California Waste Tire Market Report: 2016

CalRecycle

California Department of Resources Recycling and Recovery

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Section 1
Introduction

Background

Senate Bill (SB) 876 (Escutia, Statutes of 2000, Chapter 838) was enacted to provide a comprehensive measure to extend and expand California's regulatory program related to the management of waste and used tires. The Department of Resources Recycling and Recovery's (CalRecycle) goal, although not codified in statute, is that 75 percent of waste tires be recycled by the year 2020. Affiliated goals include the following:

- Developing long-term, sustainable, and diversified market demand for California tire-derived products;
- Ensuring the protection of public health, safety, and the environment while developing a safe and high-quality supply infrastructure to meet that demand; and
- Fostering information flow and technology and product development so environmental protection and diversion goals are achieved with supply and demand in balance.

CalRecycle's Five-Year Plan for the Waste Tire Recycling Management Program, which is revised every two years, guides efforts to achieve these goals. The latest version of the five-year plan was approved on May 22, 2017.

This report summarizes waste tire recycling and market trends in 2016, with additional information on trends in early 2017. The report was prepared under CalRecycle contract by Boisson Consulting, with research and analysis support provided by DK Enterprises and Louis Berger U.S. Following this introduction, Section 2 provides a snapshot of key findings. Section 3 describes detailed market trends by market segment. Section 4 analyzes the outlook for increased diversion and recycling, and Section 5 provides some concluding remarks on the challenges of waste tire market development. Finally, Appendix A provides a glossary of key terms, and Appendix B summarizes the report methodology and limitations.

Interpreting and Using Report Findings

As detailed in Appendix B, findings in this report are based on detailed analysis of data and information from numerous sources, including: industry surveys and interviews, CalRecycle's Waste Tire Management System (WTMS), and CalRecycle grant and permitting information. Following are a few key points to consider when interpreting and using the report's findings:

Findings Focus on Use of California-Generated Waste Tires: The report estimates the quantity of California-generated whole or size-reduced waste tires flowing into each market segment. These estimates do not include flows of tire-derived material (TDM) or

tire-derived products (TDP) entering California from outside the state. Nor do they include buffings from retread operations that are used in some of the same applications as crumb rubber produced from waste tires. Consequently, the market data presented do not constitute estimates of total market size. While not included in the market flow estimates, some findings on retreader buffings and imported TDM and TDP are separately presented in Section 3. Imported whole waste tires flowing to California processors (unlike imported TDP or TDM) are tracked closely, and the flow of TDM from processors receiving imported tires is discounted proportionately so that only California generated tires are included in reported quantities in this report.

The Tire Recycling and Diversion Rates Are Not Adjusted for Residuals or Disposed TDPs: The majority of the steel extracted in the tire recycling process, or from de-rimmed tires, was recycled and most fiber was combusted at California cement kilns. However, as in most tire studies, diversion and recycling rates are not adjusted for the relatively small amount of steel and fiber residuals generated by TDM producers that was disposed. (Also, most TDPs are currently disposed at the end of their useful life, but rates are not adjusted to reflect this common practice. CalRecycle is beginning to address this topic, as discussed in Section 5).

Flow Analysis is Based on Tons: All data obtained for this study is converted to tons during the analysis, using the most appropriate and accurate conversion factors available. However, in this report findings are often reported in Passenger Tire Equivalents (PTEs[1]), to facilitate comparison with other reports.

Reasonably Accurate Trend Information: The authors strive to develop the most complete and accurate estimates for each market segment, while avoiding double counting. However, estimating California waste tire flows is challenging due to data gaps, data quality issues, WTMS data entry and conversion issues, and conflicting sources of information. Nevertheless, the authors believe this report provides data that can be used to evaluate California's waste tire market trends over time.

Industry Overview

Figure 1 illustrates how waste tires and TDM flow through different industry sectors involved in California waste tire management. To analyze 2016 waste tire flows, research focused on the following types of California facilities:

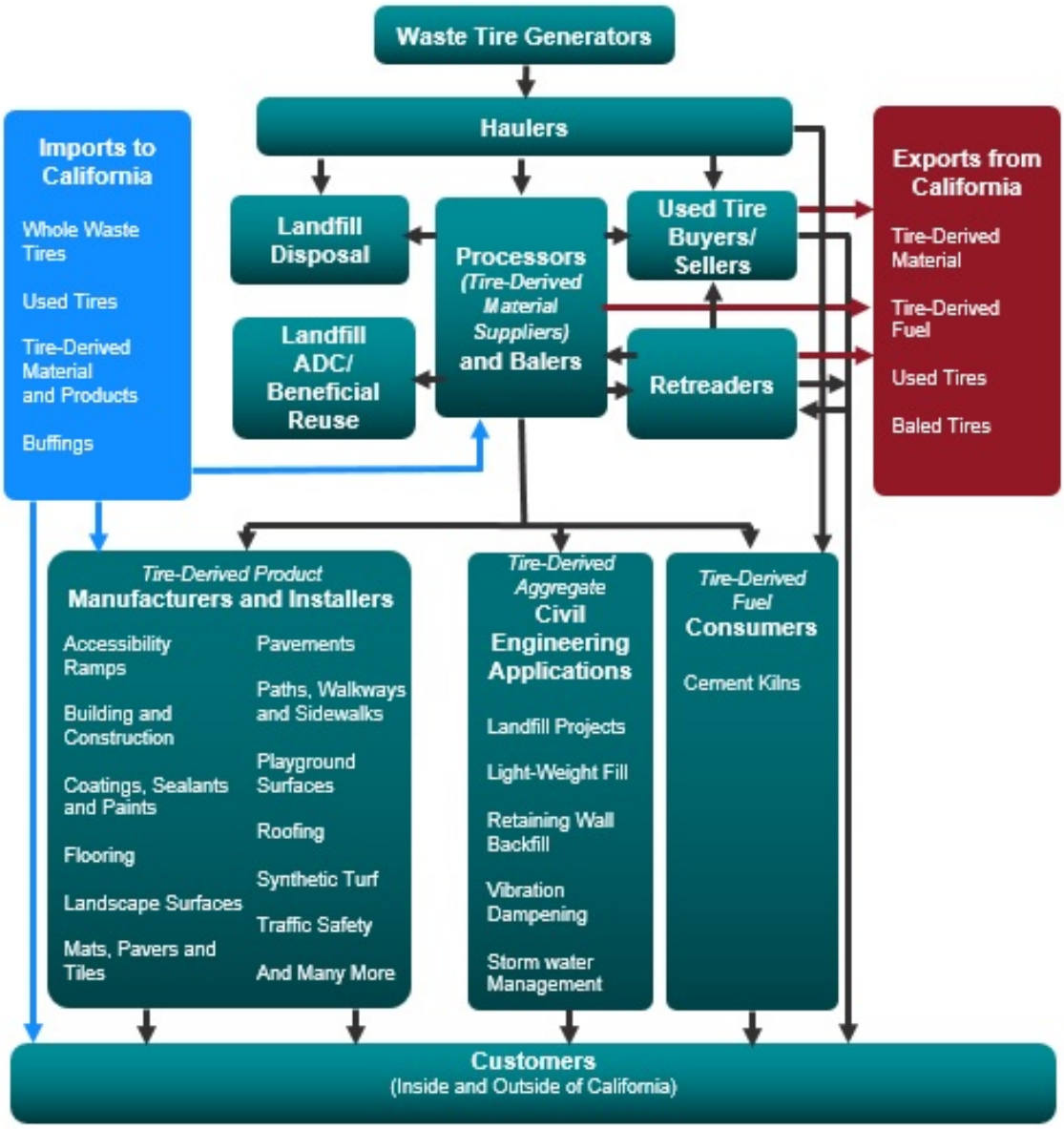
- Sixteen facilities that receive whole waste tires and ship used tires, TDM or whole tires (sometimes baled) to various market segments;
- Twenty-four firms that manufacture, market, and/or install TDPs;

[1] PTE stands for Passenger Tire Equivalent, defined by in regulations by CalRecycle (14 CCR § 17225.770) to equal 20 pounds of tire rubber. The PTE is a useful standard for reporting purposes; however, according to the Rubber Manufacturers Association and other analysts, the actual average weight of scrap passenger tires is closer to 22.3 pounds.

- Four cement kilns that combust whole waste tires or processed tire-derived fuel (TDF);
- Twenty-nine landfills that have received significant amounts of tires used in civil engineering, as alternative daily cover (ADC), or for disposal; and
- Thirty-two retreaders that retread truck tires and generate buffings sold as TDM for use in a variety of products and end uses.

Detailed information on California-made TDPs is available in CalRecycle's California Tire-Derived Product Catalog at www.calrecycle.ca.gov/Tires/Products/Catalog/.

