Preface

This petition was prepared for the California Stormwater Quality Association (CASQA) under the supervision of CASQA's Watershed Management & Impaired Waters Subcommittee. It is a component of CASQA's Source Control Initiative, which seeks to address stormwater and urban runoff pollutants at their sources. The petition was developed in collaboration with the California State Water Resources Control Board (State Water Board) for the reduction of zinc as a water pollutant by focusing on a major source – zinc in tires. The petition was commissioned to present scientific information to inform decision-making by the California Department of Toxic Substances Control (DTSC) regarding the addition of motor vehicle tires to the DTSC Priority Products list.

Note to Reviewer

This petition presents the information required for the listing of Priority Products to be addressed by the DTSC Safer Consumer Products program. The required information is set forth in the California Code of Regulations, Title 22, section 69503, which implements Health and Safety Code section 25253. This petition is structured to follow the regulations. Therefore, in some cases, the information is repeated. In most cases, reference is made to earlier or later sections, as appropriate.

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Zinc from Tires

Petition for Addition of Motor Vehicle Tires to the Priority Products List

Submitted to:

California Department of Toxic Substances Control

Submitted by:

California Stormwater Quality Association

May 2018

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Executive Summary

The Request

This petition is a request to add a Product-Chemical Combination – zinc in tires – to the Priority Products list. A Priority Product is a consumer product identified by the California Department of Toxic Substances Control (DTSC) that contains one or more chemicals – known as Candidate Chemicals – that have a hazard trait that can harm people or the environment. A request to add a Product-Chemical Combination to the list is submitted to DTSC in the form of a petition, including supporting information.

The Problem / Effect

This petition is intended to demonstrate how aquatic organisms may become exposed to zinc from motor vehicle tires and the potential for this zinc to contribute to or cause significant and widespread adverse impacts. Humans are also exposed, but this exposure does not appear to be significant. Zinc is present in tires at a concentration of approximately 1%[1]. The on-road abrasion of tire tread results in both airborne and surface particulates containing zinc. Some of this zinc remains on road surfaces and adjacent areas and may be washed off by rain and carried by stormwater into waterways. Aerially transported zinc-containing particles from tire treads can be deposited onto impervious surfaces such as roofs and other hardscapes and may also be carried by stormwater and other urban runoff (e.g., overwatering) into waterways. These waterways—streams, rivers, and lakes—contain aquatic organisms that are potentially impacted by zinc. In many locations, stormwater runoff from urban areas and interurban highways is a significant source of zinc exposure to aquatic organisms. For example, on an annual basis, stormwater contributes about 90% of the zinc loading to the Los Angeles River.[2]

A related issue of increasing concern is the mandated use of crumb rubber from tires in rubberized asphalt on California roads and highways. The California Department of Transportation (Caltrans) is required by statute—AB 338 (Levine, 2005)—to use tire rubber in 35% of its paving projects. This crumb rubber contains zinc and potentially increases the amount of zinc in runoff when used in rubberized asphalt.

The hazardous character of zinc released by tire abrasion onto roadways appears to be demonstrated by the frequent exceedances of water quality standards established by U.S. EPA and the State Water Resources Control Board (State Water Board) for the protection of aquatic species. The exceedances occur in stormwater runoff at the point of discharge into waterways and also in the streams and rivers receiving these discharges. The State Water Board has listed waterways in California as impaired by zinc from various sources under the provisions of section 303(d) of the Clean Water Act (CWA).

The 2012 303(d) list includes 40 zinc listings, the sources of which have been or could be attributed to runoff (see table below).[3] Eight of the 40 listings are for "zinc (sediment)", which should be considered as potentially caused by urban or roadway runoff since much of the zinc released by tires is in

[1] California Stormwater Quality Association (CASQA). *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here. (Attachment F to this document)
[2] Los Angeles Regional Water Quality Control Board. *Attachment B - Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise the Los Angeles River and Tributaries Metals TMDL*. April 9, 2015. Table 7-13.1. (Source Analysis). Available here.
[3] The approved 2012 Clean Water Act 303(d) list of impaired waterways is based on the 2008/2010 303(d) list with updates for the North Coast, Lahontan, and Colorado River Basin Regional Water Boards. It applies to data collected through August 30, 2010. The State Water Board has recently updated the list. Available here.

particulate form and would be expected to settle out in waterways.[4] The 303(d) listings of impaired waterways typically increase during each listing cycle. Additional 303(d) listings for zinc are likely as more waterways are sampled and data becomes available that complies with the listing threshold specified in the State Water Board Listing Policy.

2012 Clean Water Act Section 303(d) Listings of Zinc-impaired Waterways in California

Regional Water Board	Total Listings	Zinc	Zinc (sediment)
1 – North Coast	0	0	0
2 – San Francisco Bay	4	1	3
3 – Central Coast	1	1	0
4 – Los Angeles	14	9	5
5 – Central Valley	14[5]	14	0
6 – Lahontan	0	0	0
7 – Colorado River	0	0	0
8 – Santa Ana	2	2	0
9 – San Diego	5	5	0
Totals	**40**	**32**	**8**

The Source / Cause

Land Development

Monitoring by municipal separate storm sewer systems (MS4s) often shows exceedances by zinc of the hardness-adjusted water quality objectives. For example, data from the Los Angeles Flood Control District *2013 – 2014 Annual Stormwater Report*[6] (see table below) shows that sixteen of the 26 wet weather samples analyzed for dissolved zinc exceeded the applicable water quality objectives. (*Note*: the objectives vary because they are hardness-dependent). Dry weather monitoring at these same in-stream locations reported no exceedances.

The water quality objectives are based on U.S. EPA-established criteria to protect aquatic species. The objectives vary with the measured hardness in the receiving water. The 61% (16/26) exceedance rate shown in the table below and the high end of the data range for the monitored waterways indicate the difficulty of attaining objectives in the absence of a strong source control program directed at zinc sources including zinc in tire tread.

[4] See the following table with highway edge-of-pavement monitoring data; over 60% of the total zinc is particulate based on median values. As discussed later, tires are a major source of zinc as measured edge-of-pavement.
[5] Not counting nine additional listings attributed to resource extraction (mining).
[6] Los Angeles County Flood Control District. *Annual Stormwater Report 2013 – 2014*; Attachment L – Stormwater Monitoring Report. Required by NPDES permit, Order No. R4-2012-0175. Available here.

Example of exceedances of standards
Los Angeles Flood Control District - Zinc in-stream monitoring data
Water quality objectives (WQO) compared with median results and concentration ranges

Location	Vacant %	WQO	Median (range)	#Samples	#Exceed
Ballona Creek at Sawtelle Blvd. S01	11.1	59.6-241.7	345 (284-535)	4	**4**
Malibu Creek at Piuma Rd. SO2	79.3	379.3-379.3	56.55 (50-63.1)	4	0
Los Angeles at Wardlow Rd. S10	40.4	65.1-183.7	384.5 (117-988)	4	**4**
Coyote Creek at Spring St. S13	14.3	59.6-228.6	330 (145-765)	4	**4**
San Gabriel River at SGR Parkway S14	66.7	127-231.2	54.1 (48.9-62.6)	3	0
Dominguez Channel at Artesia Blvd. S28	0.0	65.1-201.9	357 (218-600)	4	**4**
Santa Clara River S29	87	346.9-379.3	24.9 (19.5-121)	3	0
Totals				**26**	**16**

All data ug/L dissolved; Zn was detected in all samples; data excerpt from Annual Report Table 4-4 and Figures 2-2 through 2.8

The monitoring locations at Malibu Creek, San Gabriel River, and Santa Clara River did not have exceedances because of relatively low zinc concentrations. These data are best explained by the fact that the in-stream concentrations vary with the level of urban development in the watershed areas contributing to the stream. Higher level of development correlates with the higher zinc levels in the in-stream monitoring. All the areas with no exceedances had more than 65% vacant land.

Motor Vehicle Tires

Caltrans completed a comprehensive statewide monitoring of runoff from highways. The results were compiled in the *Discharge Characterization Study Report*,[7] which estimated that total zinc from highway and related facilities exceeds standards over 80% of the time; dissolved zinc exceeded standards over 50% based on a default assumption of hardness.[8] For identifying tire-contributed zinc loadings, the highway edge-of-pavement data collected by Caltrans (see table below) is useful because it does not include galvanized structure surfaces or guardrails as possible sources.[9] The data collection was specifically designed to avoid non-road surface sources. This data can be used to isolate the contribution of highway surfaces.

[7] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-18. Available here.
[8] For the California Toxics Rule metals criteria, including zinc, the objectives are adjusted for hardness based on the lowest observed hardness for the data set for the most stringent assessment of percent exceedance. Consequently, exceedances may be less frequent for waterways with higher hardness values.
[9] Caltrans, *Roadside Vegetated Treatment Sites (RVTS) Study Final Report*, CTSW-RT-03-028, 2003; available here.

Caltrans highway edge-of-pavement samples monitored for zinc[10] (all µg/L)

Monitoring location	Dissolved	Total
Sacramento	14.8	74.3
Cotton-wood	41.4	130.9
Redding	15.8	39.0
San Rafael	43.5	119.7
Irvine	79.8	290.3
Moreno Valley	261.4	351.2
San Onofre	77.9	279.5
Yorba Linda	137.6	329.8
Mean (edge of pavement)	**84.0**	**201.8**
Mean (statewide highways)	**68.8**	**187.1**

Applicable water quality objectives will vary based on the site-specific hardness

Mean values are presented to provide information on the typical concentrations of zinc and they are also indicative of the potential for exceedances. Note that National Pollutant Discharge Elimination System (NPDES) permits require attainment at all times, not attainment of the mean.[11] Also shown in the table above are data on the mean concentrations of zinc found statewide in highway runoff (i.e., from all sources).[12] A comparison of the edge-of-pavement data with the statewide highways data shows the levels of zinc from the edge-of-pavement are high enough to account for the levels of zinc found statewide in highway runoff.[13] Other possible sources for highway zinc such as galvanized fencing or traffic barriers do not appear to have a significant impact since edge-of-pavement zinc concentrations measured at these sites are similar to the statewide highway runoff concentrations. Furthermore, the edge-of-pavement concentrations appear to be almost exclusively from tires. Other possible sources for zinc in edge-of-pavement runoff include zinc in natural soils (dust) and motor oil but these contributions appear to be minor (see Attachment D – Minor Sources of Zinc in Waterways).

[10] Zinc concentrations in runoff can vary significantly due to location and the time of sampling. Some locations have a higher or lower volume of runoff compared with traffic count (traffic volume). Areas with lower traffic counts will result in the generation of less tire debris and less zinc. The length of the antecedent dry period before sampling is also a major factor. For this edge-of-pavement study, all sampled storm events were preceded by at least 24 hours without rainfall. The desired minimum antecedent dry period was 72 hours. Longer antecedent dry periods before sampling could result in significant buildup of tire residue and associated zinc.

[11] The acute criterion, which is most appropriate for stormwater, is a one-hour average, but typically only a single sample is taken in a day for comparison with the standard.

[12] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-2 for highway runoff zinc. Available here. Other possible sources for zinc in edge-of-pavement runoff include zinc in natural soils (dust) and motor oil but these contributions appear to be minor as discussed later in the report.

[13] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-2 for highway runoff zinc. Available here.

The Response

In addition, the presence of elevated zinc concentrations in runoff results in significant problems for municipal agencies subject to Clean Water Act NPDES permits for stormwater discharges:

(1) The municipal stormwater permits mandate attainment of water quality standards. These standards for ambient waters are promulgated to protect aquatic life. In urban areas, the sources of zinc in stormwater runoff appear to be primarily tire tread and zinc-coated metal as described in the CASQA report on zinc sources.[14] These discharges containing elevated zinc place the permittees in potential non-compliance with their permits.

Municipal stormwater permittees participating in watershed programs are required to submit a reasonable assurance analysis (RAA) or similar report as part of their stormwater management plan to demonstrate that their proposed watershed control measures will result in attainment of water quality standards and associated effluent limitations. Treatment of stormwater for zinc is generally financially and technically infeasible, and therefore source control is essential. Municipal stormwater permittees will need to demonstrate that source controls on zinc will result in attainment of standards. These source controls will almost certainly require controls on zinc released from tire treads.

(2) Waterways in California with monitored ongoing exceedances of the zinc standards are listed as impaired as required by the Clean Water Act. These impairments require the development of specific plans—total maximum daily loads (TMDLs)—to bring the waterways back into attainment of the standards. The presence of zinc in runoff may prevent the municipalities from meeting the deadlines in these TMDLs to reduce the stormwater loading of zinc to waterways.

Zinc, copper, and sometimes lead are frequently the primary metals of concern being addressed by TMDLs to protect aquatic organisms.[15] Copper and lead are already being addressed by source control programs that are resulting or will result in significant reductions of discharges of these metals to waterways. Tire treads are a significant source of zinc in waterways as shown by the data in this petition, including edge-of-pavement monitoring on highways where other sources are minimized. Consequently, it appears that source control for zinc released from tire tread is essential to attain significant improvements in water quality.

Copper and lead source controls were put into effect by California and national legislation. At the time, the California legislature approved the copper reduction mandates —SB 346 (Kehoe, 2010)—legislative members recommended that the relatively new DTSC Green Chemistry program be used for addressing future pollutants of concern such as zinc.

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[14] California Stormwater Quality Association. *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here. (Attachment F to this document)

[15] For example, the U.S. EPA-issued *TMDL for Metals and Selenium - San Gabriel River and Impaired Tributaries* (2007) assigns wet weather allocations for copper, lead, and zinc. Available here, see Tables 6-1 through 6-3. Another example is the *Chollas Creek TMDL for Metals* (copper, lead, zinc). Available here.

Background for the Petition

Names of Petitioners

- California Stormwater Quality Association

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Description and Uses of the Product-Chemical Combination

- *Description* – Motor vehicle tires with tire-tread containing zinc.

  Tire-tread rubber has a zinc content of approximately 1% by weight (see Attachment A – Zinc Concentration in Tires). Tires for heavier commercial vehicles may have a higher concentration.

  The main categories of tires are passenger, light truck, and medium/heavy truck. In the vehicle code, the vehicle categories are passenger vehicle and motortruck. The Air Resources Board recognizes thirteen vehicle classes as shown in Attachment B – Vehicle Classes.

  The primary concern is the tire tread, which is abraded on roadways, releasing zinc into the environment. A lesser concern is the entire tire, which potentially releases zinc during reuse as tire derived fuel (TDF) or tire derived products (TDP). Passenger tires may have as many as 8 types of rubber and commercial tires, including retreads, may have 14 types of rubber.
- *Uses* – On-road transportation and hauling; reuses include production of tire derived products.

Purpose and Function of Zinc in Tires

Vulcanization of rubber takes place at an elevated temperature and results in the cross-linking of polymers, which provides strength and durability. Zinc oxide (ZnO) and stearic acid are typically used as activators or accelerants in the vulcanization process. Together with other compounds, the activators lower the temperature needed for vulcanization and improve vulcanization efficiency. Zinc may also have other functions in tire manufacturing and use.

Manufacturers and Importers

See Attachment C – Manufacturers and Importers.

Basis for the Petition and Supporting Information

The following sections summarize the requirements in California Code of Regulations, Title 22, section 69503, and present the information necessary for assessing the Product-Chemical Combination. Non-relevant subsections of the regulations are not addressed.

Adverse Impacts and Exposure Factors - §69503.3

Evaluate the potential adverse impacts posed by the Candidate Chemical in the product due to potential exposures during the life cycle of the product.

(a) Adverse Impacts - §69503.3(a)

1) Evaluate the potential for the candidate chemical to contribute to or cause adverse impacts, by considering one or more of the following factors for which information is reasonably available:

   A. Hazard trait(s) and/or environmental or toxicological endpoint(s)

   ….

Zinc is potentially toxic to aquatic organisms at very low concentrations in the water column (parts per billion). Effects of accumulated zinc in waterway sediments may also be a concern. Humans may be exposed to zinc when tires are recycled for use in playgrounds and similar uses although the Office of Environmental Health Hazard Assessment (OEHHA) has determined that this potential risk is minimal. Consequently, the main focus of this petition is the protection of aquatic organisms. These organisms may be ecologically important and potentially susceptible to adverse impacts from zinc. In some cases, they may also be protected under U.S. and state laws and regulations pertaining to endangered species.

OEHHA describes "hazard trait" as incorporating a range of data and information relevant to human health and environmental hazards and exposure potential, such as:[16]

- Traditional toxicological and environmental endpoints
- Emerging and "upstream" endpoints
- Physical chemical characteristics
- Structural features
- Other indicators of hazard or exposure potential

Toxicological endpoints in the aquatic environment include growth, reproduction, avoidance behavior, and mortality.

The sections below provide the following information:

- Toxicity of zinc to aquatic organisms as established by U.S. EPA and the State of California in the promulgation of water quality standards.
- Research on which U.S. EPA and the state based the standards for the protection of aquatic organisms.
- Possible future changes to the water quality standards for zinc.

Toxicity to aquatic organisms – U.S. EPA and State criteria for zinc toxicity

As shown in later sections, zinc from tire wear is present in urban and highway stormwater runoff[17] and potentially contributes to aquatic toxicity when the zinc is present at levels above water quality criteria

[16] OEHHA. Presentation, *Update on OEHHA's Hazard Trait Research*. 2009. Available here.

[17] An early reference to zinc in automobile tires being a major contributor to the zinc in urban runoff is Eric Christensen and Vincent Guinn. *Zinc from Automobile Tires in Urban Runoff*. 1979. Journal of the Environmental Engineering Division, Vol. 105, Issue 1, Pg. 165-168. Later documents, including California Stormwater Quality Association *Zinc Sources in California Urban Runoff*. April 2015, support this conclusion. For the Los Angeles River

established by U.S. EPA or the State and Regional Water Quality Control Boards (Regional Water Boards). U.S. EPA recommended aquatic life ambient water quality criteria for dissolved zinc are shown in the table below. These freshwater values are hardness–dependent; the values shown are based on a hardness of 100 mg/L. Toxicity decreases with increasing hardness and increases at low levels of hardness.

Zinc in ambient waters at concentrations less than the following criteria is not expected to pose a significant risk to the majority of species in a given environment.

U.S. EPA zinc water quality criteria for aquatic habitat[18]
(all values µg/L; hardness: 100 mg/L)

Zinc	**Freshwater CMC** (acute)	**Freshwater CCC** (chronic)	**Saltwater CMC** (acute)	**Saltwater CCC** (chronic)
Dissolved	120	120	90	81
Total	123	122	95	86

CMC: Criterion Maximum Concentration
CCC: Criterion Continuous Concentration
(Total criteria based on dissolved criteria and CTR conversion factors)

U.S. EPA promulgated these zinc criteria for fresh and saline waters in the California Toxics Rule (CTR): *Establishment of numeric criteria for priority toxic pollutants for the State of California*).[19] These criteria apply to most inland surface waters in California. The Regional Water Boards use the dissolved or total zinc concentration in NPDES discharge permits and in other regulatory mechanisms to protect aquatic organisms.

Separate water quality objectives (criteria) for zinc apply to ocean waters.[20] These were promulgated by the State Water Board in the California Ocean Plan and are shown in the following table.

