- Background
- Field Characterization
- Exposure Characterization
- Toxicity Evaluation
- Risk Characterization
- Environmental Data
- Conclusion

Background


Why These Goalies Are Worried About Unknown Toxins In Artificial Turf
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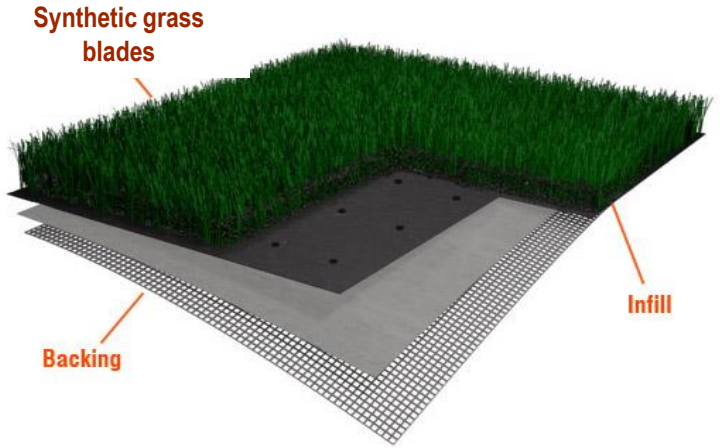
How Safe Is the Artificial Turf Your Child Plays On?
Industry says synthetic playing fields made of ground up tires are safe, but coach raises questions after seeing many cancer cases among goalies.
Cancers among soccer players who have played on synthetic turf and reported their cancers to U of Washington associate women's soccer coach Amy Griffin.

Background



Synthetic grass blades:

- soften the play surface
- look like natural grass

Backing materials

Crumb rubber infill:

- is made from chopped-up waste tires
- supports synthetic grass blades
- cushions falls

OEHHA Synthetic Turf Study

Goal: to characterize the exposures and health risks from crumb rubber infill on synthetic turf fields, considering:

- Multiple age groups of athletes, coaches, referees and spectators;
- Fields of various ages and in different climate zones across California; and
- Multiple exposure routes (inhalation, dermal, oral)

Research Partners

- Lawrence Berkeley National Laboratory (LBNL)
- California Institute of Quantitative Sciences at the University of California Berkeley (UCB)
- UCB Center for Environmental Research and Children's Health
- University of Arizona

Uniqueness of the Study

Field Characterization:

- Collected air and particle samples on active fields
- Conducted non-targeted analyses to identify unknown chemicals for analyses of field samples

Exposure Characterization:

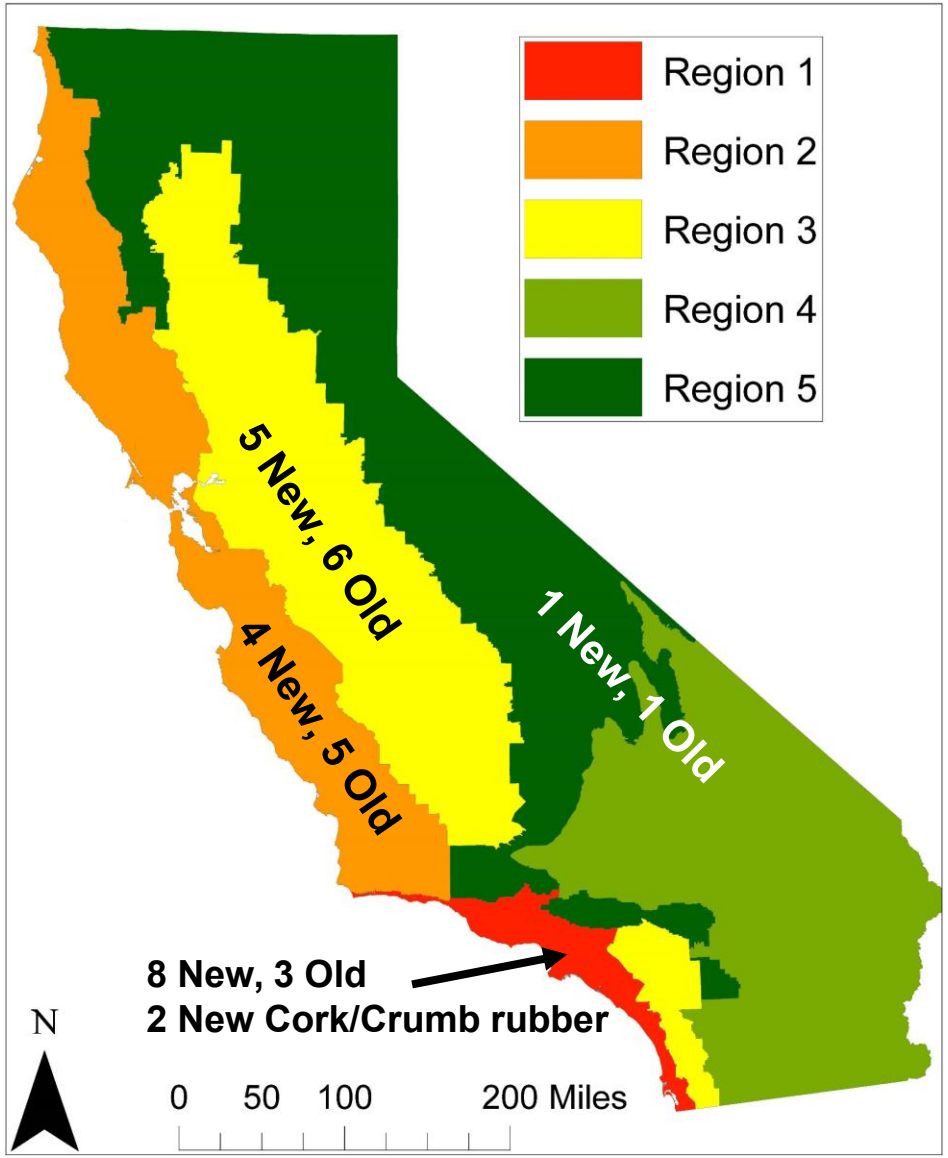
- Collected soccer player sport activity data
- Determined soccer exposure data by decoding video recordings of soccer events

