CalRecycle

California Department of Resources Recycling and Recovery

California Waste Tire Market Report: 2022

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Acknowledgments

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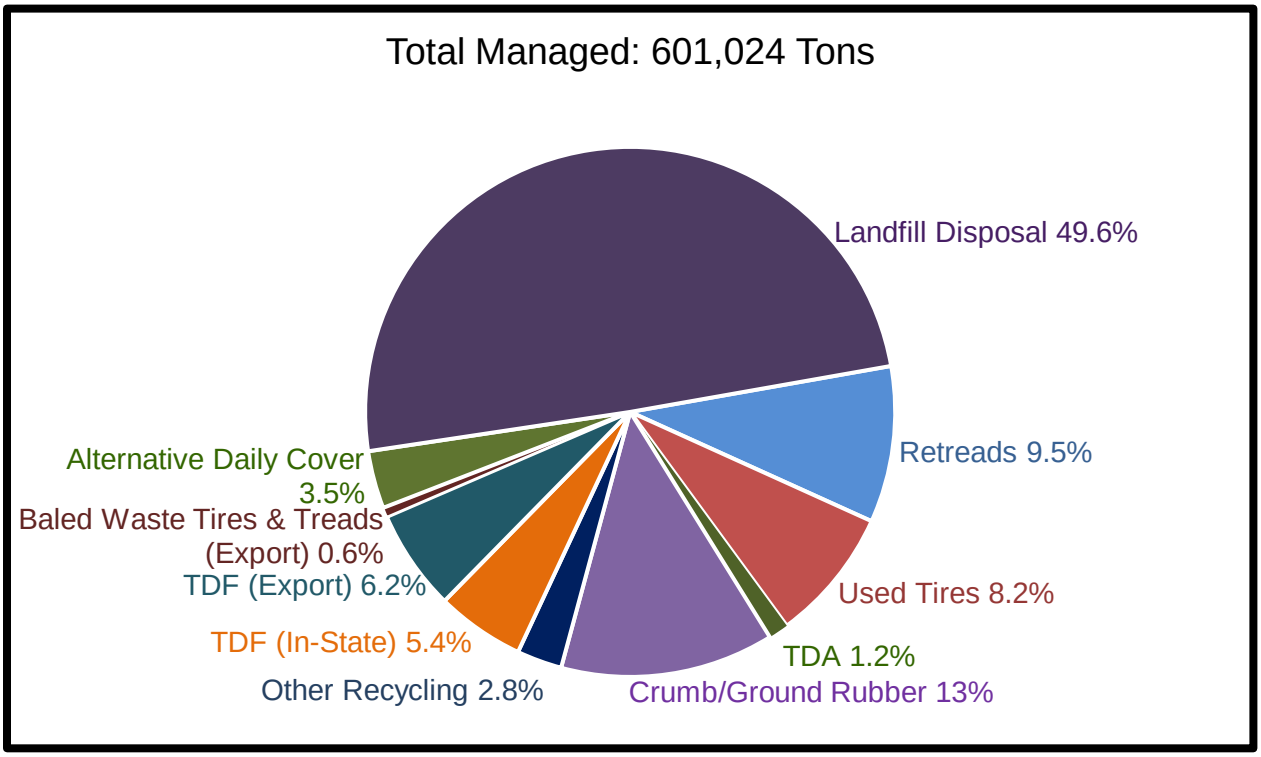
Executive Summary

This report describes California waste tire flows in 2022 and trends as of Winter 2023, based on analysis of data from industry surveys, interviews, California Department of Resources Recycling and Recovery (CalRecycle) databases, and other sources.

As shown in Figure 1, in 2022, an estimated 601,204 tons (60.1 million PTEs[1]) of California-generated waste tires were managed. California waste tires flowed to 10 different market segments, however, a variety of disruptions impacted business operations and markets. These disruptions included ongoing shifts in COVID infections, health-related impacts, and associated restrictions. Additionally, factors such as economic growth followed by high inflation and the prospect of a potential 2023 recession, persistent staffing and hiring challenges, high trucking and ocean shipping costs combined with logistical challenges, and a variety of supply chain disruptions impacted diverse commodities and products related to tire-derived products (TDPs).

Figure 1 California-Generated Waste Tire Flows in 2022

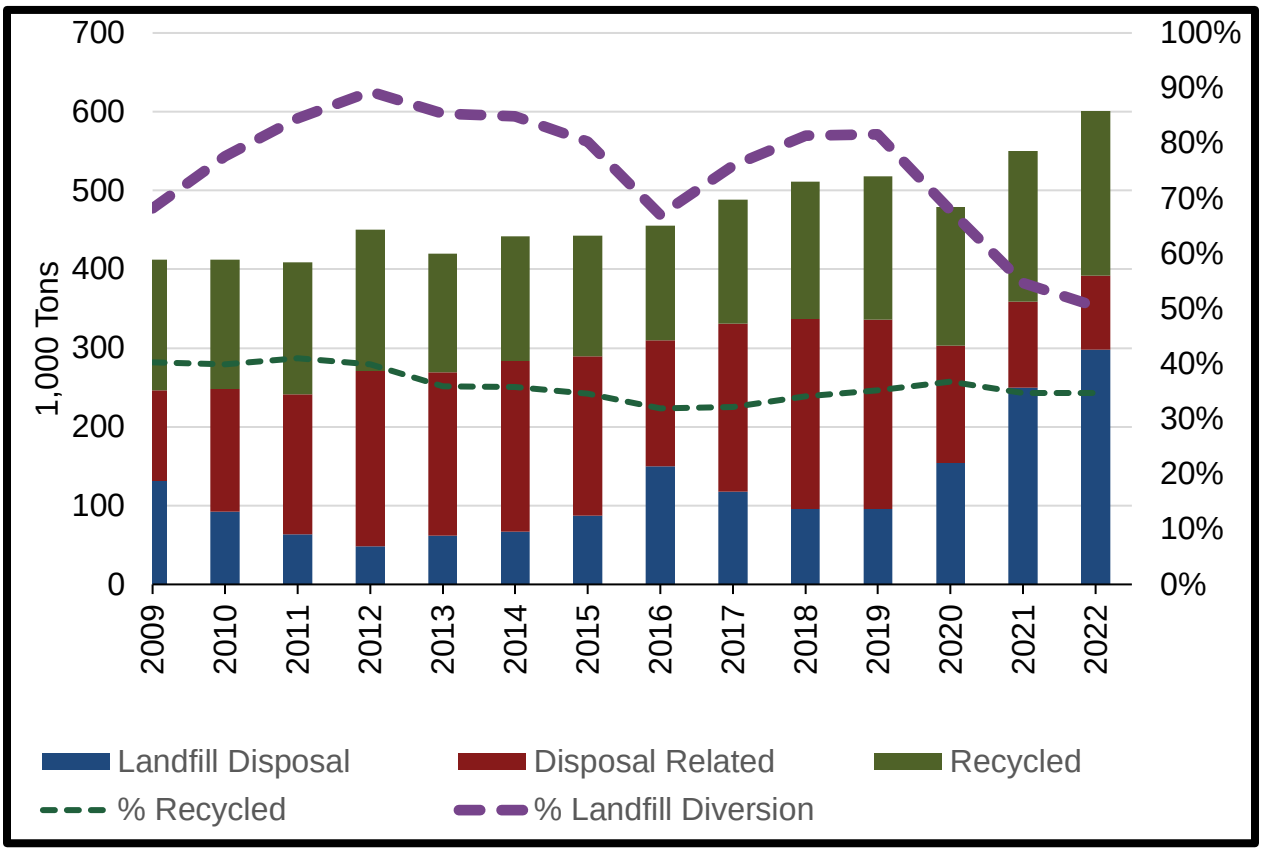


See source data for Figure 1 in Appendix C.

[1] PTE means passenger tire equivalent, defined by CalRecycle (14 CCR § 17225.770) as 20 pounds. The PTE is a useful standardized reporting metric; but actual tire weights vary significantly by type, and passenger tires typically weigh more than 20 pounds.

CalRecycle has informally adopted a 75% waste tire recycling goal, consistent with a statewide 75% recycling goal covering all waste materials mandated by AB 341 (Chesbro, Chapter 476, Statutes of 2011). As Figure 2 shows, after modest gains over four years, the California waste tire recycling rate remained steady in 2022 at 34.7%. Recycled tons increased by 8.1% to 208,777 tons (20.8 million PTEs); however, this was accompanied by an 8.9% increase in total generation. Retreading grew by 5% in 2022, driven by supply chain disruptions that reduced new tire supplies and increased new tire pricing.

Figure 2 California-Generated Waste Tire Recycling, Disposal Related and Landfill Disposal Trends, 2009-2022



See source data for Figure 2 in Appendix C.

The following are some key trends by market segment:

- Crumb/ground rubber production increased by 10.6% from 2021 to 2022, driven by gains in the paving segment, the molded/other product, and crumb rubber market segments.
- Turf infill and playground surfacing in the state declined since June 2015, coinciding with the announcement of the Office of Environmental Health Hazard Assessment (OEHHA) report commissioned by CalRecycle to investigate potential human health impacts of synthetic turf. Tire Incentive

Program (TIP) and tire-derived products Fiscal Year (FY) 2021-2022 grants excluded multiple high-volume uses of crumb rubber anticipating a report determination. In general, roofing and flooring uses increased the use of crumb although turf infill tonnage did contribute with a slight rise from 2021 to 2022.

- Retread sales continued to be strong with a 4.8% increase over 2021.
- Used tire sales rebounded in 2022 from the decline in 2021, almost reaching 2020 values, indicating a robust market.
- The use of tire-derived aggregate (TDA) in civil engineering increased slightly, but overall tonnage remains low compared to pre-Covid years.
- Landfill disposal increased in 2022 to 298,084 tons, a 19.5% increase from 2021, and is continuing an upward trend from 2020, reaching the highest levels in 20 years.
- Exported tire-derived fuel (TDF) declined by 7.7% due to reduced usage in some countries, port issues, and logistical challenges.
- In-state TDF shipments declined by 32.7% as one of the four cement kilns changed its tire-derived fuel specifications, requiring material particles to be 1 inch, a substantial reduction from the past. This was not cost effective for processors to make, and that resulted in a decrease in TDF use. There is currently no indication that the other cement kilns are changing their TDF specifications.

In 2023 and 2024, there is potential for further growth in recycling, especially in the retreading, paving, and molded/other market segments. Recent changes in ownership and investments aimed at expanding or enhancing waste tire recycling operations may also contribute to sustained growth. Continued expansion and diversification in TDP markets and the types of California-made TDPs are essential.

Tire-derived material (TDM) is a category of feedstock produced from end-of-life tires that can be used to make TDPs, TDF, or for use as a civil engineering material for road infrastructure projects. TDM markets supply the TDP market with feedstock material. Strong performance in TDM markets indicates there are businesses effectively managing California waste tires.

1. Introduction

The California Department of Resources Recycling and Recovery (CalRecycle) oversees management of waste and used tires in California as authorized by Senate Bill 876 (Escutia, Statutes of 2000, Chapter 838).[2] CalRecycle's long-term, informal goal is to achieve a 75% waste tire recycling rate. This is consistent with the requirements of AB 341 (Chesbro, Chapter 476, Statutes of 2011), which established a 75% statewide recycling rate goal for all materials by 2020.

This report estimates the 2022 California tire recycling rate. It describes current and historical trends in the flow of California-generated waste tires and TDM to different market segments, including TDPs, TDF and civil engineering. GHD Inc. prepared the report in partnership with industry specialists DK Enterprises and Boisson Consulting and with research support from WEC LLC. Findings are based on detailed analysis of data and information provided by California waste tire management companies, CalRecycle staff and databases, and other sources.

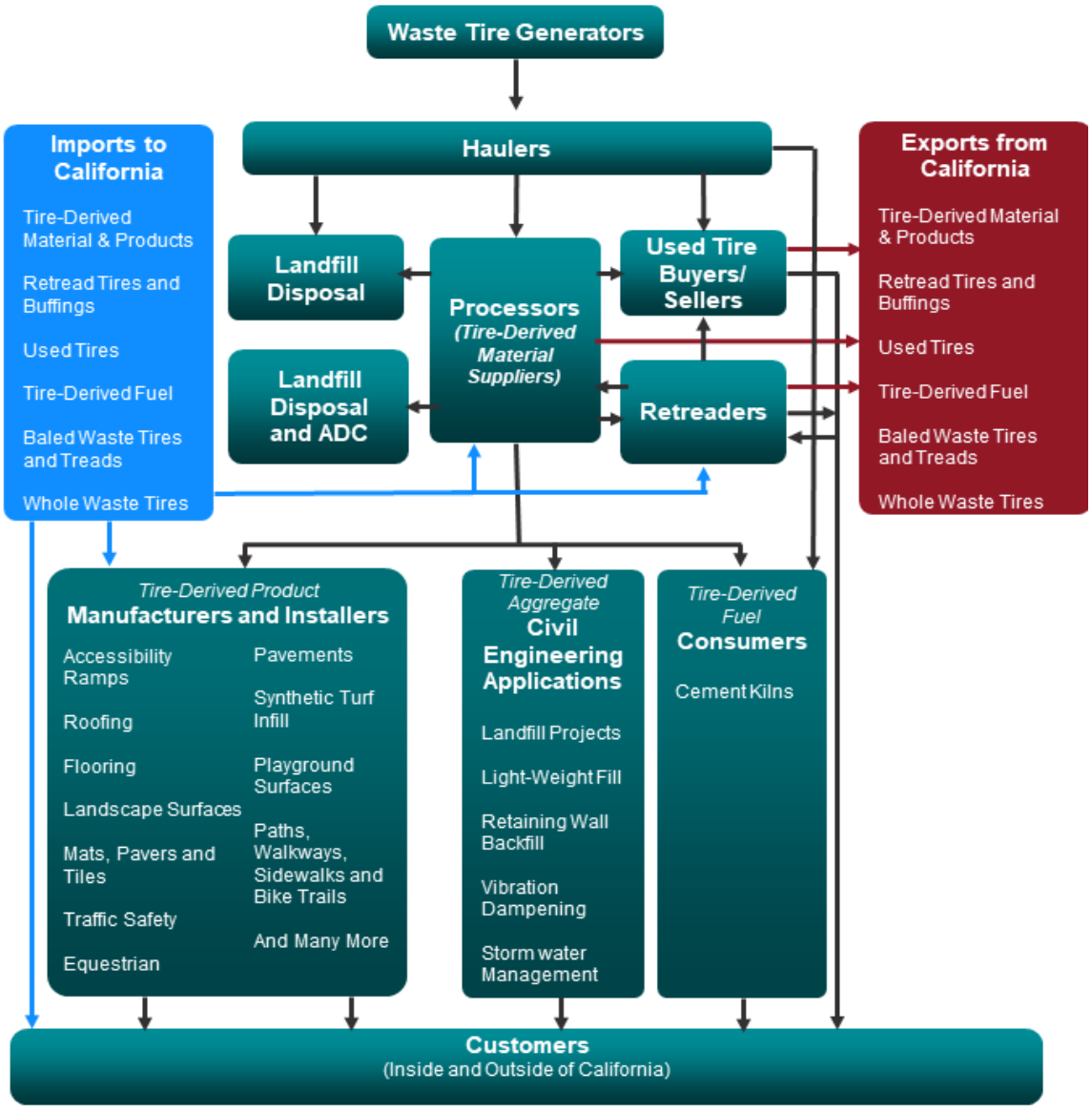
Following this introduction, Section 2 summarizes California's waste tire management infrastructure. Section 3 identifies broad trends influencing waste tire markets, while Section 4 provides detailed findings by market segment. The main report concludes with Section 5, discussing the outlook for increased tire recycling. Appendix A is a glossary of key terms and acronyms, while Appendix B covers the report methodology. Appendix C provides notes and source data for graphs and charts to ensure accessibility in compliance with the American Disabilities Act, Government Code sections 11546.7, 7405, and 11135, and Web Content Accessibility Guidelines 2.0. Finally, the End Notes section at the end of the report lists cited information sources.

