Department of Toxic Substance Control (DTSC)
Attn: Safer Consumer Products (SP) Program, 1001 I St., Sacramento, CA 95814
From: Dianne Woelke MSN
2 July 2020
Submitted via online portal at https://calsafer.dtsc.ca.gov/
Proposed Regulation: **6PPD in Motor Vehicle Tires**

Dr. Meredith Williams:

I am writing in support of inclusion of 6PPD in Motor Vehicle Tires as a Priority Product. My rationale was laid out in comments submitted 4 September 2021.

Human Exposure as a "distraction"

I am in disagreement with Dr. Brinkman's conclusions that "sections on potential human exposures and potentially resulting toxicological risks in humans are distracting from the main concern."

Dr. Brinkman is from an area where a quick review revealed two synthetic turf fields with unknown infill. This would suggest a lack of awareness of of more than thirty thousand fields across the U.S. with crumb rubber infill (FieldTurf, 12 July 2021), a large percentage being in California. Additionally, these comments seem to indicate a lack of awareness of the degree to which California promotes used tire crumb in asphalt,[1] in recreation,[2] or that many synthetic turf playing fields and used tire crumb playground[3] surfaces are built near or on waterways, reservoirs and beaches.

Research in Australia (2021)[4] showed that 1.2 million used tire crumbs per 40m^2 circumference playground surface migrated within the first 4m distally, with 2.5 million crumbs migrating 4m at one playground. As with synthetic turf, completely unregulated and no system to track or trace where these surfaces are located, what happens to them at their "end of life" and what is done to mitigate the chemical and heavy metal leachate and remediate the soil beneath at removal of the surface…the risk to children and the environment goes unabated. In their 2021 report, the Australian Marine Debris Initiative[5] noted:

> *"…the huge pollution issue caused by rubber crumb is crystal clear…The limited longevity of these surfaces shows that rubber crumb projects don't divert end-of-life tyres from landfill, they simply delay their way."*

Each regulation sized field requires 40,000 crumbed used car tires. The migration of 1.5 to 5 metric tons of used tire crumb from fields requires replacement annually, per field. A unique study of the amount of used tire crumb "walked off" fields in 2017 in Norway[6] revealed that after 29 minutes of play, each student left fields with 1.9ML of tire crumb, more after playing in wet weather. The "walked off" crumb tracks into vehicles, homes, and storm drains and waste water via showers and laundry.

A graphic depiction of the scope of the problem was provided by James Vallette, Healthy Building Network (2016)[7]:

> *"The Rubber Manufacturers Association (RMA)...from 2007-2013…estimated that 274.15 million pounds of ground rubber per year were used as playground mulch. According to an online rubber mulch calculator, covering a 100 square foot playground 4" deep requires 1,092 pounds of material, or 10.92 pounds per square feet. The average tread of a tire is 215 millimeters or 8.5 inches. A square foot of mulch result[s] in a 16.94"-long tread. Laying all of the ground rubber used for playground mulch along the tire-wide tread, four inches deep, leads to a track that is 49,976 miles long. Earth's circumference at the equator is 24,901 miles."*

The investigative team that discovered the 6PPDq smoking gun have called for the need for research on the toxicological effects on humans:

> *"…tire chemicals are also a concern for the effects of air pollution on human health. The smallest particles that wear from tires contribute to the particle pollution of air. These particles are inhaled when we breathe, and they release chemicals when they settle on the wet surfaces inside our lungs. We know that humans living closer to busy roads have poorer health outcomes due to air pollution [17]*[8]*. It is important that we learn whether 6PPD-quinone plays a role in the toxicity documented when human cells are exposed to chemicals released from tires [18]*[9]*…Studies are needed to determine the relative contributions of 6PPD-quinone from tires during their use on vehicles as well as the various end-of-life uses of tires such as crumb rubber in playgrounds and synthetic turf fields."* Dr. Jenifer McIntyre,[10] 15 Jul 2021, Testimony before US House of Representatives.

> *"Tire rubber disposal also represents a major global materials problem and potential potent source of 6PPD-quinone and other tire-derived transformation products. In particular, scrap tires re-purposed as crumb rubber in artificial turf fields suggest both human and ecological exposures to these chemicals. Accordingly, the human health effects of such exposures merit evaluation."* Tian, Z, et al,[11] 3 Dec 2020

On 15 July 2021, a hearing in the US House of Representatives, Natural Resources Committee, Subcommittee on Oversight and Investigations held a hearing entitled: *Are Toxic Chemicals From Tires And Playground Surfaces Killing Endangered Salmon?* In her opening remarks, the Hon. Katie Porter[12] noted:

> *"6PPD is more toxic than Mercury, 27 times more toxic than Cyanide, 425 times more toxic than Arsenic and more toxic than DDT...we do know that all those same ingredients in the chemical reaction that kills salmon are in those playground and playing surfaces...What we need is research on the risks from 6PPD quinone and on*

the possible substitutes. We need to treat this with urgency befitting a danger to our children."