California zinc water quality objectives (criteria) for Ocean waters
(all values µg/L)

Zinc	**6-Month Median**	**Daily Maximum**	**Instantaneous Maximum**
Total	20	80	200

These objectives for ocean waters are measured as total recoverable zinc and are not hardness-dependent.

Concentrations of zinc above the State and U.S. EPA criteria (objectives) in waterways and in stormwater runoff represent a potential threat to aquatic organisms. Stormwater runoff may become diluted in the

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watershed, "The single largest source of zinc has been found to be automobile tires". Bureau of Sanitation, Watershed Protection Division, City of Los Angeles. *Water Quality Compliance Master Plan for Urban Runoff*. 2009. Available here.

[18] U.S. EPA. *National Recommended Water Quality Criteria - Aquatic Life Criteria Table*. Available here.

[19] U.S. EPA. *Establishment of numeric criteria for priority toxic pollutants for the State of California (California Toxics Rule)*. 40 CFR 131.38. 2000. Available here.

[20] *Water quality objectives* is the California term for *water quality criteria*.

waterway to which it is discharged, thereby reducing the concentration of zinc and the toxicity. However, in many California waterways stormwater runoff constitutes a significant portion of the flow during wet weather and waterway concentrations are similar to discharge concentrations.[21] Similarly, waterways carrying elevated zinc levels during wet weather due to upstream discharges or other reasons may not have the capacity to dilute stormwater runoff discharges that contain zinc concentrations above the criteria.

Research on which U.S. EPA and the state based the standards for the protection of aquatic organisms

The support documents for the U.S. EPA criteria for zinc include:

- Ambient Water Quality Criteria for Zinc, 1987.[22]
- 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water.[23]

The current freshwater zinc criteria in the California Toxics Rule of 120 µg/L (hardness-dependent) were updated in 1995 based on previous criteria and two additional studies. Information on the procedures for derivation of the U.S. EPA criteria is available on its website.[24] The promulgation of the U.S. EPA recommended criteria is subject to public review and comment.

The State Water Board has a similar public review process for promulgating water quality objectives (criteria), including those in the Ocean Plan. The objectives for zinc were first established in the 1978 California Ocean Plan.[25] The 6-month median objective was established based on the approximate midpoint (geometric mean) between the background seawater concentration (BSC = 0.008 mg/L) and the conservative estimate of chronic toxicity (CECT = 0.04 mg/L). At the request of the Department of Fish & Game, the Board also adopted shorter duration objectives: the daily maximum and the instantaneous maximum in the ratios of 4 and 10 times the six-month median, respectively. The State Water Board re-evaluated the zinc objective in 1983, but the new data available at that time did not warrant changing the 1978 objectives.[26]

Possible future changes to the water quality standards for zinc

U.S. EPA periodically updates the recommended criteria and will in the future consider the use of the biotic ligand model (BLM) for zinc. This model takes into account site-specific receiving water characteristics and would replace the current hardness-dependent criteria. These site-specific characteristics affect toxicity and include pH, dissolved organic carbon (DOC), major cations, and major anions. Several zinc BLMs have already been developed but have not been adopted by U.S. EPA.[27] A BLM-based standard could lower the applicable toxicity criterion for some waters and but will likely raise

[21] *Related*: State Water Board. *Report of the Effluent-Dependent Waters Task Force*. 1995. Includes definition of effluent-dependent water, page 3. Available here.

[22] U.S. EPA. *Ambient Water Quality Criteria For Zinc*, 1987. Available here.

[23] U.S. EPA. *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water,* EPA-820-B-96-001. September 1996. Available here.

[24] See the U.S. EPA online section *Aquatic Life Criteria and Methods for Toxics*, available here.

[25] The 1978 and other versions of the Ocean Plans are collected in SWRCB. *Compilation of the California Ocean Plan 1972 -2001*. Available here.

[26] Personal communication. Steven Saiz. Dec. 15, 2017.

[27] *Example*: DeForest DK, Van Genderen EJ. *Application of U.S. EPA guidelines in a bioavailability-based assessment of ambient water quality criteria for zinc in freshwater*. 2012

the criterion in many others.[28] The U.S. EPA Science Advisory Board has encouraged U.S. EPA to incorporate the best science and models, including the BLM, into its standards setting procedures.[29]

A combination of source control for zinc and revised standards based on the BLM (i.e., higher environmental endpoint) could potentially provide municipal separate storm sewer systems and other stormwater dischargers with the means of attaining water quality standards.

(a) Adverse Impacts - §69503.3(a)

1) Evaluate the potential for the candidate chemical to contribute to or cause adverse impacts, by considering one or more of the following factors for which information is reasonably available:

………..

B. Aggregate effects

Aggregate effects can be considered as the cumulative impact of tire zinc with other sources of zinc. A separate category—cumulative effects—addresses zinc combined with other chemicals in a waterway with a similar hazard trait and these are described in a subsequent section.

As demonstrated elsewhere in this document[30], zinc from tires, combined with zinc from other sources such as galvanized surfaces, often results in exceedances of the water quality criteria for zinc in stormwater discharges, TMDL allocations to protect receiving waters, and in the receiving waters. Zinc exceedances are often one of the key drivers for watershed management programs in southern California. For example, a recent presentation by Los Angeles County identified zinc and bacteria as the governing pollutants for programs in the watersheds regulated by the Los Angeles MS4 permit.[31]

A key question is whether zinc from tire tread abrasion presents a significant source compared with galvanized surfaces and other sources. Galvanized surfaces include roofs, drains, and pipes. The CASQA report: *Zinc Sources in California Urban Runoff,* focused on answering this question. The main conclusion in this CASQA report is that the major sources of zinc in urban runoff are outdoor zinc surfaces (including galvanized surfaces) and tire wear debris.[32]This conclusion was based on a thorough review of existing literature[33], including for example as shown in a later section of this petition, data

[28] Scott Tobiason, et al. *Comparison of hardness-based and BLM-based water quality criteria for copper and zinc in streams near Los Alamos National Laboratory*. Available here.

[29] Science Advisory Board. *An SAB Report: Review of the Biotic Ligand Model of the Acute Toxicity of Metals*. 2000. Available here.

[30] For example, see the tables for the Los Angeles Flood Control District, Ballona Creek, and Los Cerritos Channel in the section: (b) Exposures - §69503.3(b), … (2) The occurrence, or potential occurrence, of exposures to the candidate chemical.

[31] Los Angeles County DPW presentation: *The County of Los Angeles' MS4 Permit Experience: Viewing Stormwater as an Asset*, March 2016, available here.

[32] California Stormwater Quality Association. *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here. (Attachment F to this document)

[33] "Almost every zinc emissions inventory has identified tire wear as a major source of zinc in urban runoff (Councell et al. 2004; Hjortenkrans et al. 2007; Kennedy and Sutherland 2008; Vos and Janssen 2008). Many detailed estimates of zinc releases from tires and their contribution to runoff have been performed (Blok 2005;

from Virginia urban-suburban watershed correlated traffic levels with zinc accumulation in sediment.[34] The CASQA report also notes that other local zinc sources may contribute significant quantities of zinc in some watersheds.

The conclusion that tire wear is a significant source is also supported by highway edge-of-pavement monitoring results. As described later in this document[35], these results are roughly in the same range of zinc concentrations present in highway runoff, in general, and also in urban runoff. Tire zinc is the only significant contributor to the edge-of-pavement concentrations because other potential significant sources such as galvanized roofs, fences, and traffic barriers are absent. Potential on-road sources of zinc such as natural soils and motor oil are also not considered significant – see Attachment D – Minor Sources of Zinc in Waterways.

A related and increasing concern is the legislatively mandated use of crumb rubber asphalt (CRA) made from waste tires. California Assembly Bill 338 (Levine, 2005) requires Caltrans to use tire rubber in 35% of its paving projects, beginning at 20% in 2007 and increasing to 35% in 2013. This crumb rubber contains zinc, and asphalt containing rubber appears to increase the amount of zinc in runoff, at least for some uses.[36] The use of tire-derived rubber in road projects is likely to increase because of the potential to improve pavement performance.[37] This legislation also requires Caltrans and the California Integrated Waste Management Board (CIWMB) to develop procedures for using crumb rubber and other derived tire products in other projects. These other projects could potentially produce additional sources for zinc entering waterways.

Relatively minor sources of zinc contained in stormwater runoff include brakes, wheel weights, gasoline and diesel exhaust, automotive oil & grease, and zinc naturally present in soils (See Attachment D). Other discharges to waterways include effluents from publicly owned treatment works (POTWs) and industrial sources. The POTW and industrial discharges are generally well-controlled by NPDES permits, which include numeric water quality-based effluent limitations (WQBEL) to ensure standards are not exceeded. These minor sources are described in more detail in Attachment D.

In some waterways, resource extraction (mining) has contributed excessive zinc loadings that resulted in waterway impairment. Nine of these waterways with resource extraction impairment are included in the Clean Water Act 303(d) list of impaired waters in California – see Attachment E – Zinc Impaired Waterways - 303(d) listings in the 2012 Integrated Report. Although mining activities may contribute the bulk of the zinc loading in these waters, roadway runoff could add to the zinc burden in these waterways.

Aggregate effects can also include the impact of zinc on toxicity as mediated by the physicochemical characteristics of the waterways into which zinc is released. The toxicity of zinc and other heavy metals varies in freshwater due to factors such as hardness, pH, and dissolved organic carbon. The U.S. EPA zinc criteria established for the protection of water quality are hardness-dependent. As hardness

Kennedy and Sutherland 2008; Whiley 2011; Hjortenkrans et al. 2007, Ten Broeke 2008)." (See full references in the CASQA report, 2015)

[34] See chart in *(a) Adverse Impacts - §69503.3(a) 1) Evaluate the potential for the candidate chemical …E. Environmental fate*.

[35] See *(b) Exposures - §69503.3(b) ...(2) The occurrence, or potential occurrence, of exposures to the candidate chemical.* Table - Caltrans Highway Edge of Pavement Samples Monitored for Zinc.

[36] *See for example*: Laura C. Sampson. L.C., et al. Abstract: *Water Quality and Hydraulic Performance of Permeable Friction Course on Curbed Sections of Highways*. 2014. Available here. "*The effect [on runoff] of two different binder compositions was also compared, showing an increase in zinc when recycled rubber is used*."

[37] Walker, D. (article). *Understanding how tires are used in asphalt*. Asphalt Magazine. 2010. Available here.

increases, the toxicity decreases. Consequently, the applicable zinc objectives in waterways with elevated hardness are significantly higher than in waterways with low hardness values. The equations for making the hardness adjustment are included in the California Toxics Rule. The other physicochemical factors can be evaluated by using the biotic ligand model, as discussed previously. U.S. EPA has applied this BLM methodology to the development of the copper criteria but not yet to zinc or the other "heavy metals".[38]

(a) Adverse Impacts - §69503.3(a)

1) Evaluate the potential for the candidate chemical to contribute to or cause adverse impacts, by considering one or more of the following factors for which information is reasonably available:

………..

C. Cumulative effects with other chemicals with the same or similar hazard trait(s) and/or environmental or toxicological endpoint(s)

Several other heavy metals exhibit a similar high level of toxicity to aquatic organisms. These include copper, lead, silver, cadmium, chromium (VI), and nickel. All of these metals have relatively restrictive water quality criteria in California as promulgated by U.S. EPA in the California Toxics Rule or by the Water Boards. Low pH increases the toxicity of the metals, while elevated hardness generally decreases the toxicity.

The concern is whether zinc combined with other toxicants—especially the other heavy metals—can exert more than just an additive effect (i.e., the sum of the individual toxicities which produces a greater overall toxicity). Simultaneous exposure of organisms to more than one heavy metal may produce toxic effects that are additive, antagonistic (neutralizing) or synergistic (more toxic than the sum of the individual toxicities). One research paper reported that toxicity tests using multiple heavy metals, including zinc, have found that these heavy metals generally displayed synergistic killing effects on a nematode species (*Caenorhabditis elegans*).[39] However, the zinc salt ($ZnSO_4 \cdot 6H_2O$), used in the test "often exhibited a neutralizing effect on a number of metal ions tested." The lethality was additive when zinc was combined with lead or chromium and synergistic when combined with copper or mercury. Earlier work by U.S. EPA reported on contradictory research regarding whether zinc was synergistic with copper.[40] U.S. EPA suggested that water hardness may be the determining factor.

Another study, with *Ceriodaphnia dubia* and *Daphnia carinata*, assessed combinations of lead, copper, and zinc.[41] Most of the metal interactions were additive although in some cases the toxic effects were synergistic.

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[38] "Heavy metals" generally refers to metals that have a high atomic weight and a relatively high density (e.g., > 5 times greater than that of water).

[39] K. Wah Chu, et al. *Synergistic toxicity of multiple heavy metals is revealed by a biological assay using a nematode and its transgenic derivative*. Aquatic Toxicology 61 (2002) 53 – 64. 2002. Available here.

[40] U.S. EPA (Robert Schneider). *The Impact of Various Heavy Metals on the Aquatic Environment*. 1971. Available here.

[41] Cooper, NL. *Toxicity of copper, lead, and zinc mixtures to Ceriodaphnia dubia and Daphnia carinata* (Abstract). 2009. Available here.

A separate literature review reported that combinations of zinc and cadmium were described as synergistic by some researchers but antagonistic by others.[42]

The possibility of synergistic effects with copper is important because copper and zinc are two of the heavy metals in stormwater discharges that frequently exceed water quality criteria established for the protection of aquatic organisms. California has enacted a legislative mandate to reduce copper in runoff by phasing out copper in brake pads, but no similar source controls are being applied to zinc.

Waterways included on the Clean Water Act 303(d) list for multiple metals would be expected to potentially have cumulative effects on aquatic species depending on the metals involved and water hardness and other constituents present. California waterways listed as impaired by zinc plus other metals are presented in Attachment B.

A related question is whether zinc acts synergistically with non-metal aquatic toxicants. In California, the State Water Board's Surface Water Ambient Monitoring Program (SWAMP) has linked most waterway toxicity to pesticides.[43] In recent sampling, 19% of the ambient water samples contained pesticides exceeding toxicity thresholds.[44] No information appears to be available regarding the possible synergistic effects on aquatic organisms of mixtures of zinc and pesticides.[45] Relevant data may be difficult to attain because of the ongoing substitution of new pesticides.

(a) Adverse Impacts - §69503.3(a)

1) Evaluate the potential for the candidate chemical to contribute to or cause adverse impacts, by considering one or more of the following factors for which information is reasonably available:

   ………..

   E. Environmental fate

The environmental fate depends on the final location of the tire residue washed from roadways and the zinc released by the use and disposal of waste tires.

This section examines the environmental fate of zinc for the following main categories:

a) Stormwater carrying tire-derived zinc into waterways
   - Water column
   - Sediment
   - Roadside areas (prior to discharge)
b) Stormwater diverted for use (infiltration, green technology, etc.)
c) Tire derived fuel in California
d) Other reuse of tire derived products
e) Export

[42] Wuncheng Wang. *Factors affecting metal toxicity to (and accumulation by) aquatic organisms — Overview*. Environment International, Volume 13, Issue 6. 1987. Available here.

[43] Surface Water Ambient Monitoring Program (SWAMP) webpage here.

[44] State Water Board-SWAMP. *2017 Water Quality Status Report*. Available here.

[45] For a combination of nickel and Chlorpyrifos resulting in a decrease in marine toxicity, see: Dondero F, et al. *Interactions of a pesticide/heavy metal mixture in marine bivalves: a transcriptomic assessment*. Available here.

f) Civil engineering uses
g) Disposal in landfills
h) Aerial deposition

Information on end use volumes for categories c) through g) is available from CalRecycle and is used in the following discussions:[46]

Estimated End Uses for California-Generated Waste Tires, 2015

Category	Sub-Categories	Tons	Percent of total
Crumb Rubber	Paving, Turf Infill, Ground Rubber/Nuggets, Molded & Extruded, Other	76,195	17.2%
Export	Processed tire derived fuel; Baled Waste Tires; Used Tires (export of used tires is 1.6%)	101,168	22.9%
Tire - Derived Fuel	[none]	85,721	19.4%
Reuse	Retread, Used Tires (Domestic)	67,158	15.2%
Civil Engineering	Landfill Applications, Non-Landfill Applications	11,668	2.6%
Landfill	Alternative Daily Cover	15,217	3.4%
Landfill	Disposal	84,699	19.1%

The environmental fate of zinc from tires directed to these use or disposal categories is addressed in the sections below.

a) Environmental fate - tire-derived zinc entering waterways

Most of the tire tread particles containing zinc will likely initially be located on the road surface, although very small particles may become airborne immediately, propelled by automotive-generated wind. Heavier particles that have left the roadway will likely tend to settle out nearby. The amount of released zinc that remains on the roadway will vary significantly with the length of the antecedent dry period, street sweeping, and other factors.[47]

In urban areas, many of the heavier particles leaving the roadway due to automotive-generated wind will likely be located relatively nearby. These particles potentially will be mobilized by stormwater runoff and carried into waterways especially if they have settled out on impervious surfaces.

Tire tread particles deposited on roadways and other impervious surfaces and subsequently discharged to waterways are the main concern for impacts on aquatic life. However, some stormwater flows are diverted for infiltration or other uses. The following subsections describe tire

[46] CalRecycle. *California Waste Tire Market Report: 2015*. 2016. Available here.
[47] "Longer Antecedent Dry Periods result in higher pollutant concentrations in runoff. This factor provides a measure of the "buildup" of pollutants during dry periods between storms." See: Caltrans. *Discharge Characterization Study Report*. 2003. Available here.

zinc present in the water column, deposited in sediment, directed to reuse, and settled in soils near roadways.

Discharge to waterways – water column

In California urban areas, a portion of the zinc from tread wear is highly likely to be deposited on road surfaces and nearby impervious surfaces and may be carried by stormwater runoff into municipal or other separate storm sewer systems and then discharged into a stream or river, usually without treatment.[48] Most of these discharges are regulated by the NPDES Phase I or Phase II permits issued by the Water Boards for municipal separate storm sewer systems.[49] The zinc in these waterways may subsequently be carried into terminal lakes, bays, estuaries, or ocean waters, which are the final receiving waters. Some zinc may be retained, at least temporarily, in the sediment in the waterways.

A later section—Exposures - §69503.3(b)—provides information on criteria exceedances in inland and coastal waterways resulting from the discharge of stormwater.