[2] Unlike some tire recycling studies, this report covers waste tires, used tires and retread tires. See definitions and regulatory references in Appendix A.

2. California Waste Tire Management Infrastructure

Figure 3 illustrates flows of California-generated waste tires and tire-derived materials (TDM). Table 1 lists the number of distinct types of facilities and companies serving California. Waste tire collection and processing companies serve all areas of the state. CalRecycle's California Tire-Derived Product Catalog provides detailed product information, maps, and directories with company contacts. The TDP Catalog is available online.

Figure 3 California Waste Tire Recycling Industry Flow Chart



See detailed description of Figure 3 in Appendix C.

Table 1 California Waste Tire Management: Active Facilities and Companies in 2022

Category	Counts
Registered Waste Tire Haulers	> 1,300[1]
Registered Waste Tire Generators	> 23,000[2]
Number of 2022 Waste Tire Shipments (Each Documented with a Comprehensive Trip Log in CalRecycle's Waste Tire Manifest System)	> 530,000[3]
Retreaders	37[4]
Facilities with a Major Waste Tire Facility Permit (Specified onsite maximums range from 9,960 to 336,300 PTEs)	15[5]
Facilities with a Minor Waste Tire Facility Permit (Allowing up to 4,999 PTEs onsite)	17[6]
Processors Reporting Crumb Rubber or Ground Rubber Shipments	6
Processors Reporting TDA Shipments	3
Processors Reporting In-State TDF Shipments (Includes size-reduced TDF, whole tire TDF and residual fluff from crumb rubber production)	6
Processors Reporting Exported TDF (e.g., chips, shreds) and/or Baled and Cut Waste Truck Tire Tread Shipments	4
Tire-Derived Product Manufacturers Listed in the California TDP Catalog	16[7]
Tire-Derived Product Installers Listed in the California TDP Catalog	8[8]
California Cement Kilns Consuming TDF	4
California Landfills Disposing Size Reduced Waste Tire Material On-Site (Two additional landfills in Nevada received California waste tires in 2022)	29

3. Broad Trends Influencing Markets

As in 2021, important trends continued to create uncertainty and disrupt business operations and markets to varying degrees in 2022 and early 2023. These trends include:

- **The COVID 19 Pandemic – continued infection waves, but with fewer restrictions.** Repeated variant-fueled spikes in infections occurred in 2022 and early 2023, with decreasing hospitalizations and deaths due to increasing vaccination rates and infection-acquired immunity. A trend towards relaxing restrictions has eased concerns over shutdown orders, while staffing shortages sometimes disrupt specific workplaces due to periodic spikes in infections.
- **Shifting economic outlook**. Strong federal and state relief programs for small businesses and industry in 2021 were extended into early 2022, supporting some California waste tire management companies. Protests and strikes at major global shipping hubs in 2022 impacted the supply chain and return on investments. By early 2022, the state had accumulated a surplus,[9] with separate dedicated funding identified for roads and other infrastructure at the state and local levels. However, inflation had grown steadily, reaching 8.6% by May 2022.[10] To offset inflationary costs, the governor signed a $9.5 billion tax refund legislation in June 2022. The economic outlook had come full circle with widely acknowledged recession risks as inflation and interest rates rose.
- **Staffing challenges**. With continuing low unemployment and increased inflation rates, waste tire management companies (like other industries) have dealt with persistent staffing and hiring challenges, and rising wages. This is a widely cited issue for companies in all market segments covered in this report.
- **Trucking and ocean shipping costs and challenges.** Staffing shortages are particularly an issue in the trucking industry, and costs have skyrocketed in recent years. In 2022, ports continued to be severely disrupted by increased volumes and worker disruptions caused by lingering COVID breakouts, union negotiations, strikes, port closures, and other factors. As a result, shipping costs were extremely high, and securing shipping containers became extremely challenging. Exports slowed because containers were not available, and two countries declined imported baled tires for a period in 2022. In 2023, one of those two countries was again accepting baled tires, and the other had restricted the number they will accept.
- **Supply disruptions.** Companies in most market segments experienced a degree of supply disruptions. While sometimes this led to reduced production, some respondents said the main effect was merely to slow and/or complicate

ordering and scheduling of projects. Retreads had a record-breaking year in 2022, with a continued growth trajectory as there were new tire supply disruptions resulting in reduced new tire inventory, and inflationary pressures caused prices for new tires to increase that year. Retread numbers generally increase when there are economic concerns.

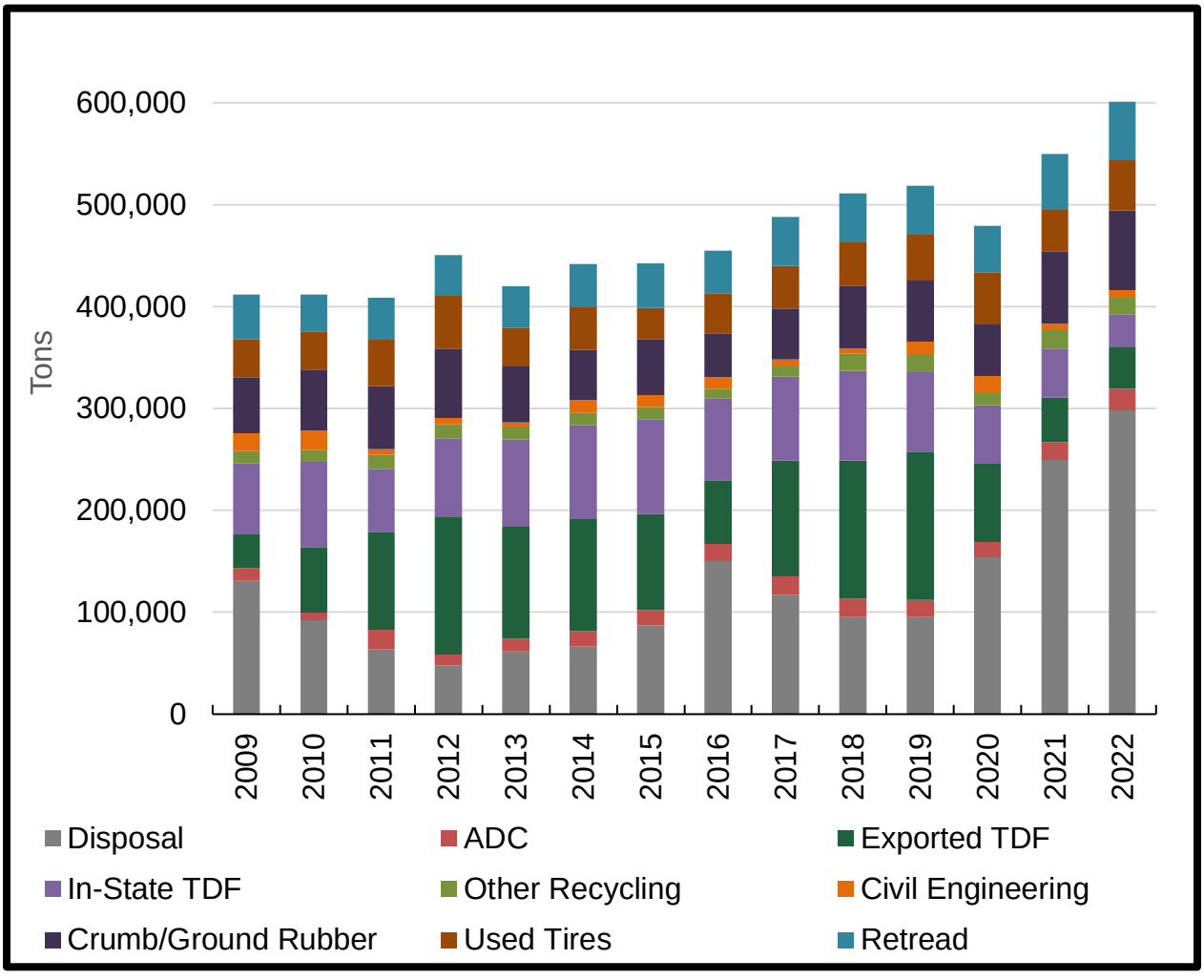
- **Potential global marketplace changes.** Disruptions and uncertainty were poised to affect the waste tire industry in 2023 and 2024. International demand for TDM is slightly increasing, potentially growing California's export of TDM in the future. Increased imports of inexpensive truck tires can likely decrease the national retread market. The recent invasion of Ukraine and other wars on various fronts have disrupted flows of many commodities, leading to broader shipping and economic changes. International politics can, and often do, change our local and world marketplace. Global politics can shift the focus of economic activity through the world's growing connectedness and movements in capital, people, and information; and the acceleration in the scope, scale, and economic impact of technology. The impact of these dynamics is felt worldwide in the nation, in California, and our local markets.

4. Trends by Market Segment

4.1 Historic Trends

Figure 4 shows the long-term trend in uses of California-generated waste tires and TDM, while Table 2 (on the next page) provides additional detail for the past three years. These findings are based exclusively on California-generated waste tires, excluding imports. The flow estimates do not include buffing materials from retread operations. Appendix B describes the report methodology. The remainder of Section 4 describes trends within each market segment.

Figure 4 Historical Market Trends for California-Generated Waste Tires and TDM by Segment, 2009-2022



See Figure 4 source data in Appendix C.

Table 2 summarizes the estimated end uses of California end-of-life tires in tons, by category, and shows the respective percentage of Total Managed for years 2019-2022, along with the percentage change from 2021 to 2022.

The Retread, Used Tire, Crumb/Ground Rubber, Tire Derived Aggregate, and Other Recycling categories are combined and referred to as the subtotal Recycled. Tire Derived Fuel, Bailed Tires and Treads, and Landfill Alternative Daily Cover are combined and referred to as sub-total Disposal Related. Landfill Disposal is the tonnage of end-of-life tires going directly to the landfill as waste material.

As shown in Table 2, the subtotal Recycled category increased tonnage from 2021 to 2022 by 8.1%. The Total Managed tonnage increased from 2021 to 2022 by 8.9%. Although the Recycled tonnage increased, the overall Total Managed increased by 0.8% more. This resulted in the subtotal Recycled category percentage of the Total Managed for 2022, 34.7%, to be less than the previous year's value of 35%. The Disposal Related subtotal decreased by 13.4% from 2021 to 2022. While the Landfill Disposal subcategory increased by 19.5% from 2021 to 2022.

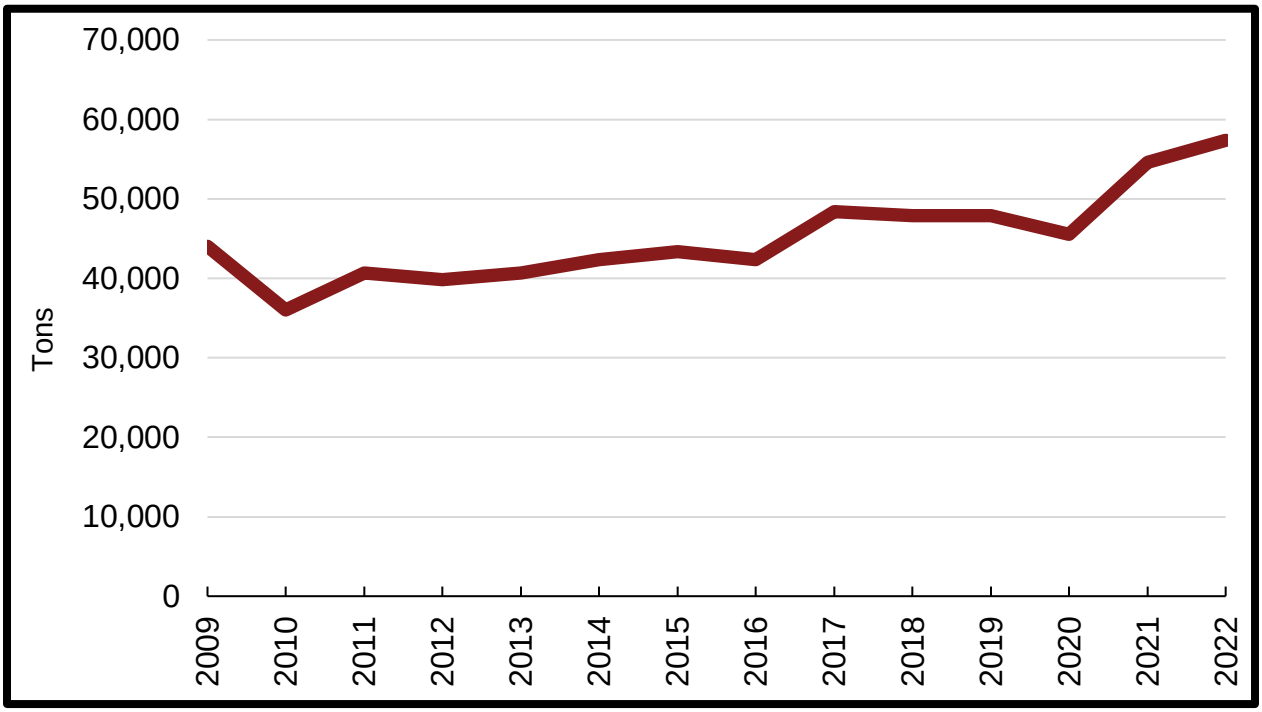
Table 2 Estimated End-Uses for California-Generated Waste Tires, 2019 – 2022