Human Health Risk Assessment:

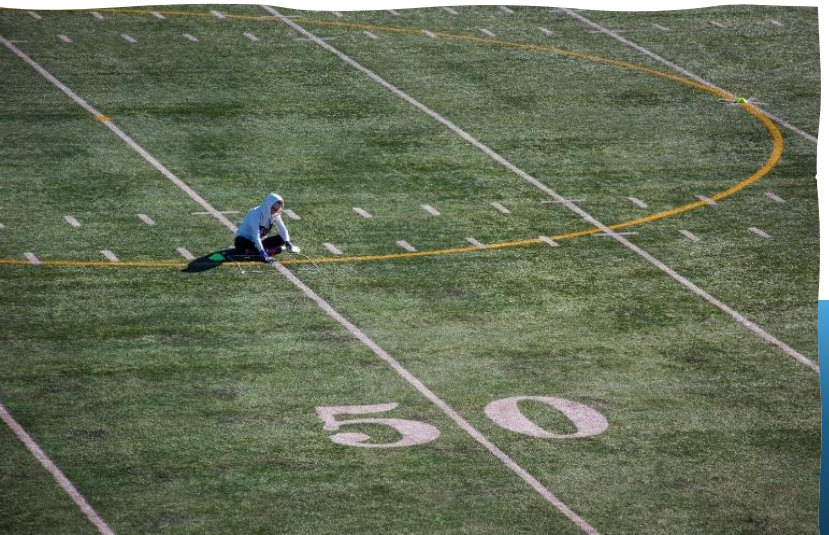
- Complied and derived toxicity criteria of selected tire related chemicals
- Exposure assessment and risk characterization for athletes, coaches, referees, spectators – both on average (across 35 fields) and at individual field level

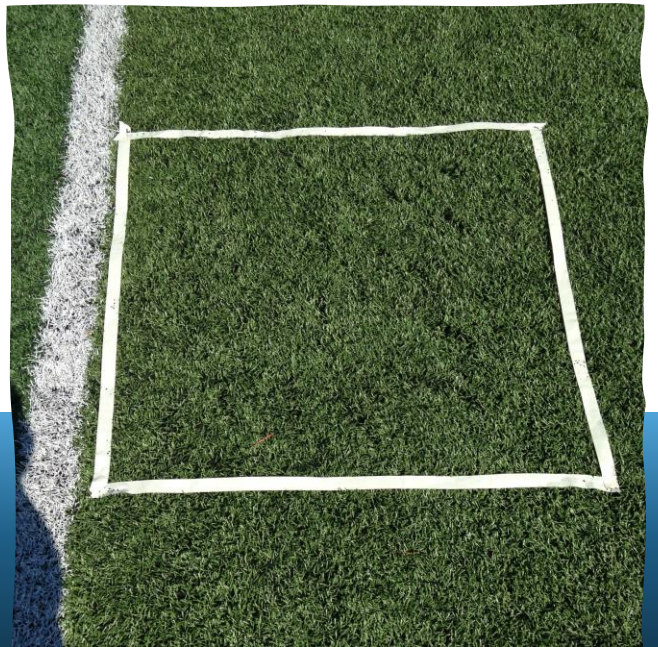
Summary of Field Selection

Climate Region		No. of Fields Sampled
1	Southern coastal areas	13
2	Northern and central coastal areas	9
3	Southern interior valleys and northern Central Valley	11
4/5	Southern high and low deserts and mountainous areas	2
	Total	35



Goal: Collect samples to characterize and quantify the chemicals that may be released from synthetic turf fields





Air samples

Analyzed for:

- VOCs
- SVOCs
- Carbonyls

Crumb rubber

Analyzed for:

- Organics
- Metals

Chemicals Detected

Air (600+ samples)

Chemical class	Detected	Targeted
Volatile organic compound: On-field	46	55
Volatile organic compound: Off-field	45	55
Carbonyl: On-field	11	13
Carbonyl: Off-field	3	13
Semi-volatile organic compound: On-field	62	70
Semi-volatile organic compound: Off-field	60	70

Crumb Rubber-Simulated Biofluids (300+ samples)

Biofluid	Detected	Targeted
GI-metals	30	31
GI-organic	76	86
Dermal-organic	75	86

Includes aldehydes, alkanes and alkenes, oxygen containing organics, fatty acids, phthalates, nitrogen organics, PAHs (no PFAS detected)

Chemical Designation = “Field-Related”

- All metals, metalloids and SVOCs: target chemicals identified from crumb rubber analysis
- VOCs in air: concentrations decreased with increasing vertical height observed for stratified on-field tower data
- Aldehydes and Ketones:
  - concentrations decreased with increasing vertical height observed for stratified on-field tower data, OR
  - concentration higher than environmental monitoring data collected in the MATES V study, OR
  - no tower or MATES V study data available