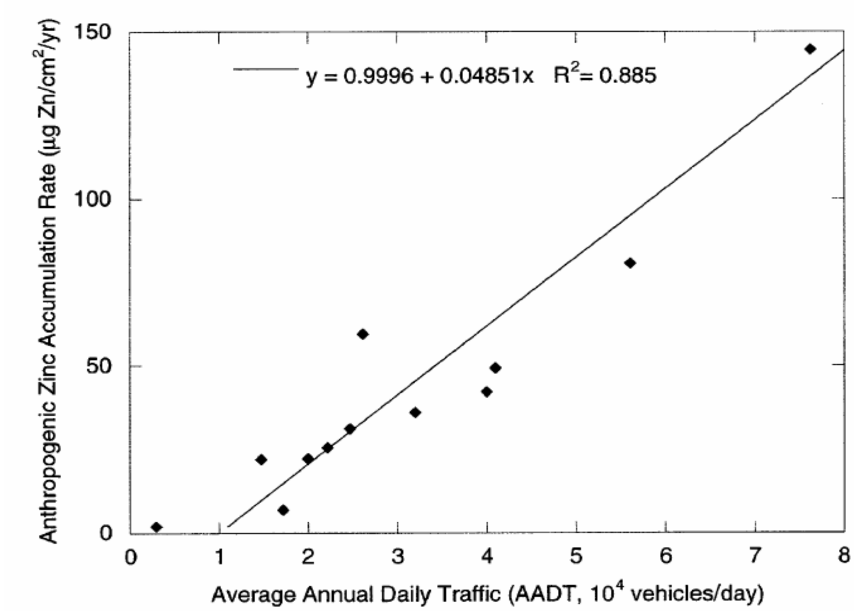
[48] San Francisco and a portion of Sacramento are served by combined sewers (wastewater and stormwater) which may provide treatment for the combined flows, thereby potentially capturing much of the zinc in stormwater.

[49] As required by Clean Water Act, Section 402(p), stormwater permits are required for discharges from a municipal separate storm sewer systems serving a population of 100,000 or greater or a Phase II Permit Program (for municipalities less than 100,000). Caltrans also has a Phase I stormwater permit. Phase II permit coverage also includes many “non-traditional” sources such as transportation centers, schools, etc.

Discharge to waterways – sediment

Some zinc remains in the sediment in waterways. Work by USGS in the Lake Anne urban-suburban watershed (Fairfax County, Virginia) correlated traffic levels with zinc accumulation in sediment. [50]

Zinc accumulation rate and traffic volume - Lake Anne watershed Virginia



Average annual daily traffic (AADT; vehicles/day) versus anthropogenic Zn accumulation rate (µg Zn/cm^2/yr.). The anthropogenic Zn accumulation rate is the total Zn in the 1990s sediment minus the total Zn in the 1950s baseline sediment (µg Zn/g sediment), multiplied by the mean mass sedimentation rate (g of sediment per cm^2 of lake surface deposited annually). (From Figure 3 in the USGS report)

A separate study examined the chemical fractionation of zinc in roadway runoff in order to characterize exposure to pond-dwelling organisms.[51] For this location, zinc exceeded the U.S. EPA water quality criteria in approximately 20% of storm samples. Zinc in the sediment was 39-62% recalcitrant, which suggests low bioavailability; however, it was more bioavailable than copper, which was also studied. The researchers also noted that most of the sediment concentrations for zinc exceeded published threshold effect concentrations (TEC). In addition, zinc often exceeded the probable effect concentrations (PEC).[52]

The State Water Board's Stream Pollution Trends (SPoT) program tracks waterway sediment trends. Urban stream sediment tends to have higher zinc concentrations compared with agricultural and "other" locations.[53] Zinc was the dominant metal of the four metals included in the study.

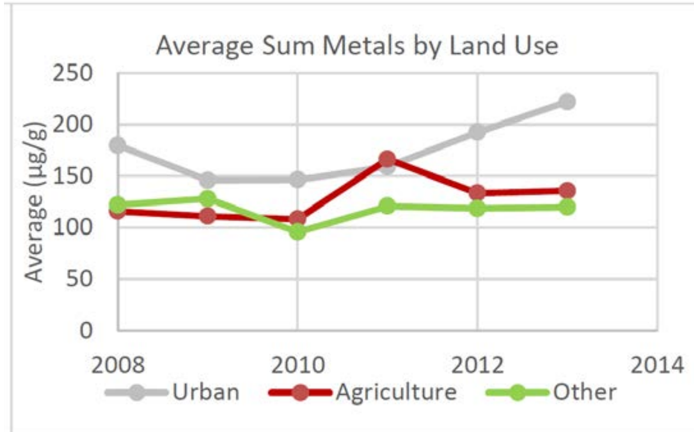
[50] Councell, TB, et al. U.S. Geological Survey. *Tire-Wear Particles as a Source of Zinc to the Environment*. Environ. Sci. Technol. 2004, 38, 4206-4214. 2004. Available here.

[51] Camponelli, K ., et al. *Chemical Fractionation of Cu and Zn in Stormwater, Roadway Dust and Stormwater Pond Sediments*. Abstract available here.

[52] TEC: Concentration below which adverse effects are not expected to occur; PEC: concentration above which adverse effects are expected to frequently occur.

[53] Statewide monitoring by the Stream Pollution Trends (SPoT) program provides information on sediment contamination and toxicity; the sum of four metals (Cd, Cu, Pb and Zn), is used in the report as an indicator of metal contamination; see the *Fourth Report — Seven-Year Trends 2008-2014*; available here.

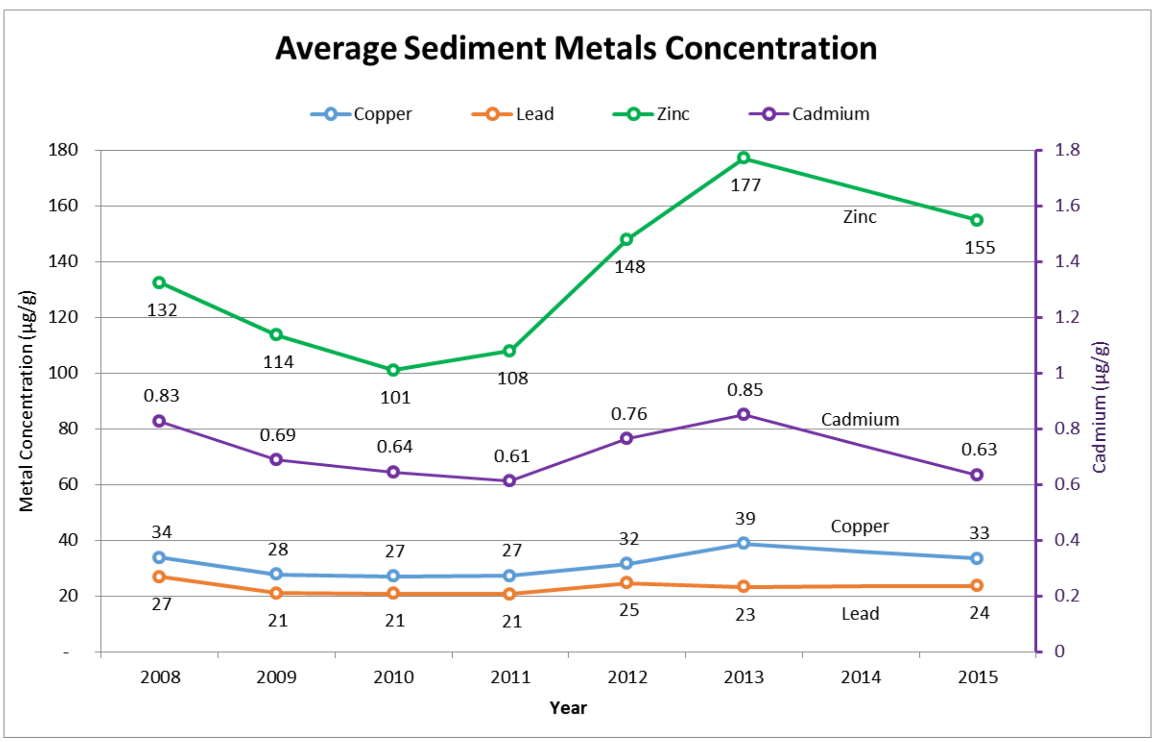
Sediment concentrations of 4 metals: copper, lead, zinc, and cadmium
(Excerpted from SPoT Report)



Watersheds were defined as urban, agricultural or other depending on the dominant land uses within 5 km of the sampling location.

A graph of concentrations of the individual metals based on the SPoT data indicates a possible increasing trend for zinc compared with the other metals.

Sediment concentrations for copper, lead, zinc, and cadmium
(based on SPoT data through 2015; Cd on right axis)



The changes in zinc concentrations did not appear to correlate with rainfall.

Runoff to roadside areas

In rural areas, highway runoff is sometimes drained from the impermeable surface by sheet flow to areas adjacent to the roadway. During intense rainfall, these surface soils may, in some cases, be mobilized and carried into waterways.

b) Environmental fate - diversion of stormwater to infiltration facilities

Diversion of stormwater to large-scale infiltration

In limited cases, including some Central Valley municipal areas, a significant portion of roadway and other urban runoff is diverted and infiltrated into the groundwater rather than being discharged to waterways. [54] These programs require the availability of land for infiltration and adequate depth to groundwater, as well as collection and transport infrastructure. The infiltration facilities may be regulated by Waste Discharge Requirements (or waivers) issued pursuant to the State Water Code. Infiltration projects are likely to increase significantly as MS4s attempt to reduce the volume of their discharges. TMDLs, lawsuits and consent decrees, and possible future legislation will encourage or require infiltration to meet discharge requirements or to supplement groundwater supplies.[55]

Zinc particulates from the infiltrated stormwater will likely remain on the sediment bed of the infiltration ponds together with other particulates and may need to be removed periodically. Dissolved zinc may infiltrate some distance into the soil profile. A study at various locations in Los Angeles found that pollutants, including zinc, generally appeared to be attenuated in the soil column.[56] In some cases, zinc penetrated to depth which resulted in relatively high monitored results from lysimeters. Nevertheless, groundwater did not appear to be adversely impacted during the study period:

> *The data collected during this study show no immediate impacts, and no apparent trends to indicate that stormwater infiltration will negatively impact groundwater at these sites*.

A 2008 update report[57] indicated that in some cases, zinc in groundwater appeared to increase due to the stormwater infiltration:

> *In most cases, concentrations of metals tended to be higher in storm water than in subsurface water samples. Metal concentrations in subsurface samples showed continued variability and generally stable or decreasing concentrations. Exceptions are slightly increasing trends of copper and zinc in one of the lysimeters at the Sun Valley site that could be associated with infiltration of storm water with relatively higher concentrations of these metals. A similar trend occurred in one lysimeter at the metal recycler. These trends are not reflected in groundwater samples*.

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[54] The Fresno-Clovis metropolitan area, for example, infiltrates most of the area stormwater runoff; description available here.

[55] Examples: Enhanced Watershed Management Program for Ballona Creek Watershed; Total Maximum Daily Loads for Indicator Bacteria, Project I -Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek); City of San Jose, Civil Case No: 15-CV-00642-BLF; SB-985 Stormwater resource planning (Pavely, 2014, signed); SB 633, Water quality objectives: stormwater (Portantino, 2017, Returned to Secretary of Senate 2-01-2018)

[56] Council for Watershed Health. *Ground Water Augmentation Study*. 2005. Available here. (Also see related reports).

[57] The Los Angeles and San Gabriel Rivers Watershed Council. *Los Angeles Basin Water Augmentation Study Phase II Monitoring Report Update*. 2008. Available here.

In general, zinc in stormwater runoff does not appear to present a significant threat to groundwater when infiltrated, at least in the locations tested. The infiltration beds may need periodic scraping due to severely reduced drawdown time. Disposal of the sediment would be dependent on the concentration of toxics. With greater emphasis placed on infiltration, zinc may be a potential problem in locations where it could enter the groundwater at concentrations of concern.

Diversion of stormwater to small-scale infiltration (green infrastructure)

In urban areas, low impact development (LID) or green infrastructure projects are increasingly being used to divert stormwater that would otherwise enter waterways. Some projects use subsurface infiltration systems.

These diversions allow the stormwater to infiltrate into the soil or direct it to some other use. As with large scale infiltration, some zinc would potentially remain on the surface of the infiltration facility and the dissolved zinc may move into the soil to some depth. Over time, zinc levels may increase, especially at the soil surface and require corrective action such as scraping.

A study in Sweden compared the topsoil of roadside green areas with infiltration to natural rural areas. [58] The concentrations of heavy metals—zinc, lead, and copper—were present at about 2 to 8 times the concentrations in the natural rural area.

c) Environmental fate - burning tires as a supplemental fuel (California)

The concern with burning tires is that zinc, present in tires at approximately 1%[59], could be released in air emissions. Thirteen facilities in the state are permitted to burn waste tires in combination with coal, coke, or biomass (ARB Report).[60] Only five of these facilities burned tires in 2014. The tires are shredded before combustion and distributed as tire derived fuel. Four of these facilities are cement plants and one is an electrical power facility. Approximately 10.8 million tires were burned as a supplemental fuel in 2014. Most of the facilities are in remote locations.

The total fuel number in the table below includes tires and other fuel. The metal emissions numbers represent the emissions from whole combined-fuel process (e.g., coal and tires), not solely the tire-derived fuel portion. Zinc and several other metals are present in coal combustion residues at elevated levels.[61] The total metal emissions of 69 pounds for the year do not appear significant.[62] However, elevated zinc in the ash may require disposal of the ash as a hazardous waste if the concentrations of any of the metals exceed the Title 22, CCR, section 66261.24 thresholds. These requirements establish two limits for zinc in a waste: 250 mg/L for the Soluble Threshold Limit Concentration (STLC) and 5,000 mg/Kg for the Total Threshold Limit Concentration (TTLC). Ash from energy recovery facilities that burn tires and which is classified as a hazardous waste for disposal

[58] Lind, B., et al., *Stormwater infiltration and accumulation of heavy metals in roadside green areas in Göteborg, Sweden*. 1995. Abstract available here.
[59] California Stormwater Quality Association. *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here. (Attachment F to this document)
[60] California Air Resources Board. *2016 Report on Air Emissions from Facilities Burning Waste Tires in California*. July 2016. Available here.
[61] IEA Clean Coal Center. *Trace element emissions from coal* (webpage). 2012. Available here.
[62] More information available from the ARB Emission Inventory Branch.

purposes, potentially could be recycled as a zinc fertilizer, unless other metals or pollutants are present at levels of concern.[63]

Number of tires burned by facilities in California and total metal emissions in 2014

Air District	Facility Name; Location	Tires Burned in 2014	Total Fuel (Tons)	Tires in Fuel (%)	Total Metals (lbs./yr.)
Mojave Desert	Cemex –California Cement, LLC; Apple Valley	3.3 million	276,351	12	30
Shasta County	Lehigh Southwest; Redding	1.1 million	49,344	23	5
Mojave Desert	Mitsubishi Cement Company; Lucerne Valley	2.0 million	205,096	10	23
Eastern Kern	National Cement Company; Lebec	4.3 million	96,895	44	11
South Coast	Desert View Power; Mecca	0.1 million	380,358	<1	<1

d) Environmental fate – crumb rubber recycled for paving and other uses

The subsections below examine several of the higher volume recycling end-uses for their potential to impact water quality or other environmental categories.

CalRecycle has established the Rubberized Pavement Grant Program to promote markets for recycled-content surfacing products derived from waste tires generated in California. This program was formerly called the Rubberized Asphalt Concrete (RAC) Grant Program. A significant volume of waste tires is turned into crumb rubber and reused. The waste tires are reduced to uniform granules with the steel, fiber, and other inert materials removed.

Estimated sales of crumb rubber made from California tires (2015)

	Millions of Pounds	Percent of Total
Paving	56.7	52%
Turf Infill	26.2	24%
Ground Rubber/Nuggets	16.8	15%
Molded & Extruded	8.6	8%
Other/Unidentified	1.1	1%
Total	109.4	100%

[63] U.S. EPA – Federal Register Notice - 67 FR 48393. *Zinc Fertilizers Made From Recycled Hazardous Secondary Materials*. Available here.

As indicated in the following discussion, reducing the zinc content in tires will reduce the risk to water quality from paving and potentially some of the other end uses of recycled tires.

Paving

The major water quality risk resulting from recycling of crumb rubber occurs when it is used for paving, some of which will potentially be carried by runoff into waterways. Caltrans is required by statute (AB 338, Levine, 2005) to use tire rubber in 35% of its paving projects, for an average of 11.6 pounds per metric ton of total asphalt paving materials used. In 2014, Caltrans used approximately 34.2 million pounds of crumb rubber which accounts for approximately 60% of crumb rubber use in the paving category.

The question then, is whether the zinc contained in the rubber could be released and impact water quality. Research using column tests for crumb rubber found that zinc leaching increases with smaller crumb rubber and longer exposure time.[64]

Some information is available on the impact on runoff zinc concentrations of recycled rubber used in permeable (or open-graded) friction courses on highways. Asphalt-rubber is a blend of asphalt cements, ground recycled tire rubber, and possibly other additives used as binder in pavement construction. This material can be used in standard road-surface applications and also in permeable friction courses (PFC). Permeable (or open-graded) friction courses have certain benefits when used as surface layers such as sound reduction, better traction, and improved visibility (due to reduced spray). PFC also generally reduce pollutant concentrations in runoff.[65]

When recycled tire rubber is used for the friction course the concentration of zinc in the runoff increases substantially compared with PFC formulated without tire rubber. These following results are based on monitoring of two urban highway sites in Texas.[66]

Depending on local hardness values in the receiving water, the use of rubberized PFC could result in highway runoff exceeding zinc standards at the point of discharge - 120 µg/L dissolved, at a total hardness of 100 mg for freshwater. The Ocean Plan standard is 80 µg/L daily maximum, not hardness-dependent and 200 µg/L instantaneous maximum.

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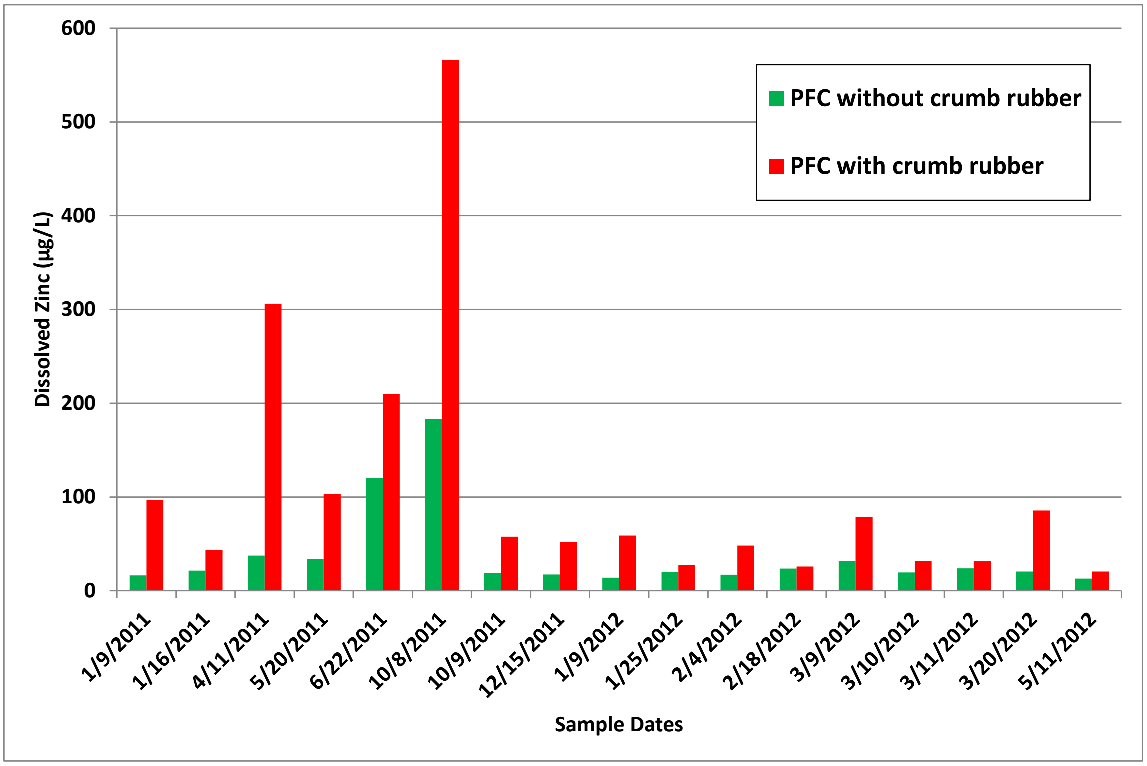
[64] Rhodes, et al. *Zinc Leaching from Tire Crumb Rubber*. Available here.
[65] Eck, B. et al. *Water Quality of Drainage from Permeable Friction Course*. 2012. Journal of Environmental Engineering, 138 (2). Available here. *From the abstract*: The data show that concentrations of total suspended solids from PFC are more than 90% lower than from conventional pavement. Lower effluent concentrations are also observed for total amounts of phosphorus, copper, lead, and zinc.
[66] Barrett, M. *Porous Pavement and Open Graded Friction Course*. Nov. 5, 2012. Presentation - CASQA 2012 Annual Conference.