Leading health experts[13] have called for a precautionary approach to the toxic mix of chemicals in used tire crumb for over a decade. 6PPD and 6PPDq are the latest in an extremely lengthy list of chemicals that are harmful to human and environmental health:

> *"Children's' brains and nervous systems particularly are developing rapidly and there are unique windows when they are more susceptible to toxins….We have to think about exposures that might cause disease that [have] long latency."*
> Dr. Joel Forman, pediatrician, Mt.Sinai School of Medicine

> *"We know children are more vulnerable to these chemicals. They are more heavily exposed pound for pound. They are biologically more vulnerable. They don't have the ability to break these chemicals down and get rid of them."*
> Dr. Phillip Landrigan, pediatrician, epidemiologist."

> *"The whole thing is a recipe for disaster."*
> Dr. David Brown, Public Health Toxicologist

Given the multiple exposure pathways for 6PPD and 6PPDq in used tire crumb, the fact that the US FDA[14] prohibits its use in reusable food containers should in and of itself warrant inclusion of human health toxicity in consideration of this chemical as a Priority Product in Motor Vehicle Tires and used on playing surfaces.

> *"...antiozonants (excluding 6PPD) are permitted for use in rubber articles intended for repeat food-contact use in the US (FDA regulations chapter 21 Part 177.2600). The biggest disadvantage of 6PPD is its partial decomposition during the vulcanization leading to the formation of toxic primary aromatic amines (PAA), such as aniline and secondary aromatic amines (SAA). A number of new PPDs have been developed and patented, that due to their chemical structures, are far less soluble in aqueous solutions*
>
> *but a lot more soluble within the rubber matrix. They therefore show significantly less migration of PAA and SAA. These new antiozonants were investigated and compared to 6PPD using commercial rubber materials with a certain content of antiozonant with regard to their migration of PAA and SAA into three different food simulants. The lowest concentration of PAA and SAA in all food simulants was measured in the RU 997 stabilized elastomer. Due to this fact RU 997 was permitted as a new antiozonant for commodities based on rubber according to the Recommendation XXI 'Articles based on natural and synthetic rubber' of the Federal Institute for Risk Assessment (BfR). RU 997 therefore represents an alternative for 6PPD with less migration of aromatic amines."*

6PPD in used tire crumb playing fields

With respect to Dr. Pertti J. Hakkinen's comments, 6PPD has been found in used tire crumb from synthetic turf fields:

- OEHHA[15] - 31 May 2019, pg 3-14: 1,4-Benzenediamine, N-(1,3-dimethylbutyl)-N'-phenyl- INCHIKEY: ZZMVLMVFYMGSMY-UHFFFAOYSA-N
- US EPA FRAP 1[16] - 25 July 2019, Entry 159, (N-1,3-dimethyl-butyl)-N'-phenyl-p-phenylenediamine (6PPD)
- Yale 2019[17] - Evaluation of potential carcinogenicity of organic chemicals in synthetic turf crumb rubber, Pg.12, Table 3, entry 11
- In Tian, Z (2022)[18] - Both 6PPD **and 6PPDq** found in synthetic turf crumb rubber (slides 18-24).
- While not directly related to used tire crumb from synthetic turf fields, recent research from Hong Kong (2022)[19] found daily intake doses of PPD-Qs in Hong Kong are:

  "…estimated to be 1.08 ng/(kg·day), which exceeded the doses from their parent compounds [0.71 ng/(kg·day)] under the same exposure scenarios. The results indicated that ingestion of roadside soil dust was the main contributor to human exposure of PPDs and PPD-Qs. Dermal absorption represents the second highest exposure pathways, accounting for almost 15% intake rate of oral ingestion."

6PPD in motor vehicle tires ranges from 35g to 175g per tire and between 0.35g to 12.5g or more of 6PPDq. Truck tires have between 200g - 1,000g of PPD and between 2g - 556g of PPDq (2022, slide 17).[20] Rather than separating out various types of tires in this proposed priority product, much as with PFAS in Carpets initially excluding carpet types or use location (synthetic turf, carpet in boats, trains and planes), I fully support inclusion of ***all*** tires, including Off Highway Vehicles (OHVs), agricultural and aviation.

"Wreckreational" tire use

In 2008, there were reportedly 1.1 million OHVs in use in the US with an estimated growth of 100,000 per year. As a $20 billion per year industry in California,[21] there is a growing availability of public taxpayer funding for feasibility studies, planning and construction of OHV facilities. There is also an ever increasing grab for a slice of the grant pie.