Exposure Assessment: Groups and Pathways

Age Group	Athletes	Coaches	Referees	Spectators	Spectators
Exposure	**On-field**				**Off-field**
Third trimester fetus				✓	✓
0<2 years				✓	✓
2<6 years	✓			✓	✓
6<11 years	✓			✓	✓
11<16 years	✓			✓	✓
16<30 years	✓	✓	✓	✓	✓
30<40 years	✓	✓	✓	✓	✓
40<50 years	✓	✓	✓	✓	✓
50<70 years	✓	✓	✓	✓	✓

Pathway	Pathway-specific parameters	Age and receptor-specific parameters
Inhalation	❖ Exposure concentration ❖ Breathing rate ❖ Inhalation absorption	❖ Bodyweight ❖ Event frequency ❖ Event time ❖ Annual event time ❖ Exposure duration
Dermal	❖ Bioaccessible dermal concentration ❖ Dermal load ❖ Skin absorption	
Ingestion ❖ hand-to-mouth ❖ hand-to-object-to-mouth ❖ object-to-mouth	❖ Bioaccessible gastrointestinal concentration ❖ Gastrointestinal absorption ❖ Ingestion rate	

Time-Activity Studies

Goal: Characterize exposure-related human activity patterns to support OEHHA's efforts to model exposures resulting from use of synthetic turf fields in California (soccer-specific)

Survey

Soccer players and their parents throughout California

Field Observational Study

Videotape soccer players at practices and games on turf fields containing crumb rubber

Archived Video Recording Study

Review and translation of video footage from previous studies on children playing on turf and playground settings

Information Collected:

- Demographic
- Contact frequency
- Potential dermal and ingestion exposures
- Exertion to inform inhalation exposure estimates
- Hygiene practices
- Player history

Toxicity Evaluation

- Toxicity criteria from OEHHA and other government agencies
  - Most health-protective value based on the most sensitive toxicity endpoint
- Extrapolation using toxic equivalency factors
- Adopting toxicity criteria from structurally similar chemicals
- Conducting route-to-route extrapolation of toxicity criteria
- Development of de novo toxicity criteria of chemicals

Without toxicity criteria: not included in risk characterization

Risk Characterization

Health Outcome	Exposure Route	Receptor Group
Acute toxicity	Inhalation	Athletes (2<70 years) Coaches (16<70 years) Referees (16<70 years) Spectators (Third trimester fetus<70 years)
Developmental and reproductive toxicity (DART)	Inhalation, dermal, ingestion	
Sensory irritation	Inhalation	
General chronic toxicity	Inhalation, dermal, ingestion	
Cancer	Inhalation, dermal, ingestion	

Concentration Data

Individual field data

May represent a local “home” field exposure scenario

Relevant for acute effects and DART endpoints

Average across 35 fields

May reflect exposure at multiple fields across CA due to travel, or tournaments, during the soccer season

Relevant for all other health endpoints

Risk Characterization

$$\text{Hazard Quotient(HQ)} = \frac{\text{Exposure Metric}}{\text{Toxicity Criterion}}$$

Exposure metric: Exposure concentration or dose of the chemical

Toxicity Criterion (TC): Concentration or dose which is likely to be without an appreciable risk of deleterious effects to humans

- HQ for all chemicals were summed together to calculate the hazard index (HI) for each receptor category and field
- HI ≤1: Considered not to present a health hazard (acute toxicity, DART, sensory irritation, and general chronic toxicity)

$$\text{Cancer Risk} = \text{LADD} \times \text{CSF}$$

LADD = Lifetime Average Daily Dose integrating the age sensitivity factors specific to each age group

CSF = Cancer Slope Factor for the route of exposure

- Risk calculations conducted for multiple chemicals via multiple exposure routes (inhalation, dermal, and ingestion) for all age groups
- 1×10^{-6} (1 excess cancer in a population of 1 million people over a lifetime) is considered a negligible risk or *de minimis* risk level

Hazard Index Results

Acute toxicity: All HI<1

Sensory irritation: All HI<1 for field-related chemicals (maximal value exceeded 1 for non-field-related sensory irritants)

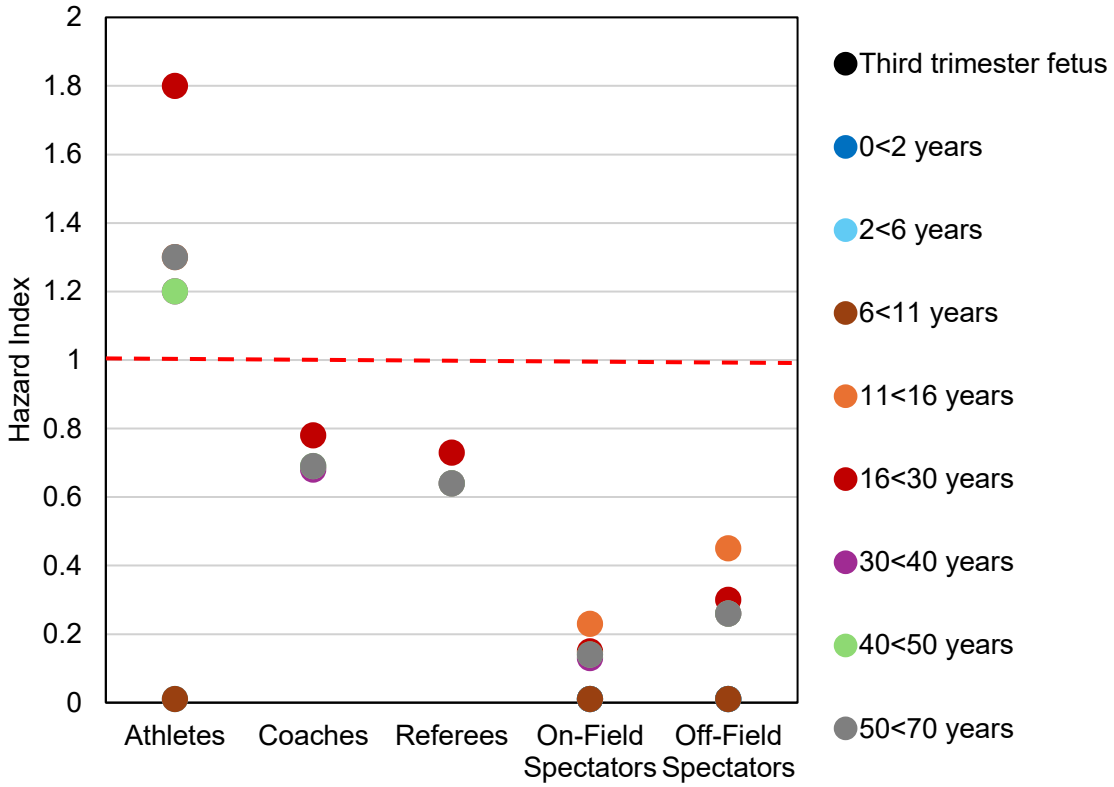
Chemical Group	On-Field Acute HI	Off-Field Acute HI
Field-Related Chemicals	<0.01	<0.01
Non-Field-Related Chemicals	0.47	0.13
All Chemicals Acute HI_{inh}	0.47	0.13