Figure 1
California Waste Tire Recycling Industry Flow Chart



Section 2
Market Snapshot

This section provides a snapshot of California waste tire markets in 2016 and key trends as of spring 2017. More detailed market information is provided in Section 3.

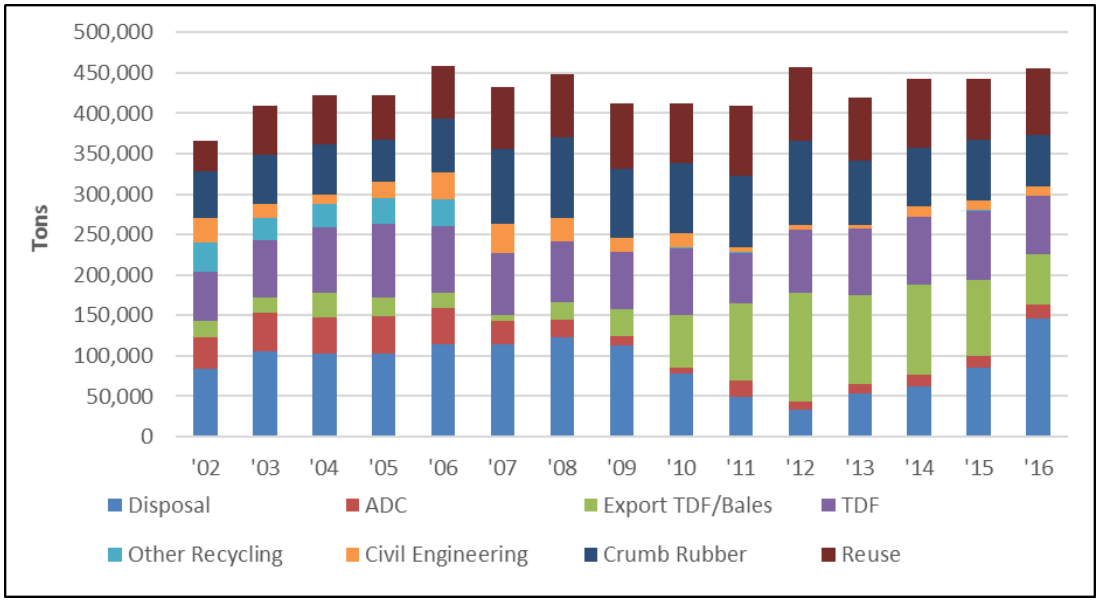
2016 Diversion and Recycling Rates

Table 1 (on the next page) lists the annual amount of California waste tires consumed and the percentage of total generation, for each market segment from 2014 to 2016. The diversion rate dipped for the fourth year in a row to 67.8 percent (including all market outlets other than disposal), down from an all-time high of 92.9 in 2012. Similarly, the recycling rate (excluding TDF and ADC) also fell for the fourth year in a row to 34.4 percent, down from 44.3 percent in 2012.

Synopsis of Trends

Figure 2 shows trends by broad market category since 2002. The diversion rate in 2017 may rise, as growth is expected in domestic and exported TDF. However, the trend for recycling is less clear. Expected paving growth may not fully materialize until 2018 and beyond, while use of crumb rubber in turf infill and loose-fill playground and landscaping applications, as well as retreading, may further decline. Potential growth in molded and other TDPs and civil engineering may help to stem any declines to a degree.

This c Figure 2
Twelve-Year Trend in California Waste Tire End Uses[2]



[2] In some cases methodological differences complicate comparisons between California tire reports prior to 2007 (prepared by CalRecycle Staff) and more recent consultant reports.

Table 1
Estimated End-Uses for California-Generated Waste Tires, 2014–2016

Category	Sub-Category	2014			2015			2016			% Change 2015 - 2016
		Tons	Million PTE	% of Total	Tons	Million PTE	% of Total	Tons	Million PTE	% of Total	
Export	Size-ReducedTDF	73,958	7.4	16.7%	65,614	6.6	14.8%	47,476	4.7	10.4%	-28%
	Baled Waste Tires	36,446	3.6	8.2%	28,426	2.8	6.4%	15,000	1.5	3.3%	-47%
	Used Tires (Export)	17,943	1.8	4.1%	7,128	0.7	1.6%	8,522	0.9	1.9%	20%
	Subtotal	128,346	12.8	29.0%	101,168	10.1	22.9%	70,997	7.1	15.6%	-30%
Reuse	Retread	42,341	4.2	9.6%	43,358	4.3	9.8%	42,341	4.2	9.3%	-2%
	Used Tires (Domestic)	24,336	2.4	5.5%	23,800	2.4	5.4%	30,510	3.1	6.7%	28%
	Subtotal	66,677	6.7	15.1%	67,158	6.7	15.2%	72,851	7.3	16.0%	8%
Crumb Rubber	Paving	34,708	3.5	7.8%	38,736	3.9	8.8%	NA[3]			Roughly Flat
	Turf Infill	16,821	1.7	3.8%	18,686	1.9	4.2%	NA[3]			Down 20-40%
	Ground Rubber/Nuggets	11,404	1.1	2.6%	12,144	1.2	2.7%	NA[3]			Down 25-35%
	Molded & Other TDP	7,855	0.8	1.8%	5,849	0.6	1.3%	NA[3]			Roughly Flat
	Other Crumb Rubber Uses	2,098	0.2	0.5%	780	0.1	0.2%	NA[3]			Down 50-75%
	Subtotal	72,887	7.3	16.5%	76,195	7.6	17.2%	64,408	6.4	14.2%	-15%
Civil Engineering	Landfill Applications	8,806	0.9	2.0%	10,374	1.0	2.3%	7,083	0.7	1.6%	-32%
	Non-Landfill Applications	3,826	0.4	0.9%	1,294	0.1	0.3%	3,878	0.4	0.9%	200%
	Subtotal	12,632	1.3	2.9%	11,668	1.2	2.6%	10,961	1.1	2.4%	-6%
Alternative Daily Cover		14,691	1.5	3.3%	15,217	1.5	3.4%	16,798	1.7	3.7%	10%
Other Recycling		564	0.1	0.1%	533	0.1	0.1%	0	0.0	0.0%	-100%
Tire-Derived Fuel		83,934	8.4	19.0%	85,721	8.6	19.4%	72,723	7.3	16.0%	-15%
Landfill Disposal		62,579	6.3	14.1%	84,699	8.5	19.1%	146,429	14.6	32.2%	73%
Estimated Total Managed		442,311	44.2	100.0%	442,358	44.2	100.0%	455,168	45.5	100.0%	3%
Total Diverted from Landfill		379,731	38.0	85.9%	357,659	35.8	80.9%	308,738	30.9	67.8%	-14%
Total Recycled		170,138	17.0	38.5%	162,680	16.3	36.8%	156,741	15.7	34.4%	-4%
Imports		12,661	1.3	2.9%	23,382	2.3	5.3%	55,253	5.5	12.1%	136%

[3] To protect confidentiality, estimated use of California waste tires in these segments is not reported for 2016.

Exports: After peaking in 2012 at 13.5 million PTE, export of size-reduced TDF (typically 2- to 4-inch shreds) and baled waste tires have dropped steadily to 6.2 million PTE in 2016, with about ¾ of these exports comprised of size-reduced TDF and the remainder baled waste tires. In addition, California facilities exported an additional 1.2 million PTE of size-reduced TDF in 2016 from whole tires delivered to them from out-of-state. Reduced pricing due to reduced fuel prices and increased competition from global suppliers reportedly reduced tonnage exported, although this trend is reportedly turning with fuel prices on the increase. In addition, about 0.9 million PTE of used tires were exported in 2016, up about 20 percent over the 2015 estimate as demand in Mexico and other countries increased and appears to be remaining strong in 2017.

Reuse: Reuse was estimated to increase by about eight percent (including retreads and used tires sold domestically) in 2016. About 4.2 million PTEs of truck tires were retread in 2016, down slightly from the 2015 estimate. In addition to the exported used tires, in 2016 an estimated 3.1 million PTEs of used tires were culled from waste tire flows for sale domestically. Companies involved in the reuse segment (both used tires and retreading) report that increasing sales of lower-tier tires from China is undercutting their volumes, a trend that may intensify as the U.S. International Trade Agency surprised industry observers by deciding not to impose tariffs on these imported tires.