California is the home of 9 of 63 National Parks, more than any other state. With the recent acquisition of Dos Rios Ranch near Modesto, there are now 280 State Parks and likely to increase under the California 30x30 Plan. OHV enthusiasts from across the country flock to California for its climate and vast array of OHV terrain.

The use of OHVs has been referred to as "wreckreational" activity with a multitude of complaints about "wreckreactionists" destroying sensitive landscapes found across the internet, including California State,[22] National[23] and Bureau of Land Management (BLM)[24] Parks (funded by CA Parks and Recreation).[25] OHV parks are also found on private lands. The increasing push for more[26] OHV sites calls for a broader, more proactive approach by DTSC to protect human and environmental health.

> *"The California State Parks[27] Off-Highway Motor Vehicle Recreation Division is funding the planning efforts through an off-highway vehicle planning grant. The state program supports off-highway vehicle recreation in California by distributing more than $35 million annually collected from gas tax, entrance fees and off-highway vehicle sticker registrations. The program supports off-highway vehicle recreation in California by providing financial assistance to cities, counties, districts, federal agencies, state agencies, educational institutions, and federally recognized Native American Tribes and non-profit entities."*

Not your typical Sunday drive through the park,[28] OHV activity clearly has the potential to degrade the quality of the environment via tire wear particle loss, across millions of acres. "Wreckreational" activity threatens to substantially reduce the habitat of fish and wildlife or cause their population to drop below self- sustaining levels, threaten to eliminate a plant and animal communities, and reduce the number or restrict the range of rare, protected or endangered plants and animals. Species found in these parks include big-horned sheep, golden eagles, red-tailed hawks, kestrels, prairie falcon, quail, wild turkeys, and pheasants, Lewis' woodpeckers, acorn woodpeckers, northern flickers, deer, coyotes, yellow legged frogs and desert tortoise. In Oceano Dunes State Park, the endangered Snowy Plover is threatened by OHV use. Brook trout,[29] found in mountain lakes and streams from the San Bernardino Mountains to Oregon and rainbow trout,[30] found in California watersheds leading to the Pacific Ocean, are also known to be negatively impacted by 6PPD-quinone.[31]

Air quality, GHG emissions, significant negative impact on historical and cultural resources, soil disturbances (erosion, loss of topsoil), surface and ground water quality degradation with the potential to violate water quality standards and waste discharge requirements are effects of OHV use:[32]

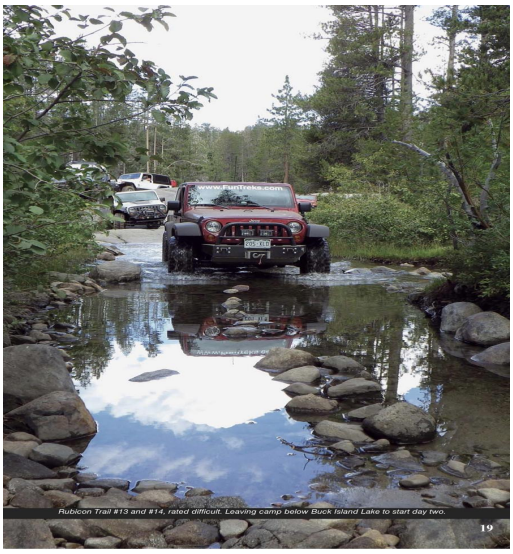
> *"…how do illegal OHV tracks in adjacent lands relate to water quality and water supply? Such damage has pervasive and widespread effects on water quality and water supply, from direct devegetation and erosion of hillsides and increased sediment loads in local streams to increased particulate matter landing on the Sierra Nevada snowpack, which accelerates melting and amplifies the already significant effects of drought and climate change."*

6PPD in tires adds to these threats.

While improving air quality, transitioning to increased use of electric vehicles (EVs) will worsen the impact of OHVs in the growing number of OHV use areas. EVs are heavier than internal combustion engine vehicles, creating more tire crumb.[33]

Tires used on OHVs[34] are generally substantially larger than motor vehicle tires- in circumference, width and tread surface area. At their end of life, they, too will be landfilled, illegally dumped, used in parks for climbing structures, swings or shredded, mulched or

crumbed. They will move from whole tires contaminating land, water, air, people, fish and animals…to more of the same in mulched and crumbed form. Testing the effects of 6PPD and 6PPDq on every known plant or species to include OHV tires in this proposed Priority Product should not be required to take this precautionary approach.



More threat to food contamination/security

Agricultural vehicles are larger still, requiring even larger tires and are also ultimately shredded to form mulch and crumb[35] to be sold for various uses, including agricultural.[36] Tire wear particles are microplastics that contribute both directly and indirectly to contamination of food crops, including roof top gardens, with voluntarily added hazardous chemicals, including 6PPD. Indirect contamination can occur via air, water and soil,[37] including through use of wastewater treatment sludge used as fertilizer. Who is testing sludge for tire crumb, 6PPD and 6PPDq that has runoff from roadways, green roofs,[38] synthetic turf fields and used tire crumb playground surfaces?