Chemical Group	HI Mean	HI Maximum
Field-related Sensory Irritants, On-field	<0.01	<0.01
Non-Field-related Sensory Irritants, On-field	0.44	1.90
All Sensory Irritants, On-field	0.44	1.90

Hazard Index Results

One-Day DART: All HI<1 for the average across individual fields for field-related chemical (based on 24 field-related chemicals)

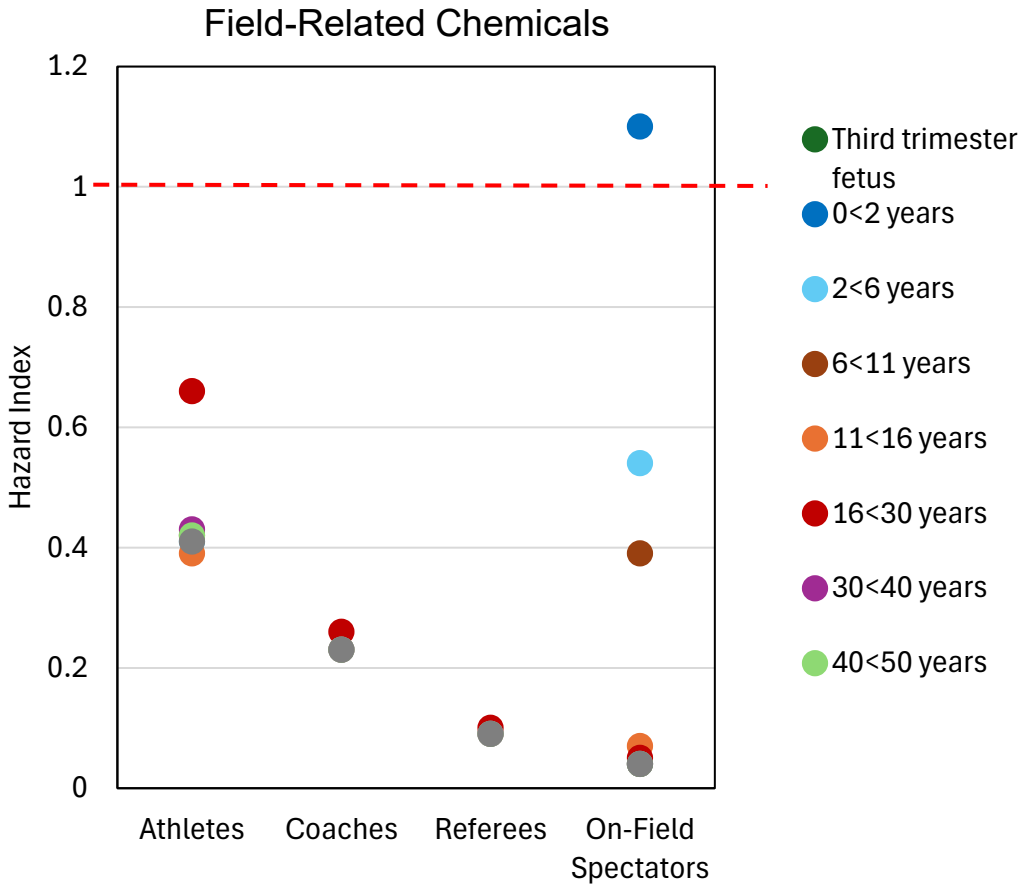
HI>1 for athletes 11-70 years for the maximum among individual fields (chemical driver: benzo(a)pyrene with an uncertainty factor of 3,000)