Crumb Rubber:[4] Overall, in 2016 use of California waste tires to produce crumb rubber is estimated to have dropped by about 15 percent from 2015, to 6.4 million PTE. While paving was flat or slightly down, crumb rubber infill used in synthetic turf athletic fields dropped by an estimated 20 to 40 percent, and ground rubber/nuggets also dropped by an estimated 25 to 35 percent. The molded and other tire-derived products segment continues to see a diverse range of innovation, but total volumes remain relatively low. As described further in Section 3, future crumb rubber trends are difficult to predict given several important drivers and barriers that are impacting different segments in different ways. Moreover, at least two new crumb rubber production facilities are expected to start operations in 2017 or 2018, further complicating projections.

Civil Engineering: Use of tire-derived aggregate (TDA) in civil engineering applications declined slightly in 2016 to 1.1 million PTEs, with about 75 percent of this quantity being used at nine landfills, and the remaining TDA being used largely in one project by Bay Area Rapid Transit (BART). Civil engineering volumes in both landfill and non-landfill applications are expected to rise modestly in 2017.

Alternative Daily Cover (ADC): In 2016, five landfills reported use of 1.7 million PTEs as ADC, about 10 percent higher than in 2015. This amount is expected to stay flat in 2017.

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[4] In this report, “crumb rubber” means tire-derived material ¼ inch or smaller, and is also used to refer to the broad market segment that also includes ground rubber, typically ¼ to 1 inch in size, and nuggets, which may exceed 1 inch.

Tire-Derived Fuel: Consumption of California whole waste tires and size-reduced TDF by four California cement kilns totaled 7.3 million PTEs in 2016, a 15 percent decrease compared to 2015. However, an additional 1.95 million PTE of TDF sourced from California processors was consumed in these kilns, but this material originated out of state. TDF consumption is expected to increase somewhat in 2017 as an unexpected closure at one kiln constrained their use in 2016.

Disposal: Waste tire disposal increased in 2016 by 73 percent to 14.6 million PTEs. This is the highest reported waste tire disposal since 1996, and a 440 percent increase over the all-time low in tire disposal reported in 2012. The increase in disposal reflects weak diversion and recycling markets in 2016, as well as the determination by some processors, that disposal was a more profitable option, in part due to lack of demand of crumb rubber and other size-reduced material. Although 2017 trends for some recycling markets are unclear, disposal may decline in 2017 as TDF export markets rebound.

The above findings and trends are described in more detail in Section 3 below.

Section 3
Key Trends by Market Segment

This section describes key market trends for each market segment in more detail, beginning with the current balance between supply and demand.

Supply and Demand Balance

As in any commodity market, the balance between supply and demand for waste tires, TDM, and TDPs is constantly in flux, influencing pricing, competitive pressures, and generally the profitability and resiliency of firms operating in the market. This section addresses two distinct sets of supply-and-demand issues related to scrap tire recycling: those involving whole tires and those involving tire-derived materials used to make products. Shifts in these supply-demand dynamics directly influence the ability to increase recycling and diversion levels.

Supply and Demand for Whole Tires

Research for this report included analyzing 2016 waste tire deliveries to, and TDM/TDP shipments from, 16 facilities serving a variety of recycling, diversion, and disposal markets. To varying degrees, these firms, along with haulers that supply tires to them or deliver whole/used tires elsewhere, compete for the limited supply of California waste tires and the associated collection fee revenues.

In 2016, supply and demand for whole waste tires appeared to be relatively balanced, as processors generally were able to secure supplies needed to meet moderated demand in several market segments. A planned, large TDA project in Northern California that would have consumed over four million PTE, requiring multiple suppliers to satisfy TDM demand, did not go forward, reportedly due to a change in design. Additionally, 2016 waste tire baler activity in California, especially in Southern California, was relatively low compared to prior years. While some established processors remain concerned about competition with balers who frequently start-up, close, or change their operational status, they generally did not cite balers as a major factor impacting their business in 2016. A large processor in Northern California closed in 2016 leading to an increase in landfilling of tires, and competitors absorbed the waste tire generator accounts.

There are indications, however, that demand for waste tires could increase significantly in coming years. First, baling activity is reportedly picking up in 2017, with increased activity in both Northern and Southern California, driven by increased fuel costs and pricing for TDF in Asia. Second, several new and existing facilities have secured, or are actively seeking, waste tire facility permits that would enable them to begin new or expand existing operations. These include two new crumb rubber production facilities that could begin operation in late 2017 or early 2018, and two baling operations, one of which has already begun operating in 2017. Together, these facilities have the potential to greatly increase competition for whole waste tires in both Northern and Southern

California. They also have the potential to increase recycling and diversion rates, if market demand proves sufficient.

Supply and Demand for Tire-Derived Materials and Products

Crumb Rubber: As in recent years, crumb rubber production capacity continues to exceed demand. Production of crumb rubber was down by about 15 percent in 2016. This was a result of one large producer closing operations as well as weak or declining markets, especially for turf infill and ground rubber/nuggets used as loose-fill playground surfacing and landscape mulch. As discussed below, there is potential for increased crumb rubber demand in the paving segment, but turf infill especially is expected to continue to drop precipitously in 2017. With two new crumb rubber facilities expected to begin operations by early 2018, there is the potential for this imbalance to be further exacerbated. Some crumb rubber continues to be imported from out of state, but only a couple survey responses cited this as a concern.

Fine-Mesh Crumb Rubber and Rubber-Plastic Compounds: In-state TDM producers are reluctant to invest in the needed equipment to produce 50 mesh crumb rubber until such time there is greater demand for the material. This is a classic chicken-and-egg situation. Similarly, California compounders may be interested in utilizing fine mesh rubber, but demand does not justify the required investment at this time. Some manufacturers that serve the high tech, medical, or airline industry are reticent or unable to change product specifications to incorporate crumb rubber tire-derived feedstock material.

Buffings: Buffings from retreaders are used extensively in certain market segments, like pour-in-place playground surfacing, molded products, and landscape mulch products. California tire processors purchase and handle approximately 14 to 18 million pounds of buffings, most of which was produced by retreaders located in California. Demand for buffings currently exceeds supply, with some firms expressing concern about both the ability to secure ample supplies and increased pricing.

Tire-Derived Products and Tire-Derived Aggregate: Generally, TDP production capacity continues to exceed demand for most of the well-established products, including paving, turf infill, ground rubber/nuggets, and tire-derived aggregate. Indeed, the need to increase demand for these products is perhaps the single most important factor that can help boost California tire recycling rates in coming years.

CalRecycle's Tire Incentive Program (TIP) is aimed in part at strengthening production and marketing of crumb rubber and TDPs, and a bill currently pending in the legislature (AB 509, Frazier) would greatly expand funding for similar tire recycling incentives.

Reuse

Reuse, including retreading and sale of partially worn used tires, remains strong in California. Overall, 8.2 million PTEs were estimated to be reused in 2016. Of this amount, 4.2 million were retread, and 4.0 million were culled, graded, and sold both domestically and internationally. (See "Export" in Table 1, Section 2.)

Both retreading and sale of used tires continue to be very strong, profitable market segments that are relatively mature and not expected to grow substantially. However, firms involved in tire reuse are concerned over the growing number of lower-tier tires made in China and sold at very low prices. These tires negatively impact reuse in several ways. First, some customers, especially small, independent trucking fleets, may be more likely to purchase low-price new tires rather than retread tires, even if they may be of lower quality. Second, according to many in the field, these tires often have a lower potential for reuse or retreading due to lower quality standards. In a surprise move, the U.S. International Trade Agency recently rejected a system of tariffs that the Department of Commerce proposed and implemented on an interim basis. As a result, some believe this issue may gain in prominence in coming years.

Retread Tires: The quantity of truck tires retread in California was estimated to decline slightly in 2016 to 4.2 million PTE. Overall, despite strong concerns over lower-tier Chinese tires (described above), retreading volumes appear to be fairly stable, with a mix of growth and contraction. Generally, larger retreaders serving national fleets (who are reportedly less likely to purchase lower tier/price tires) are faring better, while smaller retreaders serving independent trucking fleets (for whom the incentive of lower cost new tires is harder to resist) may be impacted more severely.

Used Tires: An estimated 4.0 million PTEs were culled and graded for reuse in 2016, a 10 percent increase from 2014. This includes 3.1 million PTE sold for sale domestically, and about 0.9 million PTEs estimated to have been exported for reuse, mainly but not exclusively to Mexico. A number of California processors report lower quantities of used tires in flows they receive, with culling activity apparently increasing upstream before the tires reach the processor. A significant amount of used tires are imported to California from other states, but are not quantified in this report.

Crumb Rubber

Overview

In 2016, approximately 6.4 million PTEs of California-generated tires were used to produce crumb rubber, a 15 percent decrease over the amount in 2015, and 39 percent lower than the all-time high of 10.5 million PTEs used to make crumb rubber in 2012. The 2016 estimate excludes an additional 251,000 PTEs used by California crumb rubber producers that originated in other states. While a complete estimate is not available for the quantity of tire wire and fiber residuals generated by California crumb rubber producers in 2016, the majority of both were diverted to recycled end uses. Over 9,000 tons of fiber was reportedly consumed by California cement kilns for fuel (this amount is excluded from the TDF estimates presented later in this report).