The United Nations Food and Agriculture Organization (FAO)[39] reported in July 2021 the amount of plastic pollution in agricultural land surpasses that found in oceans, posing a threat to worldwide food security, human and environmental health. Microplastics in agriculture constitute further human exposure[40] via inhalation, ingestion and dermal contact. Crops take up microplastics, impairing nutritional value and impacting human and environmental health.[41] Microplastics desorb toxic chemicals and adsorb chemicals and contaminants, acting as transport vectors.[42] While it is unknown if 6PPD is used in production of agricultural plastics,[43] 6PPD in these massive tires should not add the threat of food insecurity and human and environmental risk- not during their useful life, nor their afterlife.

Massive amounts of Plane TWP

For safety reasons, buildup of tire rubber deposited on airport runways during landings must be removed. The amount of rubber deposited is greater in the heat of summer months, a number that is continuing to increase with climate change. With each 747 landing, friction causes about

1.4 pounds of rubber to be deposited along a 1,000 foot track. Large planes have 18 tires, meaning approximately **25.2 pounds of rubber tread** is being laid down, with each landing.[44]

California has 852 built runways,[45] though there are additional remote or private landing areas where tire crumb would be deposited in native soil. The busiest airports in CA[46] include:

Los Angeles	Tijuana/San Diego
San Francisco	Burbank
San Diego	Ontario
San Jose	Long Beach
Oakland	Palm Springs
Sacramento	Fresno
Santa Ana	Santa Barbara

These **14 airports alone** have a total of 29 runways[47] and approximately **3,350 daily landings**. Based on the number of landings at each airport, 4 airports (11 runways) require weekly cleaning of their runways, 5 require cleaning every 2 weeks (12 runways), and the balance every month to 3-6 months (12 runways). As air travel is currently increasing, the number of landings will also increase.

NUMBER OF DAILY MINIMUM TURBOJET AIRCRAFT LANDINGS PER RUNWAY END	MINIMUM FRICTION SURVEY FREQUENCY
LESS THAN 15	1 YEAR
16 TO 30	6 MONTHS
31 TO 90	3 MONTHS
91 TO 150	1 MONTH
151 TO 210	2 WEEKS
GREATER THAN 210	1 WEEK

Using Fort Lauderdale-Hollywood International Airport as an example (not all planes are 747s), 7,500 pounds[48] of tire crumb, or the equivalent of 340 car tires, are removed from 2 runways per cleaning. The rubber is then "disposed of or recycled." Approximately 600 pounds of rubber are blasted off a runway per hour, using some 1,200 gallons of water. How many pounds of rubber containing 6PPD/6PPDq is power washed off California runways annually? How much is aerosolized? The water is vacuumed up by a truck attached to the power washer. Where is that water disposed of? Research related to PFAS in New Hampshire wastewater[49] has shown that *"...99% of PFAS coming into the plant in the wastewater stream leave in the water that is cleaned and discharged into the Merrimack River."* Who is testing for contaminants in water coming from airports? Who is testing for 6PPD and 6PPDq in "cleaned" wastewater?

While an extended Priority Product Notification date is certainly indicated for plane tires, the magnitude of the contamination and high likelihood of deleterious impact on the environment cannot be ignored and must be addressed.

Rubberized asphalt and building materials

Asphalt surfaced roads are endlessly recyclable. Once used tire crumbed rubber is added, Crumb Rubber Modified (CRM) asphalt surfaces ability to be recycled drops to 15%.[50] The net effect of using used tire crumb in roadways, therefore, accomplishes little more than kicking the can down the road.

First developed in the 1960s by Charles McDonald,[51] an engineer with the Federal Highway Administration in Phoenix, AZ. Rubberized Asphalt Concrete (RAC) has been most heavily researched in Phoenix, AZ.[52] This is noteworthy, as Phoenix recently removed asphalt from an 11 mile stretch of the I-10[53] in downtown Phoenix.

> *"The rubberized asphalt surfaces put down on Valley freeways in the past 10 to 15 years are now reaching the end of their life span, according to officials from the Arizona Department of Transportation. That has resulted in a growing number of potholes, cracks and deep gouges along Valley freeways...Portland cement has a life span of 40 years or more."*

With a lower upfront cost, rubberized asphalt is becoming the choice of cash strapped communities, particularly when grants[54] for used tire crumb are offered and USTMA,[55, 56]the Recycled Rubber Coalition[57] and the Synthetic Turf Council wield their self-interested influence on decision makers.[58] With their short life cycles, rubberized asphalt is a poor choice[59] economically and is environmentally devastating.