Category	2019 Tons	2019 M PTEs	2019 %Total	2020 Tons	2020 M PTEs	2020 %Total	2021 Tons	2021 M PTEs	2021 %Total	2022 Tons	2022 M PTEs	2022 %Total	2021 - 2022 % Tons Change
Retreads	47,925	4.8	9.2%	45,529	4.6	9.5%	54,635	5.5	9.9%	57,366	5.7	9.5%	5%
Used Tires	44,757	4.5	8.6%	51,036	5.1	10.7%	43,044	4.1	7.8%	49,112	4.9	8.2%	14.1%
Crumb Rubber and Ground Rubber	59,985	5.7	11.6%	50,530	5.1	10.5%	70,862	7.1	12.9%	78,341	7.8	13.0%	10.6%
Tire-Derived Aggregate	13,330	1.3	2.6%	16,911	1.7	3.5%	6,575	0.7	1.2%	7,371	0.7	1.2%	12.1%
Other Recycling	16,442	1.6	3.2%	11,862	1.2	2.5%	18,082	1.8	3.3%	16,587	1.7	2.8%	-8.3%
Sub-Total, Recycled	**182,438**	**18.0**	**35.2%**	**175,868**	**17.6**	**36.7%**	**193,197**	**19.1**	**35.0%**	**208,777**	**21**	**34.7%**	**8.1%**
Tire-Derived Fuel (In-State)	78,307	8.0	15.1%	57,611	5.8	12.0%	48,243	4.8	8.8%	32,457	3.2	5.4%	-32.7%
Tire-Derived Fuel (Export)	114,427	11.4	22.1%	73,412	7.3	15.3%	40,148	4.0	7.3%	37,037	3.7	6.2%	-7.7%
Baled Waste Tires and Truck Tire Treads (Export)	30,985	3.1	6.0%	3,200	0.3	0.7%	3,516	0.4	0.6%	3,500	0.4	0.6%	-0.5%
Landfill Alternative Daily Cover	16,784	1.7	3.2%	14,876	1.5	3.1%	17,440	1.7	3.2%	21,169	2.1	3.5%	21.4%
Sub-Total, Disposal Related	**240,503**	**33.5**	**46.4%**	**149,099**	**14.9**	**31.1%**	**109,347**	**10.9**	**19.9%**	**94,163**	**9**	**15.7%**	**-13.9%**
Landfill Disposal	**95,412**	**9.3**	**18.4%**	**154,050**	**15.4**	**32.2%**	**249,377**	**24.9**	**45.4%**	**298,084**	**30**	**49.6%**	**19.5%**
Total Managed	**518,353**	**51.5**	**100.0%**	**479,017**	**47.9**	**100.0%**	**551,921**	**55.0**	**100.0%**	**601,023**	**60**	**100.0%**	**8.9%**
Whole Waste Tire Imports	5,698	0.6	1.1%	26,813	2.7	5.6%	29,540	3.0	5.4%	61,874	6	10.3%	109.5%

4.2 Retreading

Retread companies experienced an extraordinarily strong year in 2022, with continued growth extending into 2023. Figure 5 shows an estimated 5% increase in retread tires in 2022 compared to 2021, totaling 57,366 tons (5.7 million PTEs, or 9.5% of all waste tires managed). Based on interviews with California and national industry professionals, this data was reportedly caused by significant supply chain disruptions that affected new tire supplies and increased new tire pricing. Retread businesses capitalized on this trend by fortifying their inventory, enabling them to seize the growth opportunity. The bus and commercial truck tire demand for retread tires remains high, despite ongoing challenges related to rubber supply and workforce availability. The Retread industry appears to be sustaining moderate growth into 2023. CalRecycle's Retread Tire Services Contract (2020 – 2022), contracted to DK Enterprises, conducted a series of seven virtual Retread Plant Tour Workshops, produced a video and marketing material. These workshops, by the seven leading retread and new tire manufacturers, were aimed to educate fleet managers about retreads. Additional educational materials on retread tires are available on CalRecycle's website.

Figure 5 Estimated California-Generated Retread Tire Shipments, 2009-2022



See Figure 5 Source Data in Appendix C.

4.3 Used Tires

In 2022, an estimated 49,112 tons of used tires (4.9 million PTEs, or 8.2% of all waste and used tires managed) were culled from the waste tire stream. California Vehicle Code 27465(b) [VC] is the law that makes it a traffic offense for someone to drive a

motor vehicle with tires that have overly worn tire treads. This statute imposes a minimum tread depth of at least 1/8th inch for front tires and 1/16th inch for rear tires.

Waste tires that are no longer mounted on a vehicle but are still suitable for use on a vehicle in California are considered used tires. The used tires are distributed for resale in tire shops throughout California. Similarly, importers of used tires in Mexico purchase a small portion of used tires managed in California, which are to be resold at tire shops in Mexico. Tires purchased by importers in Mexico are subject to an import quota enacted by the Government of Mexico, limiting importation of used tires to approximately 640,000 used tires per year. Regulations in Mexico also require importers of used tires to be registered as an importer and pay an import fee for each tire. The market for used tires within California proves to be profitable and is expected to remain consistent in 2023.

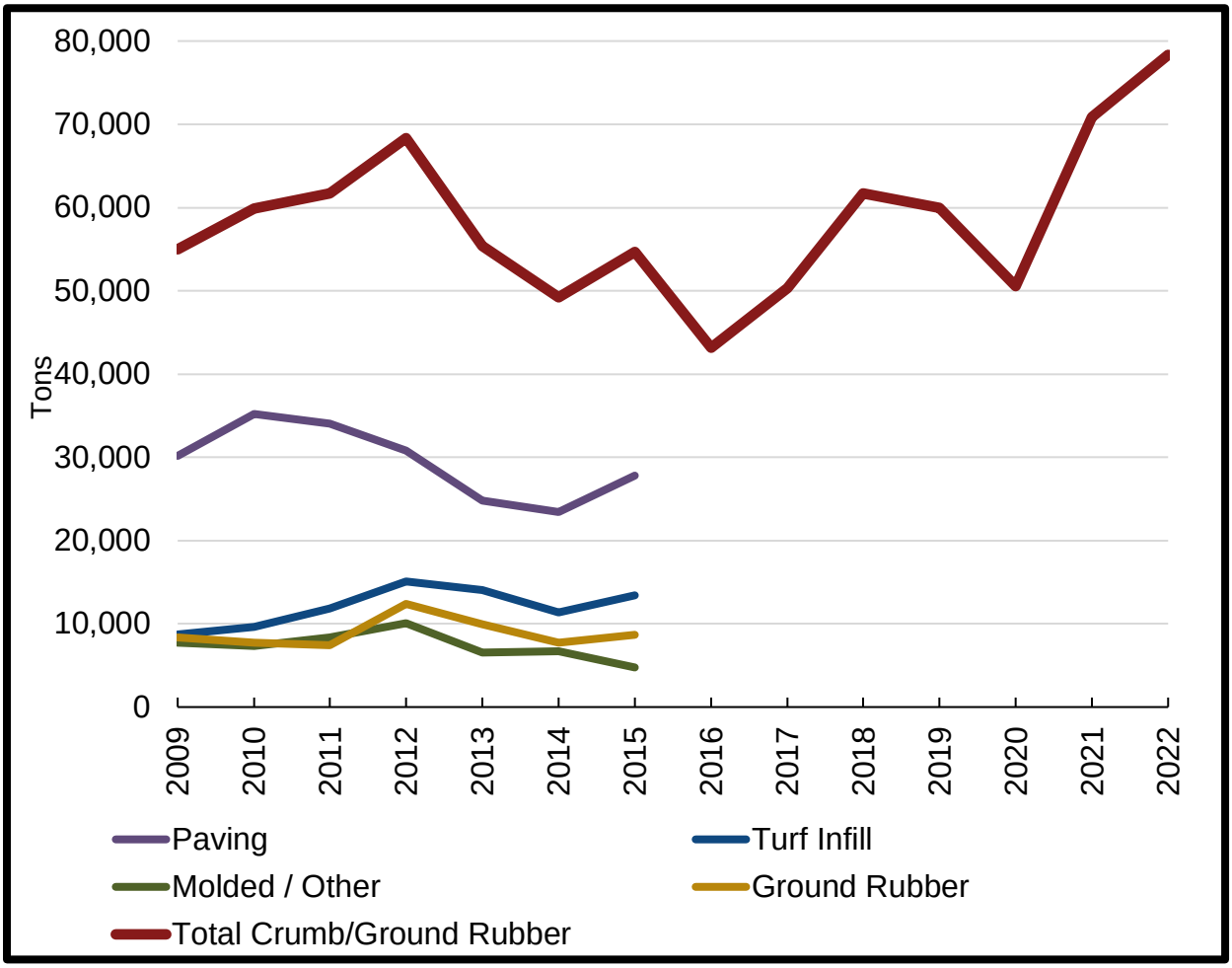
4.4 Crumb Rubber and Ground Rubber

In this report, crumb rubber and ground rubber are combined into a single category for the purpose of reporting total quantities shipped, as shown in Figure 6 below and Table 2 above. However, there is some differentiation of four subcategories of crumb/ground rubber uses. The categories are:

- Paving and chip seal surface treatments.
- Infill used on synthetic turf athletic fields and sport and playground surfacing applications.
- Molded and other products (e.g., flooring, roofing, ADA transition ramps, traffic safety devices, mats, and tiles, etc.).
- Miscellaneous products and uses made with ground rubber, including landscape surfaces, loose-fill playgrounds, and some ballistics applications, among others.

As illustrated in Figure 6, estimated shipments of California-generated crumb rubber and ground rubber increased by 10.6% in 2022, totaling 78,341 tons (156.7 million pounds, 7.8 million PTE, or 13% of all waste tires managed). This two-year upward trend followed declines in 2019 and 2020. A detailed description of trends for each subcategory follows Figure 6.

Figure 6 Shipments of California-Generated Crumb Rubber and Ground Rubber, 2009-2022



See Figure 6 source data in Appendix C.

In addition to crumb rubber and ground rubber, raw and screened buffings of different specifications also are used in certain TDPs (e.g., molded products, playground surfacing, and landscape mulch). Buffings are removed from the tread of a retreaded tire and are produced as a byproduct of the retreading process. We estimate that well over 15 million pounds of buffings were shipped to users by California retread businesses in 2022. To avoid double counting, buffing materials are not included in recycling tonnage because the retreaded tires they originated from are already counted. As of 2023, buffings continue to be in high demand. If the number of retreads declines, so does the amount of buffings used in the manufacture of TDPs.

Paving

California producers shipped 49,000 tons of crumb rubber for asphalt paving projects in 2022, an increase of over 5,000 tons from 2021. About half of all road projects are completed by municipalities and not Caltrans. Many industry representatives mentioned

they had expected more significant increases in demand by Caltrans due to the enactment of SB 1, the Road Repair and Accountability Act of 2017. However, SB 1 funds are allocated to both state and local jurisdictions and are used for various infrastructure improvements, many that do not involve rubberized asphalt placement or use. That, along with environmental concerns and Caltrans staffing changes, have resulted in an increase in bids for materials and services other than rubberized asphalt paving.

Caltrans used approximately 2.7 million metric tons of hot mix asphalt in 2022, a decrease from the 2021 value of 3.28 million metric tons. Of the hot mix asphalt used by Caltrans in 2022, 35.8% was rubberized and reflects the 34 million pounds of crumb rubber used, a decrease from the previous year's 45 million pounds used in rubberized hot mix asphalt (RHMA) placement by Caltrans.

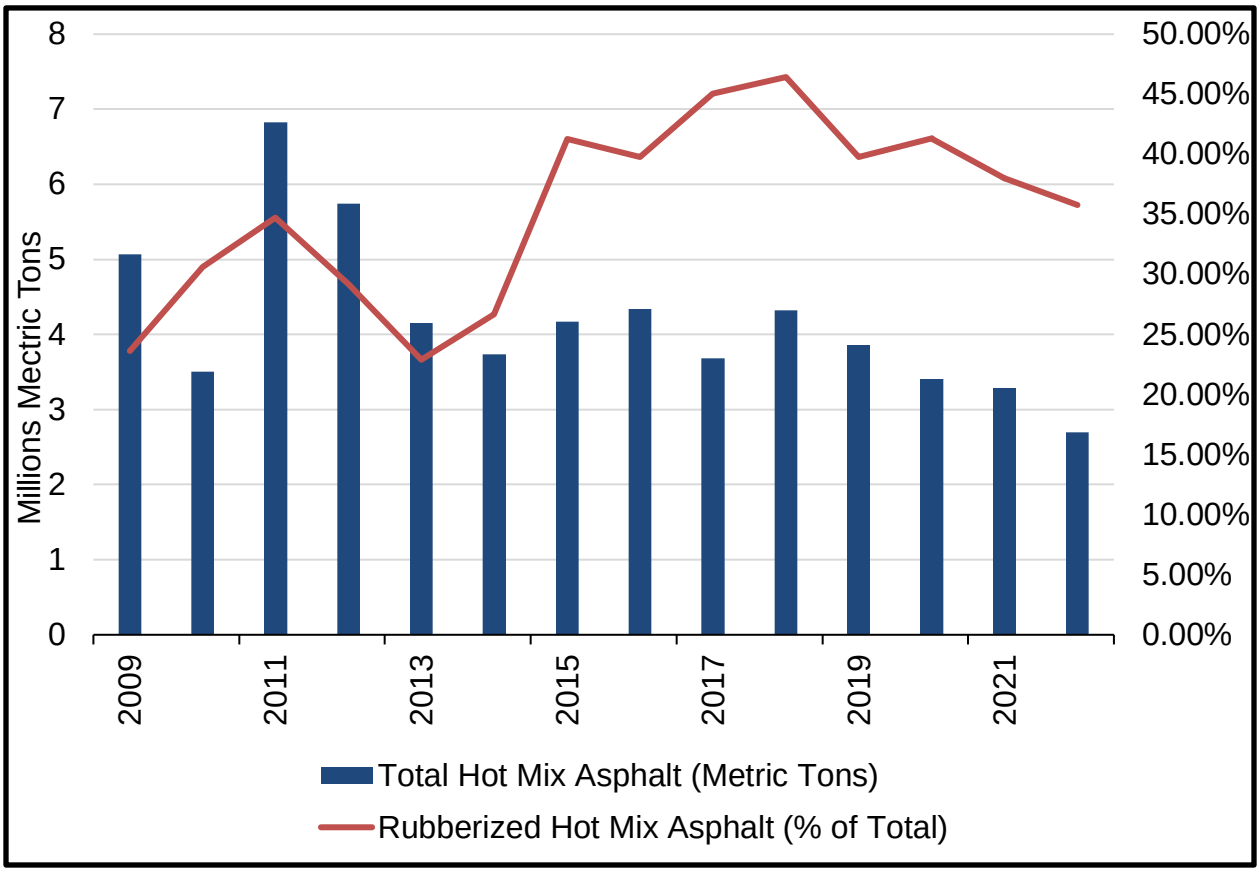
Figure 7 illustrates this trend, showing reductions in the total amount of asphalt placed over the past four years. While Caltrans has satisfied the mandate that at least 35% of its paving projects be RHMA, the actual percentage has declined in recent years.