Comparison of mix designs for permeable friction course (PFC) on zinc concentrations



As noted, permeable friction courses are effective at removing many key pollutants. The Texas study of two sites showed that total suspended solids (TSS) was reduced by 92%.[67] The following table presents a comparison of key pollutant removal by the rubberized and non-rubberized PFC.

**Comparison of runoff quality from open graded asphalt:
Rubberized vs non-rubberized (mean concentrations)**

Constituent	Non-Rubberized	Rubberized Mix	P-Value[68]
TSS (mg/L)	11.95	12	0.4247
Total Copper (µg/L)	12.7	13.1	0.484
Total Lead (µg/L)	1.63	2.4	0.0869
Total Zinc (µg/L)	37.4	85.8	<0.0001
Dissolved Copper (µg/L)	9.4	9.4	0.352
Dissolved Lead (µg/L)	1.0	1.0	0.492
Dissolved Zinc (µg/L)	20.0	51.3	<0.0001

[67] Barrett, M. and Sampson, L. *Treatment of Highway Runoff Using the Permeable Friction Course (PFC)*. 2013. ASCE - Second Conference on Green Streets, Highways, and Development. Available here. *Also see*: Barrett, M. and Larsen, K. *Significance of Zinc Levels in Stormwater Runoff from Permeable Friction Course Pavement Overlays*. 2013. Conference presentation - Transportation Research Board 92nd Annual Meeting. Available here.
[68] The p-value is used to determine the significance of the results. The low p-values above for zinc indicate a significant difference between the two types of roadways.

The presence of recycled rubber had the effect of adding an additional zinc source, which increased the median concentration of total zinc by 48 µg/L and dissolved zinc by 31 µg/L. The 85.8 µg/L median concentration for zinc is a concern because of the typical wide fluctuations in runoff concentrations.[69]

Other crumb rubber uses

Limited information is available concerning possible water quality impacts from the other uses of crumb rubber:

- Turf Infill
- Ground Rubber/Nuggets
- Molded & Extruded

Some of these uses, such as turf infill, could potentially contribute zinc to runoff.

An additional concern is buffings from retreaders. CalRecycle report states that these buffings are counted separately from crumb rubber and are used extensively in certain market segments, especially poured-in-place playground surfacing, molded products, and landscape mulch products.[70] In 2015, approximately 17.5 million pounds of buffings were directed to California processors. These reused tire buffings also could potentially be washed into storm drains in some locations.

e) Environmental fate – exported tire products

About 23% of the waste tires are exported as processed TDF, baled waste tires; and used tires (a very small portion). Zinc released from combustion of these tires may have adverse impacts, wherever they are incinerated, if the location does not have adequate emission controls.

f) Environmental fate – civil engineering uses

A relatively minor amount—2.6%—is used for structural engineering purposes in landfills and other locations. CalRecycle reports that the use of tire-derived aggregate (TDA) in civil engineering applications involved 75 percent being used at nine landfills, and the remaining TDA being used largely in one project by Bay Area Rapid Transit (BART). (See webpage with examples of TDA used in public works projects and other civil engineering applications – link).

g) Environmental fate - waste tires disposed of in landfills

About 22% of the waste tires are directed to landfills, either as daily cover (shredded) or for disposal.[71] These may be municipal or private solid waste landfills.[72] Whole tires must be processed (cut apart) in some manner before being deposited in California landfills.[73] The federal (RCRA) and state regulations for landfill management are designed to ensure that leachate containing zinc or other contaminants is not released from the landfills.

[69] In the Caltrans *Discharge Characterization Study Report*, cited earlier, the total zinc concentration ranged from 5.5 µg/L to 1680 µg/L, with a median value of 111 µg/L. Available here.
[70] CalRecycle. *California Waste Tire Market Report: 2015*. July 2016. Available here. Link also applies to e),f) and g).
[71] Example of alternative daily cover using tire shreds: Facility/Site Inspection Details, County of Glenn, available here.
[72] Tires may be classified as inert wastes. *See*: Definition of Inert Waste Title 27, Division 2, Subdivision 1 §20230(a).
[73] IWMB. *California Waste Tire Program Evaluation and Recommendations*. 1999. Available here.

Chronic toxicity testing required by the Regional Water Quality Control Board (RWQCB), Region 2, was performed to assess leachate from two tire derived aggregate fills (not in California).[74] One of the fills was above the groundwater table, and the other was below. The tests found toxicity in the leachate from the TDA fill that was below groundwater level, likely due to elevated levels of metals (iron, zinc, and manganese). However, these metals quickly formed immobile, insoluble particles in the subsurface soil relatively close to the landfill and therefore were unlikely to present a general risk to groundwater.

As noted previously, elevated concentrations of zinc may result in a waste being classified as a hazardous waste. Title 22, CCR, section 66261.24 establishes two limits for zinc in a waste: 250 mg/L for the Soluble Threshold Limit Concentration (STLC) and 5,000 mg/Kg for the Total Threshold Limit Concentration (TTLC). The presence of zinc at or above these levels would cause a waste to be characterized as a hazardous waste. It is unlikely that waste tires in landfills would exceed these thresholds.[75]

h) Environmental fate - aerial deposition of small airborne particles

Most tire wear is likely propelled by automotive-generated wind off the roadway. In urban areas with roofs, sidewalks, and other impervious surfaces, this tire wear which has been deposited on impervious surfaces could potentially be carried by runoff into storm drains. Smaller particles may be carried some distance away by the wind and become part of the general deposition of airborne particulates. The 2010 California Toxic Inventory estimate for zinc is 13 tons/year for South Coast AQMD.[76] Almost all of this is from the "areawide" source category (consumer products, construction, farming, paved & unpaved road dust, etc.).[77] Although a portion of this areawide source zinc comes from road surfaces, the 13 tons/year for the entire air basin is a relatively small amount compared with the direct stormwater loading to waterways as described previously.[78]

(a) Adverse Impacts - §69503.3(a)

1) Evaluate the potential for the candidate chemical to contribute to or cause adverse impacts, by considering one or more of the following factors for which information is reasonably available:

   ………..

   F. The human populations, and/or aquatic, avian, or terrestrial animal or land organisms for which the candidate chemical has the potential to contribute to or cause adverse impacts

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[74] Sheehan work reported in CalRecycle. *Usage Guide, Tire-Derived Aggregate (TDA)*. 2016. Available here. Page 37.

[75] More information on this issue may be available from DTSC or CalRecycle: Tire Management Program Hotline: (866) 896-0600 or WasteTires@calrecycle.ca.gov

[76] The South Coast Basin includes all of Orange County and the non-desert regions of Los Angeles, Riverside, and San Bernardino Counties.

[77] Statewide is 878 total tons/year, mostly areawide and natural. On-road is 43 tons/year.

[78] For example, the roughly 44 tons per year of zinc released by seasonal stormwater to the Los Angeles River watershed.

Potential impacts on aquatic species – TMDLs and discharge exceedances

As discussed in previous sections, the primary concern regarding zinc in tires is that the zinc released during on-road tire use contributes to adverse impacts on aquatic organisms. This risk is indicated by the frequent exceedances of the criteria established by regulatory agencies to protect these organisms.

For specific examples of exceedances of the standards established to protect aquatic species, see the later section on *Exposures - §69503.3(b)…(2) The occurrence, or potential occurrence, of exposures to the candidate chemical*.

These exceedances occur at the point of discharge of stormwater runoff to waterways and, in addition, some waterways have ongoing exceedances within the waterways. Persistent exceedances in waterways by zinc may trigger the development of total maximum daily loads as required in the Clean Water Act to reduce the loading of zinc to levels that do not threaten aquatic organisms. Three Regions currently have TMDLs underway that address zinc in 303(d)-listed impaired waterways. These TMDLs also typically address other metals and toxic organics. In some cases, zinc is the limiting pollutant, meaning that zinc is the most intractable pollutant and control measures targeting zinc will also ensure attainment of wasteload allocations (WLAs) for other pollutants.

The following table includes TMDL allocations for zinc that will be assigned to stormwater runoff from industrial facilities regulated by the Stormwater Industrial General Permit (IGP). These allocations were compiled from the proposed list of TMDLs for inclusion in the IGP. This list is a good example of the locations where the candidate chemical has the potential to contribute to or cause adverse impacts.

Proposed Total Maximum Daily Loads for
Industrial Discharges of Zinc to Impaired Waterways[79]
(***note***: other allocations apply to municipal discharges)

TMDLs that Address Zinc	Zinc Allocations
Los Angeles Regional Water Board	
Ballona Creek Metals	108 µg/L total Zn IM TNAL
Ballona Creek Estuary Toxics	150 mg/kg (dry weight) Zn IM TNAL
Colorado Lagoon	150 mg/kg (dry weight) Zn IM NEL
Los Angeles and Long Beach Harbor Waters - Dominguez Channel & Torrance Lateral Channel	899 µg/L interim total Zn IM TNAL 697 µg/L final total Zn IM NEL
Los Angeles and Long Beach Harbor Waters - Dominguez Channel Estuary	85.6 µg/L total Zn IM TNAL
Los Angeles and Long Beach Harbor Waters - Greater Los Angeles/ Long Beach Harbor waters	85.6 µg/L total Zn IM TNAL
Los Angeles and Long Beach Harbor Waters - Consolidated Slip	85.6 µg/L total Zn IM TNAL
Los Angeles and Long Beach Harbor Waters - Fish Harbor	85.6 µg/L total Zn IM TNAL
Los Angeles River (& Tributaries) Metals	159 µg/L total Zn IM TNAL
Los Cerritos Channel	95.6 µg/L total Zn IM TNAL
Marina del Rey Harbor Toxics	150 mg/kg (dry weight) Zn IM TNAL
San Gabriel River Metals & Selenium (Coyote Cr.)	158 µg/L total Zn IM TNAL
Santa Ana Regional Water Board	
San Diego Creek and Newport Bay Toxics - San Diego Creek (freshwater)	208 µg/L total Zn IM TNAL
San Diego Creek and Newport Bay Toxics - Upper Newport Bay (saltwater)	95 µg/L total Zn IM NEL
San Diego Creek and Newport Bay Toxics - Rhine Channel area of Lower Newport Bay (saltwater)	95 µg/L total Zn IM NEL
San Diego Regional Water Board	
Chollas Creek Metal	84.5 µg/L Zn IM TNAL

IM Instantaneous Maximum
TNAL TMDL Numeric Action Level
NEL Numeric Effluent Limitation

[79] State Water Board. *2017 Proposed Industrial General Permit Amendment - Attachment E-TMDL Implementation.* Available here [linked 12-26-2017]. The final amendment may have different wasteload allocations; in addition, IGP permittees have alternative compliance options including an off-site compliance option.

These TMDLs identify zinc-impaired waterways where stormwater runoff from industrial dischargers (and other dischargers) must attain specific wasteload allocations to ensure the protection of aquatic species. In addition, these TMDLs may apply separate allocations—usually weight-based—to stormwater discharges from municipal facilities. The wasteload allocations applied to industrial runoff provide useful information on the concentrations being targeted by the TMDL which can be compared with the typical concentrations in stormwater runoff. Exceedances of numeric effluent limitations in TMDLs may be permit violations. The TMDL Numeric Action Levels (TNALs) require specific corrective measures if exceeded; a permit violation occurs if these remedial measures are not implemented.

In addition to 303(d)-listed impaired waterways and the associated TMDLs, a major concern is the frequent exceedances that occur in other waterways at the point of discharge of MS4 stormwater runoff. NPDES permits require these agencies to not discharge pollutants that "cause or contribute" to exceedances of water quality standards. Even though the zinc concentration may become diluted further downstream in a waterway, the discharge typically causes some area within the waterway to experience elevated concentrations that potentially threaten aquatic species.

As noted in earlier sections, copper and lead will be significantly reduced in runoff because of ongoing source control efforts. These include the ban on copper in brake pads and the ban on lead tire weights (and the earlier removal of lead from gasoline). No similar source control program is available for zinc.

Potential impacts on humans

In limited situations, zinc in tires may result in exposure to humans. The primary example is the use of tire shreds in playground or similar recreational facilities. An OEHHA report on the potential health impacts of recycled tires included the following statements in the executive summary indicating that the risk of adverse health effects is low.[80]

> ***Evaluation of toxicity due to ingestion of tire shreds based on the existing literature***
>
> OEHHA found 46 studies in the scientific literature that measured the release of chemicals by recycled tires in laboratory settings and in field studies where recycled tires were used in civil engineering applications: 49 chemicals were identified. Using the highest published levels of chemicals released by recycled tires, the likelihood for noncancer health effects was calculated for a one-time ingestion of ten grams of tire shreds by a typical three-year-old child; only exposure to zinc exceeded its health-based screening value (i.e., value promulgated by a regulatory agency such as OEHHA or U.S. EPA). Overall, we consider it unlikely that a one-time ingestion of tire shreds would produce adverse health effects. [*excerpt*]
>
> ***Evaluation of toxicity due to chronic hand-to-surface-to-mouth activity***
>
> OEHHA performed wipe sampling of in-use playground surfaces containing recycled tire rubber; one metal (zinc) and four PAHs were measured at levels that were at least three times background. Assuming ingestion of the above five chemicals via chronic hand-to-mouth contact, exposures were below the corresponding chronic screening values, suggesting a low risk of adverse noncancer health effects. [*excerpt*]

[80] OEHHA. *Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products, Contractor's Report to the Board*. Completed for the Integrated Waste Management Board. Publication #622-06-013. 2007. Available here.

Also, zinc oxide and several other zinc compounds are on the U.S. FDA's generally recognized as safe, or GRAS, substances list.[81] These are food substances that are not subject to premarket review and approval by FDA because they are generally recognized to be safe under the intended conditions of use.

(a) Adverse Impacts - §69503.3(a)

………..

2. Special consideration of the potential for the candidate chemical in the product to contribute to or cause adverse impacts for:

……….

B. Environmentally sensitive habitats

C. Endangered and threatened species listed by the CA Department of Fish and Wildlife

D. Environments in California that have been designated as impaired by a California state or federal regulatory agency

B. Environmentally sensitive habitats

As defined in the California Coastal Act, an Environmentally Sensitive Habitat Area (ESHA) is a designated protective area within the Coastal Zone of California. It is an area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily damaged by human activities or developments. These areas can include coastal lagoons, coastal and inland waterways, and smaller drainages supporting wetland or riparian habitats. The areas are described in plans developed by the Certified Local Coastal Programs.

The State Water Board's Surface Water Ambient Monitoring Program does not target ESHAs specifically. However, to the extent that urban or highway runoff enters these areas; the ESHAs may be impacted by the zinc contained in the runoff, which frequently exceeds federal and state standards for the protection of aquatic life at the point of discharge, as discussed in other sections. (Also, see California Coastal Act 2010, Section 30107.5.)

C. Threatened and endangered species listed by the California Department of Fish and Wildlife

Threatened and endangered species include those listed by government agencies and subspecies. Roadway runoff containing zinc may impact these species if they are present when the concentration of zinc exceeds the standards for protecting aquatic life. Exceedances take place in waterways receiving urban runoff. The listed species include: Salmon, Smelt, Steelhead, Trout, and Sucker which are present in many waterways in California including those receiving stormwater discharges. Also see the California Department of Fish and Wildlife (CDFW) full list of *Threatened and Endangered Fish*.[82]

[81] See the FDA GRAS list here.

[82] CDFW list. *Threatened and Endangered Fish*. Available here.

For example, the listed Santa Ana Sucker is endemic to California and is currently found in only a few waterways in Southern California.[83] Many of these waterways are channelized with concrete sides and bottoms for at least part of their length, which has negatively affected these species. These waterways are typically in highly urbanized areas with relatively high concentrations of zinc in stormwater runoff. The stormwater runoff may constitute a major portion of the flow in these waterways during wet weather which results in limited or no dilution to the elevated zinc concentrations in the runoff.

In addition, several of these waterways are near areas of dense traffic and tire debris may be carried by traffic-induced turbulence into the waterways.

D. Environments in California that have been designated as impaired by a California state or federal regulatory agency

The 2012 303(d) list includes 40 zinc listings, the sources of which have been or could be attributed to runoff (see table below).[84] Eight of the 40 listings are for "zinc (sediment)", which should be considered as potentially impacted by urban or roadway runoff since much of the zinc released by tires is in particulate form and would be expected to settle out in waterways. (Also see Attachment E, which includes the individual 2012 listings.)

2012 Clean Water Act Section 303(d) Listings of Zinc-impaired Waterways in California

Regional Water Board	Total Listings	Zinc	Zinc (sediment)
1 – North Coast	0	0	0
2 – San Francisco Bay	4	1	3
3 – Central Coast	1	1	0
4 – Los Angeles	14	9	5
5 – Central Valley	14[85]	14	0
6 – Lahontan	0	0	0
7 – Colorado River	0	0	0
8 – Santa Ana	2	2	0
9 – San Diego	5	5	0
Totals	**40**	**32**	**8**

The CWA 303(d) list consists of the following categories of water quality-limited segments.

4a: segments being addressed by a U.S. EPA approved TMDL
4b: segments being addressed by actions other than TMDLs
5: segment where standards are not met and a TMDL is required, but not yet completed, for at least one of the pollutants being listed for this segment

[83] Big Tujunga Creek in the LA River Basin, the headwaters of the San Gabriel River in the San Gabriel Mountains in Angeles National Forest in Los Angeles County, parts of the Santa Clara River system in Los Angeles and Ventura counties, and the lower part of the Santa Ana River in Orange County. (From article, available here)
[84] The approved 2012 Clean Water Act 303(d) list of impaired waterways is based on the 2008/2010 303(d) list with updates for the North Coast, Lahontan, and Colorado River Basin Regional Water Boards. It applies to data collected through August 30, 2010. The State Water Board has recently updated the list. Available here.
[85] Not counting nine additional listings attributed to resource extraction (mining).