Buffings from retreaders are excluded from crumb rubber estimates and are not included in recycling rates (since the retread tires they originated from are already counted under retreads). Buffings are used extensively in certain market segments, especially pour-in-place playground surfacing, molded products, and landscape mulch

products. In 2016, California processors handled an estimated 14 – 18 million pounds of buffings, most of which was produced by retreaders located in California. Buffings are currently in high demand.

California crumb rubber production infrastructure and markets are undergoing a shift. One long-time producer closed in 2016. Some processors have reduced crumb rubber production, while others continue to report producing at a rate similar to past years. Shipments to the turf infill and ground rubber/nugget segments declined in 2016. The largest crumb rubber segment, paving, is holding steady for now amidst optimism of future increased demand. And the smallest crumb rubber market segment, molded and other tire-derived products, is the most diverse but still consumes low volumes. These factors have increased competition among active suppliers, and with two new crumb rubber facilities planning to start-up in late 2017, competition may further intensify. To protect confidentiality in light of these shifts and increased competitive environment, this year's report does not include quantitative estimates of California crumb rubber shipments by market segment.

While new crumb rubber production capacity holds the potential to increase California waste tire recycling levels, realizing this potential would require significantly increased demand. Ideally, this would occur in several ways: through growth in existing markets; by converting established manufacturers from virgin rubber and other raw materials to recycled tire crumb rubber feedstocks; and by developing new products and applications that use the beneficial and unique characteristics of crumb rubber to satisfy customer requirements. Unfortunately, such market development has been slow to advance. Crumb rubber markets have not grown significantly in several years, nor have new high volume users been created. The paving segment looks promising as new transportation funding and potential new Caltrans policies take hold, and CalRecycle's increased focus on incentive payments and other support could potentially help to catalyze more rapid market development. CalRecycle's Feedstock Conversion Technical Assistance and Material Testing contract provides additional support aimed at commercializing new TDP types and applications and finding new customers. Pending legislation (AB 509, Frazier) would increase funding levels for incentive payments.

Paving

In recent years, the paving segment has consumed about half of all California-produced crumb rubber. According to crumb rubber and paving industry representatives, use of crumb rubber in paving applications in 2016 was roughly flat compared to 2015 but appears to be experiencing modest growth in 2017. However, for several reasons, many are optimistic about the potential for much higher demand in the paving segment in coming years.

First, some cite the Caltrans 2015 policy to establish Rubberized Hot Mix Asphalt as the pavement of choice in certain projects as helping to establish a more stable level of demand, at least in some Caltrans districts. Combined with long-standing use by certain local governments (especially in Southern California), this has helped establish a solid base demand for rubberized asphalt products.

Second, Caltrans could substantially increase its already large share of rubberized paving use in coming years. Caltrans is required by statute (AB 338, Levine, Chapter 709, Statutes of 2005) to use tire rubber in 35 percent of its paving projects, for an average of 11.6 pounds per metric ton of total asphalt paving materials used. Prior to 2015, this statute specifically required use of rubber asphalt or "field blend" (also referred to as the "wet process"). As of January 2015, Caltrans may use any paving technology to achieve the required levels. Caltrans has not released annual reports detailing its use of waste tires in 2015 or 2016. However, the previous report estimated that in 2014, 2.7 million PTEs were consumed, an amount that translates to 34.2 million pounds of crumb rubber (based on a standardized conversion of 12 pounds of crumb rubber per PTE used by Caltrans and CalRecycle), with rubberized asphalt used in 26.7 percent of projects.

Caltrans has been actively exploring potential new policies to increase its use of crumb rubber in paving. Approaches under consideration include requiring incorporation of crumb rubber into binders at yet-to-be-determined levels using so-called field blend, dry process, and terminal-blend application technologies. With CalRecycle funding support, Caltrans has commissioned a series of tests and has convened an industry stakeholder forum to provide input into the process. Test results are expected in 2018 and new policies could potentially be in place shortly thereafter. The process is controversial as the selection of an approach and the details of any new policy may benefit some industry participants over others. There is also discussion over the performance benefits and cost-effectiveness of different approaches.

Third, recently adopted legislation (SB1, Bealle) will provide over $52 billion for public transportation projects over the next 10 years, providing a much-needed boost to the industry. Several cities and counties have separately adopted local transportation funding packages that will further boost paving activity.

Finally, CalRecycle continues to offer grants to local agencies to help support use of rubberized paving and pending legislation (AB 509, Frazier) holds the potential to further strengthen this support. Combined with ongoing technical assistance and promotional services, these factors all seem likely to result in much stronger demand for rubberized paving in the next several years, a bright spot in the outlook for crumb rubber use.

Turf Infill

In recent years, roughly a quarter of California-produced crumb rubber has been used as infill in synthetic turf athletic fields. However, persistent media reports of concerns over environmental health and safety issues are now significantly impacting this crumb rubber market. Nationwide, representatives of the Synthetic Turf Council currently estimate use of crumb rubber as turf infill is down approximately 30 percent. Consistent with this national trend, use of California crumb rubber as turf infill was down approximately 20 to 40 percent in 2016. Indications are that California use may further decline in 2017.

Some industry observers are optimistic that the recent studies produced in 2016 and 2017 will help to stimulate the use of crumb rubber infill

- The Washington State Department of Health[5] (WSDOH) analyzed concerns that an unusually high number of soccer players were contracting cancer and concluded that there was "less cancer among the soccer players than expected based on rates of cancer among Washington residents of the same ages." This finding "does not suggest that soccer players, select and premier soccer players, or goalkeepers in Washington are at increased risk for cancer compared to the general population." WSDOH "recommends that people who enjoy soccer continue to play, irrespective of the type of field surface."
- The Netherlands National Institute for Public Health and the Environment[6] tested rubber granulate from 100 synthetic turf fields in the Netherlands for numerous substances such as polycyclic aromatic hydrocarbons (PAHs), bisphenol A (BPA), phthalates (plasticizers), metals and benzothiazoles (including 2-MBT). The report concluded that these substances from crumb rubber are released in very small quantities, making the risk to health from playing sports on these synthetic turf fields virtually negligible.
- European Chemical Agency[7] (ECHA) found no reason to advise people against playing sports on synthetic turf containing recycled rubber granules as infill material. The report also found that the general public, children, professional players, and workers that install or maintain the synthetic turf fields with recycle rubber infill were not at risk. This advice is based on ECHA's evaluation that there is a very low level of concern from exposure to substances found in the granules.

Determining exposure and risks levels of any substance is complex, and each of the above studies also included some caveats regarding study limitations and the need for continuing research. Consequently, some market observers believe that volumes of crumb rubber used as turf infill may continue to decline or remain at relatively low levels compared to recent years.

Two additional ongoing studies in the U.S. could provide the most in-depth analysis and conclusions regarding the safety of crumb rubber infill:

[5] Washington Department of Health, "Investigation of Reported Cancer Among Soccer Players in Washington State." 2017.

[6] The Netherlands National Institute for Public Health and the Environment, "Evaluation of Health Risks of Playing Sports on Synthetic Turf Pitches with Rubber Granulate." December 2016.

[7] European Chemical Agency. "An Evaluation of the Possible Health Risks of Recycled Rubber Granules used as Infill in Synthetic Sports Fields." February 2017.

- Under contract to CalRecycle, the California Office of Environmental Health Hazard Assessment (OEHHA) is conducting a study on synthetic turf and potential human health impacts. The new study is analyzing hazard identification and exposure risks and is expected to be completed in 2019.
- The U.S. Environmental Protection Agency (U.S. EPA), the Centers for Disease Control and Prevention (CDC), Agency for Toxic Substances and Disease Registry (ATSDR), and the Consumer Product Safety Commission (CPSC) are engaged in a multi-agency Federal Research Action Plan on Recycled Tire Crumb Used on Playing Fields and Playgrounds to study key environmental and human health questions. The study is covering potential exposures field users may experience, identifying and characterizing constituents found in tire crumbs, and (pending final approval) a playground study analyzing overall risk (led by CPSC). The report could be completed within 2017.

Approximately 75 fields in California are projected to reach their end of life (EOL) in 2017. Reuse of crumb rubber infill from these fields is reportedly beginning to increase and will be examined further under CalRecycle's Tire Outreach and Market Analysis contract in 2017.