Since 2018, the RHMA percentage decrease has a general correlation to the total hot mix asphalt placed. However, in the future, Caltrans is expected to meet its mandated percentage of rubber usage in hot mix asphalt, therefore, we would expect the rubberized asphalt percentage to remain at 35% or greater regardless of the total amount placed.

Some survey respondents suggested a need for additional training, especially in Caltrans districts with relatively low RHMA usage rates, to reinforce policies calling for the use of RHMA as the surface of choice. CalRecycle outreach and training has been ongoing for multiple years. The current grant program for RHMA installation sees repeat local government usage and is oversubscribed, reflecting that jurisdictions are embracing the use of RHMA. CalRecycle also has previously published a basic introduction to RHMA usage to accompany outreach and training efforts. The Public Works Standards Greenbook has published standards for asphalt rubber hot mix and continues to update the standards based on new proven technologies and methods.

For smaller jurisdictions with smaller size projects, the current method of RHMA installation is slightly more costly than traditional asphalt. It has specific technical placement requirements that can reduce its attractiveness.

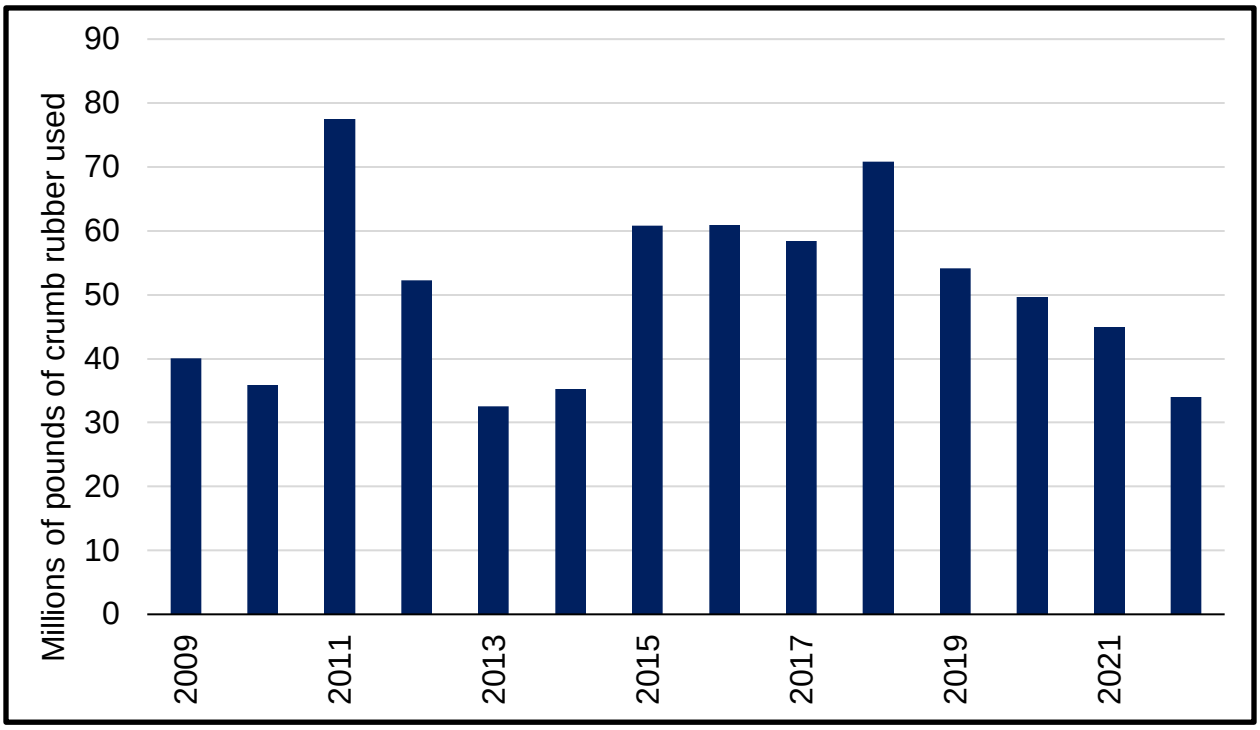
Figure 7 Caltrans Asphalt Placement and Rubberized Asphalt Percent of Total, 2009-2022 [11]



See Figure 7 source data in Appendix C.

The net pounds of crumb rubber used is depicted in Figure 8, indicating a reduction in estimated annual Caltrans crumb rubber use to about 34 million pounds in 2022. Since 2009, with removal of the 2011 and 2018 outlier points, Caltrans has used an average of 46.5 million pounds of crumb rubber each year.

Figure 8 Caltrans Annual Use of Crumb Rubber in Paving Applications, 2009-2022[12]



See Figure 8 source data in Appendix C.

Many California local governments use crumb rubber in paving projects. CalRecycle supports a portion of this use through the Rubberized Pavement Grant Program (TRP). In the most recent grant cycle for the 2022-23 fiscal year, 25 projects were approved with a combined projected total use of 8.7 million pounds of crumb rubber, intended for use in projects through the end of the grant cycle in April 2024. Historically, the program has funded an average annual use of 8.8 million pounds of crumb rubber each year. This average is based on analyzing eight years of completed grants, culminating in the 2020-21 fiscal year. Data from the most recent grant cycles are not used because, historically, the actual use is typically less than the amount estimated in grant applications due to changes or cancelations of some projects.

Molded and Other Products

Based on received survey responses, California producers shipped over 9,000 tons of crumb rubber to manufacturers and installers of molded and other products in 2022. This diverse category includes a variety of applications such as roofing, flooring, tiles, traffic sign bases, ADA (American's with Disabilities Act) transition ramps, and more. The quantity of crumb rubber feedstock consumed by firms in this category ranges widely, with some using less than 50,000 pounds per year, while a few commonly use at least five million pounds annually.

CalRecycle's Tire Incentive Program (TIP) is crucial in supporting most of the crumb rubber used in this category. The program offers direct payments to tire-derived product (TDP) manufacturers, providing 10 cents per pound for new and existing products, 40 cents per pound for feedstock conversion projects involving new use of recycled feedstock in existing products or devulcanized TDM, and 50 cents per pound for fine mesh crumb rubber of at least 50 mesh.

In the most recent TIP grant cycle for the 2022-23 fiscal year, seven companies were awarded grants, with a combined projected use of 15.6 million pounds of crumb rubber through April 2024. Based on the analysis of six years of completed grants culminating in FY 2019-20, the TIP program supported an average of 12.9 million pounds per year. It is important to note that data from the most recent grant cycles are not used because, historically, actual TDM use is typically less than the amount estimated in grant applications due to changes, postponement, or cancelation of some projects. TDM purchases and use can occur anytime within the three-year grant cycle.

CalRecycle's Feedstock Conversion Technical Assistance and Material Testing Services Contracts (FCS) (FY 2017-22) aimed to increase sales and expand demand for different and higher-value TDPs, supporting the TIP. The contractor, DK Enterprises, provided material and product testing and technical assistance services to 11 qualified candidate manufacturers, resulting in the development and production of 34 newly designed products using a minimum of 5% crumb rubber instead of another raw material. Also, over 640 certified laboratory tests were conducted through FCS. As part of its role, DK Enterprises supported the TIP by performing particle size testing as per American Society for Testing and Materials (ASTM) International Standards D5603 (Classification) and D5644 (Test Methods) for material provided by the TDM suppliers and used by the TDP manufacturers. Support was also provided to encourage participation in TIP. Additionally, the contractor produced an educational video tutorial and user guide titled, "Test and Classify the Source of Recycled Rubber Video Tutorial and User Guide," to encourage closer collaboration between the TDM suppliers and new/existing TDP manufacturers.

Turf Infill

California producers shipped 20 million pounds of crumb rubber for infill in new and replacement synthetic turf athletic fields in 2022, with some likely sold out of state. While there was a reported slight increase over 2021 of 1,618 tons, the long-term trend since 2015 has been downward. This decline is attributed to the cautious approach of California feedstock suppliers and potential users awaiting the results of the Office of Environment Health Hazard Assessment (OEHHA) study on potential health concerns.

For a small portion of replacement fields in California, the end-of-life tires crumb rubber sand mixture extracted from the dismantled fields was reused in new replacement fields. Although this practice is reportedly more common in the northeast and other U.S. regions, it is currently not widespread in California.

Other Ground Rubber Applications

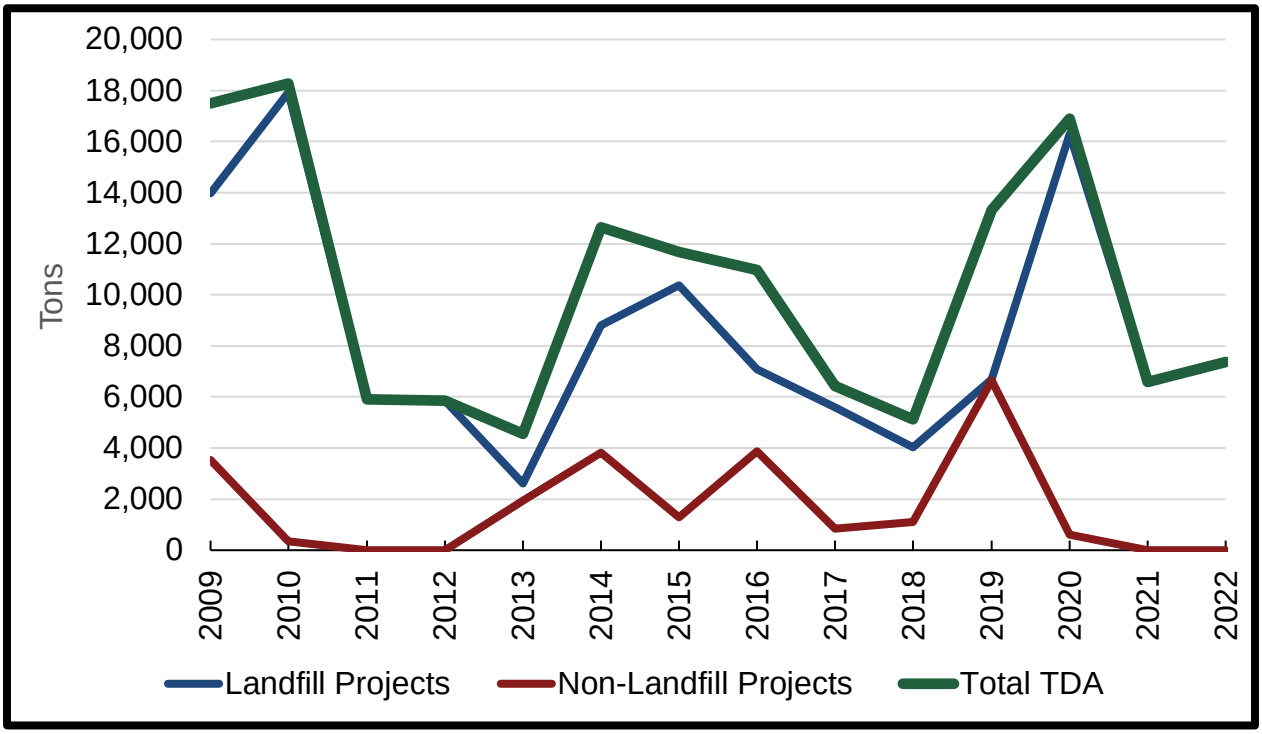
Tire-derived materials (TDM), in the other ground rubber applications category, find applications in playgrounds, landscaping, and ballistics, among other uses. California producers shipped 2,600 tons of ground rubber in 2022, reflecting a slight decrease from the 2,900 tons reported in 2021. As the California feedstock suppliers and potential TDP grant users of playground surfacing await the OEHHA study on potential health concerns, we expect to see this trend continue into 2023. CalRecycle's TDP Grant Program supports a portion of these uses. In recent years, the program has been offered every other year and was not offered in 2022. Based on an analysis of six years of completed grants culminating in the 2020-21 fiscal year, the program supported 3 million pounds per year of TDM use. Data from the most recent yet-to-be-completed grant cycles are not used because, historically, actual TDM use is typically less than the amount estimated in grant applications due to changes, postponements, or cancelations of some projects.

4.5 Civil Engineering

Figure 9 shows how the use of California-generated tire-derived aggregate (TDA) in civil engineering projects has varied in recent years. In 2022, TDA use increased by 12.1%, totaling 7,371 tons (.73 million PTEs or 1.2% of all waste tires managed), compared to the 2021 usage of 6,600 tons (0.7 million PTEs or 1% of all waste tires managed). Notably, TDA was utilized in projects at landfills, primarily related to landfill gas collection systems, although some of those uses also involved road construction. Since 2011 non landfill TDA use has historically been between 1500-4500 tons. However, there were zero non-landfill uses in 2022 due to the environmental concerns related to the recent discovery of 6PPD-q.

Outside of landfills, common TDA applications involve roadside repair, retaining wall backfill, embankment fill, stormwater infiltration galleries, and light rail vibration dampening projects, among others. Although recent environmental concerns have decreased the use of TDA in civil engineering applications, CalRecycle's TDA Grant Program support for these uses can lead to ongoing usage.

Figure 9 California-Generated Tire-Derived Aggregate Shipped for Use in Civil Engineering Projects, 2009-2022



See Figure 9 source data in Appendix C.

According to CalRecycle's TDA technical assistance team, a major contributing factor to the reduced demand for TDA is a 2020 study[13] linking a chemical known as 6PPD-q derived from tire wear particles to urban runoff mortality syndrome in coho salmon. The California Department of Toxic Substances Control's (DTSC) Safer Consumer Product Program has proposed to list motor vehicle tires containing 6PPD as a priority product, and is anticipated to be listed in 2023 Adopted Priority Product: Motor Vehicle Tires Containing 6PPD | Department of Toxic Substances Control (ca.gov). CalRecycle is currently developing investigative research to understand how 6PPD-q may relate to TDA uses and projects and how the project design can incorporate soil layer elements that will mitigate the potential release of 6PPD-q from TDA leachate to surface water or groundwater.