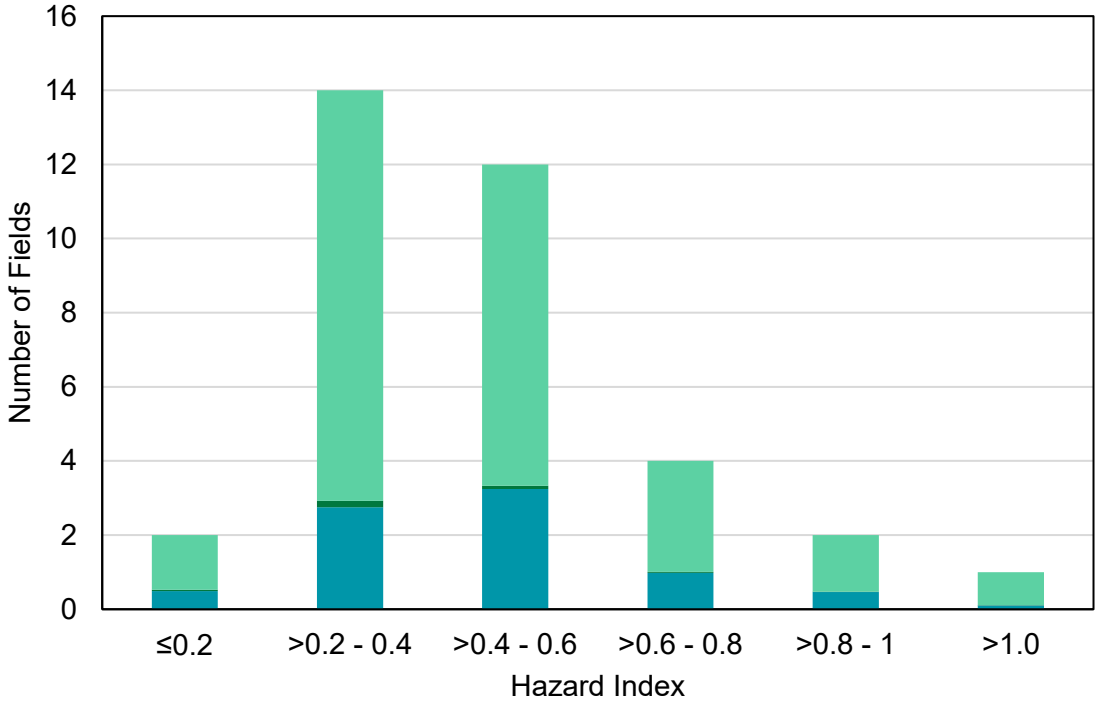
Hazard Index Results

Chronic toxicity: All HI<1 for the average among individual fields (based on 99 field-related chemicals and 21 non-field related chemicals)

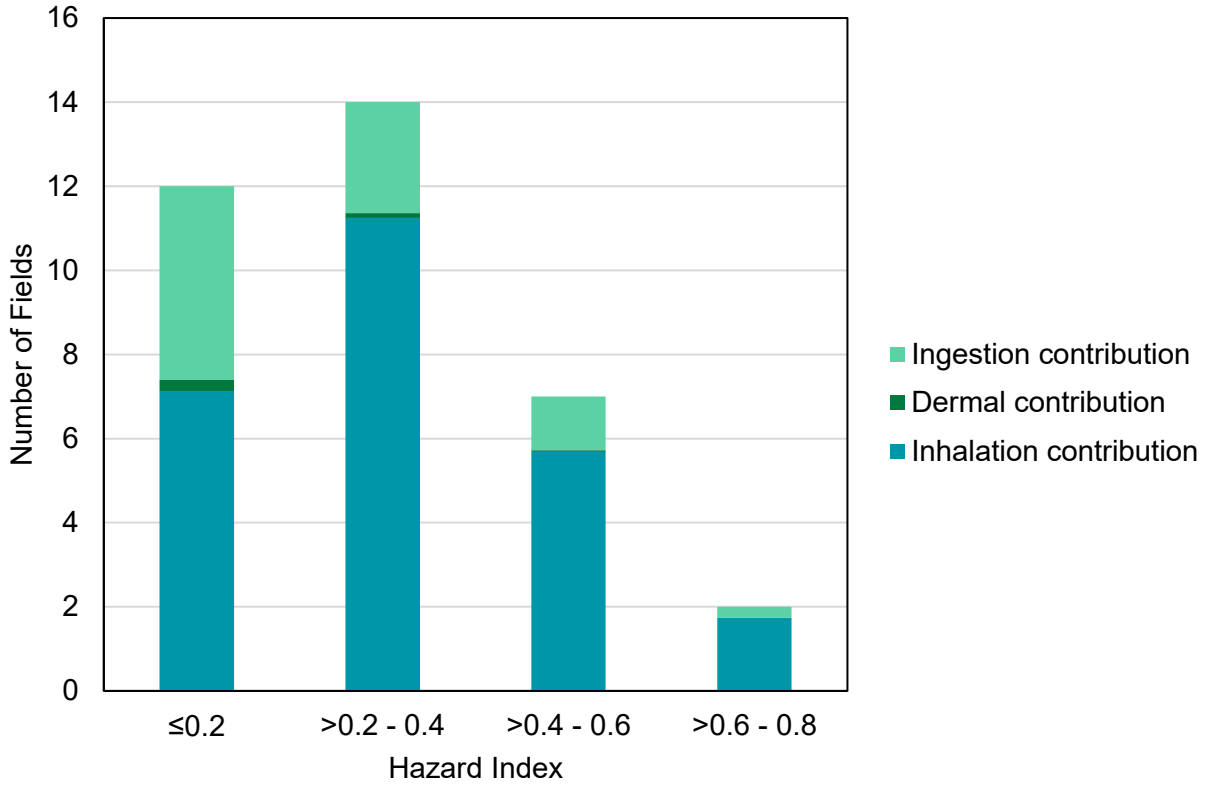
HI>1 for on-field spectators 0<2 years (HI = 1.2) for the maximum among individual fields (of the 99 field-related chemicals contributing to the HI, lead was the driver, contributing to 66% of the total value through the ingestion route)