Ground Rubber/Nuggets

This segment includes several different products such as loose-fill playground surfacing, nuggets used as landscape mulch, equestrian surfacing; and ballistics applications. These market segments are grouped together because they all use ground rubber (i.e., tire-derived material of ¼ inch to ¾ inch in size) or nuggets (which may range in size to more than 1 inch). Buffings—often used in playground surfacing, molded rubber products, and mulch applications—are discussed separately in this report and are not included in the crumb rubber use estimate reported in this category. In 2016, consumption of California TDM in the ground rubber and nugget market category is estimated to have declined by 25 to 35 percent. The decline was most evident in loose-fill playground surfacing applications. Also, some producers shifted focus due to environmental health concerns and reduced demand.

Molded and Other Tire-Derived Products

In recent years, this market segment has consumed about 15 percent of California crumb rubber. In 2016, use of California-produced crumb rubber to manufacture molded tire derived products was roughly flat compared with the amount in 2015. As detailed in CalRecycle's California Tire-Derived Product Catalog (available online at www.calrecycle.ca.gov/Tires/Products/Catalog/), about twenty California firms produce a wide variety of molded and other TDPs not covered in other categories of this report. These products are sold to customers in the flooring, roofing, landscaping, coatings & sealants, building construction, transportation, cleaning tools, playground tiles, animal care, automotive and accessibility products industries, among others.

In recent years, many of these firms have developed new TDPs or have steadily worked to incorporate crumb rubber into their existing product lines (i.e., feedstock conversion). Unfortunately, they continue to use relatively low volumes of crumb rubber as they work toward expanding production and sales. Reasons for low volumes include historically low prices for oil and virgin raw materials as well as the challenges associated with commercializing and expanding sales for products newly incorporating crumb rubber raw materials. In addition to California-produced crumb rubber, some of these firms also use significant quantities of buffings or imported crumb rubber compounds that may not be available in California.

In the short term, the volume of crumb rubber consumed is expected to remain low. In the long-term, there is potential for more significant use, especially if the segment continues to diversify with more manufacturers involved or is supported by CalRecycle activities regarding feedstock conversion.

Civil Engineering

The use of tire-derived aggregate in civil engineering applications was relatively unchanged between 2015 and 2016, at about 1.1 million PTEs. TDA use appears to be stabilizing; however, there are indications that demand could increase in 2017 and 2018 due to road repair needs related to a very harsh California winter, approval of new state and local funding for transportation-related projects, and continued CalRecycle grant support.

Landfill Civil Engineering Applications

CalRecycle's TDA Grant Program helped to catalyze use of 0.7 million PTEs of TDA by seven landfills in 2016, although two landfills used the material without grant support. At least two additional landfills said they planned to submit grant requests that would increase their use in 2017 and 2018. While some are currently using low volumes, landfills as a category could potentially be a consistent market for TDA. California landfills generally report using TDA in connection with gas collection systems.

Non-Landfill Civil Engineering Applications

In 2016, about 400,000 PTEs of TDA were used in non-landfill civil engineering applications in a vibration mitigation application related to the Bay Area Rapid Transit (BART) System outside of the grant program. Unfortunately, a very large lightweight fill/road fill project in Solano County, that received CalRecycle funding approval and was projected to use more than 4.2 million PTEs, did not come to pass due to project design changes. A growing number of civil engineering applications are beginning to consume TDA. In April 2017, CalRecycle approved three grants expected to use over 120,000 tons of TDA in a low-impact development (LID) storm water management project, as bottom fill in roadside horizontal drains, and as lightweight fill behind retaining walls. CalRecycle's TDA team is focusing on outreach to cities and counties who may have road repair and other needs related to the recent heavy rains and storms. Funding from a recently adopted statewide transportation funding bill (SB1, Bealle), along with some

increased local transportation funding, could further boost TDA use in non-landfill applications.

Alternative Daily Cover

Tire shreds are used as ADC at some landfills to cover disposed waste at the end of each day. In 2016, five landfills reported combined use of 1.7 million PTEs of tire shreds as ADC, a ten percent increase over the amount used in 2015. This amount is expected to remain static in 2016.

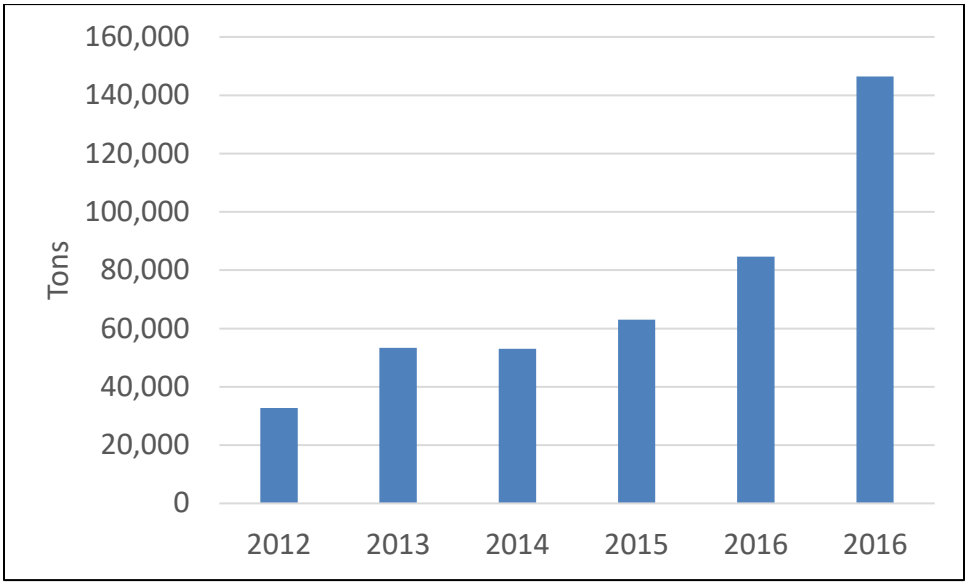
Tire-Derived Fuel

Four California cement kilns continue to use significant quantities of size-reduced TDF or waste tires, providing a strong, steady market that thrives without government support. (CalRecycle is precluded from promoting TDF markets by statute.) In 2016, these plants consumed 7.3 million California PTEs, 15 percent less than in 2015. Part of the reason for the decline is that one plant had an unexpected closure that curtailed their operations for four months. However, these plants also used an additional 1.9 million PTEs that were supplied by California processors but were imported from outside the state (based on allocation of imports across the market segments served by California processors receiving imported tires). The plants also reported consuming over 9,000 tons of fiber derived from crumb rubber producers. These cement kilns are already using TDF at or near their maximum potential based on current permitting restrictions. However, because of the extended closure of one plant in 2016, TDF use by California cement kilns is expected to grow slightly in 2017.

Disposal

As shown in Figure 3, disposal of California-generated waste tires increased for the fourth straight year, reaching 14.6 million PTE, or nearly a third of total generation. This is the highest waste tire disposal since 1996. The increase in disposal was caused by a combination of factors, including weak or declining markets for crumb rubber and TDF (both domestic and export), determinations by some processors that landfill constituted the most profitable option given current market conditions, and operational issues at some facilities that required disposal of accumulated waste tire inventories. With TDF and bale export markets rebounding, disposal may decline somewhat in 2017, even in the face of possibly continued weak crumb rubber demand.

Figure 3
Six-Year Trend in Total California Waste Tire Disposal (Tons)



Imports and Exports

Used Tire and Casing Imports and Exports

Culled and graded used tires have long been a staple export from California. In 2016, an estimated 0.9 million PTEs of California used tires were exported, 20 percent more than the amount in 2015. Moreover, based on WTMS data and survey responses, significant quantities of already-culled used tires were also shipped into California from other western U.S. states. Although not quantified in this report, the 2015 California Waste Tire Market Report estimated the quantity at over 1 million PTE. As shown in Table 2, retreader surveys indicate at least 2,500 tons of truck tire casings originating out-of-state flowed to and were retread by California facilities.

Waste Tire Imports

In 2016, an estimated 5.3 million PTEs of waste tires (excluding retreadable casings) were imported from out of state and flowed to several California processors. This estimate does not include already-culled used tires imported into California directly for the purpose of sale or export, as previously discussed. The processors importing these waste tires, in turn, shipped whole waste or used tires and TDM to a variety of market segments, and this share of their shipments was subtracted from the market segment estimates presented in Table 1 for California-generated tires. The amount of imported tires or TDM subtracted from the flows from California processors to each market segment is shown in Table 2.