DTSC has also listed motor vehicle tires containing zinc as a priority product under the Safer Consumer Products program. A recent CalRecycle sponsored Humboldt State University study[14] found that the "use of rubberized hot mix asphalt pavement plays a minor role in the zinc concentration in runoff from road surfaces. Leaching of zinc from tire wear particles generated by vehicles on the roadway and from galvanized materials along the roadway are the largest sources of zinc in the runoff from roads identified in this work, and both deserve additional study."

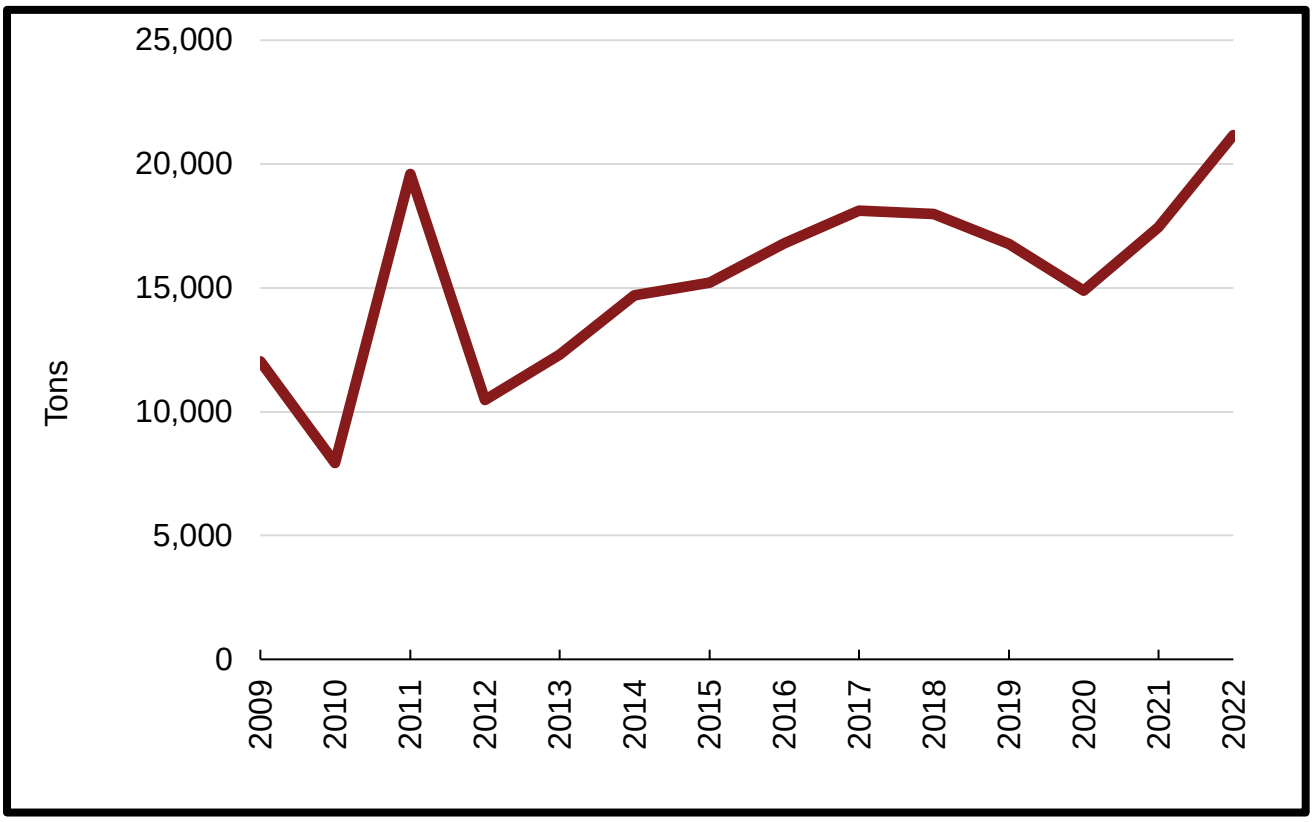
Two projects involving light rail vibration dampening are expected to use an estimated 6,700 tons of TDA in 2023. Historically, based on an analysis of eight years of

completed grants culminating in the 2020-21 fiscal year, the TDA Grant Program has supported 5,000 tons per year of TDA use. Data from the most recent grant cycles are not used because actual TDM use is typically less than the amount estimated in grant applications due to changes, postponements, or cancelations of some projects.

4.6 Landfill Alternative Daily Cover

The use of ADC is a disposal related activity, as shown in Table 2. California landfills are required to apply an approved type of daily cover to the top of active landfill faces at the end of operations each day, and all landfill permits allow the use of alternative materials, such as tire shreds. As Figure 10 shows, a significant quantity of tire shreds was used as alternative daily cover (ADC) in California. In 2022, 21,169 tons (2.1 million PTEs or 3.5% of all waste tires managed) were used as ADC. There are a few landfills that consistently have used tire shreds for ADC in the past, therefore, we expect this amount to remain relatively stable in the coming years.

Figure 10 California-Generated Tire-Derived Material Used as Landfill Alternative Daily Cover, 2009-2022



See Figure 10 source data in Appendix C.

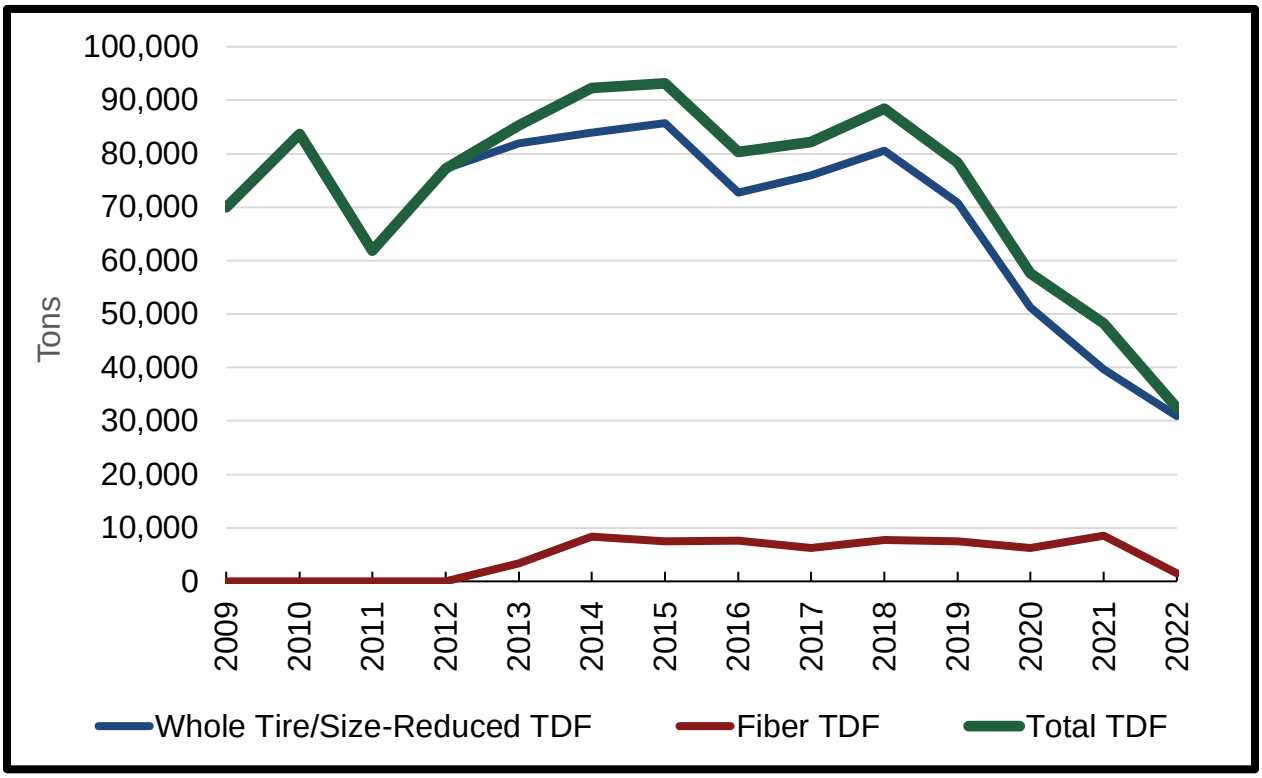
4.7 Tire-Derived Fuel (In-State)

Four California cement kilns continued to consume TDF in 2022. As illustrated in Figure 11, reported shipments of California-generated TDF declined in 2022 by 32.7%, totaling

32,457 tons (3.2 million PTEs, or 5.4% of all waste tires managed). This amount includes 12,898 tons (1.2 million PTEs) of whole waste tires and size-reduced TDF, as well as 1,500 tons of tire fiber generated as residual by processors. Despite a national increase in TDF use, its utilization in California has declined. One of the major users of TDF in 2022 changed their required fuel specification to a smaller particle size. The smaller the particle size, the more expensive it is for the TDM supplier to produce. To our knowledge, the California producers chose not to produce the smaller specifications. Cement plants consistently seek the most economical and high BTU value feedstock and may change their preferred fuel at any time.

In 2021 SB 596 was signed by Governor Newsom, which requires CARB to develop a comprehensive strategy for the cement sector to achieve a greenhouse gas emission intensity 40% below baseline levels by 2035 and net zero by 2045. During 2022 CARB sponsored workshops to identify actions to overcome barriers to achieve the net zero goals. In the future, feedstock materials will likely be evaluated and selected, based in part by their greenhouse gases (GHG) emission values. Finally, a small share of TDF consumed is comprised of residual tire fiber from processors. According to cement kiln respondents, overall use of TDF is declining. One cement company in California accepted tire fiber from California producers. The cement company dictates whether to accept materials based on their volume requirements and particle specification.

Figure 11 California-Generated Whole Waste Tires, TDF and Residual Fiber Consumed at California Cement Kilns, 2009-2022



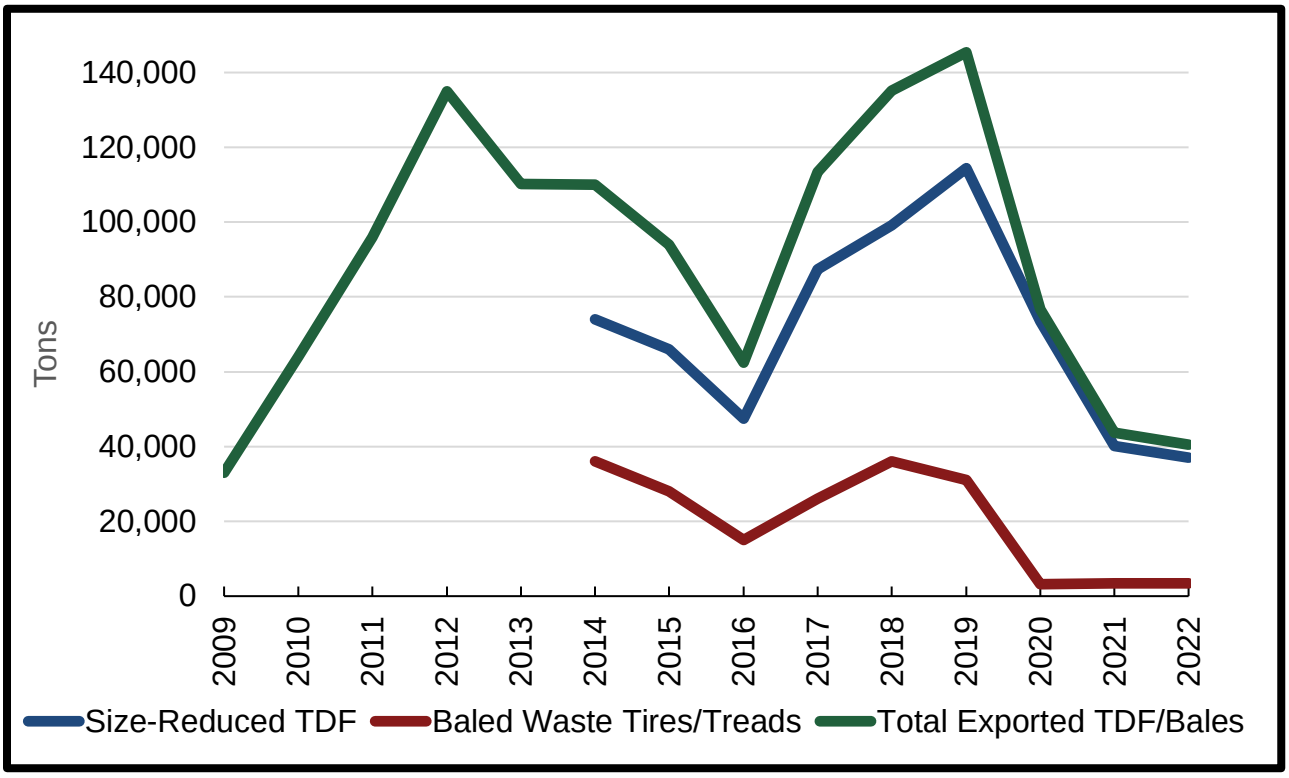
See Figure 11 source data in Appendix C.

4.8 Tire-Derived Fuel and Baled Waste Tires and Truck Treads (Export)

As Figure 12 shows, the export of California-generated TDF (e.g., size-reduced TDF, baled waste tires, baled truck tire treads) peaked in 2019 and continued to decline through 2022. Exported TDF declined by 7.2%, totaling 40,537 tons (4.0 million PTEs, or 6.7% of all waste tires managed) in 2022. Of the total TDF exported, an equivalent of 3,500 tons consisted of waste tires from out-of-state sources. Japan is the largest size-reduced TDF user, while baled waste tires and truck tire treads were shipped to India and Pakistan in 2022. Korea resumed accepting TDF in late 2022.

The combination of unavailability of shipping containers, low return for exported TDM, labor union port issues, and some countries refusing imported waste tires in 2022 led to the continued reduction of TDF exports from California. However, in 2023, the international demand for TDF and improved economic returns for California processors exporting should reflect an increase in the exported TDF from California.

