

# The Outlook for Crumb Rubber Feedstock Conversion

Lessons Learned Through CalRecycle's Tire-Derived  
Product Business Assistance Program



California Department of Resources Recycling and Recovery

**September 12, 2013**

Contractor's Report  
Produced Under Contract By:

**SAIC**<sup>®</sup>

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Publication # DRRR 2014-1510



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*Prepared as part of contract number DRR-10033*

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# Executive Summary

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The California Department of Resources Recycling and Recovery (CalRecycle) is responsible for ensuring proper management of waste tires generated in the state and promoting tire recycling. Several years ago, CalRecycle established a goal of 90 percent diversion by 2015. This goal was achieved for the first time in 2012, due to a combination of in-state industry/market expansion and a strong surge in the export of waste tires and of tire shreds used as tire-derived fuel (TDF).

This report provides an update on the outlook for feedstock conversion, an important type of market development opportunity that CalRecycle pioneered through the Tire-Derived Product Business Assistance Program (TBAP). Feedstock conversion is defined as a manufacturer deciding to use crumb rubber produced from recycled tires to replace other conventional raw materials (e.g., virgin rubber or plastic). This report also covers to a degree companies that have sought to develop and launch new TDPs from scratch, since many of the same challenges must be overcome. For brevity, the term feedstock conversion in this report sometimes refers to both replacing feedstock with crumb rubber and developing new TDPs. This report is a follow-up to a 2009 TBAP report on feedstock conversion<sup>1</sup> that summarized initial research and helped lead to establishing feedstock conversion as a priority in TBAP Grant Cycles 3 and 4, conducted between 2009 and 2013. Information presented in this report is based largely on experience working with 10 TBAP grantees that received direct support for feedstock conversion and/or new TDP development activities during this time.

## ***Market Status and the Need for Feedstock Conversion***

In 2012 SAIC estimates that 45 million waste tires were generated in California, and that approximately 92 percent of these, or 417,000 tons, were diverted from landfill. About 98,000 tons or 10 percent of California waste tire generation, were used to produce approximately 137 million pounds of crumb rubber. Feedstock conversion and new TDP development are focused mainly on the use of crumb rubber, a raw material that can be used in a variety of manufacturing processes to make a diverse range of products. The three largest uses for California's crumb rubber are rubberized asphalt concrete (RAC) and other paving applications, synthetic turf infill, and coarse crumb rubber nuggets used as mulch or loose-fill playground surfaces. A small amount is used in pour-in-place surfacing. Feedstock conversion is primarily focused on the remaining market segment, molded and extruded products. Currently, this category uses about 14 percent of California crumb rubber, or about 18.6 million pounds. Products include a variety of flooring, roofing, mats, tiles, parking stops, and landscaping products, among many others.

## ***CalRecycle Support for Feedstock Conversion***

CalRecycle's Tire-Derived Product Business Assistance Program (TBAP) has directly supported at least 10 firms involved in feedstock conversion or new product development. No further TBAP grant cycles are currently scheduled. However, the following CalRecycle activities have, or potentially could, support feedstock conversion efforts:

- TBAP industry-wide activities, including a 2009 Feedstock Conversion Project Report and ongoing outreach and education activities designed to raise awareness of all types of tire-derived products produced in California.

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<sup>1</sup> Available at <http://www.calrecycle.ca.gov/Publications/Documents/Tires%5C2009016.pdf>

- TDP and rubberized pavement grants that offset a portion of the purchase price of products made from California waste tires.
- Recycling Market Development Zone Loan Program, which can provide low-interest loans to firms undertaking feedstock conversion activities that meet program financial, market, and other criteria.
- A pilot Tire Incentive Program (TIP), which CalRecycle staff is currently developing
- The Plastics Market Development Incentive Program, which provides funding to processors and manufacturers using California-generated beverage containers.

## ***Feedstock Conversion Opportunities***

The 2009 Feedstock Conversion Project Report identified several rubber products for which crumb rubber from waste tires could potentially add value compared to virgin rubber raw materials. Some of the potential benefits that have driven California firms to undertake feedstock conversion projects include:

- Reducing production cost by replacing higher cost raw materials with crumb rubber.
- Enhancing product performance by taking advantage of the inherent characteristics of crumb rubber related to particle size, particle size distribution, density, rubber chemistry and surface morphology. Potential benefits may include: durability, flexibility, water resistance, slip resistance, tensile strength, cushioning, and sound or vibration dampening.
- Sales Expansion related to new or reformulated product lines.
- Green marketing opportunities (though products typically must compete as well based on cost and performance).
- Additional opportunities such as advancing corporate sustainability, supporting the local economy and/or promoting a made in the USA brand.
- The 2009 Feedstock Conversion Project Report concluded that a plausible goal would be for California manufacturers to collectively use about 52 million pounds of crumb rubber per year in making such products. While not a precise estimate of potential feedstock conversion demand, this figure is useful for evaluating alternative feedstock conversion activities.