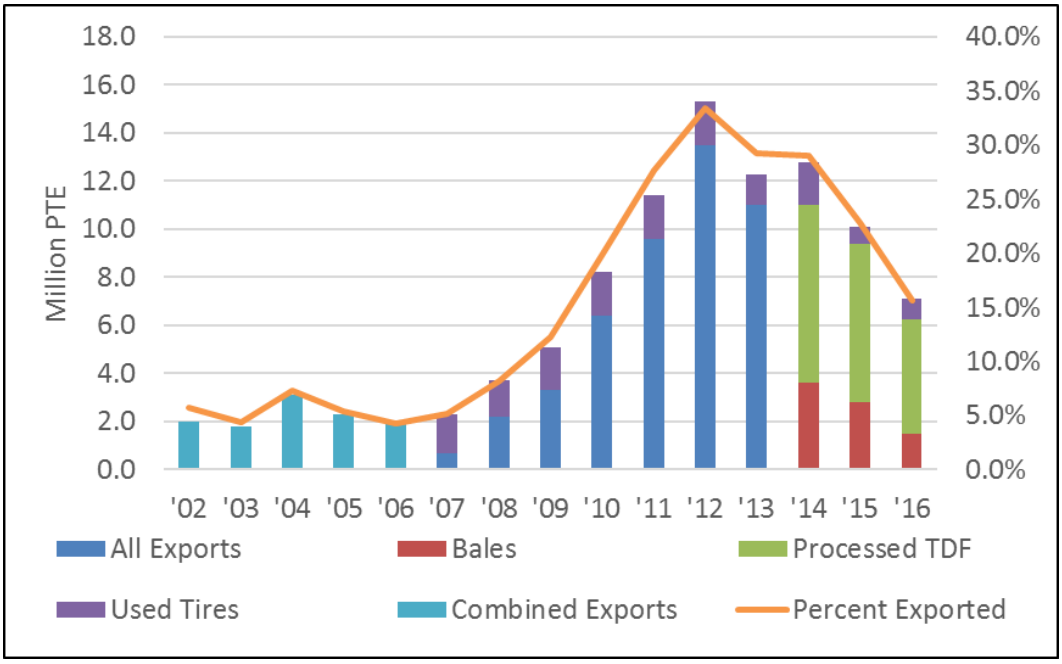
Table 2
Estimated Market Disposition of Waste Tires Imported to California Processing Facilities

Category	Sub-Category	Adjustments Made to Shipments from California Processors to Account for Imported Tires (Tons)
Export	Size-reduced TDF	10,218
	Baled Waste Tires	0
	Used Tires (Exported)	2,930
	Subtotal	13,148
Reuse	Retread	2,520
	Used Tires (Domestic)	7,491
	Subtotal	10,011
Crumb Rubber		2,517
Civil Engineering	Landfill Applications	1,195
	Non-Landfill Applications	238
	Subtotal	1,433
Alternative Daily Cover		0
Other Diversion		0
Tire-Derived Fuel		19,500
Landfill Disposal		8,643
Total Imports		55,253

Export of Size-reduced TDF and Baled Waste Tires

As shown in Figure 4, after a rapid and consistent rise beginning in 2007, export of TDF and baled waste tires for purposes of TDF in Asian countries peaked in 2012 at an estimated 13.5 million PTEs, before beginning a steady decline. In 2016, an estimated 4.7 million PTEs of size-reduced TDF were exported, primarily to Japan and Korea, a 28 percent decline from 2015, and an estimated 1.5 million PTEs of baled waste tires were also exported, primarily to Vietnam and Korea, a 47 percent decline from 2015. Also, as shown in Table 2 above, an additional 10,128 tons of size-reduced TDF were exported by California processors from tires imported from out of state. The reduction in TDF exports in 2016 was reportedly caused mainly by reduced pricing and increased competition from other suppliers. Exports may increase in 2017 as pricing has begun to rebound in 2017.

Figure 4
Trends in Export of TDF, Baled Waste Tires, and Used Tires



Crumb Rubber and TDP Imports and Exports

In 2016, crumb rubber from other states and Canadian provinces was sold in California at competitive prices, despite transportation costs. This is possibly due in part to the incentive payment subsidies and favorable operating conditions in some of these jurisdictions. California crumb rubber producers have often cited low-priced imported crumb rubber as a factor in the reduction of what they believe to be fair market prices. However, only a couple survey responses cited this issue for 2016.

Section 4
Outlook for Increasing Waste Tire Diversion and Recycling

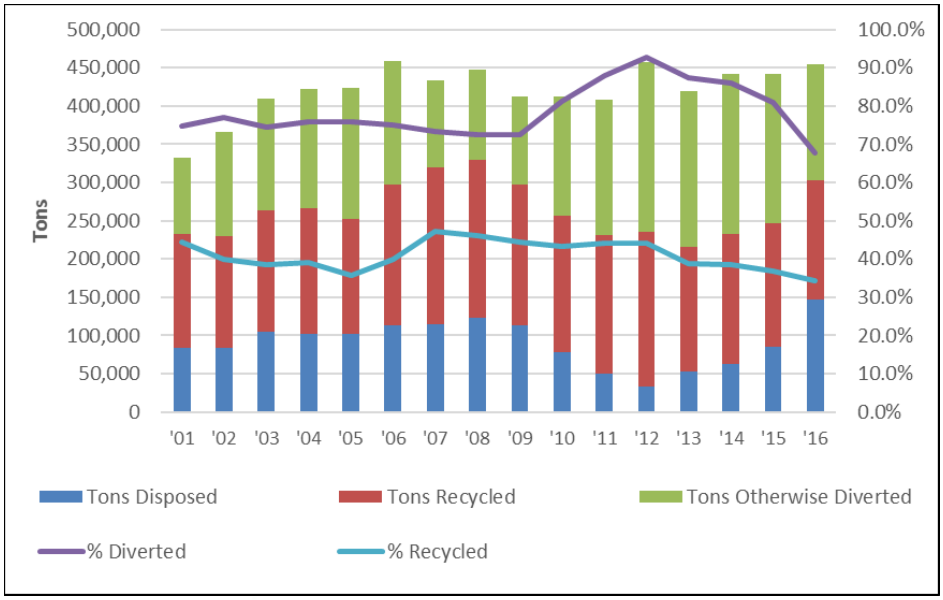
This section begins with a historical look at waste diversion and recycling trends and is followed by an overview of the short-term and long-term outlook for increasing levels in the future.

Historical Waste Tire Diversion and Recycling Trends

As detailed in Section 1, CalRecycle now has a goal of achieving a 75 percent recycling rate for all waste materials including tires by 2020. The recycling-based measurement is defined in this report to exclude waste tire and TDF exports (but not used tire exports), ADC, and TDF sold domestically. Excluding these segments, the 2016 waste tire recycling rate fell for the fourth year in a row to 34.4 percent (157,000 tons or 15.7 million PTE), down from a recent high of 44.3 percent in 2012 (202,000 tons or 20.2 million PTE). Additionally, the waste tire diversion rate dipped for the fourth year in a row to 67.8 percent (309,000 tons or 30.9 million PTE), down from an all-time high of 92.9 in 2012 (424,000 tons or 42.4 million PTE).

As illustrated in Figure 5, over the past 15 years California waste tire recycling volumes have fluctuated from 146,000 tons (14.6 million PTE) to 206,000 tons (20.6 million PTE) per year. Diversion volumes have been more erratic, ranging from 249,000 tons (20.9 million PTE) to 424,000 tons (42.4 million PTE) over the same period, with large shifts occasionally occurring in exports and ADC.

Figure 5
Waste Tire Diversion and Disposal Trends



Diversion and Recycling Outlook

Table 3 on the next page lists some of the key barriers impeding expansion of waste tire recycling. Current CalRecycle programs aim to help the industry overcome these barriers through a variety of funding, research, technical assistance, outreach, and direct business assistance activities. Drawing on specific information gleaned during research for this report, Table 4 summarizes projections for short- and long-term recycling and diversion of California waste tires. In the short term, the recycling trend is difficult to predict as it is unclear whether expected increases in paving, molded, and other TDPs and TDA will offset expected further declines in turf infill, ground rubber, and nuggets used as loose-fill playground surfacing and landscape mulch. Given projected increases in exports and TDF, there is potential for the diversion rate to increase in 2017, as long as any net declines in recycling are not too large.

In the long term, given the diversity of diversion markets and their proven ability to sustain large volumes, it appears likely that diversion levels will continue to be relatively high, in the 65 to 90 percent range, possibly with occasional spikes approaching CalRecycle's 90 percent goal, and dips as markets grow and contract. The potential for substantial, long-term growth in recycling volumes rests mainly on whether there are large increases in customer demand for existing and new products made with crumb rubber and TDA. Unfortunately, the barriers listed in Table 3 have precluded this level of growth in recent years.