Figure 12 California-Generated Exported TDF and Baled Waste Tires and Truck Treads, 2009-2022



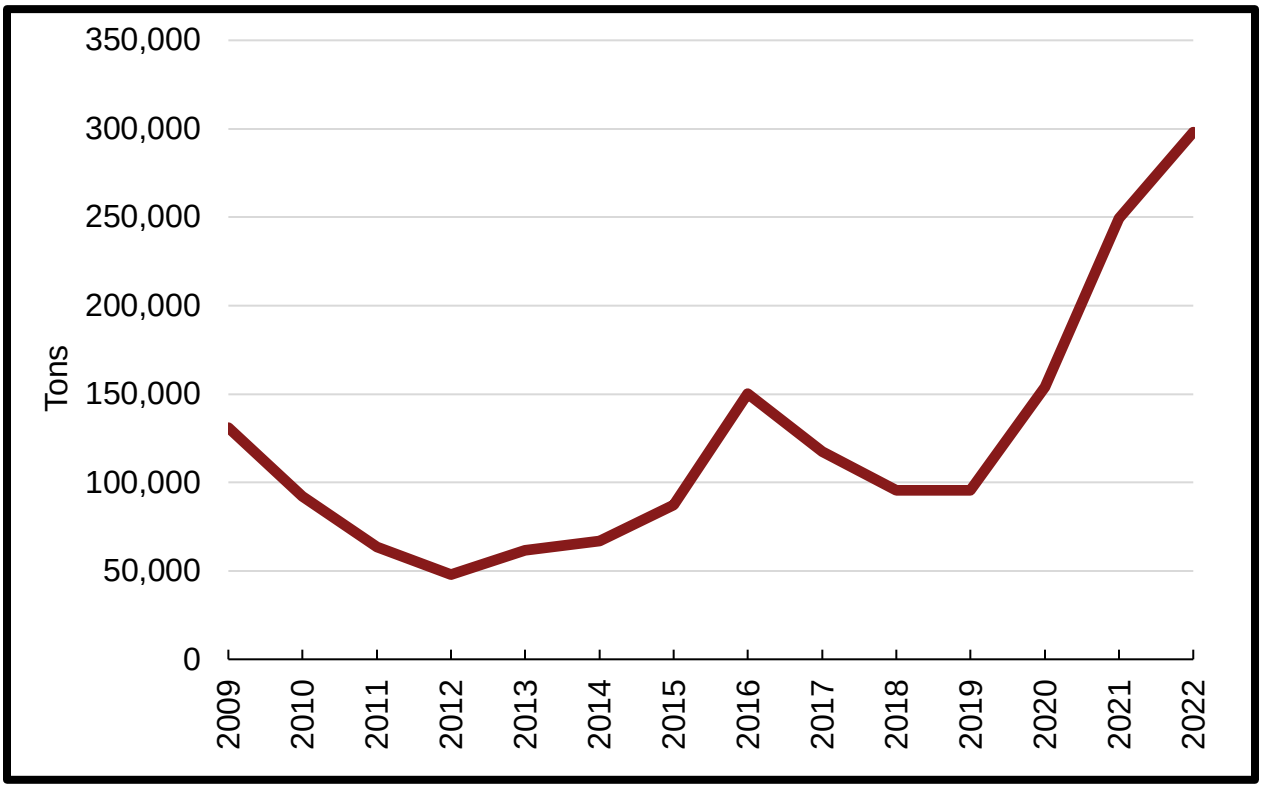
See Figure 12 source data in Appendix C.

4.9 Landfill Disposal

As shown in Figure 13, following a 61% rise in 2020, the landfill disposal of California-generated waste tires increased markedly again in 2021 by a 62% rise. The 2022 rate

of rise slowed to a 19.5% increase, reaching 298,084 tons (29.8 million PTEs or 49.6% of all waste tires managed). As discussed in Section 4.8 above, a contributing cause of the landfill disposal spikes in 2020 and 2021 was the disrupted export economics, logistical feasibility, and bans of imported TDM from previously accepting countries, leaving companies that typically export with limited options. Although some of these market trends have subsided or relaxed the total amount of end-of-life tires managed in 2022 also increased. An additional element was the TDF specification change from one California cement kiln, that processors were not interested in manufacturing, as discussed in Section 4.7 above. These circumstances prompted TDF producers and exporters to redirect waste tire flows to landfills. Landfill disposal is expected to remain high in 2023.

Figure 13 California-Generated Waste Tires Disposed in Landfills, 2009-2022



See Figure 13 source data in Appendix C.

4.10 Waste Tire Imports

In 2022, an estimated 61,874 tons (6.1 million PTEs or 10% of all waste tires managed) of whole waste tires were imported from out-of-state and flowed to a limited number of California processors. Most of the out-of-state inbound waste tires originated from Oregon and Arizona. The waste tire import tonnages are subtracted from the total managed tonnages for the respective processors and are not included in the recycling rate calculation.

5. The Outlook for Increased Waste Tire Recycling

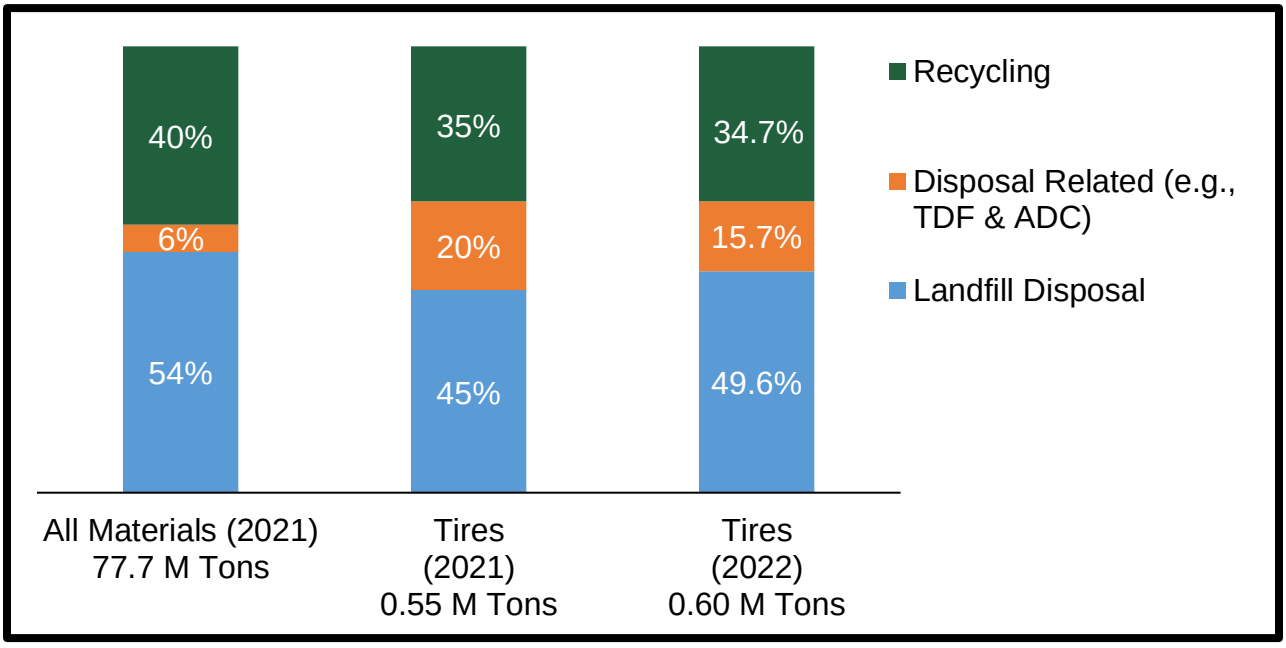
The following sections examine California waste tire management and recycling in the context of all types of waste, historical trends in waste tire recycling, and the outlook for increasing California waste tire recycling.

5.1 Waste Tire Recycling in the California Context

California has a mandatory statewide 75% recycling rate goal by 2020 for all waste types per AB 341 (Chesbro, Chapter 476, Statutes of 2011). While not codified in statute, CalRecycle has also informally adopted a 75% recycling goal specifically for waste tires. Consistent with AB 341, the recycling rate measurement excludes landfill ADC and fuel-related uses, including TDF (included in the "disposal related" category) to distinguish them from recycling (broadly defined to include reuse) and landfill disposal.

Figure 14 illustrates how California waste tire management compares to management of the entire waste stream. The figure shows the 2021 breakdown for all waste materials (the most recent data available), along with 2021 and 2022 high-level data on waste tire management for comparison.

Figure 14 Comparison of All California Waste Materials and California Waste Tires Management

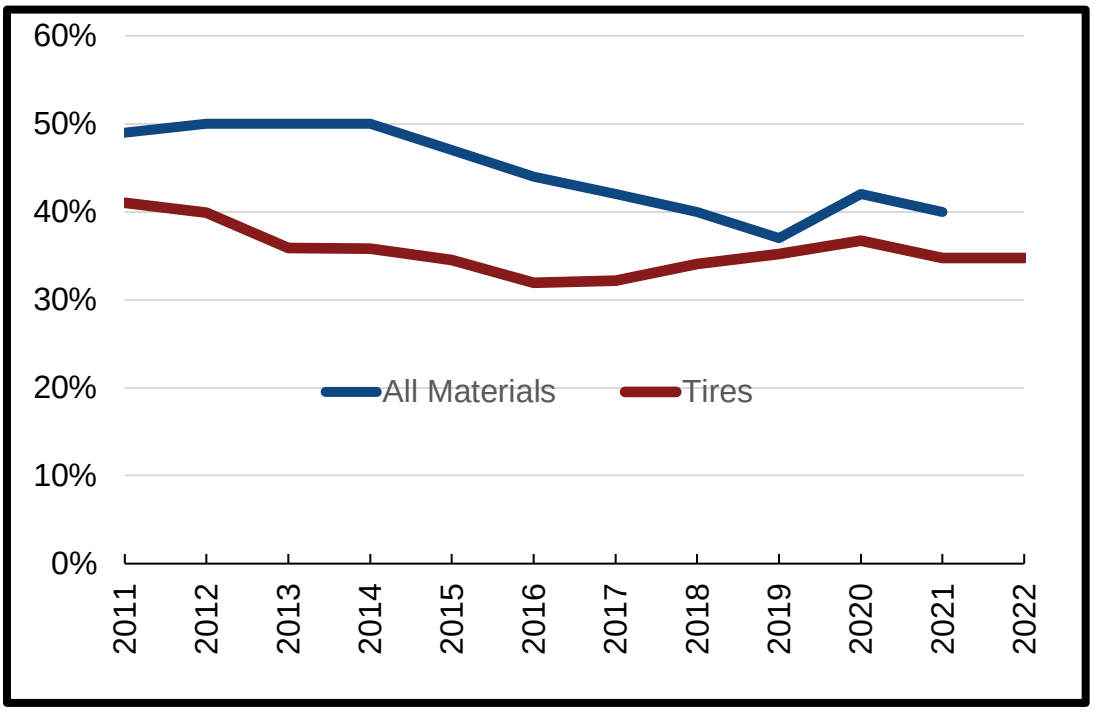


See Figure 14 source data in Appendix C. Source for all materials: State of Disposal and Recycling in California

Figure 15 shows historical recycling percentage rates for All Materials compared to waste tire recycling percentage rates. The recycled groups used in CalRecycle waste characterization studies are divided by material types and then grouped into 10 different commodity categories. These categories generally contain types made from the same base material, such as paper, glass, or organics.

Traditionally, waste tire recycling rates have been lower than All Materials recycling rates, and in recent years similar trends have been seen in the change of rates for both All Materials and Tires. Based on interviews with industry experts, changes that affect the overall state recycling market generally are reflected in both rates simultaneously. The period from 2020 to 2022 likely reflects that the same general economic marketplace shifts have influenced changes in the tire recycling market and the total recycling market rates.

Figure 15 California All Waste Materials and California Waste Tires Recycling Rates, 2011-2022



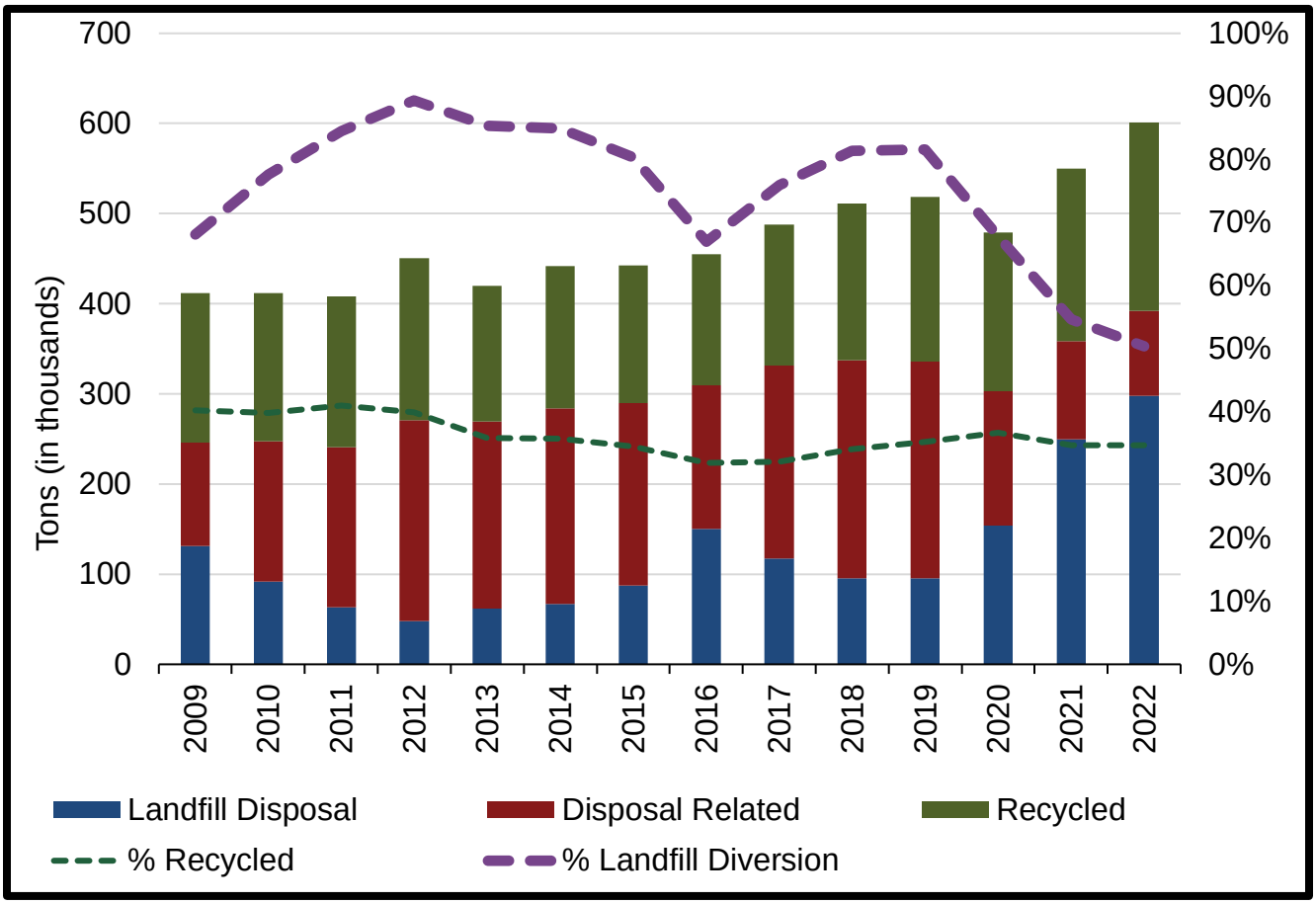
See Figure 15 source data in Appendix C.