In California, these three categories are included in the California 303(d)/305(b) Integrated Report. The 303(d) listings cannot be used as the basis for identifying the only locations where water quality is threatened by zinc because limited sampling has been completed for many California waterways and the available data may not meet the requirements of the State Water Board Listing Policy. The 303(d) listings typically increase during each listing cycle. Additional 303(d) listings for zinc are likely as more waterways are sampled and data becomes available that complies with the listing threshold specified in the State Water Board Listing Policy. As discussed previously, achieving attainment of the resulting TMDLs will be difficult because of the lack of viable source control measures, especially controls for zinc released from tires.

An example of potential future listings is provided by saltwater monitoring data collected by the Coordinated Integrated Monitoring Program (CIMP) for the Ballona Creek Estuary.[86]

Constituents not currently on the 303(d) list, but which appear to meet listing criteria
(Excerpt from Table 9; wet weather)

Waterbody	Total Recoverable	Dissolved
CTR Saltwater Acute Criteria	95 (µg/L)	90 (µg/L)
Frequency of exceedance	**19%**	**13%**

The table notes that this waterway had not been sampled for zinc in the past 5 years. This data suggests that more waterways may be included on the CWA 303(d) list in the future based on discharger sampling or sampling completed by the State Water Board's Surface Water Ambient Monitoring Program.

(b) Exposures - §69503.3(b)

(1) Market presence of the product, including:

A. Statewide sales by volume

B. Statewide sales by number of units; and/or

C. Intended product use(s), and types and age groups of targeted customer base(s).

The sales and volume data based on tires shipped in 2016 are shown below. These include national data and an estimate for California based on the percentage of registered vehicles in the U.S. and in California. The estimates for California may be low because tire usage per registered vehicle is likely higher in California than the national average because of longer commuting distances. CalRecycle estimates that approximately 45.5 million passenger tire equivalents (PTE) were directed to various waste categories in 2016.[87] Presumably, a roughly equivalent amount of replacement and original equipment tires were shipped, which also suggests the estimates below for California are low. (California sales information for replacement and original equipment tires has been difficult to obtain.)

[86] Ballona Creek Watershed Management Group. *Coordinated Integrated Monitoring Program (CIMP) for the Ballona Creek Watershed. September 7, 2015.* Available here.
[87] CalRecycle. *California Waste Tire Market Report: 2016*. July 2017. Available here. See Table 1.

Estimate of replacement and original equipment (OE) tires units shipped in the US in 2016[88]

Tires	Millions of units (imports included)	**Estimate for California**
Passenger	205	26.6
Light truck	31.0	4
Medium/Heavy truck	18.4	2.4
Total	*254.4*	*33*

Estimate basis: California - 35.3 million registered vehicles (2016),[89] US - 263.6 million (2015),[90] therefore CA share is approx. 13%.

Tires are used for transportation and hauling. Tires are generally classified in the following categories: passenger, light truck, and medium/heavy truck. Targeted customers are anyone purchasing tires for use on roadways.

(b) Exposures - §69503.3(b)

……….

(2) The occurrence, or potential occurrence, of exposures to the candidate chemical

Examples of exposures from key sources of zinc entering waterways

As shown in the tables and other data presented in this section, urban runoff frequently exceeds the water quality criteria (objectives) for zinc established by the Water Boards and by U.S. EPA, placing aquatic organisms at risk. The elevated levels of zinc in urban roadway runoff have been identified for some time. An ASCE paper from 1997 determined that "Event mean concentrations of Zn, Cd, and Cu exceed surface water quality discharge standards."[91] The attainment goal, as noted, is not the EMC but attainment of the acute criterion for all samples (or 1-hr average).[92]

[88] Modern Tire Dealer. *2017 Facts: Overview*. 2017. Available here. *See Chart 3*

[89] Department of Motor Vehicles. Statistics for Publication. Available here.

[90] Statistica. Number of vehicles registered in the United States from 1990 to 2010. Available here.

[91] Sansalone, et al, *Partitioning and First Flush of Metals in Urban Roadway Storm Water*. 1997. Abstract here.

[92] For ocean discharges the California Ocean Plan daily maximum objective for Zn (80 µg/L total) is a daily average. The Ocean Plan also has an instantaneous maximum objective of 200 µg/L.

Particularly in urban areas, the zinc loading from stormwater runoff can be a significant portion of the total zinc carried by the waterway. *Example*:

LA River- Stormwater runoff results in 90% of the wet weather zinc loading.[93]

> *During wet weather, most of the metals loadings are in the particulate form and are associated with wet-weather storm water flow. On an annual basis, storm water contributes about 40% of the cadmium loading, 80% of the copper loading, 95% of the lead loading and **90% of the zinc loading*** [emphasis added]

The following subsections present examples of specific sources of zinc and exceedances or measured toxicity, which are an indication of exposure.

- Urban runoff into inland waterways
- Urban runoff into ocean waters
- Highways – general runoff and edge-of-pavement runoff (almost exclusively from tires)
- Highway runoff including zinc from recycled rubber
- Recycled rubber used for waste treatment and other civil engineering purposes
- Other uses of recycled rubber including use on playgrounds

a) Source: Urban runoff into inland waterways:

Zinc sources in urban runoff include tire wear, galvanized metal, paint, and other minor sources. Monitoring by MS4s often shows exceedances by zinc of the hardness-adjusted water quality objectives. The TMDLs that are needed to reduce zinc loadings to safe levels often identify the frequency of exceedances of the zinc targets. Several examples are included below. In addition, TMDL deadlines do not appear achievable in many cases due to the lack of best management practices, including treatment, to reduce the zinc levels. This will potentially result in extended periods of exposure above the standards.

- **Los Angeles Flood Control District**

  The following example is from Los Angeles Flood Control District *2013 – 2014 Annual Stormwater Report* (see table below). [94] Sixteen of the 26 wet weather samples analyzed for *dissolved zinc* exceeded the applicable water quality objectives. (*Note*: the objectives vary because they are hardness-dependent). Dry weather monitoring at these same in-stream locations reported no exceedances.

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[93] Los Angeles Regional Water Quality Control Board. *Attachment B - Amendment to the Water Quality Control Plan for the Los Angeles Region to Revise the Los Angeles River and Tributaries Metals TMDL*. April 9, 2015. Table 7-13.1. (Source Analysis). Available here.

[94] Los Angeles County Flood Control District. *Annual Stormwater Report 2013 – 2014*, Attachment L – Stormwater Monitoring Report, Table 4-4. Required by NPDES permit, Order No. R4-2012-0175. Available here.

Example of exceedances of standards
Los Angeles Flood Control District - Zinc in-stream monitoring data
Water quality objectives (WQO) compared with median results and concentration ranges

Location	Vacant %	WQO	Median (range)	#Samples	#Exceed
Ballona Creek at Sawtelle Blvd. S01	11.1	59.6-241.7	345 (284-535)	4	**4**
Malibu Creek at Piuma Rd. SO2	79.3	379.3-379.3	56.55 (50-63.1)	4	0
Los Angeles at Wardlow Rd. S10	40.4	65.1-183.7	384.5 (117-988)	4	**4**
Coyote Creek at Spring St. S13	14.3	59.6-228.6	330 (145-765)	4	**4**
San Gabriel River at SGR Parkway S14	66.7	127-231.2	54.1 (48.9-62.6)	3	0
Dominguez Channel at Artesia Blvd. S28	0.0	65.1-201.9	357 (218-600)	4	**4**
Santa Clara River S29	87	346.9-379.3	24.9 (19.5-121)	3	0
Totals				**26**	**16**

All data ug/L dissolved; Zn was detected in all samples; data excerpt from Annual Report Table 4-4 and Figures 2-2 through 2-8.[95]

The monitoring locations at Malibu Creek, San Gabriel River, and Santa Clara River sites did not have exceedances because of relatively low zinc concentrations. These data are best explained by the fact that the in-stream concentrations vary with the level of urban development in the watershed areas contributing to the stream. Higher level of development correlates with the higher zinc levels in the in-stream monitoring. All the areas with no exceedances had more than 65% vacant land. In addition, elevated hardness at these sites increased the applicable water quality objectives.

The water quality objectives are based on U.S. EPA recommended criteria to protect aquatic species. The 61% exceedance rate and high values in the range indicate the difficulty of achieving attainment in the absence of a strong source control program.

- **Ballona Creek TMDL – *Exceedances of allocations for the receiving water and for sediment***

  Total maximum daily loads establish the safe loading of a pollutant to specific waterways. Wasteload allocations are assigned to specific pollutants in order to protect aquatic species (and sometimes public health). TMDLs have been established for zinc in California and more will likely be established in the future as more waterways are listed as impaired.

  The Ballona Creek TMDL establishes zinc wasteload allocations assigned to the dischargers. The following tables include data from a Regional Water Board report and demonstrate the significant challenge for dischargers attempting to attain these site-specific targets developed to protect aquatic species.[96]

[95] Los Angeles County Flood Control District. *Annual Stormwater Report 2013 – 2014*, Attachment L – Stormwater Monitoring Report, Table 4-4; Figures 2-2 through 2-8. Required by NPDES permit, Order No. R4-2012-0175. Available here.

[96] Los Angeles Regional Water Board. *Reconsideration of Certain Technical Matters of the Ballona Creek Estuary Toxics TMDL and Ballona Creek Metals TMDL, Staff Report*. 2013. Available here.

Ballona Creek receiving water data for zinc: 2009 to 2012 (wet weather)

	Total Recoverable	Dissolved
TMDL numeric target	119 µg/L	94 µg/L
Monitoring sample count	62	62
Number of exceedances of the target	55	8
Frequency of exceedance of the target	**89%**	**13%**

The report noted:

> *Both copper and zinc frequently exceeded the current TMDL wet-weather numeric targets at all the monitoring stations. For copper, exceedances in the total fraction were observed almost twice as often as in the dissolved fraction. For zinc, exceedances in the total fraction were observed almost seven times more often than in the dissolved fraction.*

The Ballona Creek TMDL also has a sediment target for zinc:

Sediment grab sample data for zinc: 2007 to 2011

	Total Recoverable
TMDL numeric target	150 (mg/kg)
Monitoring sample count	36
Number of exceedances of the target	6
Frequency of Exceedance of the target	**16.7%**

Both tables above are excerpted from the Regional Water Board report referenced above. The receiving water data did not show any exceedances of the TMDL target during dry weather.

The Ballona Creek watershed monitoring program also includes saltwater results from the Ballona Creek Estuary.[97] The exceedances of the Ocean Plan Saltwater Acute Criteria for zinc are presented in a previous section: (*a) Adverse Impacts - 69503.3(a)2.D. Environments in California that have been designated as impaired by a California*.

- **Los Cerritos Channel TMDL**

  Another example is the Los Cerritos Channel TMDL prepared by U.S. EPA.[98] Data collected prior to TMDL development showed exceedances of the acute and chronic criteria promulgated by U.S. EPA in the CTR. During wet weather, 68% of dissolved zinc samples taken from the Channel exceeded the standards. The following table is excerpted from Los Cerritos Channel TMDL, Table 2-5.

[97] Ballona Creek Watershed Management Group. *Coordinated Integrated Monitoring Program (CIMP) for the Ballona Creek Watershed. September 7, 2015.* Available here.
[98] U.S. EPA. *Los Cerritos Channel Total Maximum Daily Loads for Metals*. 2010. See Tables 4-3, 2-5, and 3-3. Available here.

Los Cerritos Channel - Summary of 2001-early 2009 wet-weather zinc data

No. of Samples	Number exceeding CTR acute criteria	Number exceeding CTR chronic criteria
31	21	21

Data are based on dissolved metals concentrations

To address these persistent exceedances, the TMDL developed the following targets for zinc using site-specific conversion factors for translating the dissolved criteria to total recoverable.

Los Cerritos Channel – Wet weather numeric targets for zinc

Target* (μg/L) Dissolved	Target (μg/L) Total Recoverable
38.6	95.6

* Targets are based on a median hardness of 27 mg/L

The total recoverable metal concentration is multiplied by the daily storm volume to determine the wet-weather load capacity for zinc expressed in terms of total recoverable metal. The required reductions in zinc loading are significant (from Table 6-3):

Average annual loads for zinc and percent reduction required

Allowable load (kg)	Existing load (kg)	% reduction required
669	2,127	**69.2%**

The necessary reductions in zinc loadings are converted into allocations which apply to the municipal and other stormwater dischargers based on an estimate of the percentage of land area covered under each permit. The dischargers are: City of Long Beach MS4, Los Angeles County MS4, Caltrans, and the stormwater categories of general industrial and general construction. The City of Long Beach MS4 and Los Angeles County MS4 constitute 86% of the land area addressed by the TMDL.

- **Orange County Stormwater Program - Santa Ana Region**

  In some waterways, exceedances by zinc have been limited. For example, Orange County's Long-Term Mass Emission Monitoring in the Santa Ana Region reported that only one of the 52 (2%) stormwater-influenced samples exceeded both the acute and chronic freshwater CTR hardness-adjusted criteria for dissolved zinc.[99] This was in the Costa Mesa Channel.

[99] Orange County Stormwater Program. *2015-16 Unified Annual Progress Report – Attachment C-11*. November 15, 2016. Available here.

b) Source: Urban runoff into coastal ocean – impacts on toxicity

Several studies in coastal California have tracked stormwater plumes carried by streams or rivers into coastal waters:

- **Chollas Creek and San Diego Bay**

  This study assessed the area impacted and toxicity of the wet-weather discharge from Chollas Creek into San Diego Bay.[100] The study determined that the impact zone was at times as large as 2.25 km^2 and about half the plume was toxic to marine life based on sea urchin fertilization tests. The study used toxicity identification evaluations and determined that trace metals, most likely zinc, caused the toxicity. Zinc was also identified using a TIE within Chollas Creek.

- **Ballona Creek and Santa Monica Bay**

  This study assessed the impact of stormwater carried by Ballona Creek into Santa Monica Bay.[101] Zinc was a critical pollutant:

  > Zinc was the most important toxic constituent identified in stormwater. Copper and other unidentified constituents may also be responsible for some of the toxicity measured.

  The sampling indicated that the toxic zone of the stormwater plume varied from 1/4 to 2 miles into the ocean offshore of Ballona Creek. Toxicity tests of the plume indicated that even with the expected dilution in the ocean, toxicity was still present:

  > Toxicity was frequently detected in surface water within the stormwater plume offshore of Ballona Creek, indicating that the initial dilution of stormwater discharge from this watershed was not sufficient to reduce the concentrations of stormwater toxicants below levels that are harmful to marine organisms.

  This study included sampling of urban stormwater to compare with pollutant concentrations in the plume and in other (background) offshore samples:

  > Undiluted samples of urban stormwater collected from drainage channels (before discharge into the ocean) usually contained toxic concentrations of constituents. Toxicity was detected in virtually every sample obtained from Ballona Creek and this toxicity was often present even after the sample was diluted 10-fold in the laboratory.

  The study also showed that the time of year that the sampling was conducted was important. Because of the antecedent dry period, the first storms would be expected to carry the heaviest pollutant load:

  > Samples of Ballona Creek stormwater, obtained from the first storm of the season, were between two and ten times more toxic than samples from later storms. These data indicated that the first storms of the year provide the most concentrated inputs of toxicants to the environment.

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[100] Schiff, et al. (Southern California Coastal Water Research Project). *Stormwater Toxicity in Chollas Creek and San Diego Bay*. 2001. Available here.

[101] Bay, S., et al. (Southern California Coastal Water Research Project). *Study of the Impact of Stormwater Discharge on Santa Monica Bay – Executive Summary*. 1999. Available here.

The study concluded that "zinc is responsible for a portion of the stormwater toxicity. The influence of pesticides and other organics is uncertain."

c) Source: Highway runoff including edge-of-pavement monitoring results

Urban areas contain sources in addition to tires. These include zinc used in galvanized metal surfaces such as rain gutters and zinc used in paint. Even highways, which tend to be geographically separated from surrounding land uses, can include significant sources of zinc besides tires, such as galvanized highway guard rails as well as minor sources, such as motor oil (see Attachment D). However, that separation means that if other sources can be avoided, removed, or otherwise controlled for, highways can present opportunities to monitor runoff in ways that isolate the contribution of zinc from tires.

C**altrans (highways)**

Caltrans completed a comprehensive statewide monitoring of runoff from highways. The results were compiled in the *Discharge Characterization Study Report*,[102] which estimated that total zinc from highway and related facilities exceeds standards over 80% of the time; dissolved zinc exceeded standards over 50% based on a default assumption of hardness.[103]

Caltrans edge-of-pavement monitoring

For identifying tire-contributed zinc loadings, the highway edge-of-pavement data collected by Caltrans is useful because it does not include galvanized structure surfaces or guardrails as possible sources.[104] The data collection was specifically designed to avoid non-road surface sources. This data can be used to isolate the contribution of highway surfaces.

Mean values are presented to provide summary information on the concentration of zinc. They are also indicative of the potential for exceedances. Note that NPDES permits require attainment at all times - not attainment of the mean.[105] Also shown in the table below are data on the mean concentrations of zinc found statewide in highway runoff (i.e., from all sources).[106] A comparison of the edge-of-pavement data with the statewide highways data shows the levels of zinc from the edge-of-pavement are high enough to account for the levels of zinc found statewide in highway runoff.[107] Other possible sources for highway zinc such as galvanized fencing or traffic barriers do not appear to have a significant impact since edge-of-pavement zinc concentrations are similar to statewide highway runoff concentrations. Furthermore, the edge-of-pavement concentrations appear to be almost exclusively from tires. Other possible sources for zinc in edge-of-pavement runoff include zinc in natural soils (dust) and motor oil but these contributions appear to be minor (see Attachment D).

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[102] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-18. Available here.
[103] For the California Toxics Rule metals criteria, including zinc, the objectives are adjusted for hardness based on the lowest observed hardness for the data set for the most stringent assessment of percent exceedance. Consequently, exceedances may be less frequent for waterways with higher hardness values.
[104] Caltrans, *Roadside Vegetated Treatment Sites (RVTS) Study Final Report*, CTSW-RT-03-028, 2003; available here.
[105] The acute criterion which is most appropriate for stormwater is a one-hour average, but normally only a single sample is taken.
[106] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-2 for highway runoff zinc. Available here. Other possible sources for zinc in edge-of-pavement runoff include zinc in natural soils (dust) and motor oil but these contributions appear to be minor as discussed later in the report.
[107] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-2. Available here.

Caltrans Highway Edge of Pavement Samples Monitored for Zinc (all µg/L)[108]

Monitoring location	Dissolved	Total
Sacramento	14.8	74.3
Cottonwood	41.4	130.9
Redding	15.8	39.0
San Rafael	43.5	119.7
Irvine	79.8	290.3
Moreno Valley	261.4	351.2
San Onofre	77.9	279.5
Yorba Linda	137.6	329.8
Mean (edge-of-pavement)	**84.0**	**201.8**
Mean (statewide highways)	**68.8**	**187.1**

As described in the CASQA report, galvanized surfaces are a significant contributor in the urban environment along with tire wear.[109] The highway data above suggests that tire wear potentially represents a significant component of zinc in urban runoff because the highway zinc concentration data is in the same general range as urban runoff.

d) Highway runoff from surfaces using rubberized asphalt

As described in an earlier section, (b) *Environmental fate of recycled rubber*, use of some forms of rubberized asphalt can significantly increase the concentration of zinc in runoff from highways.

e) Recycled rubber used for waste treatment and other civil engineering purposes

A report produced by Humboldt State University personnel for CalRecycle examined possible risks of tire-derived aggregate used in various civil engineering applications.[110] In some tests, leaching of zinc produced concentrations as high as 250 µg/L, although the concentrations were generally lower. The concentration of 250 µg/L could be a significant problem for a discharge to surface waters especially in locations with low hardness.