Hazard Index for Chronic Toxicity



On-field Spectators 0<2 Years

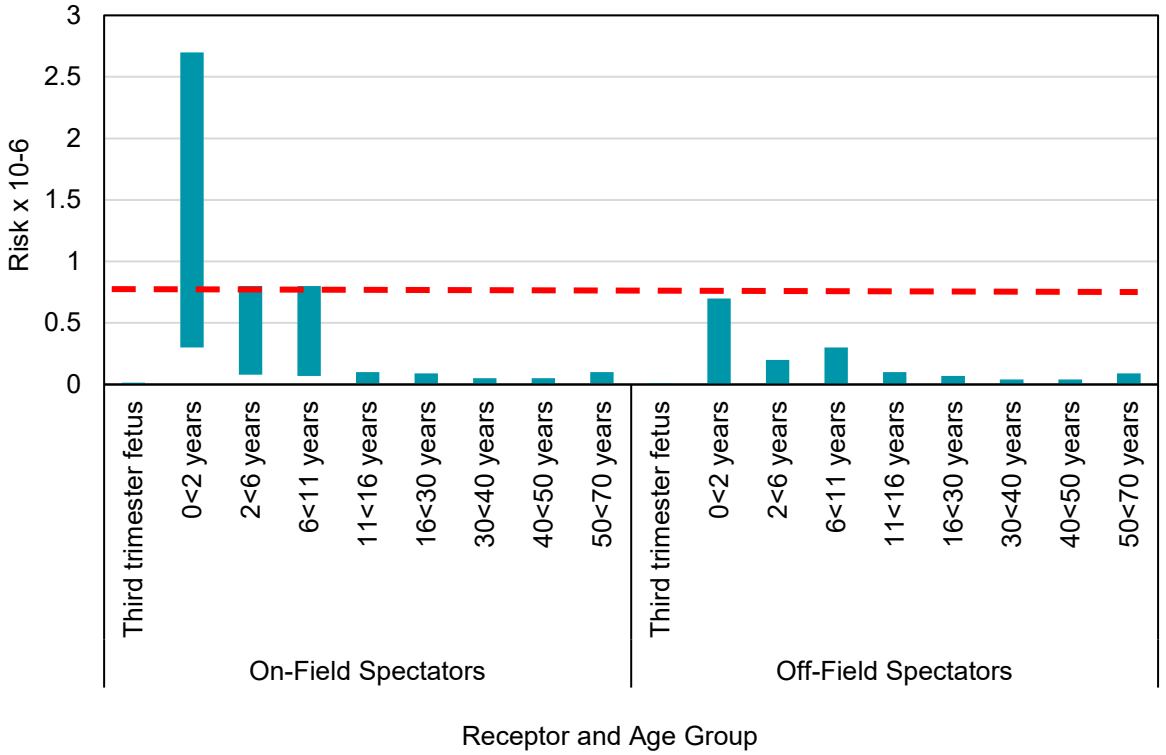


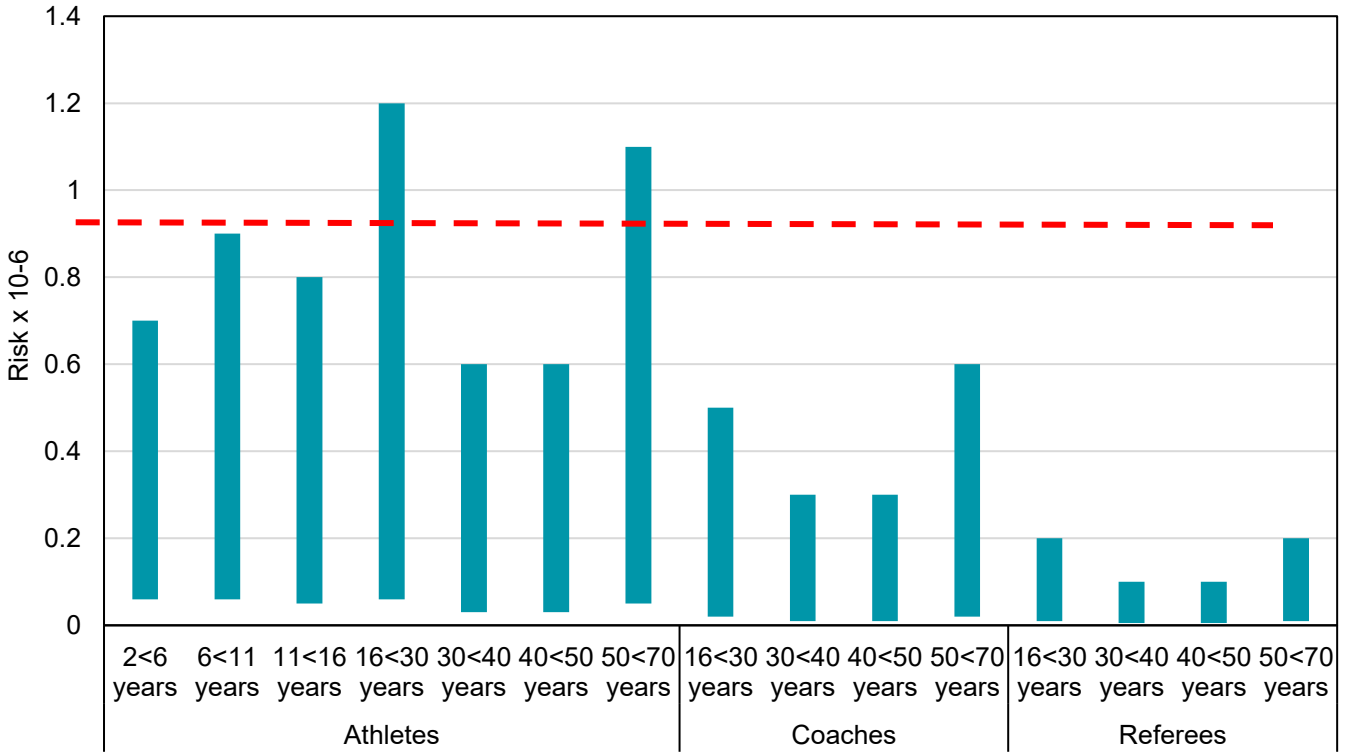
Athletes 16<30 Years

Cancer Risk

- Mean cancer risk from combined exposure to 16 field-related and 7 non-field-related carcinogens was > 1 in a million for all receptors, primarily driven by non-field-related carcinogens
- Mean cancer risk levels, associated with the field-related chemicals, in athletes, coaches, referees and spectators were < 1 in a million, while for the on-field infant spectators it was 1.1 in a million
- Based on individual field cancer risk levels, the maximum was > 1 in a million in two groups:
    - On-field infant spectators ranged from 0.3 to 2.7 in a million
    - Athletes ranged from 0.03 to 1.2 in a million

Multiroute, Multichemical Incremental Cancer Risk





Variability Considerations

Sample Heterogeneity

- Crumb rubber infill from a wide variety of automobile waste tires (different tire types, models, brands, production years, age in traffic)

Time-Activity and Exposure Parameters

- Mean values in exposure assessment

Athlete Player Position