5.2 Historic Recycling, Disposal Related and Landfill Disposal Trend

As shown in Figure 16, the California waste tire precent recycled rate has fluctuated within a narrow range over the past 12 years. The rate reached a low point in 2016 of 32% but has increased slowly since then, reaching 37% in 2020. Subsequently, in 2021, recycled tons increased by 10% to 193,197 tons (19.1 million PTEs or 35% of all waste tires managed). However, at the same time, the percent recycled rate declined by 2.0 percentage points to 35% because the overall growth in waste tire generation outpaced the increase in recycled tons. This pattern persisted in 2022, with the percent recycled

rate remaining relatively stable at 34.7%, despite an 8.1% increase in recycled tons to 208,777 tons.

Figure 16 California Waste Tire Recycling, Disposal Related and Landfill Disposal Trend, 2009-2022



See Figure 16 source data in Appendix C.

5.3 Future Tire Recycling Trends and Considerations

Table 3 summarizes the short-term outlook for each market segment in 2022, building on the trends identified earlier in this report. Predicting growth in 2023 and 2024 presents challenges, but here are several considerations:

- **Sustainability of 2022 Recycling Gains.** The report highlights a 5% increase in retreading and a 10.6% growth in the crumb rubber/ground rubber market segment in 2022. Initial feedback suggests retreading is on track for continued growth in 2023. The crumb rubber markets, especially in the local government paving and molded/other segments appear strong with the potential for further growth.

- **Emergence of new products and markets.** The Tire Incentive Program in 2023 supports manufacturers utilizing crumb rubber in tire-derived products. Industry professionals recognize that new markets and applications need to be developed for all sizes of TDM, not just crumb rubber. Growth and investment in tire recycling are constrained by economic forecasts in California and increased regulatory and environmental concerns surrounding TDM use.
- **Continuation of Disruptions.** Unfortunately, the primary disruptions impacting waste tire management and recycling companies, summarized in Section 3, do not appear to have subsided in 2022. Persistent challenges include staffing shortages, elevated trucking and ocean shipping costs, inflation, and supply disruptions across various commodities and products. Some market segments may benefit from distribution disruptions, such as retread gains due to distribution delays, inflation, and trucking costs. However, these challenges are likely to continue to constrain efficient business operations and market expansion in most waste tire management and recycling industry segments by adding complications and costs.
- **Impact of Business Ownership Changes and Investments.** In 2022, the industry witnessed changes and consolidations in TDP manufacturers, retread, and other market segments, with the long-term impact yet to be fully realized. Investments that align with customer needs, especially in high-volume applications, can potentially drive tire recycling expansion.

Table 3 The Outlook for California Waste Tire Recycling

Category	2022 Tons	2022 M PTEs	2022 % Total	Outlook Toward 2023
Retreads	57,366	5.7	9.5%	Stable after record-breaking years in 2021 and 2022, with expected growth to continue
Used Tires	49,112	4.9	8.2%	Used tires remain steady
Crumb Rubber and Ground Rubber	78,341	7.8	13%	Steady increase if infrastructure and rubber pavement placement continue to grow
Tire-Derived Aggregate	7,371	0.7	1.2%	Relatively steady landfill use, new grant-funded light rail projects 2023
Other Recycling	16,587	1.6	2.8%	Stable usage expected, 2022 saw some businesses closed or changed ownership
Total Recycling	**208,777**	**20.8**	**34.7%**	**Same percentage as 2022 although increased tonnage**
TDF (In-State)	32,457	3.2	5.4%	Stable rate of use for TDF, continued CARB analysis of feedstock
TDF (Export) and Bales	40,537	4.0	6.7%	Expected increases in exported TDF due to international demand
Landfill Alternative Daily Cover	21,169	2.1	3.5%	Slight increase, steady use at a few landfills
Total Disposal Related	**94,163**	**9.4**	**15.7%**	**Stable to slight increase, related to stable ADC usage and TDF export demand**
Landfill Disposal	298,084	29.8	49.6%	Slight increase, total tonnage managed and TDF export challenges influence the increase or decrease in landfill disposal
Overall Diversion	302,940	30.2	50.4%	Stable
Waste Tires Managed	601,024	55.2	100.0%	Slight increase based on strong economics, increasing passenger tire size and EV

5.4 Concluding Remarks

California has a robust and diverse waste tire management infrastructure. In the upcoming years, there is potential for growth in recycled tire tonnages, especially within the retread, paving, and molded/other market segments. Recent changes in business ownership and investments to expand or enhance waste tire recycling operations may further bolster this positive trajectory. However, the industry disruptions discussed earlier do not appear to be diminishing as of 2023. A crucial need for ongoing expansion and diversification in TDP markets is necessary to sustain growth. Developing and expanding CalRecycle programs that promote existing and new markets may be advantageous.

CalRecycle has multiple ongoing programs aimed at improving recycling. They include the Rubberized Pavement (TRP) Grant Program, the Tire Incentive Program (TIP), and the Tire Derived Aggregate (TDA) Program.

With added waste tire volume from the expansion of electric vehicles (EVs) and production of new larger original equipment manufacturer (OEM) tires, the waste tire industry expects to see future increases in waste tire generation. Heavier vehicles, which include EVs, use tires up to 30% faster and the annual sales of EVs is projected to increase by 50% by the end of 2023[15]. This, along with the trend of new OEM tires being larger and therefore comprised of more rubber material, is contributing to an increase in the yearly waste tire tonnage of California and the nation.

With the potential increases in waste tire tonnage on the horizon, it may be beneficial for the tire program to explore new ways to promote source reduction. Source reduction activities can include promoting proper tire maintenance and methods for tires to last longer on a vehicle, carpooling, public transportation use, and bicycle and pedestrian pathway use.

While the conditions for a transformative leap in tire recycling might not be fully established, there is promising potential for incremental progress. California’s waste tire management program remains strong, ensuring effective management of the state’s generated waste tires.

Appendix A Glossary of Key Terms and Acronyms

6PPD: An organic chemical widely used as stabilizing additive (or anti-degradant) in rubbers; all of which are common in vehicle tires. Although it is an effective antioxidant it is primarily used because of its excellent antiozonant performance. It is one of several antiozonants based around p-phenylenediamine.

6PPD-q: 6PPD-quinone is an oxidation product of 6PPD, an additive intended to prevent damage to tire rubber from ozone.

ADA: American's with Disabilities Act.

ADC: Alternative daily cover used at landfills instead of soil.

ASTM: American Society for Testing and Materials.

BTU: British thermal unit.

Buffings: Tire rubber produced as a by-product of the tire retreading process and use.

California-generated: As used in this report, this term refers to waste tires generated in California and/or tire-derived materials or products made from waste tires generated in California, excluding any amounts derived from waste tires imported into California.

Caltrans: California Department of Transportation.

CalRecycle: California Department of Resources Recycling and Recovery.

CARB: California Air Resources Board.

Circular economy: An economic system where products and services are traded in closed loops or cycles. It tackles global challenges like climate change, biodiversity loss, waste, and pollution. Circular Economy aims to redefine growth, focusing on positive society-wide benefits. It is based on three principles: Design out waste and pollution; keep products and materials in use; regenerate natural systems.

Crumb rubber: Tire-derived material equal to or less than ¼ inch in size, free of wire and fiber. In this report the broad category Crumb Rubber and Ground Rubber is defined to include the following three sub-categories of products made from crumb rubber:

- Paving, including rubberized hot mix asphalt and chip seal surface treatments.
- Infill used on synthetic turf athletic fields and other sports surfacing applications.

- Molded and other products that use crumb rubber include flooring mats and tiles, ADA transition ramps, traffic safety related products, plumbing coupling fittings, and roofing.

CTL: Comprehensive trip log. Paper or electronic forms used by haulers and waste tire facilities to document waste and used tire pickup or delivery transactions. Forms are submitted to CalRecycle and entered in the Waste Tire Manifest System database.

Disposal-Related Activities: As defined in CalRecycle's annual State of Disposal and Recycling Reports, a set of activities considered as part of overall disposal: alternative daily cover, alternative intermediate cover, other beneficial reuse at landfills (such as construction activities, landscaping, and erosion control), transformation, engineered municipal solid waste, and waste-tire derived fuel.

DTSC: Department of Toxic Substances Control.

EVs: Electric vehicles.

ELT: End-of-life tire**.** Refers to tire products that have reached the end of their useful life and are ready to be discarded and managed, whether through reuse, recycling, landfill disposal, or another means.

FCS: CalRecycle's Feedstock Conversion Technical Assistance and Material Testing Services.

Feedstock conversion: The process whereby a manufacturer converts a portion of the raw materials (e.g., virgin rubber, EPDM, plastic, aggregate, or other raw material) used to make a product with recycled tire rubber.

GHG: Greenhouse gases.

Ground rubber: The tire-derived material is larger than ¼ inch and up to one inch in size. For some applications, the material is referred to as landscape nuggets. It is also used in walkways, playground applications, and ballistic walls. In this report Ground Rubber is also a sub-category of products within the broader Crumb Rubber and Ground Rubber category that includes any product made with ground rubber.

Landfill disposal: Disposal of waste materials at a landfill, excluding materials disposed as part of LFG and ADC activities.

LFG: Landfill gas**.** LFG can be captured, converted, and used as a renewable energy resource.

OEHHA: California Office of Environmental Health Hazard Assessment.

OEM: Original equipment manufacturer.

PTE: Passenger tire equivalent. Defined as 20 pounds of tire rubber for the purpose of making consistent comparisons in this and other reports. (The actual weight of waste passenger tires may vary considerably.)

Retread tire: A quality casing satisfying established standards to which a new tread has been affixed to extend the usable life of the tire.

RHMA: Rubberized hot mix asphalt.

TDA: Tire-derived aggregate. Tire-derived material used to replace conventional aggregates like rock in civil engineering applications.

TDF: Tire-derived fuel. Whole waste tires or tire-derived material consumed as fuel (referred to as size reduced TDF in this report). Residual tire fiber from crumb rubber operations sent used as fuel in California cement kilns is also categorized as tire-derived fuel in this report.

TDM: Tire-derived material. Tires processed to meet market specifications, for example, crumb rubber, ground rubber, tire-derived aggregate, and tire-derived fuel.

TDP: Tire-derived product. Product made entirely or in part from tire-derived material.

TIP: Tire incentive program. A CalRecycle program launched in June 2015 to promote feedstock conversion and the use of crumb rubber as feedstock by California manufacturers.

Used tire: 30 PRC § 42806.5 defines "used tire" as a tire that: a) is no longer mounted on a vehicle but is still suitable for use as a vehicle tire; b) meets applicable requirements of the Vehicle Code and Title 13 of the California Code of Regulations; and c) meets specified storage requirements.

WTMS: Waste tire manifest system. Waste Tire Management System. A CalRecycle database containing information on waste tire management firms, permits, and submitted comprehensive trip log data.

Waste tire: 30 Public Resources Code (PRC) § 42807 defines a "waste tire" as a tire that is not mounted on a vehicle and is no longer suitable for use as a vehicle tire due to wear, damage, or deviation from manufacturer original specifications.

Appendix B Methodology

The main goal of the annual Waste Tire Market Report series is to document California waste tire recycling trends, the recycling rate, and the quantity of California-generated waste tires managed (including used tires and retread tires) along with trends in each segment they ultimately flow to.

Conducting the annual market analysis involves the following steps:

- Update a list of currently operating California facilities and companies waste tire management, including processors, TDP manufacturers and installers, asphalt rubber blender operators, brokers, retreads, cement kilns, and landfills that dispose waste tires. Sources include CalRecycle databases, industry networking, and online searching.
- Compile information on these facilities through surveys, CalRecycle databases (especially the Waste Tire Manifest System) and online searches.
- Enter facility specific data into a customized flow model spreadsheet and systematically analyze flows, with emphasis on flows to and from waste tire facilities to end-use market segments. This is an iterative process in which researchers identify issues and repeatedly follow up with facilities to refine and validate the analysis. The process continues until researchers conclude that the findings are as complete and accurate as possible while avoiding double-counting.
- Where data are unavailable or contradictory, estimations are made based on the information available, and perspectives offered by industry representatives.

Readers should keep the following in mind when interpreting and using findings:

- Findings reported in the main body of the report are rounded to the nearest one hundred tons, reflecting a reasonable level of accuracy. However, the underlying source data used to generate charts, as presented in Appendix C, lists the exact numerical estimates generated using the customized flow model.
- The findings quantify California-generated waste tires and TDM/TDPs made from waste tires. Imported waste tires and TDM/TDPs made from them are excluded from the California-generated findings, as are buffings from retread operations since the rubber has already been “counted” as part of the retreading process.
- The findings do not represent estimates of California’s total market for TDM or TDPs.
- The waste tire market report series employs a consistent methodology that the authors strive to refine and improve over time. This includes extensive

data gathering and validation through multiple sources wherever possible, and rigorous and systematic data analysis. Because of this, despite the need to address data gaps and inconsistencies, the authors believe the findings provide reasonably accurate information that can be used to evaluate trends over time.

Appendix C Accessibility Notes and Source Data

Following is the source data used for charts and figures in this report. Note that in the body of the report, findings are rounded to the nearest one hundred, reflecting a reasonable level of accuracy. However, in this appendix we present the exact estimates as generated in the waste tire flow model used by the study team to produce charts that reflect the best information available.

Supporting data for Figure 7 and 8 is derived from Caltrans annual Crumb Rubber Reports. (2022 data are draft estimates based on discussion with Caltrans representatives.)