## ***Feedstock Conversion Barriers***

Experience through the TBAP program shows success requires addressing several challenges, including:

- Identifying and recruiting candidates for feedstock conversion.
- Need for a timeline and objectives tailored to the firm's specific customer requirements and market positioning.
- Defining feedstock needs and securing suppliers, including consideration of crumb rubber mesh size and performance characteristics, compounded raw materials, established specifications and ensuring crumb rubber is made from California-generated tires.
- Refining production capabilities.

- Refining marketing and sales systems.
- Organizational constraints, costs, and the need for a sustained commitment.

## **Conclusions and Recommendations**

While perhaps a long-term approach that requires overcoming significant barriers, feedstock conversion holds the promise of diversifying tire recycling markets far more than they have been to date, while providing a high-price market that can strengthen California crumb rubber producers and fuel expansion of TDP manufacturing firms.

The 2009 Feedstock Conversion Project Report concluded that a plausible goal would be for California manufacturers to collectively use about 52 million pounds of crumb rubber per year in making such products. Achieving this level of demand through feedstock conversion would be equivalent to a 38 percent increase in current production of crumb rubber, or a 280 percent increase over the current use of crumb rubber in molded and extruded products. This would increase the number of California waste tires being used in crumb rubber for molded and extruded products from 1.3 million PTE to 3.7 million, or slightly more than 8 percent of the amount generated in 2012. In short, achieving such an increase would represent a significant expansion in the state's crumb rubber and TDP manufacturing infrastructure, but would not "solve" the state's need for waste tire markets.

The 10 TBAP grantees involved in feedstock conversion generally have made demonstrable progress and have strong prospects to expand demand in a variety of diverse markets offering relatively high prices for crumb rubber. However, to date this crumb rubber demand has been slow to materialize, despite significant investments by CalRecycle of over \$1.7 million in grant services. Based on information provided by the firms, SAIC estimates that in the short-term (i.e., one or two years), they are poised to use approximately 1 – 1.5 million pounds of crumb rubber a year (including buffings), or 5 – 8 percent of the 18.6 million pounds currently flowing to the molded and extruded product category. In five years they could be using three-to-five million pounds of crumb rubber and buffings.

Given the important need for new types of products using recycled tire rubber, SAIC believes feedstock conversion is still a very essential component of CalRecycle's tire market development program, despite the cost and time involved. However, feedstock conversion should be viewed as a long-term effort that holds the promise, over time, to transform crumb rubber markets that currently rely on a few, large relatively low-value markets by creating higher-value demand in a wide variety of niche market segments. In the long run, if successful feedstock conversion could literally transform the industry.

To support feedstock conversion, SAIC recommends that CalRecycle consider the following recommendations:

- Provide technical assistance and ongoing monitoring and encouragement.
- Closely monitor rubber supplies used in feedstock conversion efforts.
- Provide monetary support for feedstock conversion efforts.
- Conduct training and promotion.
- Conduct outreach to customers.
- Develop a feedstock conversion plan.

Overall, feedstock conversion is a long-term tire market development strategy that, while costly and slow to yield results, holds the potential to transform crumb rubber markets, benefitting waste tire recycling firms and helping to achieve CalRecycle's waste tire recycling goals.

# Background

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The California Department of Resources Recycling and Recovery (CalRecycle) is responsible for ensuring proper management of waste tires generated in the state and promoting tire recycling. Several years ago, CalRecycle established a goal of 90 percent diversion by 2015. This goal was achieved for the first time in 2012, due to a combination of in-state industry/market expansion and a strong surge in the export of waste tires and of tire shreds used as tire-derived fuel (TDF).

CalRecycle administers a number of programs designed to expand and diversify markets for recycled tires, including: grants; loans; technical assistance; outreach and education; and market/product research. Since 2006, one key CalRecycle tire recycling market development initiative has been the Tire-Derived Product Business Assistance Program (TBAP). TBAP has provided customized technical assistance services to several dozen California waste tire processors and TDP producers/vendors. In addition to this company-specific support, TBAP has also involved a variety of industry-wide activities such as: outreach to prospective TDP customers; market research; and analysis of market development barriers, opportunities and policies/programs.