In addition to the high level concerns related to 6PPD and 6PPDq and other chemicals of concern in these penny wise and pound foolish investments in rubberized asphalt road surfaces, they are also contributing to the heat island[60] effect and climate change. Concrete roadways are more cost effective when life cycle investments of concrete vs. asphalt are considered. The reflectivity of concrete is also greater, resulting in cooler surfaces than asphalt. The cooler effect is increased further with use of white vs. grey concrete.

In addition to the heat island effect, other factors associated with climate change will continue to wreak havoc and we must act to minimize the potential risk that toxic chemicals have on our environment, including in roadways.

FEBRUARY 15

Palm Springs Aerial Tramway Shutdown Due to Severe Damage From Storm

15 Feb 2019

Broken and weathered chunks of asphalt from storm-ravaged State Road 399 mix with sugar white sands throughout Gulf Islands National Seashore on Monday, Dec. 17, 2018. *Tony Giberson/tgiberson@pnj.com*

Here are Marin County's top headlines:

Marin coastal areas brace for king tides

King tides are coming to the Bay Area, and low-lying, coastal communities in Marin are preparing for potential flooding. **Read the story**

SANTA VENETIA: Marin County is set to move forward with preliminary work on a **key flood control project** in east San Rafael despite lacking most of the estimated $14 million needed to get the job done.

12 July 2022 Marin Independent Journal

There is an increased push for permeable pavements. It should be noted that many incorporate flexible used tire crumb rubber,[61] plastics[62] and recycled HDPE with UV inhibitors[63] (possibly PFAS flame retardants, as used in synthetic turf [6;2FTSA, for example]). The chemical contamination that some of these products introduce to surface and groundwater also warrants consideration.

We now know that 6PPDq[64] is more lethal to coho salmon than previously thought. We also know that even more species of fish[65] are impacted by this same ozonation product. We know that human fertility has decreased by nearly 50 percent[66] in the past four decades and that 6PPD[67] is recognized as having the potential to impair fertility and harm an unborn child. 6PPD has been declared as Very Persistent, Very Bioaccumulative and is listed in the United Nations Recommendations on the Transport of Dangerous Goods.

> *"The lifetime mass balance of 6PPD, 6PPD-Q, and related chemicals in rubber tires that are subject to widespread environmental dispersal should also be thoroughly characterized to advance the safe use, disposal, and recycling of these materials as we work toward more environmentally benign and sustainable consumer products."* Tian, Z et al, (2022)[68]

There is clear evidence of the need for regulation. Time is of the essence. Please heed the call to "…*treat this with urgency befitting a danger to our children."*
Hon. Katie Porter,[69] 2021

Actions:

- Declare used tire crumb a hazardous substance requiring disposal in hazardous waste landfills
- Ban the use of used tire crumb in synthetic turf playing fields and playground surfaces, including waterparks
- Include OHV and agricultural tires in the 6PPD in Motor Vehicle Tires as a Proposed Priority Product
- Include plane tires in the same proposal, with extended time consIderations for assessment, evaluation and planning
- Remove underperforming tires from circulation
- Create a labeling system that rates tires based on tire crumb release
- Prohibit use of tires underwater reefs, aquaculture seeding
- Work with CA Natural Resources Agency, Ocean Protection Council, the Statewide Commission on Recycling Markets and Curbside Recycling and their staff (CalRecycle), State Legislators, additional stakeholders and the public to educate and work towards necessary regulations, laws, discontinuation of grants related to used tire crumb and protection of schools, parks, public lands and waterways
- Work with OEHHA and research institutions to ensure ***timely*** initiation and ***completion*** of research on human health effects of 6PPD and 6PPDq
- Work with OEHHA to require signage regarding health and environmental risks related to used tire crumb on ***all*** current playing fields and playground surfaces
- Secure additional funding as necessary for additional research, resources, mitigation
- Require disclosure of chemicals of concern, including those considered as Confidential Business Information, by manufacturers

Respectfully submitted,
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Bibliography:

1. Martin, M (21 Dec 2021). Email communication re: Request for Approval, Rubberized Pavement Grant Program for fiscal year (FY) 2021–22; >3.5million in funding. https://www2.calrecycle.ca.gov/PublicNotices/Documents/13783

2. CalRecycle (Oct 2021). Revised California Tire Derived Product Catalogue. https://www.e-productcatalog.com/TDPCatalog/204/

3. Laura and Rudy (2010). Trying to save the playground. Used tire crumb playground surface, Oceanside, CA https://www.youtube.com/watch?v=MQOQoUGBZZA

4. Reef Clean (Nov 2021). Rubber Crumb Loss Assessment from Play Areas in the Great Barrier Reef Catchment. Tangaroablue.org https://drive.google.com/file/d/17fg_5hu0LbwLg_gaIPq0GL8Pj0wOkbb2/view?usp