[108] Zinc concentrations in runoff can vary significantly due to location and the time of sampling. Some locations have a higher or lower volume of runoff compared with traffic count (traffic volume). Areas with lower traffic counts will result in the generation of less tire debris and less zinc. The length of the antecedent dry period before sampling is also a major factor. For this edge-of-pavement study, all sampled storm events were preceded by at least 24 hours without rainfall. The desired minimum antecedent dry period was 72 hours. Longer antecedent dry periods before sampling could result in significant buildup of tire residue and associated zinc.
[109] California Stormwater Quality Association. *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here. (Attachment F to this document)
[110] Finney, B. et al. *Properties of Tire-Derived Aggregate For Civil Engineering Applications*. Contract report for CalRecycle. 2013. *Also see* page 58, Figure 31. Zinc concentrations in the rock and TDA leach fields. Available here.

Maximum zinc concentrations in tested leach fields
(µg/L; excerpt from Table 9)

Parameter	Max. Rock Effluent Value	Max. TDA Effluent Value
Zinc	46	250

Iron was also significantly elevated in the TDA leach field.

See the extended discussion of civil engineering use of recycled tires in the section: *(a) Adverse Impacts - §69503.3(a) - 1)….E. Environmental fate*. Other research appeared to indicate that civil engineering uses, excepting rubberized asphalt, are not likely to be a problem.

f) Other uses of recycled rubber including use on playgrounds

This topic has been discussed previously. Use of recycled rubber on playgrounds does potentially result in some exposure to children but this exposure has been assessed as not significant. See the California Integrated Waste Management Report: *Effects of Waste Tires, Waste Tire Facilities, and Waste Tire Projects* (1996)[111]

(b) Exposures - §69503.3(b)

……….

(4) Potential exposure to the candidate chemical in the product during the product's life cycle, considering:

A. Manufacturing, use, storage, transportation, waste, and end-of-life management practices and the locations of these practices

……………

E. Frequency, extent, level and duration of potential exposure for each use scenario and end-of-life scenario

……………

F. Containment of the candidate chemical within the product, including potential accessibility to the candidate chemical during the useful life of the product and the potential for releases of the candidate chemical during the useful life and at the end-of-life

G. Engineering and administrative controls that reduce exposure concerns associated with the product

H. The potential for the candidate chemical or its/their degradation products to be released into, migrate from, or distribute across environmental media, and the potential for the candidate chemical or its'/their degradation products to accumulate and persist in biological and/or environmental compartments or systems

[111] CIWMB. *Effects of Waste Tires, Waste Tire Facilities, and Waste Tire Projects*. 1996. Available here

A. Manufacturing, use, storage, transportation, waste, and end-of-life management practices and the locations of these practices

Manufacturing – Tire manufacturing takes place throughout the U.S. and in many foreign countries. Exposure of zinc to aquatic organisms is unlikely in the U.S. because of state and federal waste and wastewater laws and regulations. For example, wastewater discharges require NPDES permits and these include numeric WQBELs to ensure that standards are not exceeded.

Use – As discussed in prior sections, on-road use of tires containing zinc results in tire tread wear containing zinc being carried by roadway runoff into waterways.

Transportation (of used or unused tires) – Not a likely source of exposure to aquatic organisms.

Waste – Disposal of tires in landfills in compliance with the combined State Water Board/CIWMB requirements in the California Code of Regulations, Title 27, Division 2, is unlikely to impact water quality. Some leaching has been identified if the tires are below the water table, however, that should not occur in California due to regulations pertaining to landfills.

Other end-of-life management practices – As discussed previously, use of recycled tire rubber in asphalt used in roadways could potentially result in zinc from the rubberized asphalt being carried by stormwater runoff into waterways leading to exposure to aquatic organisms. Potential exposure from playground runoff appears limited.

E. Frequency, extent, level and duration of potential exposure for each use scenario and end-of-life scenario

Use –The use scenario of concern is the roadway use of tires containing zinc and the loss of tire tread on the road surface. Exceedances of criteria for the protection of aquatic life from zinc exposure occur most often during wet weather when runoff carries zinc from roadways and other surfaces into waterways. Zinc exposure is almost always a wet weather phenomenon and, as shown in the data presented earlier, concentrations in the runoff and in the waterways frequently exceed the criteria. Exposures are likely to be higher after prolonged antecedent dry periods because more zinc accumulates on the road surface and on surrounding surfaces such as sidewalks and roofs.

Benthic organisms may also be exposed to zinc that has settled out in the waterway. This exposure would be ongoing. Settled zinc may contribute to zinc in the water column if the sediment becomes anoxic leading to the secondary release of metals.

End-of-life use – End-of-life use of recycled tire material (crumb rubber) in roadway construction may also contribute to elevated levels in runoff, as discussed previously. In addition, use of tire shreds in playground material may also be a source in runoff although this is likely to be minor.

F. Containment of the candidate chemical within the product, including potential accessibility to the candidate chemical during the useful life of the product and the potential for releases of the candidate chemical during the useful life and at the end-of-life

Aquatic organism exposure to zinc likely occurs during the life of the product (tires) as tire tread material is lost to road surfaces by abrasion. Tire tread material is likely also dispersed by wind to nearby areas where it can be carried into waterways by runoff. Tire sidewalls are not currently a major source because most tire wear occurs on the tread in contact with the road. Zinc in tire sidewalls may become significant as tires are reused and tire rubber is incorporated into paving materials. (See discussion in (a) Adverse Impacts - §69503.3(a) 1) Evaluate the potential for the candidate chemical … B. Aggregate effects.)

On roadway surfaces, the abraded tire tread material appears to collect other materials to form a particulate mixture. The original tire tread may have a zinc concentration twice that found in roadway particles.[112] These larger mixed particles may reduce the likelihood of zinc being removed from the road surface by traffic-induced turbulence.

G. Engineering and administrative controls that reduce exposure concerns associated with the product

Best management practices (BMPs) can potentially be implemented by municipalities, Caltrans, and other stormwater dischargers to reduce the release of pollutants to waterways. These BMPs may be source controls such as administrative or operational (street-sweeping) practices, or treatment controls (capture and infiltration or treatment).

Administrative controls sometimes used by municipalities include product bans such as the San Francisco Bay areawide ban on copper compounds used in sewers.

Local administrative controls do not appear viable. Regulatory action to address zinc may be possible under the federal Toxic Substances Control Act (TSCA) which was recently revised by the Frank R. Lautenberg Chemical Safety for the 21st Century Act. An unsuccessful attempt was made by environmental NGOs to address lead from tire weights using TSCA.

Street sweeping removes some of the zinc originating from tire wear as well as other potential pollutants, but most municipalities already have comprehensive street sweeping programs in place. Highways are also swept although safety, traffic disruption, limited operating hours, and related problems can be significant in the highway environment. Sweeping may not address zinc that has been carried by traffic-general wind to surrounding areas and surfaces.

Treatment BMPs such as physical-chemical treatment and filtration are very expensive from the standpoint of capital and operations/maintenance. Filtration or chemical treatment has very infrequently been implemented for stormwater in California. In addition, filtration would not address dissolved zinc which is normally present in runoff at about 30% to 50% of the total zinc. See Ballona Creek example:

Ballona Creek wet weather metals dissolved to total ratio[113]

Percentile	Zinc
25 Percentile	0.166
Average	0.447
Median	0.286
75 Percentile	0.765

[112] Kreider, M.L., et al. *Physical and chemical characterization of tire-related particles: Comparison of particles generated using different methodologies*. 2009. Abstract available here.

[113] California Regional Water Quality Control Board, Los Angeles Region. *Reconsideration of Certain Technical Matters of the Ballona Creek Estuary Toxics TMDL and Ballona Creek Metals TMDL*. 2013. See Table 3-7. Available here.

An additional problem is that treatment BMPs require capture of the runoff. Stormwater runoff typically enters waterways through multiple discharge points and large capacity interceptors would need to be constructed along waterways to catch and divert the stormwater flows. Storage capacity would also be needed because treatment facilities could not be sized to immediately treat the very large volumes produced during storms. Particularly in urban environments, capturing storm flows is very expensive as well as disruptive.[114] A recent bacteria water quality study in Southern California concluded that, "*Southern California simply does not possess the infrastructure to store and treat large volumes of stormwater runoff prior to its discharge at the beach*." [115]

Infiltration is effective at preventing the discharge of zinc; however, similar to other treatment options, infiltration requires capturing the stormwater and directing it to a location where infiltration is feasible. In addition, pretreatment may be required to protect groundwater quality and a storage capability is also usually necessary since all stormwater runoff cannot be immediately infiltrated. Infiltration is increasingly being investigated as a possible method of increasing water supplies, however, in most cases only a portion of the total stormwater flow can be ultimately infiltrated.[116]

H. The potential for the candidate chemical or its/their degradation products to be released into, migrate from, or distribute across environmental media, and the potential for the candidate chemical or its'/their degradation products to accumulate and persist in biological and/or environmental compartments or systems

Potential for the candidate chemical to be released into environmental media

The potential is very high for zinc to be released from tires and carried into waterways where it is exposed to aquatic organisms. This conclusion is based on data collected by municipal storm sewer system and other permittees and discussed elsewhere in this petition.

Potential for the candidate chemical to accumulate and persist in biological and/or environmental compartments or systems

Zinc released to waterways by stormwater does not degrade. The zinc is carried in the water to the final location (ocean, terminal lake) or deposited in the sediment. A study in the Lake Anne urban - suburban watershed (Fairfax County, Virginia), which drains to the Potomac River determined that the atmospheric flux of zinc to the watershed from tire wear was estimated at 42 $\mu g/cm^2/yr$.[117] The measured accumulation rate of total zinc in age-dated sediment cores from Lake Anne was 27 µg/cm2/yr. This data suggested that the watershed retains a significant portion of the vehicular

[114] The City and County of San Francisco have constructed shoreline interceptors (called storage/transports) to capture the combined sewage and stormwater flows during wet weather. Nevertheless, full capture is not possible with this system.
[115] Southern California Coastal Water Research Project, UC Berkeley, Soller Environmental and Surfrider Foundation. *The Surfer Health Study*. September 2016. Available here.
[116] As discussed elsewhere in this document, some California communities such as Fresno have been able to capture and infiltrate a significant portion of the stormwater flows. The Fresno area has more land available than most of the coastal cities and also substantial depth to groundwater. Lack of depth to groundwater is a significant impediment in many locations.
[117] Councell, TB, et al. U.S. Geological Survey. *Tire-Wear Particles as a Source of Zinc to the Environment*. Environ. Sci. Technol. 2004, 38, 4206-4214. 2004. Available here.

inputs. Alternatively, some of the zinc may have been carried further downstream.[118] Also see earlier State Water Board SPoT data on sediment accumulation in California waterways (p. 19).

Adverse Waste and End-of-Life Effects - §69503.2(b)(1)(B)

Product uses, or discharges or disposals, in any manner that have the potential to contribute to or cause adverse waste and end-of-life effects associated with the candidate chemical in the product

These waste and end-of-life effects have been addressed in the preceding sections.

One potential end-of-life adverse effect that has not been described above is the impact in foreign countries where waste tires from California may be shipped to be used as fuel. See article: California's Old Tires Cross the Ocean and Come Back as Smog ... (2016). The recipient countries may not have air quality regulations as strict as those in California.

Availability of Information - §69503.2(b)(1)(C)

Consider the extent and quality of information that is available to substantiate the existence or absence of potential adverse impacts, potential exposures, and potential adverse waste and end-of-life effects.

1. The level of rigor attendant to the generation of the information, including, when relevant, the use of quality controls
2. The degree to which the information has been independently reviewed by qualified disinterested parties
3. The degree to which the information has been independently confirmed, corroborated, or replicated
4. The credentials and education and experience qualifications of the person(s) who prepared and/or reviewed the information
5. The degree to which the information is relevant for the purpose for which it is being considered

Two categories of information form the basis for this petition:

- Water quality criteria (objectives) for the protection of aquatic species developed by U.S. EPA (inland waters and bays and estuaries) or the State Water Board (Ocean waters).
- Monitoring data collected by permittees and in some cases, state agencies, which is compared with the criteria.

The technical information in both of these categories is developed from mature and long-standing programs with significant regulatory direction or oversight. Consequently, the key information produced, such as water quality standards and monitoring data, would appear to be acceptable for determining the existence or absence of potential adverse impacts. In addition, substantial monitoring data is available.

[118] Also of interest from this study: The atmospheric flux of total Zn (wet deposition) to the watershed was 2 μg/cm^2/yr. compared with the flux of Zn to the watershed estimated from tire wear of 42 μg/cm^2/yr.

The material below summarizes how this information is developed.

Federal and State Criteria

An earlier section— *Adverse Impacts and Exposure Factors - §69503.3(a)… Hazard trait(s)*—described the derivation of the zinc water quality standards by the U.S. EPA and the State Water Board. In general, U.S. EPA criteria are derived using U.S. EPA's 1985 *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. The derivation of numerical national water quality criteria is a complex process that uses information from many areas of aquatic toxicology.

> *If a thorough review of the pertinent information indicates that enough acceptable data are available, numerical national water quality criteria are derived for fresh water or salt water or both to protect aquatic organisms and their uses from unacceptable effects due to exposures to high concentrations for short periods of time, lower concentrations for longer periods of time, and combinations of the two.*

The Guidelines include specific procedural steps in developing criteria. A final review involves rechecking each step of the Guidelines. The Guidelines specify that items that should be especially checked include:

- If unpublished data are used, are they well documented
- Are all required data available,
- Are any of the other data important?
- Do any data look like they might be outliers?
- Are there any deviations from the Guidelines? Are they acceptable?

More information on criteria development is available in the Guidelines.

The regulatory promulgation of the criteria is also a multi-step process. The draft criteria are released for public comment. Comments from the general public and an external expert peer review panel are then reviewed by U.S. EPA and changes made to the draft criteria as appropriate. In addition, USFWS completes a consultation pursuant to Section 7 of the Endangered Species Act which is often the most restrictive step of the promulgation process.

The State Water Board has a similar multi-step approach for promulgating water quality objectives (criteria). At the State level, objectives are developed in accordance with the provisions of both the Clean Water Act and the State Water Code (section 13240, et seq.). As previously noted, the Department of Fish & Game (now Fish & Wildlife) was involved in developing the Ocean Plan zinc objectives.

Monitoring data collected by permittees and state agencies

Permittee data for NPDES compliance is collected by permittee staff or consultants working for the permittees. Statewide monitoring data is also collected by the State Water Board's Surface Water Ambient Monitoring Program as described in earlier sections. Some of the key data in this petition was developed by Caltrans. Caltrans has partnered with California State University Sacramento and University of California Davis for much of the stormwater work including monitoring. The data collection procedures for highway runoff, including sample collection, data management, and validation are described in the Caltrans statewide characterization report as well as other Caltrans stormwater documents submitted to the State Water Board.[119]

For NPDES permittees, sampling, analysis procedures, preservation technique, sample holding time, and sample container requirements are specified at 40 CFR Part 136 as authorized by section 304(h) of the Clean Water Act. Exceptions are possible if specifically authorized in the permit.

The NPDES stormwater permits contain additional specifications. For example, the statewide Small MS4 Permit includes requirements for the Quality Assurance Project Plan (QAPP):[120]

> Where applicable, the Permittee shall prepare, maintain, and implement a Quality Assurance Project Plan (QAPP) in accordance with the Surface Water Ambient Monitoring Program. All monitoring samples shall be collected and analyzed according to the Program QAPP developed for the purpose of compliance with this Order. SWAMP Quality Assurance Program Plan (2008) is available at:
>
> http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/qapp/qaprp082209.pdf

NPDES data entry functions are the responsibility of the Discharge Monitoring Report Processing Center (DMRPC) of the State Water Board. The State Water Board also has a laboratory accreditation program (ELAP) deemed equivalent to U.S. EPA's national DMR-QA program.[121]

Serious penalties can result from the submittal of false information:

> 40 CFR 122.60(d)(2): …the Clean Water Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than six months per violation, or by both.

Other Regulatory Programs - §69503.2(b)(2)

> Consider the scope of other California State and federal laws applicable treaties or international agreements with the force of domestic law under which the product or the candidate chemical in the product is/are regulated and the extent to which these other regulatory requirements address, and provide adequate protections with respect to the same potential adverse impacts and potential exposure pathways, and adverse waste and end-of-life effects, that are under consideration as a basis for the product-chemical combination being listed as a Priority Product. If the product is regulated by another entity with respect to the same potential adverse impacts and potential exposure pathways, and potential adverse waste and end-of-life effects,… may list as priority only if it determines that the listing would meaningfully enhance protection of public health and/or the environment with respect to the potential adverse impacts, exposure pathways, and/or adverse waste and end-of-life effects.

[119] Caltrans. *Discharge Characterization Study Report*. 2003. See Section 2. Available here.
[120] State Water Board. *Phase II Small MS4 Permit*. 2013. Available here. See provision E.13.d.1. Receiving Water Monitoring, section (iii) Reporting.
[121] More information on the State Water Board Quality Assurance/Quality Control program – available here

Zinc from tires and other sources is regulated by the NPDES municipal and industrial stormwater permits that are issued by the Regional Water Boards and the State Water Board. These permits specify that pollutants in discharges must not cause or contribute to an exceedance of water quality standards. However, as discussed in this petition, these requirements are not adequate to ensure that exceedances do not occur.

Controls potentially implemented through the municipal permit program

The municipal permits apply to the Phase I and Phase II communities and related facilities such as transportation centers. These permits require permittees to develop and implement a Stormwater Management Plan/Program with the goal of reducing the discharge of pollutants to the maximum extent practicable. In addition, these permits typically contain either a prohibition or a receiving water limitation specifying that the discharges not result in the exceedance of water quality standards.

Example:[122]

> *Discharges shall not cause or contribute to an exceedance of water quality standards contained in a Statewide Water Quality Control Plan, the California Toxics Rule (CTR), or in the applicable Regional Water Board Basin Plan.*

In addition, permittees developing watershed management programs (WMP) are required to submit a Reasonable Assurance Analysis or similar assurance to demonstrate that applicable water quality based effluent limitations and receiving water limitations will be achieved.[123]

As discussed previously, zinc is often one of the pollutants identified in MS4 permittee monitoring that exceeds standards, at least at the point of discharge. The permittees have several options for controlling zinc:

- Source control
- Capture and treatment
- Diversion
- Variance – potentially an interim solution

These regulatory control options are summarized below:

- ***Source control***

  While the Water Boards require attainment of standards; the administrative actions or controls must generally be completed by the permittees. Permittees may be able to implement education programs and possibly ordinances to control zinc released from galvanized surfaces. However, the permittees do not have the authority to prevent tires from releasing zinc that subsequently enters waterways at levels that exceed standards. This inability to control pollutant sources over which permittees have no or limited jurisdiction is sometimes acknowledged in the permits. *Example from the Central Valley Board*:[124]

[122] This example is from Water Quality Order No. 2013-0001-DWQ which contains waste discharge requirements applicable to stormwater discharges from Small Municipal Separate Storm Sewer Systems (Phase II Small MS4 General Permit). Available here.
[123] The Los Angeles Regional Board Reasonable Assurance Analysis (RAA) Guidelines are available here.
[124] Central Valley Region Water Board. *General Permit for Discharges from Municipal Separate Storm Sewer Systems*, Order R5-2016-0040. 2016. Available here.