- Goalie-specific scenario used to compute risk values for the all-athlete scenarios

Uncertainty Sources and Impact

Chemical Characterization and Source Designations

- Field-related vs non-field-related chemicals

Exposure assessment

- Parameters for coaches, referees, and spectators based on TAS collected in athletes (highest mean values)
- Literature data used to estimate the direct ingestion amount

Dose-Response Assessment

- Noncarcinogens: chemicals without established non-cancer toxicity criteria, OEHHA derived new toxicity criteria & use of single exposure event for DARTs
- Carcinogens: Benzo[a]pyrene-based potency-equivalency factors (PEFs)

Study Boundaries and Limitations

- Evaluation limited to crumb rubber infill and not backing materials or grass blade components
- No alternative infills were evaluated
- No analysis for metals in fine particulate matter from the air on the fields
- Assessments for each receptor category and not for various scenarios of combined receptor roles

Environmental Data

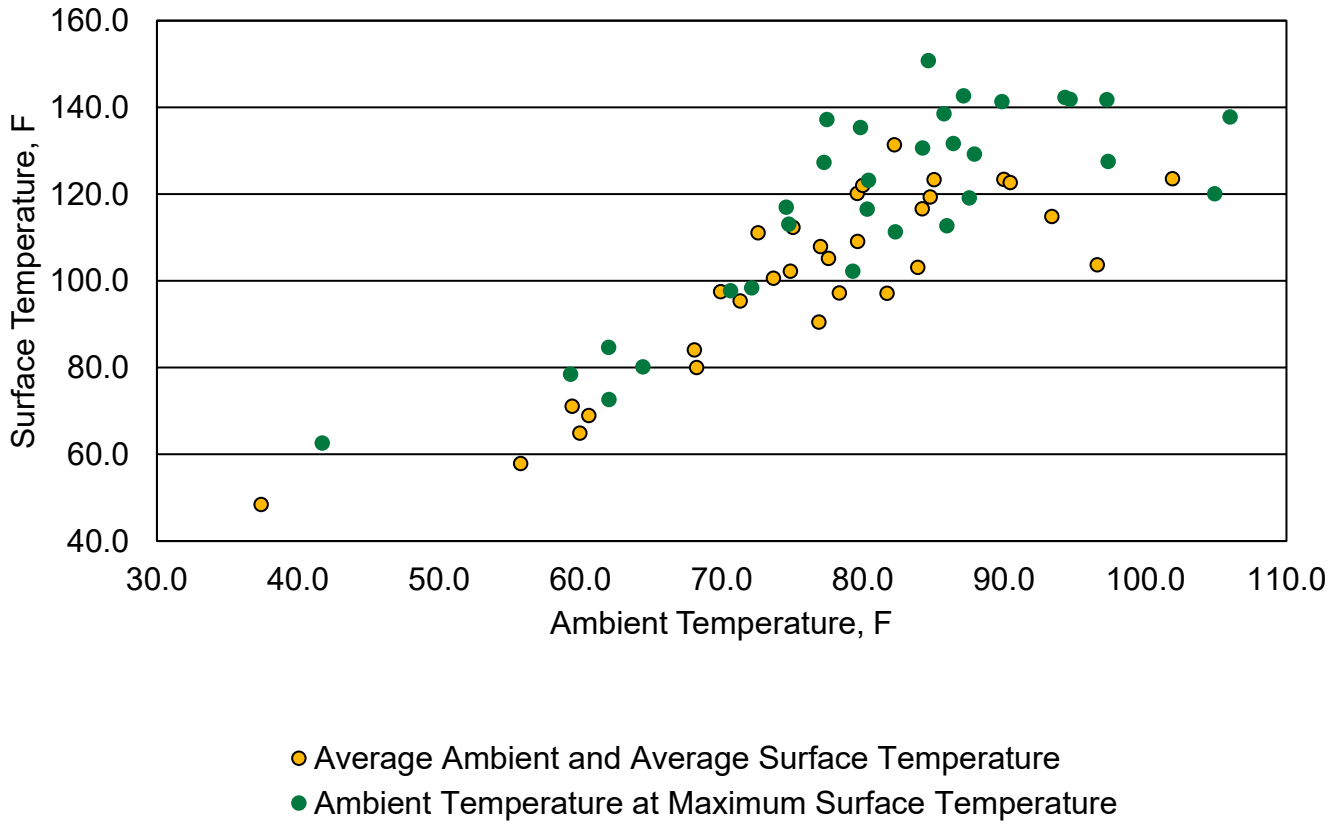
Ozone

- No measurement exceeded 1-hour CA standard (90 ppb)
- 3 exceedances of 8-hr CA and National standard (70 ppb): max value 87.0 ppb