Table C-1 Source Data for Figure 1 California Waste Tire Flows in 2022

Category	2022 Tons	2022 Percent
Retreads	57,366	9.5%
Used Tires	49,112	8.2%
Crumb/Ground Rubber	78,341	13.0 %
Tire-Derived Aggregate	7,371	1.2%
Other Recycling	16,587	2.8%
Tire-Derived Fuel (In-State)	32,457	5.4%
Tire-Derived Fuel (Export)	37,037	6.2%
Exported Baled and Cut Waste Tires	3,500	0.6%
Alternative Daily Cover	21,169	3.5%
Landfill Disposal	298,084	49.6%
Total Managed	**601,024**	**100.00%**
Total Recycled	**208,777**	**34.7%**
Total Disposal Related	**94,163**	**15.7%**

Table C-2 Source Data for Figure 2 California Waste Tire Recycling, Disposal Related and Disposal Trends, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Landfill Disposal	131,152	92,033	63,444	47,908	61,682	66,770	87,170
Disposal Related	114,968	155,603	177,500	222,695	207,754	217,043	202,382
Recycled	165,997	164,206	167,516	179,768	150,741	158,094	152,767
% Recycled	40.3%	39.9%	41.0%	39.9%	35.9%	35.8%	34.5%
% Landfill Diversion	68.2%	77.7%	84.5%	89.4%	85.3%	84.9%	80.3%

Category	2016	2017	2018	2019	2020	2021	2022
Landfill Disposal	150,226	117,448	95,401	95,412	154,050	249,377	298,084
Disposal Related	159,654	213,707	241,597	240,503	149,099	109,347	94,163
Recycled	145,288	156,994	174,264	182,438	175,868	193,197	208,777
% Recycled	31.9%	32.2%	34.1%	35.2%	36.7%	35.0%	34.7%
% Landfill Diversion	67.0%	75.9%	81.3%	81.6%	67.8%	54.8%	50.4%

Accessibility Notes for Figure 3, California Waste Tire Recycling Industry Flow Chart

This chart illustrates how California waste tires, tire-derived material (TDM), and tire-derived products (TDPs) flow between various entities. Haulers pick up waste tires from generators and may deliver them to either a landfill for disposal, a processor (who may produce TDM), a used tire buyer or seller, or a TDF consumer (i.e., one of four California cement kilns). Processors may dispose of whole tires or size-reduced material at a landfill or divert the size-reduced TDM for use in the following: civil engineering projects and other beneficial uses; for sale as used tires; for use as a compound mix in the manufacture of TDPs and installed applications; and TDF use at cement plants in the production of cement. Imports into California and exports from California include Whole waste tires, TDM and TDPs, retread tires and buffings, used tires, tire-derived fuel (size-reduced tires, baled waste tires and truck tire treads). Such imports may flow to California processors, TDP manufacturers and installers, TDF consumers, or directly to customers. Such exports may flow from California processors, TDP manufacturers, used tire buyer and sellers, and retreaders.

Categories of manufacturers and installers include:

- Accessibility ramps
- Flooring
- Landscape surfaces
- Mats, pavers, and tiles
- Paths, walkways, and sidewalks
- Pavements
- Playground surfaces
- Sport surfaces
- Synthetic turf infill
- Retreading
- Roofing
- Traffic related products

Types of civil engineering applications include:

- Landfill projects
- Light-weight fill
- Retaining wall backfill
- Vibration dampening
- Storm water management

Finally, TDP manufacturers and installers, civil engineering project leads, and TDF consumers sell products directly to their customers, inside and outside of California.

Table C-3 Source Data for Figure 4
Historical Market Trends by Segment, 2009-2022

Category	2009	2010	2011	2012
Landfill Disposal	131,152	92,033	63,444	47,908
ADC	12,042	7,928	19,589	10,486
Exported TDF & Bales	33,000	64,000	96,000	135,000
In-State TDF	69,926	83,675	61,911	77,209
Other Recycling	12,221	12,121	13,427	14,059
Civil Engineering	17,510	18,274	5,915	5,844
Crumb/Ground Rubber	55,000	59,850	61,700	68,350
Used Tires	37,266	37,942	45,823	51,678
Retread	44,000	36,018	40,651	39,838
Total Managed	**412,117**	**411,842**	**408,459**	**450,372**

Category	2013	2014	2015	2016	2017
Landfill Disposal	61,682	66,770	87,170	150,226	117,448
ADC	12,316	14,691	15,217	16,798	18,108
Exported TDF & Bales	110,144	110,000	94,000	62,476	113,405
In-State TDF	85,295	92,352	93,165	80,380	82,194
Other Recycling	12,166	11,643	12,114	9,790	10,433
Civil Engineering	4,557	12,632	11,668	10,961	6,431
Crumb/Ground Rubber	55,350	49,200	54,700	43,165	50,345
Used Tires	38,033	42,278	30,927	39,032	41,375
Retread	40,635	42,341	43,358	42,341	48,409
Total Managed	**420,177**	**441,907**	**442,318**	**455,168**	**488,149**

Category	2018	2019	2020	2021	2022
Landfill Disposal	95,401	95,412	154,050	249,377	298,084
ADC	17,975	16,784	14,876	17,440	21,169
Exported TDF & Bales	135,236	145,412	76,612	43,664	40,537
In-State TDF	88,386	78,307	57,611	48,243	32,457
Other Recycling	16,791	16,442	11,862	18,082	16,587
Civil Engineering	5,127	13,330	16,911	6,575	7,371
Crumb/Ground Rubber	61,728	59,985	50,530	70,862	78,341
Used Tires	42,692	44,757	51,036	43,044	49,112
Retread	47,925	47,925	45,529	54,635	57,366
Total Managed	**511,262**	**518,353**	**479,017**	**551,921**	**601,204**

Table C-4 Source Data for Figure 5 Estimated California-Generated Retread Tire Shipments, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Retreads	44,000	36,018	40,651	39,838	40,635	42,341	43,358

Category	2016	2017	2018	2019	2020	2021	2022
Retreads	42,341	48,409	47,925	47,925	45,529	54,635	57,366

Table C-5 Source Data for Figure 6 Shipments of California-Generated Crumb Rubber and Ground Rubber, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Paving	30,160	35,206	34,043	30,793	24,806	23,429	27,808
Turf Infill	8,723	9,605	11,871	15,089	14,034	11,355	13,415
Molded / Other	7,733	7,308	8,357	10,076	6,583	6,719	4,759
Ground Rubber	8,383	7,731	7,428	12,392	9,927	7,698	8,718
Total Crumb/Ground Rubber	**55,000**	**59,850**	**61,700**	**68,350**	**55,350**	**49,200**	**54,700**

Category	2016	2017	2018	2019	2020	2021	2022
Paving	NA	NA	NA	NA	NA	NA	NA
Turf Infill	NA	NA	NA	NA	NA	NA	NA
Molded / Other	NA	NA	NA	NA	NA	NA	NA
Ground Rubber	NA	NA	NA	NA	NA	NA	NA
Total Crumb/Ground Rubber	**43,165**	**50,345**	**61,728**	**59,985**	**50,530**	**70,862**	**78,341**

Table C-6 Source Data for Figure 7, Caltrans Total Asphalt Placement and Rubberized Asphalt Percent of Total, 2009-2022

Year	Total Asphalt Placed (Tons)	RHMA % Total
2009	5,589,914	23.60%
2010	3,860,646	30.60%
2011	7,522,354	34.70%
2012	6,333,678	29.20%
2013	4,578,258	22.90%
2014	4,120,457	26.70%
2015	4,602,421	41.30%
2016	4,785,160	39.80%
2017	4,056,991	45.03%
2018	4,767,951	46.43%
2019	3,860,363	39.75%
2020	3,405,088	41.31%
2021	3,280,000	38.00%
2022	2,695,298	35.79%

Table C-7 Source Data for Figure 8 Caltrans Use of Crumb Rubber in Paving Projects, 2009-2022

Year	Crumb Rubber Used (Million Pounds)
2009	40,103,331
2010	35,919,690
2011	77,543,629
2012	52,286,289
2013	32,514,454
2014	35,220,943
2015	60,775,793
2016	60,892,762
2017	58,456,877
2018	70,839,587
2019	54,133,231
2020	49,611,420
2021	45,000,000
2022	34,030,984

Table C-8 Source Data for Figure 9 California-Generated Tire-Derived Aggregate Shipped for Use in Civil Engineering Projects, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Landfill Projects	13,975	17,924	5,915	5,844	2,612	8,806	10,374
Non-Landfill Projects	3,535	350	0	0	1,945	3,826	1,294
Total TDA	**17,510**	**18,274**	**5,915**	**5,844**	**4,557**	**12,632**	**11,668**

Category	2016	2017	2018	2019	2020	2021	2022
Landfill Projects	7,083	5,583	4,021	6,682	16,311	6,575	7,371
Non-Landfill Projects	3,878	853	1,106	6,648	600	0	0
Total TDA	**10,961**	**6,431**	**5,127**	**13,330**	**16,911**	**6,575**	**7,371**

Table C-9 Source Data for Figure 10 California-Generated Tire-Derived Material Used as Landfill Alternative Daily Cover or in Beneficial Reuse Applications, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
ADC	12,042	7,928	19,589	10,486	12,316	14,691	15,217

Category	2016	2017	2018	2019	2020	2021	2022
ADC	16,798	18,108	17,975	16,784	14,876	17,440	21,169

Table C-10 Source Data for Figure 11 California Whole Waste Tires and TDF Consumed at California Cement Kilns, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Whole Tire/Size-Reduced TDF	69,926	83,675	61,911	77,209	81,982	83,934	85,721
Fiber TDF	0	0	0	0	3,313	8,418	7,443
Total TDF	**69,926**	**83,675**	**61,911**	**77,209**	**85,295**	**92,352**	**93,165**

Category	2016	2017	2018	2019	2020	2021	2022
Whole Tire/Size-Reduced TDF	72,723	75,989	80,603	70,807	51,315	39,704	30,915
Fiber TDF	7,656	6,205	7,783	7,500	6,297	8,539	1,542
Total TDF	**80,380**	**82,194**	**88,386**	**78,307**	**57,611**	**48,243**	**32,457**

Table C-11 Source Data for Figure 12 California-Generated TDF and Bales of Waste Tires and Truck Tire Treads, 2008-2022

Category	2008	2009	2010	2011	2012
Size-Reduced TDF	NA	NA	NA	NA	NA
Baled and Cut Waste Tires	NA	NA	NA	NA	NA
Total Exported TDF/Bales	**22,000**	**33,000**	**64,000**	**96,000**	**135,000**

Category	2013	2014	2015	2016	2017
Size-Reduced TDF	NA	74,000	66,000	47,476	87,317
Baled and Cut Waste Tires	NA	36,000	28,000	15,000	26,089
Total Exported TDF/Bales	**110,144**	**110,000**	**94,000**	**62,476**	**113,405**

Category	2018	2019	2020	2021	2022
Size-Reduced TDF	99,197	114,427	73,412	40,148	37,037
Baled and Cut Waste Tires	36,039	30,985	3,200	3,516	3,500
Total Exported TDF/Bales	**135,236**	**145,412**	**76,612**	**43,664**	**40,537**

Table C-12 Source Data for Figure 13 California-Generated Waste Tires Disposed in Landfills, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Landfill Disposal	131,152	92,033	63,444	47,908	61,682	66,770	87,170

Category	2016	2017	2018	2019	2020	2021	2022
Landfill Disposal	150,226	117,448	95,401	95,412	154,050	249,377	298,084

Table C-13 Source Data for Figure 14 Comparison of California All Materials and Waste Tires Management

Category	All Materials (2021) 77.7 M Tons	Tires (2021) 0.55 M Tons	Tires (2022) 0.60 M Tons
Landfill Disposal	54%	45%	49.6%
Disposal Related (e.g., Fuel & ADC)	6%	20%	15.7%
Recycling	40%	35%	34.7%

Table C-14 Source Data for Figure 15 Historic California All Materials and Waste Tires Recycling Rates

Year	All Materials	Tires
2011	49.0%	41.0%
2012	50.0%	39.9%
2013	50.0%	35.9%
2014	50.0%	35.8%
2015	47.0%	34.5%
2016	44.0%	31.9%
2017	42.0%	32.2%
2018	40.0%	34.1%
2019	37.0%	35.2%
2020	42.0%	36.7%
2021	40.0%	35.0%
2022	N/A	34.7%

Table C-15 Source Data for Figure 16 California Waste Tire Recycling, Disposal Related and Disposal Trends, 2009-2022

Category	2009	2010	2011	2012	2013	2014	2015
Landfill Disposal	131,152	92,033	63,444	47,908	61,682	66,770	87,170
Disposal Related	114,968	155,603	177,500	222,695	207,754	217,043	202,382
Recycled	165,997	164,206	167,516	179,768	150,741	158,094	152,767
% Recycled	40.3%	39.9%	41.0%	39.9%	35.9%	35.8%	34.5%
% Landfill Diversion	68.2%	77.7%	84.5%	89.4%	85.3%	84.9%	80.3%

Category	2016	2017	2018	2019	2020	2021	2022
Landfill Disposal	150,226	117,448	95,401	95,412	154,050	249,377	298,084
Disposal Related	159,654	213,707	241,597	240,503	149,099	109,347	94,163
Recycled	145,288	156,994	174,264	182,438	175,868	193,197	208,777
% Recycled	31.9%	32.2%	34.1%	35.2%	36.7%	35.0%	34.7%
% Landfill Diversion	67.0%	75.9%	81.3%	81.6%	67.8%	54.8%	50.4%

Appendix D End Notes

[1] CalRecycle, Waste Tire Program, Facilities Search Web Page.

[2] See end note 1.

[3] Analysis of Waste Tire Manifest Data as provided by CalRecycle to GHD_____ 2023.

[4] CalRecycle, California Tire-Derived Product Catalog, October 2021 Revision, Appendix A, Business Directories.

[5] Updated list of permitted waste tire facilities as provided to Boisson Consulting by CalRecycle on April 25, 2022.

[6] See end note 5.

[7] See end note 4.

[8] See end note 4.

[9] Cal Matters, "Behind Newsom's $301 billion budget, big financial concerns," May 16, 2022.

[10] U.S. Inflation Calculator, U.S Inflation Rates 2000-2022.

[11] Chart data is based on Caltrans annual Crumb Rubber Reports available online in various locations. The 2020 report is available here. 2021 data are unpublished estimates based on verbal discussion with Caltrans representatives.

[12] See end note 12.

[13] "A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon." The Journal Science, Vol 371, Issue 6525. December 3, 2020.

[14] "Contribution of Leachate from Rubberized Hot Mix Asphalt to Zinc Loading in Roadway Stormwater Runoff." Prepared by Humboldt State University under contract to CalRecycle. May 2021. Page 6.

[15] RRC EV White Paper (squarespace.com)