> *Certain pollutants present in storm water and/or urban runoff may be derived from extraneous sources over which Permittees have no or limited jurisdiction/control. Examples of such pollutants and their respective sources are: PAHs which are products of internal combustion engine operation, nitrates, bis(2-ethylhexyl) phthalate and mercury from atmospheric deposition, lead from fuels, copper from brake pad wear, zinc from tire wear,…* [emphasis added]

The permittees do not have the authority to order the reduction of zinc in tires and consequently, source control for zinc released from tires must be implemented at the state or national level.

State Water Board staff is developing a staff report presenting options to address zinc exceedances in urban receiving waters. The final report is expected to be completed in mid-2018. This project is part of the Strategy to Optimize Resource Management of Stormwater (STORMS).[125] The STORMS program mission is to lead the evolution of stormwater management in California. STORMS includes nine Phase I projects including project 6b: *Identify Opportunities for Source Control and Pollution Prevention*. The 6b Pilot Projects include:

- Department of Toxic Substances Control – Zinc in tires petition
- Caltrans - "Protect Every Drop" educational campaign
- Statewide Trash Amendments

- ***Capture and treatment***

Capture of stormwater for subsequent treatment is discussed above: *G. Engineering and administrative controls that reduce exposure concerns associated with the product.* Capture and treatment is not a feasible method of control. The high costs of stormwater capture, storage, transport, and treatment make treatment-based controls generally infeasible. In some cases, diversion and infiltration may provide adequate stormwater control for a portion of the flow, as discussed below.

- ***Diversion and infiltration – large and small scale***

Increasingly, communities are implementing low impact development or green technology projects that capture some of the runoff and redirect it to infiltration or other uses. In some cases, this stormwater must be treated before infiltration. The potential for these relatively small-scale projects is limited, especially in the coastal urban areas where infiltration may not be feasible due to soil conditions or inadequate depth to groundwater. The remaining stormwater flows still need to be addressed after LID, pervious pavers, and other methods have been implemented. Large-scale diversion is particularly difficult in the built-out coastal urban areas due to limited locations for pipelines, storage facilities, and infiltration basins, including pre-treatment facilities, when necessary.

Some inland California communities are able to capture much of their stormwater and direct it to infiltration. As discussed earlier, the Fresno-Clovis metropolitan area infiltrates 70 – 80% of the average annual stormwater runoff.[126] As a result, an estimated 70% of the total zinc is prevented from reaching receiving waters. Consequently, zinc and other pollutants discharged from roadways to waterways have been significantly reduced. Nevertheless, the Fresno area stormwater permittees continue to focus their pollutant control programs on their identified pollutants of

[125] State Water Board. *Strategy to Optimize Resource Management of Stormwater (STORMS)*. Available here.
[126] Fresno-Clovis Storm Water Quality Management Program (SWQMP); November 27, 2013; description available here.

concern (POC): copper, lead, zinc, and PAHs which are discharged with the flows that cannot be diverted.

- ***Variances***

  The required zinc reductions do not appear feasible in the near-term given the lengthy timeline for reducing zinc from tires and controlling other sources in the watershed. Variances may allow permittees to remain in compliance as source control is being implemented. Variances are typically temporary and are reviewed every few years, usually as part of the Triennial Review process required under the Clean Water Act. Apparently, a variance applicable to MS4s may not be possible under U.S. EPA regulations at 40 CFR 131.14. However, a variance ("exception") may be possible based on the State Water Code.

Controls potentially implemented for the Industrial General Permit or Construction General Permit

In some TMDLs, wasteload allocations have been assigned to construction projects and industrial sites. *Example*: Waste Load Allocations Proposed Translation for Toxic Pollutants in Ballona Creek Estuary

> *Metals per Acre Waste Load Allocations for Individual General Construction or Industrial Storm Water Permittees (grams/year/acre) – Zinc: 13 (grams/year/acre)*[127]

The two non-MS4 statewide permits also have specific or general requirements that apply to zinc in stormwater:

> **Statewide Industrial General Permit -** The IGP regulates zinc in industrial stormwater discharges through a numeric action level (NAL). In addition, TMDL wasteload allocations for zinc and other pollutants are in the process of being added to the IGP. Proposed changes will add TMDL NALS (TNALs) and also numeric effluent limits in some cases.
>
> The current statewide annual NAL for zinc is 260 µg/L. This NAL is the highest value used by U.S. EPA based on their hardness table in the 2008 Multi-Sector General Permit (MSGP).
>
> **Construction General Permit (CGP)**
>
> The CGP does not have a specific zinc limitation but does include the following Receiving Water Limitation:
>
> *Construction-related activities that cause or contribute to an exceedance of water quality standards must be addressed.*
>
> *…..*
>
> *This General Permit requires that storm water discharges and authorized non-storm water discharges must not contain pollutants that cause or contribute to an exceedance of any applicable water quality objective or water quality standards.*

Construction site runoff is controlled using mandated best management practices focused on sediment control. Except possibly in urban areas, this runoff would appear unlikely to exceed water quality standards because the zinc concentration in natural soils in California is relatively low (geomean: 145 mg/kg).

[127] See Industrial General Permit - Order 2014-0057-DWQ, page 23, Available here.

Controls imposed by U.S. EPA

As discussed previously, U.S. EPA could potentially address zinc from tires under the provisions of the Frank R. Lautenberg Chemical Safety for the 21st Century Act, which updated the Toxic Substances Control Act (TSCA). A petition would need to be submitted to U.S. EPA.

Safer Alternatives - §69503.2(b)(3)

> Potentially also consider whether there is a readily available safer alternative that is functionally acceptable, technically feasible, and economically feasible.

Safer alternatives are tires containing less zinc or no zinc. Materials used to replace zinc would also need to not present a risk to water quality or public health. Several articles and patents listed below indicate that the industry has previously investigated these options.

During discussions regarding this petition, tire industry representatives stated that zinc is essential in tires and alternatives are not viable. In a March 16, 2016, letter to Sen. Ben Allen, D-Santa Monica, concerning SB 1260, the Rubber Manufacturers Association stated that zinc oxide is essential in the manufacturing of tires and "fundamental breakthroughs in basic rubber chemistry" would be needed to reduce the zinc.[128]

The following articles and patents describe efforts to identify tire construction methods with reduced or no zinc. Also included are several brochures for companies advertising reduced zinc tires.

Articles and papers

- *Article:* Rubber & Plastics News (10/3/2005, updated 11/15/2012). Describes the goals of Michelin to reduce zinc:[129]

  > Michelin also said it is studying ways to reduce its use of zinc oxide as a vulcanization accelerator, because zinc salts—which are soluble in water—are considered a toxic substance. Zinc oxide represents about 1 percent of a typical passenger tire tread compound, and the zinc is deposited into the environment as tires wear down.
  >
  > Michelin estimates the equivalent of 4,500 metric tons of zinc is deposited in Western Europe each year. The solutions being considered reduce zinc oxide use by 50 to 80 percent, Michelin said.

- *Thesis*: Research thesis entitled "*Reduced zinc oxide levels …*" prepared by G. Heideman (2004). See next.
- *Article*: Heideman, G., et al. *Influence of zinc oxide during different stages of sulfur vulcanization. Elucidated by model compound studies*. 2005. Available here.

  > The cure characteristics indicate that with nano-ZnO, a reduction of zinc by a factor of 10 can be obtained.

[128] Rubber and Plastics News. Article: *California bill no longer includes zinc or tires*. March 31, 2016. Available here.
[129] Rubber and Tire News. *Michelin to phase out aromatic oils by 2010*. October 3, 2005. Available here (requires registration)

Also: Heideman, G., et al. *Various ways to reduce zinc oxide levels in S-SBR rubber compounds*. 2007. Abstract available here.

> Results with s-SBR rubber demonstrate, that this ZnClay can substitute conventional ZnO, retaining the curing and physical properties of the rubber products, while significantly reducing the environmental impact. A reduction of the zinc concentration with a factor 10 to 20 can be realized. [*Excerpt*]

- *Article:* Steven K. Henning. *Reduced Zinc Loading: Using Zinc Monomethacrylate to Activate Accelerated Sulfur Vulcanization.* 2007. Available here.
- *Article:* Myer, B. *Sartomer zinc technology aims to fill need in market* (article). 2007. Available here.
- *Article: Schill + Seilacher to create zinc-free package*. 2009. Abstract here.

> The article reports that Schill & Seilacher intends to create a package of zinc-free chemicals which will enable rubber compounders to develop formulations containing absolutely no zinc. The key element in this package will be a replacement for zinc oxide. In addition to the zinc oxide replacement, Schill will add preexisting materials which can substitute for current zinc-containing accelerators, anti-degradants and other ingredients. [*emphasis added*]
>
> *[Related] New zinc-free additive improves NR processing*. 2004. Abstract here.
>
> The article presents information on techniques to reduce viscosity of natural rubber, which is a common problem in the entire rubber industry and especially in tires. To overcome this problem, Schill + Seilacher AG has come up with a new concept to reduce viscosity of natural rubber. The new material, Struktol HT 105, avoids drawbacks of chemical peptizers but still is zinc based. With view to the upcoming restrictions on zinc by the European Union, a zinc-free version of the new peptizer was developed, which is called Struktol XP 1440. [*emphasis added*]

- *Article* - Shaw, David. *Zinc replacement chemical can slash cure times.* European Rubber Journal. Jan/Feb 2012, Vol. 194 Issue 1, p35. Article abstract:

> The article offers information on a new material developed in South Africa, as a replacement for zinc oxide that can help to reduce by up to half, the cure times of rubber components from tyres to dock fenders.
>
> [*Related earlier 2008 article:* Shaw. *New additive could eliminate all zinc oxide from world's rubber and tyre industries,* Abstract here:]
>
> The article reports on the development of an additive by Robert Bosch, a young South African chemistry graduate who runs a company called Rubber Nano Products P/L, which has the potential to eliminate zinc oxide entirely from the tyre and rubber industry's compounding manuals. The claim of the three-year research is backed by professionals from Schill & Seilacher and major tyre makers. Bosch says he intends to license the technology to a chemical supplier.

- *Article:* Article: Guzmán, M. et al. *Zinc oxide versus magnesium oxide revisited. Part 1*. Rubber Chemistry and Technology: March 2012, Vol. 85, No. 1, pp. 38-55. Abstract available here.

> Zinc oxide is a widely used compound in the rubber industry due to the excellent properties that it shows as activator, and consequently, its role in the mechanism of

> accelerated sulfur vulcanization has been extensively studied. Due to the increased concern about its environmental effects, several research studies have been carried out in order to substitute it with different metal oxides such as MgO.

- *Article: Development of passenger tire treads: reduction in zinc content and utilization of a bio-based lubricant*. 2016, (Journal of Cleaner Production). Available here.
- *Paper*: Moresco, S., et al. *Development of passenger tire treads: Reduction in zinc content and utilization of a bio-based lubricant*. 2016. Abstract available here.
- *Paper*: Md. Najib Alam and Pranut Potiyaraj. *Precipitated nano zinc hydroxide on the silica surface as an alternative cure activator in the vulcanization of natural rubber*. 2017. Abstract available here.

> Thus, by this novel method, a greater than 60% reduction of the conventional cure activator level can be possible with improved physical properties in the vulcanization of natural rubber [*Excerpt from abstract*]

This is a sampling; similar articles and papers are available online.

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Patents

- *Patent*: *Rubber composition and pneumatic tire with low zinc content (EP 2194090 B1).* Available here.

> *From the background*: Recently it has become desirable to reduce the amount of zinc in rubber articles and in particular in the tire rubber. It would therefore be desirable to have a rubber compound and a pneumatic tire cured using a cure system with the potential for a reduced zinc content in the rubber composition. [*emphasis added; same text used below*]
>
> *Inventors:* Nicola Costantini, Georges Marcel Victor Thielen, Frank Schmitz
> *Publishing date*: 2016
> *Applicant*: Goodyear Tire & Rubber Company

- *Patent: Pneumatic Tire Containing Zinc Phthalocyanine Compound.* Available here.

> *Background*: Rubber compounds used in pneumatic tires conventionally utilize a sulfur-based curing system incorporating several curatives, such as elemental sulfur or sulfur donors, accelerators, stearic acid, and zinc oxide. Recently it has become desirable to reduce the amount of zinc in the tire rubber. It would therefore be desirable to have a rubber compound and pneumatic tire cured using a cure system with the potential for a reduced zinc content in the rubber composition. [*emphasis added*]
>
> *Inventors:* Carlo Kanz (Mamer), Uwe Frank (Wendel)
> *Filed:* Sep 25, 2007

- *Patent*: *Rubber Composition with very low zinc content*. Available here.

> *Abstract*: The invention relates to a rubber composition based on at least one diene elastomer, containing less than 0.5 phe of zinc, phe signifying parts per hundred parts of elastomer, and based on at least:…
>
> *Publishing date*: 2011

Assignee: Societe De Technologie Michelin (Clermont-Ferrand, FR); Michelin Recherche et Technique S.A. (Granges-Paccot, CH)

- *Patent*: Pneumatic tire containing zinc naphthalocyanine compound

  US 20070054994 A1. Available here.

Reduced zinc tires

- *Roadrunner Tires* - Brochure (targets specialty industrial uses such as forklifts); 0.56% zinc; also, online advertisement here.
- *Aeolus Tire* – Brochure

  "….2. Environmentally friendly materials – through the use of clean oil, lead free and reduced zinc materials, Aeolus tires are helping to reduce the impact on the environment." [*emphasis added*]

  Related article: Denise Koeth. *Aeolus and Alliance Set to Expand With Green Production, Enhanced Products*. Tire Review. August 10, 2011. Available here.

  Aeolus also upgraded the zinc oxide used in its tires to decrease the amount of heavy metal – especially lead – present in each product. Rather than 0.14% of normal zinc, the company now uses 0.04% of upgraded zinc, according to Aeolus. [*emphasis added*]

Attachment A – Zinc Concentration in Tires

Summary of Tire Tread Zinc Concentration Data (from CASQA report)[130]

Tire Type	Mean Zinc Concentration (percentage)	Data Source
Car	0.94	Sweden, 52 tires (Hjortenkrans et al. 2007)
	0.847	New Zealand, 7 tires (Kennedy et al. 2002)
	0.95	Netherlands Industry data (Blok 2005)
	1.48	Japan, 2 tires (Ozaki et al. 2004)
	1.025	France (Legret and Pagatto 1999)
	0.96	EU Rubber Industry survey (Smolders and Degryse 2002)
Truck	1.7	Netherlands Industry data (Blok 2005)
	1.6	New Zealand, 2 tires (Kennedy et al. 2002)
	1.7	EU Rubber Industry survey (Smolders and Degryse 2002)

[130] California Stormwater Quality Association. *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here.

Attachment B – Vehicle Classes

In the vehicle code, the vehicle categories are passenger vehicle and motortruck. The Air Resources Board recognizes thirteen vehicle classes as shown in the table: [131]

Vehicle Class	Code	Description	Vehicle Weight (lbs.)
1	PC	Passenger cars	ALL
2	T1	Light-duty trucks	0 - 3,750
3	T2	Light-duty trucks	3,751 - 5,750
4	T3	Medium-duty trucks	5,751 - 8,500
5	T4	Light-heavy duty trucks	8,501 - 10,000
6	T5	Light-heavy duty trucks	10,001 - 14,000
7	T6	Medium-heavy duty trucks	14,001 – 33,000
8	T7	Heavy-heavy duty trucks	33,001 – 60,000
9	T8	Line-haul trucks	60,000 +
10	UB	Urban buses	ALL
11	MC	Motorcycles	ALL
12	SB	School buses	ALL
13	MH	Motor homes	ALL

[131] Air Resources Board. Excerpt from EMFAC2000. Available here.

Attachment C – Manufacturers and Importers

Note: the following are partial lists; additional lists are available online from various sources.[132]

- **Zinc free or reduced zinc tire manufacturers** (also listed above)

  Aeolus Tire – brochure and *Roadrunner Tires* - brochure (targets industrial users)

- **Manufacturers**

New Tires (manufactured in the US)	Retreaders
Goodyear Tire & Rubber Company	Goodyear Tire & Rubber Co., dba Goodyear Commercial Tire & Service Centers
Cooper Tire & Rubber Company	Southern Tire Mart LLC
Michelin North America	Bridgestone Americas Tire Operations LLC, dba GCR Tires & Service
Pirelli	Purcell Tire & Rubber Co.
Continental AG	Best-One Tire Group
Bridgestone Corporation	Snider Tire Inc., dba Snider Fleet Solutions
Yokohama Rubber Company	Pomp's Tire Service Inc.

Also see extended list: http://www.moderntiredealer.com/uploads/stats/2016-top-100-retreaders-web-1.pdf

- **Importers from China[133] [assumes exporter from China is importer to the US]**

Exporter	Producer
Prinx Chengshan (Shandong) Tire Co., Ltd	Prinx Chengshan (Shandong) Tire Co., Ltd
Actyon Tyre Resources Co., Limited	Chao Yang Long March Tyre Co., Ltd
Actyon Tyre Resources Co., Limited	Shandong Haohua Tires Co., Ltd
Actyon Tyre Resources Co., Limited	Shandong Longyue Rubber Co., Ltd
Aosen Tire Co., Ltd	Qingdao Taifa Group Co., Ltd
Aosen Tire Co., Ltd	Shandong Chuanghua Tire Co., Ltd
Aosen Tire Co., Ltd	Shandong Hawk International Rubber Industry Co., Ltd
Aosen Tire Co., Ltd	Shandong Hugerubber Co., Ltd
Aosen Tire Co., Ltd	Shandong Yongsheng Rubber Group Co., Ltd
[***see full list in Federal Register link***]	

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[132] More comprehensive lists are available online, for example, *Rubber and Plastics News* (http://www.rubbernews.com/article/20161222/data/161229984/directory-of-global-tire-manufacturers-2016)

[133] Full list is in the Federal Register. Truck and Bus Tires from the People's Republic of China: Final Affirmative Determinations of Sales at Less Than Fair Value and Critical Circumstances. A Notice by the International Trade Administration on 01/27/2017. Apparently other exporter countries were not involved in this regulatory action from which the list is derived.