Table 3
Key Barriers to Expansion of Waste Tire Recycling

Barrier	Crumb Rubber Production	Reuse		Crumb Rubber Demand				Civil Engineering	
		Retread	Used Tires	Paving	Turf Infill	Play/ Mulch	Molded/ Other TDP	Non-Landfill	Landfill
Need for increased demand for TDM by manufacturers and for TDPs by product consumers	X	X		X	X	X	X	X	X
Concerns over insufficient quantity or quality of crumb rubber (including lack of fine-mesh material) and other TDM Supplies							X	X?	
Tire storage regulations and concerns impede ability to supply projects with tire-derived materials								X	
Competition with conventional materials/products with favorable pricing or performance	X	X	X	X	X	X	X	X	X
Competition from out-of-state suppliers' tire-derived materials and products, sometimes with subsidies or operational cost advantages	X			X	X	X	X		
Insufficient quality standards and practices, or inadequate implementation and adoption	X			X		X	X		
Concerns over increasing imports of lower-tier tires from China at below-market prices, which compete with retread/reused tires and have low potential retreading/reuse themselves		X	X						
Lack of awareness of tire-derived products, performance or pricing benefits, and past experience	X	X		X	X	X	X	X	X
Perceived concerns over environmental, health, or safety risks		X	X		X	X			
Barriers to entry in use of TDM and TDPs, which may include lack of prior experience or knowledge of sources, needed adjustments to current practices, and required time/monetary investments	X			X			X	X	X
Long lead time and investment needed for feedstock conversion and new product development				X			X		
Inherent material characteristics of tire rubber limit potential applications				X		X	X	X	
California has a relatively small rubber product manufacturing industry that may limit the potential for increasing demand through feedstock conversion							X		
Most virgin rubber is used in tires but no California crumb rubber is used in new tire production, resulting in the need for large volume, non-traditional markets for recycled tires	X								
Government agency budget constraints force government purchasers to rely solely on the alternatives with the lowest initial bid instead of basing purchases on life-cycle savings over time				X	X	X	X		

Table 4
The Outlook for Diversion and Recycling

Category		2016 Volumes		Short-Term Outlook (2017-2018)	Long-Term Outlook (2019 – 2024 and Beyond)
		Million PTEs	Per-cent		
Recycling	Reuse (Inc. Used Tire Export)	8.2	17.9%	**Flat** Mature and relatively stable industries with little room for growth and relatively low fluctuations year to year.	**Flat or Possible Decline** Potentially threatened by competition with, and poor reuse potential of, imported lower-tier Chinese tires.
	Crumb Rubber	6.4	14.2%	**Uncertain** Demand for paving may grow given current trends and new transportation funding. Demand for turf infill and ground and nugget segments is expected to fall. As in recent years, growth in molded and Other TDP is likely to be modest.	**Possible Significant Growth, Mainly Paving** Potential new Caltrans policies and increased state and local transportation funding (e.g., SB 1) could drive paving growth. Potential increased incentives could kick-start feedstock conversion and /new product development.
	Civil Engineering	1.1	2.4%	**Growth** Steady landfill use and potential spikes in non-landfill TDA demand due to storm damage and new funding could trigger notable growth.	**Increasingly Steady Use with Modest Growth** An increasing range of new applications combined with sustained CalRecycle funding and new transportation funding (e.g., SB 1) could boost TDA use.
	Overall "Recycling"	15.7	34.4%	**Uncertain** Expected growth in paving and TDA may or may not offset expected declines in turf infill, crumb rubber and nuggets.	**Potential Growth but Much Higher Demand Needed** Growth depends on increased demand for TDA and crumb rubber, including new high-volume products and applications satisfying customer needs.
Diversion	ADC	1.7	3.7%	**Flat** No major changes projected at consuming landfills.	**Flat** Current levels have been sustained for many years.
	TDF	7.3	16.0%	**Flat** California cement kilns are near current capacity.	**Flat** Growth would require new permitting and kiln investments.
	TDF Export	4.7	10.4%	**Growth** Rebounding fossil fuel prices are helping to spur increased demand and pricing for TDF in the international market.	**Sustained High Volume with Intermittent Fluctuations** Demand is strong but will likely suffer inevitable interruptions, spikes, and declines.
	Baled Waste Tire Export	1.5	3.3%	**Growth** Baling activity is picking up in early 2017.	**Erratic but Sustained High Volumes** Sustained global demand, even with low fossil fuel prices; likely continuing abrupt changes in baler operations.
	Overall Diversion	30.9	67.8%	**Modest Growth** Increasing export, TDA, crumb rubber paving applications should overcome potential declines in other segments.	**Continued High Rates but with Fluctuations** California market diversity and growth potential should sustain relatively high diversion for foreseeable future.

Section 5
Concluding Remarks: Implications for CalRecycle Market Development Efforts

As in recent years, this report's findings show that to increase the California waste tire recycling rate, the most critical barrier is the need to increase demand in current market segments, and to establish new resilient, high-volume markets. CalRecycle has long employed a variety of waste tire market development strategies. Current programs and budgets are shown in Table 5.

Table 5
CalRecycle Budget for Research and Market Development Activities

Item	FY 2017–18	FY 2018–19	FY 2019–20	FY 2020–21	FY 2021–22
Tire-Derived Aggregate Civil Engineering Technical Support; Research Efforts; Technology Center and Laboratory Testing Services	$950,000	$500,000	$950,000	$950,000	$500,000
Rubberized Asphalt Concrete Technical Support and Research	$200,000	$650,000	$650,000	$200,000	$650,000
Caltrans PG+5 Binder Project	$350,000	$350,000	$350,000	$0	$0
Research on TDPs and Non-Highway Technologies Using Waste Tires	$250,000	$250,000	$250,000	$0	$0
Research on Landfill Emissions	$250,000	$0	$0	$0	$0
Research on Potential Effects of Recycled Tire Rubber	$650,000	$1,000,000	$1,000,000	$0	$0
Feedstock Conversion Assistance and Material Testing	$500,000	$500,000	$0	$0	$0
Tire-Derived Aggregate Grant Program	$850,000	$850,000	$850,000	$850,000	$850,000
Rubberized Pavement Grant Program	$7,750,000	$7,750,000	$3,000,000	$3,000,000	$3,000,000
Tire-Derived Products Grant Program	$1,939,226	$0	$1,000,000	$0	$1,000,000
Tire Incentive Program	$2,608,858	$4,468,000	$3,418,000	$6,418,000	$5,468,000
Tire Outreach and Market Analysis	$300,000	$300,000	$300,000	$300,000	$300,000
Tire Events	$75,000	$75,000	$75,000	$75,000	$75,000
Totals	16,673,084	$16,693,000	$11,843,000	$11,793,000	$11,843,000

Source: CalRecycle. "Five-Year Plan for the Waste Tire Recycling Management Program (Ninth Edition Covering Fiscal Years 2017–18 to 2021–22)." Approved May 23, 2017.

These CalRecycle market development programs target the recycling markets with greatest potential, with considerable focus on expanding rubber pavement and use of tire-derived aggregate in civil engineering applications. Resources are also allocated to conduct research addressing environmental health and safety concerns related to turf infill and playground applications, as described in Section 3. And, CalRecycle market development programs also seek to help catalyze new product development and feedstock conversion. The Tire Incentive Program (TIP) has been allocated an increased budget, providing direct payments to manufacturers of TDPs with structured rates that incentivize feedstock conversion and use of fine grind crumb rubber. Feedstock conversion assistance and material testing activities are designed to complement the TIP by identifying qualified manufacturers able to convert to using crumb rubber feedstocks, and providing them with technical assistance and material testing support. The Tire Outreach and Market Analysis (TOMA) contract provides for research services (including this report) to assess barriers and opportunities to expanding select types of TDPs and recycling end-of-life TDPs. TOMA also includes outreach activities aimed at educating prospective TDP purchasers and specifiers about the range of California-made products available and brings leads to the TDP manufacturers from the outreach efforts.

Last year, the 2015 California Waste Tire Market Report offered several suggestions for CalRecycle waste tire market development efforts, many of which were incorporated into the latest Five Year Plan. This year, based on the research and analysis conducted for this report, a new suggestion is offered for consideration.

Consider Offering a Flexible, Performance-Based TDP Market Development Grant Program: CalRecycle may want to consider a different approach with a flexible, performance-based grant or incentive program to encourage feedstock conversion and innovative TDPs. This effort could focus on products that represent significant market potential that could be produced and sold in a relatively short time period. Using broad guidelines to encourage the largest range of ideas, this approach may yield new products or product concepts not previously considered, while providing new information to help shape future CalRecycle efforts. CalRecycle could retain the right to not fund any projects, if none meet minimum standards for likelihood of success or other identified measures. This type of program could allow private companies to develop a wide range of innovative and commercial-ready project ideas to help address the need for innovation in TDP development and for short-term development of new markets.