5. Tangaroal.org, Australian Marine Debris Initiative, AusMap (2021). Rubber Crumb Impact Report: Urgent change of tack needed for tired tyres. How a well-intentioned tyre recycling program risks becoming a micro-pollution disaster. Tangaroa.org https://drive.google.com/file/d/1QqPaBA8l-klxnVmPeoVhmagRW0sD2dCD/view?usp

6. NILU- Norwegian Institute for Air Research (7 May 2018). Thousands played soccer for science. NILU Annual Report 2018. https://www.nilu.com/2018/05/thousands-played-soccer-for-science/

7. Vallette, J. (16 Jun 2016). On Tire Wastes in Playgrounds. Healthy Building Network. https://healthybuilding.net/blog/461-on-tire-wastes-in-playgrounds

8. Brugge, D, Durant, JL, Rioux, C (9 Aug 2007). Near-highway pollutants in motor vehicle exhaust: A review of epidemiologic evidence of cardiac and pulmonary health risks. Environmental Health. https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-6-23

9. Gualtieri, M (11 Aug 2005). Toxicity of tire debris extracts on human lung cell line A549. Toxicology in Vitro 19 (2005) 1001–1008 https://d1wqtxts1xzle7.cloudfront.net/42886181/Toxicity_of_tire_debris_extracts

10. McIntyre, J. (15 Jul 2021). Written testimony before the Committee on Natural Resources, Subcommittee on Oversight and Investigations U.S. House of Representatives. https://naturalresources/2021_07_15_Written_Testimony_Jenifer_McIntyre

11. Tian, Z, Tian, Z, Zhao,H, Peter, K et al (3 Dec 2020). A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon. Nature (Vol 371, Issue 6525): pp. 185-189 https://www.science.org/doi/10.1126/science.abd6951

12. Porter, K. (15 Jul 2021). Natural Resources Committee, Subcommittee on Oversight and Investigations. Are Toxic Chemicals From Tires And Playground Surfaces Killing Endangered Salmon? United States Congress. https://naturalresources.house.gov/hearings/are-toxic-chemicals-from-tires

13. SF Parks (20 Nov 2012). Children and Synthetic Parks. Leading health experts discuss children's health and SBR artificial play surfaces. https://www.youtube.com/watch?v=tlu7jV69qo0

14. US FDA. Title 21-Food and Drugs. Chapter 1, Subchapter B, Part 177- Indirect Food Additives, Polymers, Sec.177.2600 Rubber articles intended for repeat use. 1 Apr 2020. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=177.2600

15. OEHHA (31 May 2019). Synthetic Turf Study: Synthetic Turf Scientific Advisory Panel Meeting https://oehha.ca.gov/media/downloads/crnr/may2019turfappendicespdf.pdf

16. US EPA (July 2019). Federal Research on Recycled Tire Crumb Used on Playing Fields, FRAP 1. Tire Crumb Rubber Characterization. Spreadsheet with Toxicity Reference information. https://www.epa.gov/sites/default/files/2019-07/spreadsheet_with_toxicity_reference

17. Perkins, AN, Inayat-Hussain, SH, Deziel, NC et al. Evaluation of potential carcinogenicity or organic chemicals in synthetic turf crumb rubber. 2019 Feb. Environ Res. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6396308/?report=reader#!po=51.9231

18. Tian, Z, Zhao, H, Peters, K et al (2022). Organic contaminants in tire and crumb rubber: 6PPD-quinone and beyond, Center for Urban Waters, University of Washington Tacoma Northeastern University. https://www.healthandenvironment.org/assets/images/webinarimages/Tian%20Slides.pdf

19. Cao, G, Wang, W, Zhang, J (5 Apr 2022). New Evidence of Rubber-Derived Quinones in Water, Air, and Soil. Environ Sci Technol; 56(7): 4142–4150. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8988306/

20. Dinicola, K (16 Mar 2022). Managing Stormwater in Washington, Plenary Session. Emerging Contaminants in Stormwater: Challenges and Perspectives. Department of Ecology, State of Washington at Northwest Environmental Council. https://washingtonstormwater.com/wp-content/uploads/Afrernoon-Plenary-Zhang-Et-Al

21. Dunstan, J (2 Jun 2021). New California rules make most 2022 dirt bikes illegal on public land. Online publication: Common Tread, Revzilla. https://www.revzilla.com/common-tread/new-california-rules-put-ohv-riding-in-jeopardy

22. Sampson, MP (Jun 2007). Effects of Off-Highway Vehicles on Archaeological Sites in Red Rock Canyon. California State Parks and Recreation. https://www.parks.ca.gov/?page_id=24576

23. Wines, A (7 Mar 2017). Help Restore Off-road Damage in Death Valley. National Park Service. https://www.nps.gov/deva/learn/news/ohv-grant.htm#:~:text=Death%20Valley