- **Additional Importers** (partial)

Dynamic Tire
LBD Llantas Corp
Honor Way Group Ltd
TBC International
Honor Way Group Ltd
Unicorn Tire Corp
American Omni Trading Company, LLC
Import Export Tire Company
Universal Tire International Corp.
TIRE HOTLINE (Dacotah-Walsh Tire Inc.)
Zafco International LLC

- **Misc. combined list of major world manufacturers** (not all of these export to the US)

Continental AG, Germany	Apollo Tyres Ltd., India
Bridgestone Corp., Japan	Nokian Tyres plc,
Groupe Michelin, France	Nexen Tire Corp., South Korea
Sumitomo Rubber Industries Ltd., Japan	Hangzhou Zhongce Rubber Co., China
Pirelli & C SpA, Italy	Triangle Group Co., China
Hankook Tire Co., South Korea	Shandong Linglong Rubber Co., China
Yokohama Rubber Corp., Japan	Sailun Jinyu Group Co., China
Cheng Shin Rubber/Maxxis, Taiwan	Xingyuan Tyre Co.
Giti Tire Pte. Ltd., Singapore	GITI Tire (Fujian) Co. Ltd. (and certain cross-owned companies)
Toyo Tire & Rubber Co., Japan	Shandong Yongsheng Rubber Group Co. Ltd.
MRF Ltd., India	
Trelleborg AB, Sweden	
Kumho Tire Co., South Korea	
Double Coin Holdings Ltd., China	

- **U.S./ Canadian Leaders in New Car Tire Sales - FY 2016** (These all appear to be manufacturers)

Tire company	Billions of U.S. dollars
Bridgestone Americas Inc.	$7.7
Goodyear Tire & Rubber Co.	$6.7
Michelin North America Inc.	$6.5
Continental Tire the Americas LLC	$2.9
Cooper Tire & Rubber Co.	$2.1
Hankook Tire America Corp.	$1.6
Toyo Tire Holdings of America Inc.	$1.4
Yokohama Tire Corp.	$1.1
Sumitomo Rubber Industries Ltd.	$.8
Pirelli Tire North America Inc.	$.5
Kumho Tire USA Inc.	$.5

- **Additional sources of information:**

  - List of replacement tires sales - here
  - Market Profile: Tires - here
  - Top 100 independent tire dealers in the U.S. - here
  - Top 25 Commercial Tire Dealers - here

Attachment D – Minor Sources of Zinc in Waterways

Natural soils, batteries, wildfires, etc. are potential contributors of zinc to runoff. As discussed below, these sources are likely not significant sources except possibly in certain locations:

1. **Natural soils** - Median zinc in California benchmark soils is 149 mg/Kg.[134] The median concentration of total suspended solids (TSS) in Caltrans highway runoff is 59 mg/L. Total dissolved solids (TDS) are 60 mg/L. If all the TSS and TDS on the roadway surface were the result of deposition of natural soils, the zinc concentration would be about 18 µg/L. Monitored zinc concentrations in highway runoff are generally much higher.

2. **Sewage treatment plants**. Treated effluent from sewage treatment plants (publicly owned treatment works – POTWs) must comply with numeric water quality-based effluent limitations in NPDES permits. Consequently, the discharge concentrations are less than the standards. (Exceptions are possible for ocean or similar discharges where a dilution factor has been applied during the calculation of the WQBEL.)

M**aximum discharge concentrations of zinc and receiving water objectives for several domestic wastewater treatment facilities (freshwater discharge)**

Facility	Governing water quality objective[135]	Maximum effluent concentration (MEC) measured[136]	Link to permit
City of Fortuna	73.3 (hardness = 56 mg/L)	24.2	Tentative Order No. R1-2017-0005
City of Sacramento	38 (hardness = 26 mg/L)	33.5	Order No. R5-2010-0114-01 (amended 2011)
City of Los Angeles (Tillman plant - tertiary level treatment)	257 (hardness = 246 mg/L)	135	Order No. R4–2011–0196

Note: The Tillman hardness appears very high and may possibly be representative of dry weather flow.

Although the POTWs discharge year-round, the zinc contribution from the POTWs is relatively small – see, for example, the Los Angeles River watershed:

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134 Bradford, G.R., et al. *Background Concentrations of Trace and Major Elements in California Soils*, Kearney Foundation of Soil Science, University of California, 1996, Table 2. Available here.

135 The governing WQO is based on the dissolved chronic criteria in the California Toxics Rule or in the Basin Plan converted to total recoverable using the conversion factors at 40 CFR 131.36(b)(1) and (2) [need to verify - see CTR factors]

136 This is the maximum concentration monitored in the discharges during the years of operations under the previous permit (typically 3 to 5 years).

Domestic wastewater treatment plant and stormwater discharges to the LA River watershed

Annual Discharge Total Zinc	POTWs (3 total)	Seasonal stormwater (highly variable)
Kg	4,676	≈40,000
Tons	5.15	44

(From the LA River Metals TMDL, Final Staff Report, 2005[137])

According to the Regional Water Board Staff Report, the loading of zinc associated with indirect atmospheric deposition is accounted for in the estimates of the stormwater loadings. As shown in the table, the loading to the LA River from the three POTWs is low compared with the stormwater loading. This is because much of the domestic wastewater (and industrial wastewater) from the basin is discharged to the ocean via lengthy outfalls designed to receive a high level of dilution. This is similar to most of the other coastal cities in California – treated domestic wastewater is discharged to the ocean but stormwater is generally discharged to inland waterways.

3. **Batteries** - Batteries have been suggested as potential problem, especially in shopping mall parking lots as people switch out their old alkaline batteries; however, batteries have not been identified as a significant urban problem. This potential source should be investigated, however, and may warrant a targeted education program.

4. **Wildfires** - Wildfires occur infrequently in locations where California urban areas would be impacted. This is because the prevailing winds are predominantly from the west. ARB data for the South Coast AQMD shows that natural sources, including wildfires, are not a significant contributor of zinc. However, fires may contribute to spikes in zinc in aerial deposition. For example, the 2003 Simi/Malibu fires significantly increased the zinc concentration in Ballona Creek (to nearly 1,200 µg/L).[138]

5. **Vehicles (fuel), areawide air emissions inventory**, **and aerial deposition** – It has also been suggested that emissions due to fuels and other sources have contributed to aerial deposition of zinc, which may be contributing to zinc loadings to waterways.

   The 2010 California Toxic Inventory emission estimate for zinc is 13 tons/year for the South Coast AQMD.[139] Almost all of this is from the "areawide" source category (consumer products, construction, farming, paved & unpaved road dust, etc.).[140] By comparison, as shown in the table above, the seasonal stormwater total zinc loadings to the Los Angeles River watershed is roughly 44 tons/year). The stormwater runoff likely includes a portion of the emissions which have entered the watershed as wet or dry precipitation.

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[137] Referenced in U.S. EPA Region 9 & California Regional Water Quality Control Board, Los Angeles Region. *Total Maximum Daily Load for Metals, Los Angeles River and Tributaries*. 2005. Available here. Also see here.

[138] Stein, E.D., et al., SCCWRP/UCLA Presentation: *Effects of Southern California Wildfires on Storm Water Contaminant Runoff*. Available here.

[139] ARB. *2010 California Toxic Inventory*. The South Coast Basin includes all of Orange Co. and the non-desert regions of LA, Riverside, and San Bernardino Counties. Spreadsheet available here, line 1245.

[140] Statewide is 878 total tons/year, mostly areawide and natural. Onroad is 43 tons/year.

Emission Inventory - South Coast AQMD – Zinc (tons per year)

Aggre-gated Point Sources	Area wide	Onroad Diesel	Onroad Gasoline	Other Mobile Gasoline	Other Mobile Diesel	Other Mobile Other	Natural	TOTAL
0.026	6.756	2.017	0.642	2.489	0.600	0.004	0.498	13.032

The separate categories of onroad diesel and onroad gasoline contribute only 2.6 tons/year to the entire Basin. Therefore, vehicle emissions of zinc from fuel do not appear to have the potential to be a significant contributor to runoff concentrations of zinc, particularly considering that the majority of emissions will not precipitate on "directly connected" impervious areas that result in stormwater runoff of zinc. In addition, the South Coast Basin (10,750 square miles) includes a much larger area than the Los Angeles River watershed (834 square miles).

The paved road dust category which is part of "areawide" does include emissions of zinc from tire wear, but it does not appear to be significant.[141] Presumably, these emissions are the fine particulates which have become airborne and are carried some distance rather than the larger particulates which are carried by traffic-induced turbulence to the immediate surrounding areas.

A study in Milwaukee for PM10 emissions determined that zinc emissions (rate ≈ 100 µg/km) were higher than for copper or lead.[142] The same study indicated that the leachable fraction of zinc in urban dust was low (≈ 5%).

As noted in the CASQA report, the Toxics Release Inventory (TRI) Program *direct emissions* (i.e., wastewater discharges) of zinc to surface water in Los Angeles Country was only 0.4 tons/year in 2013. This is because industries must comply with water quality standards as translated into water quality-based effluent limits when zinc is present at levels of concern. Industries discharging wastewater to POTWs must comply with local and national pre-treatment standards.

6. **Motor oil** – The Office of Environmental Health Hazard Assessment completed an assessment of used oil in stormwater runoff.[143] As part of this effort, they focused on used oil constituents with numeric aquatic life criteria including zinc, lead, copper, arsenic, cadmium, nickel, and chromium.

> *The highest reported concentrations of these constituents in used oil (OEHHA, 2004) were used to calculate their amounts in runoff containing oil and grease at 5 mg/l (typical concentrations found in the studies reviewed by OEHHA were at or below 5 mg/l). These calculations yielded concentrations of these constituents that were up to five orders of magnitude lower than their respective freshwater and saltwater aquatic life water quality criteria. Nevertheless, these constituents may pose a long-term risk to the aquatic ecosystem because of their tendency to accumulate in sediment over time*.

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[141] "*The paved road dust category does not explicitly estimate reentrained particulate matter produced by brake and tire wear, or PM exhaust emissions. However, some portion of these emissions are included in the paved road dust emission estimates due to the field sampling methods used to develop the paved road dust emission factor equation. Future updates will subtract-out these brake wear, tire wear, and exhaust emissions, which may decrease the overall PM paved road dust estimate by about five percent*." See methodology, here.

[142] James Schauer, et al. *Trace Metal Emissions from Motor Vehicles*. Presentation available here.

[143] Office of Environmental Health Hazard Assessment. *Characterization of Used Oil in Stormwater Runoff in California*. 2006. Available here.

The study also noted "…the criteria for cadmium, lead and zinc will likely be exceeded at oil and grease concentrations of 33,000 mg/l." However, oil and grease concentrations measured statewide in highway runoff had a mean concentration of 1.44 mg/L with a maximum detected value of 61 mg/L.[144]

7. **Other minor traffic-related sources** - The non-tire traffic sources considered by researchers include motor oil, asphalt, vehicle brake pads, and wheel weights. See CASQA report, Table 7. Minor Zinc Sources, page 38[145].

   A research project examined the characteristics and zinc content of roadway and other particles:[146]

   - Roadway particles, from road surfaces
   - Tire wear particles (TWP) collected on a simulated laboratory driving course
   - Tread particles (TP), cryogenically ground from pieces of unused tread

   The report concluded:

   > *Based on the results from this study, the concentration of zinc in the corresponding [tread particles] is approximately two and three times higher than found in [roadway particles] and [tire wear particles], respectively. These results indicate that tread rubber is likely to be a major, although not sole contributor of zinc in the [roadway particles] and [tire wear particles].*

8. **Industrial sources**. Similar to the POTWs, industrial wastewater is generally well-controlled by NPDES permits which include numeric water quality-based effluent limitations to ensure standards are not exceeded. Stormwater from industrial sources that is not otherwise controlled through a site-specific NPDES permit will be regulated by the Stormwater Industrial General Permit if the industry is in one of the categories regulated by the IGP.[147] This permit includes a numeric action level applicable to industrial discharges and they will also be regulated where TMDLs are in place and have assigned a zinc waste load allocation to the industry.

Stormwater Discharge Numeric Action Levels for Specified Industrial Categories (& LA TMDL)

	U.S. EPA Benchmark[148]	SWRCB IGP NAL	*Example*: Interim allocation for industrial stormwater permittees (LA River TMDL)
Total Zinc (fresh)	Hardness Dependent (110 µg/L at hardness of 75-99.99 mg/L)	260 µg/L[149]	117 µg/L
Total Zinc (saltwater)	90 µg/L	260 µg/L	na

NAL = Numeric action level

[144] Caltrans. *Discharge Characterization Study Report*. 2003. See Table 3-2 for highway runoff zinc. Available here.
[145] California Stormwater Quality Association. *Zinc Sources in California Urban Runoff*. Prepared by TDC Environmental, LLC. Revised April 2015. Available here.
[146] Kreider, M.L., et al. *Physical and chemical characterization of tire-related particles: Comparison of particles generated using different methodologies*. 2009. Abstract available here.
[147] State Water Board. *Industrial General Permit 2014-0057-DWQ*, effective July 1, 2015. Available here
[148] U.S. EPA. *Multi-Sector General Permit* (MSGP). 2015. Available here. Applies to specified industrial categories.
[149] For zinc and several other metals: "*The NAL is the highest value used by U.S. EPA based on their hardness table in the 2008 MSGP*"; this corresponds to a hardness of 250+ mg/L.

Attachment E – Zinc Impaired Waterways – CWA 303(d) listings in the 2012 Integrated Report[150]

(in all cases these are multiple listings and include other pollutants)

Reg. Board	Location	Area	Listed Source (*see note 1 at end*)	Notes
2	SF Bay – Mission Creek - ***Sediment***	8.5 Acres	Unknown	Multiple sed. listings (7)
2	SF Bay - Oakland Inner Harbor (Pacific Dry-dock Yard 1 Site - ***Sediment***	1.8 Acres	Unknown	Multiple sed. listings (8)
2	SF Bay - San Leandro Bay - ***Sediment***	588 Acres	Unknown	Multiple sed. listings (5)
2	Stege Marsh	29 acres	Unknown	Multiple listings (7) [sediment?] ***(Category 4b: addressed by action other than TMDL***)
3	Majors Creek (Monterey County)	1 mile	- Unknown - Urban Runoff/ Storm Sewers	Multiple listings (4)
4	Ballona Creek*	6.5 miles	Unknown	Multiple listings (10)
4	Ballona Creek Estuary- ***Sediment***	2.3 miles	- Nonpoint Source - Point Source	Multiple sed. listings (6)
4	Calleguas Creek Reach 1	344 acres	Unknown	Multiple listings (13) **(*Cat. 4a: addressed by TMDL*);** Zn being delisted?
4	Colorado Lagoon (wetland/tidal) - ***Sediment***	13 Acres	Unknown	Multiple sed. listings (5)
4	[Compton Creek – proposed new listing]	-	-	Not included in summary list count
4	Dominguez Channel (lined portion above Vermont Ave)	6.7 Miles	Unknown	Multiple listings (7)
4	Dominguez Channel Estuary (unlined portion below Vermont Ave); estuary – ***Sediment****	140 acres	Unknown	Multiple sed. listings (3)
4	Los Angeles Harbor - Consolidated Slip - ***Sediment****	36 acres	Unknown*	Multiple listings (9)
4	Los Angeles Harbor - Fish Harbor	91 acres	Unknown	Multiple listings (15)
4	Los Angeles River Reach 1 (Estuary to Carson Street) – ***Zn, dissolved***	3.4 miles	- Nonpoint Source - Point Source	Multiple listings (11)

[150] Includes Final 2012 California Integrated Report (Clean Water Act Section 303(d) List Categories 5, 4a, & 4b. The approved 2012 303(d) list contains updates for the North Coast, Lahontan, and Colorado River Basin Regional Water Boards as well as the carryover decisions from the previous 2008/2010 303(d) list for the other Regional Boards; available here.

Reg. Board	Location	Area	Listed Source	Notes
4	Los Angeles/Long Beach Inner Harbor	3003 Acres	Unknown	Multiple listings (9)
4	Los Cerritos Channel (Wetland, Tidal)	30 Acres	Unknown	Multiple listings (9)
4	Marina del Rey Harbor - Back Basins - ***Sediment***	391 Acres	Unknown	Multiple sed. listings (5)
4	Rio Hondo Reach 1 (Confl. LA River to Snt Ana Fwy)	4.6 miles	- Nonpoint Source - Point Source	Multiple listings (7)
5	Camanche Reservoir	7389 Acres	Unknown	Multiple listings (3)
5	Dolly Creek	1.5 Miles	Unknown	Resource extraction[151]; Cu also listed
5	Horse Creek (Rising Star Mine to Shasta Lake)	0.52 Miles	Unknown	Resource extraction[6]; Cd, Cu, PB also listed
5	Humbug Creek	2.2 Miles	Unknown	Resource extraction[6]; Cu, Hg also listed
5	Keswick Reservoir (portion downstream from Spring Creek)	135 Acres	Unknown	Cd, Cu, also listed
5	Little Backbone Creek, Lower	0.95 miles	Unknown	Resource extraction[6]; Cd, Cu, also listed
5	Little Cow Creek (downstream from Afterthought Mine)	1.1 miles	Unknown	Resource extraction[6]; Cd, Cu, also listed
5	Little Grizzly Creek	9.4 Miles	Unknown	Cu also listed
5	Mokelumne River, Lower (in Delta Waterways, eastern portion)	34 Miles	Unknown	Multiple listings (6)
5	Shasta Lake (area where West Squaw Creek enters)	20 Acres	Unknown	Cd, Cu also listed
5	Spring Creek, Lower (Iron Mountain Mine to Keswick Reservoir)	2.6 Miles	Unknown	Resource extraction[6]; Cd, Cu, acid drainage also listed
5	Town Creek	0.98 Miles	Unknown	Resource extraction[6]; Cd, Cu, Pb also listed
5	West Squaw Creek (below Balaklala Mine)	2 miles	Unknown	Resource extraction[6]; Cd, Cu, Pb also listed
5	Willow Creek (Shasta County, below Greenhorn Mine to Clear Creek)	4 miles	Unknown	Resource extraction[6]; Cu, acid drainage also listed
8	Cucamonga Creek Reach 1 (Valley Reach)	9.6 Miles	Unknown	Multiple listings (5)
8	Rhine Channel	20 Acres	Unknown	Multiple listings (6) Hg, Cu, Pb also listed
9	Chollas Creek	3.5 Miles	Unknown	Cu, Pb also listed

[151] "All resource extraction sources are abandoned mines"

Reg. Board	Location	Area	Listed Source	Notes
9	Dana Point Harbor	119 acres	- Marinas and Recreational Boating - Unknown - Unknown Nonpoint Source - Urban Runoff/Storm Sewers	Cu and toxicity also listed
9	San Diego Bay Shoreline, between Sampson and 28th Streets.	53 Acres	Unknown (and unknown point and nonpoint sources)	Multiple listings (5) (Category 4b: addressed by other action than TMDL)
9	Switzer Creek	1.3 Miles	Unknown	Cu, Pb also listed
9	Tecolote Creek	6.6 Miles	Unknown	Multiple listings (10) Cd, Cu, Pb, Se also listed

* The Los Angeles Board is proposing to delist Ballona Creek and Dominguez Channel Estuary (unlined portion below Vermont Ave) for zinc for the 2016 list.
**Historical use of pesticides and lubricants, stormwater runoff, aerial deposition, and historical discharges for metals.

Note: The "Listed Source" category will be phased out in future lists due to the different approaches applied in different Regions.

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Attachment F – CASQA Report: *Zinc Sources in California Urban Runoff*

[Bound separately; also available at https://www.casqa.org/sites/default/files/library/technical-reports/zinc_sources_in_california_urban_runoff.pdf]