The following suggestions from last year's report are updated and offered again, because of their direct relevance to current conditions and the need for new markets.

Keep incentive payments simple, secure, and focused on increasing customer demand for TDPs: As CalRecycle expands the tire incentive program, determining the details will be critical and challenging. CalRecycle is already increasing the TIP program budget, and pending legislation (AB 509, Frazier) could further boost funding and adjust the program. With ample crumb rubber production capacity and TDP markets that have

not seen large expansion in many years, there is a risk that incentives will spur additional crumb rubber or TDP production without sufficient markets. Therefore, incentive payments may be more effectively focused on expansion of TDP customer demand than on production of crumb rubber or TDPs. Options to consider include maintaining or expanding funding for TDP purchasers through existing grant programs or new incentive payment policies and prioritizing incentives to TDP consumers over incentives to crumb rubber producers or TDP manufacturers. To the extent that TDM and TDP manufacturers receive payments, consider strictly requiring demonstration that the qualifying materials and products have already been sold to customers. Also, as concluded in a previous CalRecycle report on incentive payment systems, participation rules must be simple, transparent, and consistently applied, while also guarding against the high potential for fraud, to be effective. CalRecycle could also consider whether support for manufacturer marketing and sales efforts can be directly provided through the TIP. Decision makers may wish to consider studying challenges experienced in other jurisdictions that have tire incentive payment systems to help anticipate potential pitfalls and to identify lessons learned, for example, in Colorado or Louisiana.

Refresh and strengthen TDP procurement policies: A number of state procurement policies exist to promote purchase of TDPs, some of which were adopted in the mid-1990s. Since that time, the number and variety of TDPs available in California has greatly increased. While not analyzed in detail for this report, anecdotally there appears to be large potential for state and local agencies (including colleges and universities) to greatly increase use of a variety of TDPs. Decision makers could consider strengthening these policies to more strongly promote or require purchases of TDPs by certain state or local agencies.

Promote retreading and recycling of off-the-road tires. While a mature, highly competitive industry, retreaders may have room to expand operations in some cases or to use crumb rubber in the retreading process. There may be an opportunity to expand diversion of off-the-road (OTR) tires through increased retreading and processing to produce crumb rubber and buffings. OTR tires have a very high disposal cost and contain a high percentage of natural rubber. CalRecycle could consider including all retreaders and targeting OTR tires in tire market development programs.

There is no simple, proven path to greatly expand waste tire recycling markets, as shown by California's experience and the diverse range of stakeholder perspectives. However, CalRecycle's complementary strategies and options described in this report are well aligned with the goal of increasing recycling and can potentially address some of the key barriers constraining growth. As always, implementation details are vitally important and will directly influence how successful the program is in coming years.

Appendix A
Glossary of Terms

ADC	Alternative Daily Cover used at landfills instead of soil
Buffings	Tire rubber produced as a by-product of the tire retreading process.
Caltrans	California Department of Transportation
CARB	California Air Resources Board
Crumb rubber	Tire-derived material less than ¼ inch in size, free of wire and fiber.
Feedstock conversion	The process whereby a manufacturer of an existing, commercially proven product converts a portion of the raw materials used to make the product from existing one (e.g., virgin rubber, plastic, or other materials) to crumb rubber made from recycled tires
Ground rubber	Tire-derived material ¼ inch to 1 inch in size, free of wire and fiber
OEHHA	California Office of Environmental Health Hazard Assessment
Passenger tire equivalent (PTE)	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.)
Tire-derived aggregate (TDA)	Tire-derived material used to replace conventional aggregates like rock in civil engineering applications
Tire-derived fuel (TDF)	Whole waste tires or tire-derived material consumed as fuel (referred to as size-reduced TDF in this report)
Tire-derived material (TDM)	Tires processed to meet market specifications, for example, crumb rubber, ground rubber, tire-derived aggregate, and tire-derived fuel
Tire-derived product (TDP)	Product made entirely or in part from tire-derived material
Tire Incentive Program (TIP)	A CalRecycle program launched in June 2015 to promote feedstock conversion and the use of crumb rubber as feedstock by California manufacturers
WTMS	Waste Tire Management System

Appendix B
Methodology and Data Limitations

General Approach

This appendix briefly summarizes the methodology used in this study to estimate the quantity of California-generated waste tires flowing to each market segment.

In short, the methodology involves:

- Gathering data and information through direct surveys and interviews of California-based waste tire processors, balers, landfills disposing waste tires or using TDA or ADC, cement kilns consuming TDF, retreaders, TDP manufacturers/installers/marketers, and select haulers;
- Compiling and analyzing CalRecycle data such as data on tire flows as reported by haulers and facilities in Comprehensive Trip Logs and entered into the Waste Tire Manifest System; the Disposal Reporting System; facility permitting activity; and grant program data available through CalRecycle monthly meeting agendas;
- Reviewing third-party information sources such as Caltrans' annual report to the Legislature on waste tire use; California Air Resources Board data on cement kiln tire use; the Rubber Manufacturers Association data on national scrap tire market trends; and a variety of other information sources identified each year, including information from other trade associations such as the Rubber Pavement Association and the Synthetic Turf Council; and
- Interviewing a variety of other individuals knowledgeable about waste tire industry and market trends.

Detailed data on flows of California tires from these sources is entered into a master flow model and scrutinized in an effort to identify all flows as completely and accurately as possible while avoiding double counting. This is an iterative process in which researchers frequently identify issues and follow up with facilities to refine the analysis.

For most market segments, survey responses are the preferred source, subject to validation if possible from other sources. If survey responses are not available for a given facility, analysts select the alternative approach deemed to be the most accurate, usually prior survey responses or WTMS data, which may be refined based on all available data and information.

Conversion Factors

Following are some key notes regarding the use of conversion factors in this study.

- All calculations in the analysis are performed in tons, not PTEs. When the final analysis is complete, tons are then converted to PTEs using the standard definition of 20 pounds per PTE and reported that way in this report to stay consistent with past reports.[8]
- With the exception of retreaders, surveys request that flow data from companies be provided in tons, and it is nearly always provided that way. Retreaders report the number of different types of tires retreaded and are also asked to provide the average tire weight for each type. If not available, the average weight from other reporting companies is used. Occasionally, other facilities may provide flow data in terms of the number of tires, and the most accurate conversion factor available is used to convert to tons.[9]
- WTMS data are used to estimate the approximate magnitude of tires flowing to and from facilities in this study. This information helps to identify facilities and haulers handling large volumes of tires and to ask the right questions in surveys and interviews. In a very limited number of cases, if a survey response is not provided and there are no other options, WTMS data may be used to estimate deliveries to a particular facility.
- CalRecycle's WTMS database provides all data in PTEs (defined as 20 pounds), although companies may provide the data in Comprehensive Trip Logs (CTLs) as either tons, cubic yards, or the actual number of tires (regardless of the tire size or type). CalRecycle converts cubic yards to PTEs using 10 PTEs/cubic yard. CalRecycle converts the number of tires to PTEs using 20 pounds per tire, regardless of the type or size of tires (which is not identified in the CTL). These conversions are some of the main reasons why WTMS data can often differ markedly from survey responses, and why it is only used as an indicator or as a last resort flow estimate when more reliable data are not available.

Methodology Refinements

The methodology for conducting this report has been relatively unchanged since 2007. However, refinements are made from time to time. In this year's report, two changes were made. First, only a single quantitative estimate of volumes consumed for crumb

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[8] This approach is based on direction provided by CalRecycle to the contractor team and is consistent with CalRecycle practices in a number of programs and policies. For example, the California Code of Regulations defines a PTE as 20 pounds (14 CCR § 17225.770).

[9] For example, according to the Rubber Manufacturers Association, on average light duty tires such as scrap passenger tires weigh 22.5 pounds, commercial tires such as scrap truck and bus tires weigh 120 pounds, and the average of all light duty and commercial scrap tires (excluding off-the-road tires) is 32.8 pounds. Source: "2013 U.S. Scrap Tire Management Summary." Rubber Manufacturers Association, November 2014, page 4. https://rma.org/publications/scrap-tire-publications/market-reports

rubber was provided, with no estimates for the segments within the category. As described under Crumb Rubber in Section 5, this change was made to safeguard confidentiality, given the increased competition and shifts currently underway in that industry segment. Second, the “molded and extruded” product category from previous years was re-titled as “molded and other tire-derived products” to reflect the diverse range of products and manufacturing processes involved.

Conclusions

As this methodology description illustrates, estimating California waste tire flows is challenging due to a variety of data gaps, data quality issues, and conflicting sources of information. Nevertheless, the authors strive to provide estimates for each market segment that are as accurate as possible, and they generally believe the results provide a reasonably accurate data set to identify and analyze trends over time.