24. Bureau of Land Management (13 Jan 2017). BLM, OHV Advocates and Conservation Groups To Settle Longstanding Litigation. https://www.blm.gov/press-release/blm-ohv-advocates-conservation-groups-to-settle

25. Bureau of Land Management (31 Jan 2018). BLM Reschedules OHV Grant Proposals' Public Meetings. https://www.blm.gov/california/ohv-grant-proposals-public-meetings-rescheduled

26. Rider Planet USA. Interactive motorcycle and ATV trail map, California. https://www.riderplanet-usa.com/ATV/trails/california_map.htm

27. Bureau of Land Management (18 Feb 2022). BLM To Hold Virtual Public Meetings To Discuss OHV Grant Funds. https://www.blm.gov/press-release/blm-hold-virtual-public-meetings-discuss-ohv-grant

28. Woelke, D. (2022). OHV Use in California. https://docs.google.com/document/d/1BToosxN4wc5P

29. California Department of Fish and Wildlife (undated). Fishing for Brook Trout (non-native). https://wildlife.ca.gov/Fishing/Inland/Brook-Trout#35600374-distribution

30. California Department of Fish and Wildlife (undated). Fishing for Coastal Rainbow Trout / Steelhead
https://wildlife.ca.gov/Fishing/Inland/Coastal-Rainbow-Trout#35748374-distribution

31. Brinkmann, M, Montgomery, D, Selinger, S et al (2 Mar 2022). Acute Toxicity of the Tire Rubber-Derived Chemical 6PPD-quinone to Four Fishes of Commercial, Cultural, and Ecological Importance. Environmental Science and Technology Letters. 9 (4): 333–338
https://pubs.acs.org/doi/10.1021/acs.estlett.2c00050

32. Citizens of Inyo County, CA (28 Dec 2021). Off-Highway Vehicle Impacts in Inyo County, CA: A Citizens' Report in Response to Requirements of CA Vehicle Code § 38026.1
https://drive.google.com/file/d/1rhfbdzLU1vRsTBd1MS_RKVhbB-7w1GMa/view?usp

33. Continental Tires (undated). Electric vehicle tires – Everything you need to know.
https://www.continental-tires.com/car/tire-knowledge/tire-basics/electric-vehicle-tires

34. ORW, Off Road Warehouse. OHV tire sales website.
https://www.offroadwarehouse.com/products/wheels-tires/tires

35. Liberty Tire Recyclers, Agricultural Tire Recycling.
https://libertytire.com/my_products/agricultural-used-tires/

36. Rubbercycle. Rubber mulch for agricultural and landscape use.
https://rubbermulch.com/pages/rubber-mulch-for-texas

37. *Ibid:* Cao, G, Wang, W, Zhang, J 0.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8988306/

38. Crampton, M, Ryan, A, Eckert, C (14 Apr 2014). Effects of Leachate from Crumb Rubber and Zinc in Green Roofs on the Survival, Growth, and Resistance Characteristics of Salmonella enterica subsp. enterica Serovar Typhimurium. Applied and Environmental Microbiology;
80(9).
https://journals.asm.org/doi/full/10.1128/AEM.03565-13

39. Curtain, A (9 Dec 2021). Plastics in agriculture 'disastrous' new UN report says. Nation of Change, Environmental blog. Online publication.
https://www.nationofchange.org/2021/12/09/plastics-in-agriculture

40. *Ibid.* Cao, G, Wang, W, Zhang, J (5 Apr 2022)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8988306/

41. Oliveri Conti, G, Ferrantea, M, Banni, M et al (Aug 2020). Micro- and nano-plastics in edible fruit and vegetables. The first diet risks assessment for the general population. Environmental Research (Volume 187): 109677. https://www.sciencedirect.com/science/article/pii/S0013935120305703

42. Campanale, C, Massarelli, C, Savino, I et al(Feb 2020). A Detailed Review Study on Potential Effects of Microplastics and Additives of Concern on Human Health. International journal of environmental research and public health, 17(4), 1212 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7068600/?report=reader

43. Henan Go BioTech (Undated). Chemical Auxiliary Agent supplier; As a professional manufacturer of polyacrylamide for water treatment industrial, we specialize in supplying cationic polyacrylamide, anionic polyacrylamide and nonionic polyacrylamide: 6ppd chemicals used in plastic industries chemical suppliers. https://shorelinechurch.co.za/cpam/6ppd-chemicals-used-in-plastic-industries

44. Luckert, J (Jun 2016). Runway Rubber and 5 Ways To Remove It. Online blog. https://everythingairport.blogspot.com/2016/06/runway-rubber-removal-and-5-ways

45. California_Department_of_Transportation (updated 16 Feb 2022). Airport runways, California. https://gis.data.ca.gov/datasets/a845f4a557df456481af3968952550e5_0/