Particles ($PM_{2.5}$: particles with diameter less than 2.5 microns)

- On-field: 13.4 $\mu g/m^3$
- Off-field: 14.1 $\mu g/m^3$

Environmental Data



Temperature

- Ambient temperature: range 70 to 100°F
- Surface temperature: maximum 151°F

Conclusions

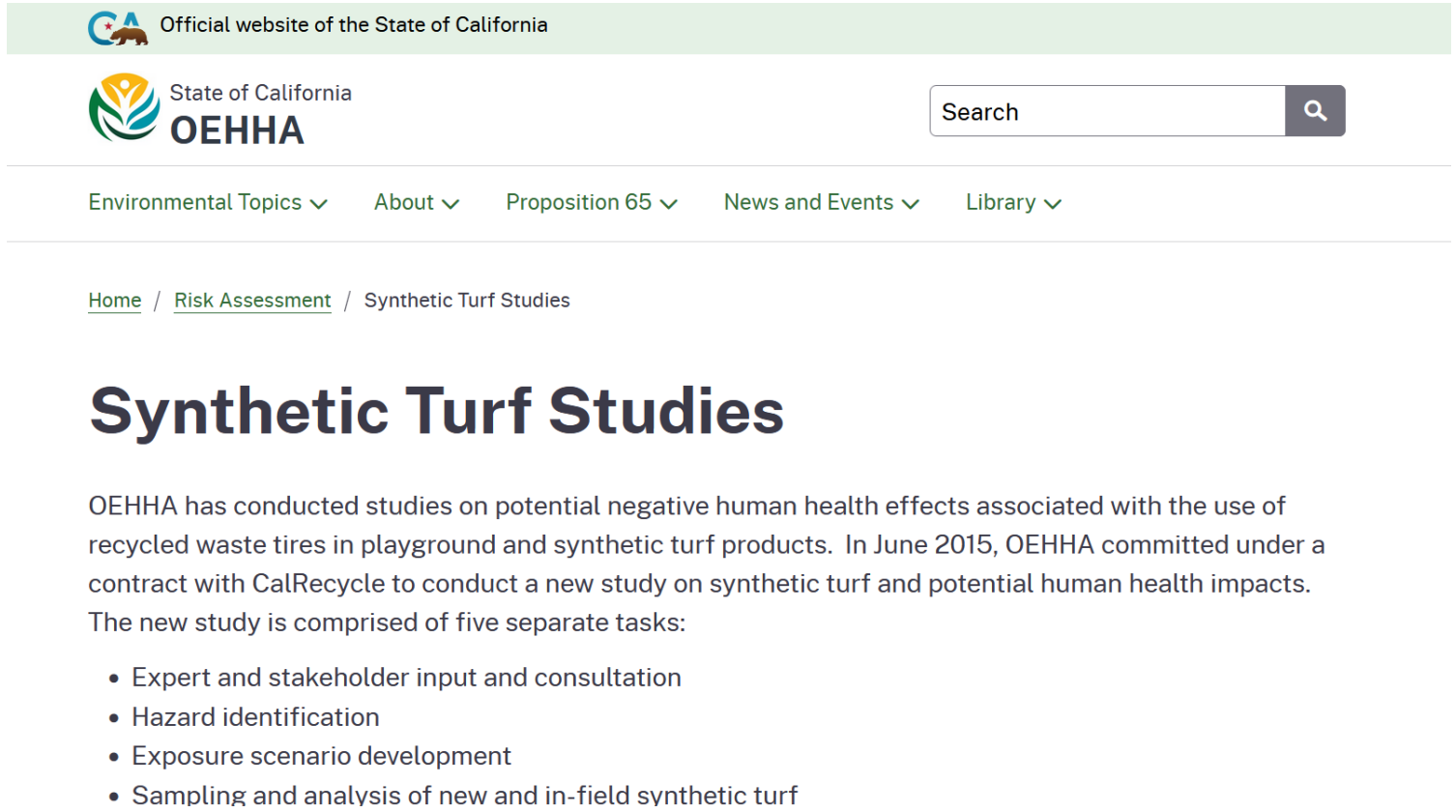
- Overall, this study found no significant health risks to players, coaches, referees and spectators from on-field or off-field exposure to field-related chemicals in crumb rubber infill from synthetic turf fields
- Based on maximal values from individual fields, there were few small exceedances that are of low probability and of low concern:
    - DART for athletes aged 11 to 70 years
    - chronic toxicity in on-field infant spectators
    - excess cancer risk in on-field infant spectators and athletes16 to 30 years
- This study found similar ambient temperatures on- and off-field, and elevated surface temperatures on synthetic turf fields in line with previous studies.

More Information

Main OEHHA webpage:
https://oehha.ca.gov/

Synthetic Turf webpage:
https://oehha.ca.gov/risk-assessment/synthetic-turf-studies

OEHHA Synthetic Turf Study Report:
https://oehha.ca.gov/risk-assessment/report/release-draft-report-synthetic-turf-and-scientific-advisory-panel-meeting



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Thank you for your time!
Questions??

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