46. Wikipedia: List of busiest airports in California. Last updated 13 May 2022. https://en.wikipedia.org/wiki/List_of_the_busiest_airports_in_California

47. *Ibid:* Wikipedia https://en.wikipedia.org/wiki/List_of_the_busiest_airports_in_California

48. Kaye, K (15 Jun 2015). Planes land - and leave behind 7,500 lbs. of rubber. South Florida Sun-Sentinel. https://www.sun-sentinel.com/local/broward/fl-runway-rubber-removal-20150607

49. Hayward, M (25 Jun 2022). Environment: Research show some PFAS destroyed, others created at Manchester incinerator. New Hampshire Union Leader. https://www.unionleader.com/news/environment/research-show-some-pfas-destroyed

50. State of California Department of Transportation (2 Feb 2005). Feasibility of Recycling Rubber-Modified Paving Materials. https://rosap.ntl.bts.gov/view/dot/27494/dot_27494_DS1.pdf

51. Park, D. (Oct 2011). Charles McDonald Father of Asphalt Rubber. Rubber Pavements Association. . https://www.rubberpavements.org/RPA_News/2011/201110

52. Stechnij, T (16 Oct 2017). Rubberized highways, roofing cool Arizona's urban heat islands. Cronkite News.
https://azbigmedia.com/business/rubberized-highways-roofing

53. *Permalink requested
https://www.azfamily.com/news/investigations/cbs_5_investigates/area-freeways

54. CalRecycle (2022). Used tire crumb, 2022 grant cycle: 37 grants totaling $5,394,448.00.
https://calrecycle.ca.gov/Tires/Grants/Pavement/

55. Recycled Rubber Coalition (10 Nov 2020). Rubberized Asphalt: Paving Our Green Future.
https://recycledrubbercoalition.org/blog/rubberized-asphalt-paving-our-green-future

56. USTMA, The Ray (25 May 2021). State of Knowledge Report on Rubber Modified Asphalt.
https://www.recybem.nl/sites/recybem.nl/files/user/rubber-modified-asphalt

57. Recycling Rubber Coalition (undated). Coalition members: Institute of Scrap Recycling Industries, Inc., Synthetic Turf Council
https://recycledrubbercoalition.org/members

58. National Lieutenant Governors Association (Jul 2020). Resolution In Support of Sustainable Infrastructure Solutions to Improve Driver Safety and Support Economic Growth.
https://nlga.us/wp-content/uploads/Resolution-In-Support-of-Sustainable-Infrastructure

59. BEX Staff (10 Nov 2020). Valley Rubberized Asphalt is Failing. AZBEX, BEX Digital Magazine.
https://azbex.com/local-news/valley-rubberized-asphalt-is-failing/

60. US EPA (May 2017). Draft: Reducing Urban Heat Islands: Compendium of Strategies Cool Pavements.
https://www.epa.gov/sites/default/files/2017-05/documents/reducing_urban_heat_islands

61. Atlantic Power and Infastructure (undated). KBI Flexi®-Pave, The Original Flexible Porous Paving System
https://apaicorp.com/flexi-pave.htm

62. TrueGrid (2022). The Complete Guide To Permeable Pavers and Paving Systems
https://www.truegridpaver.com/complete-guide-permeable-paving-

63. Layfield Group (undated). StormTank®, flexible permeable gravel pavers used in ground stabilization and protection applications. https://www.layfieldgroup.com/sharedlibrary/cut-sheet.aspx?ProductPage=16496

64. Tian, Z, Gonzalez, M, Craig, A et al (16 Jan 2022). 6PPD-Quinone: Revised Toxicity Assessment and Quantification with a Commercial Standard. Environmental Science & Technology Letters. https://www.ezview.wa.gov/Portals/_1962/Documents/StormwaterWorkGroup/Tian

65. *Ibid:* Brinkmann, M, Montgomery, D, Selinger, S et al (2 Mar 2022). https://pubs.acs.org/doi/10.1021/acs.estlett.2c00050

66. Corbyn, Z (28 Mar 2021). Interview: Shanna Swan: 'Most couples may have to use assisted reproduction by 2045'. The Guardian, News Website. https://www.theguardian.com/society/2021/mar/28/shanna-swan

67. Flexsys (4 May 2022). SAFETY DATA SHEET Santoflex(TM) 6PPD Pastilles https://drive.google.com/file/d/127FreNSLwuekCMAVvwuV_Z5Nsgz4iGwk/view?usp

68. *Ibid:* Tian, Z, Gonzalez, M, Craig, A et al (16 Jan 2022). https://www.ezview.wa.gov/Portals/_1962/Documents/StormwaterWorkGroup/Tian

69. *Ibid:* Porter, K. (15 Jul 2021). https://naturalresources.house.gov/hearings/are-toxic-chemicals-from-tires