This report provides an update on the outlook for feedstock conversion, an important type of market development opportunity that CalRecycle pioneered through TBAP. Feedstock conversion is defined as a manufacturer deciding to use crumb rubber produced from recycled tires to replace other conventional raw materials (e.g., virgin rubber or plastic). This report also covers to a degree companies that have sought to develop and launch new TDPs from scratch, since many of the same challenges must be overcome. For brevity, the term feedstock conversion in this report sometimes refers to both replacing feedstock with crumb rubber and developing new TDPs. This report is a follow-up to a 2009 TBAP report on feedstock conversion<sup>2</sup> that summarized initial research and helped lead to establishing feedstock conversion as a priority in TBAP Grant Cycles 3 and 4, conducted between 2009 and 2013. Information presented in this report is based largely on experience working with 10 TBAP grantees that received direct support for feedstock conversion and/or new TDP development activities during this time.

Following this introduction, Section 2 briefly summarizes current trends for California waste tires and crumb rubber produced from waste tires. Section 3 identifies CalRecycle programs that have or potentially could support feedstock conversion activities, including describing the 10 TBAP feedstock conversion grantees. Section 4 broadly summarizes the opportunities for feedstock conversion. Section 5 describes the many important barriers that must be overcome, and Section 6 presents SAIC's overall conclusions and recommendations for future CalRecycle feedstock conversion efforts.

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<sup>2</sup> Available at <http://www.calrecycle.ca.gov/Publications/Documents/Tires%5C2009016.pdf>

# Market Status and the Need for Feedstock Conversion

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This section briefly describes California waste tire market trends and how feedstock conversion and new TDP development can help to strengthen tire recycling firms and help to achieve CalRecycle's tire recycling goals over the long term. Figure 1 shows the trend in the market segments to which California waste tires have flowed since 2002. In 2012 SAIC estimates that 45 million waste tires (PTE) were generated in California, and that approximately 92 percent of these, or 417,000 tons, were diverted from landfills.

In 2012 about 73,000 tons or 16 percent flowed to reuse, including retreading and sale of used tires deemed suitable for reuse by processors. This market provides strong pricing and is at the top of the integrated waste management hierarchy; however, opportunities for further growth are limited.

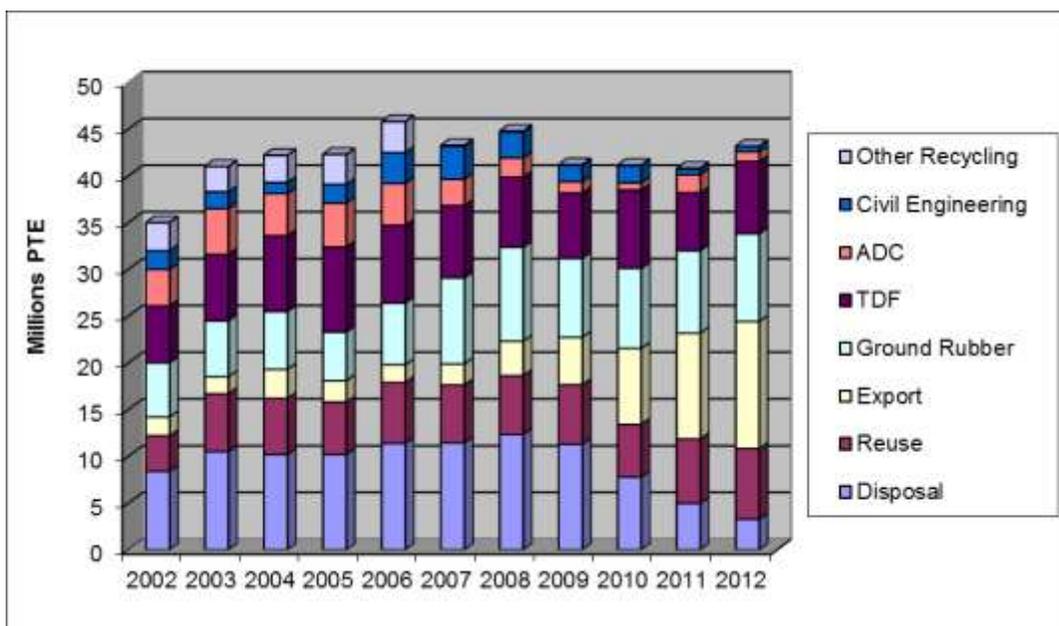
About 98,000 tons, or 10 percent of California waste tire generation, were used to produce crumb rubber, which also provides relatively strong pricing and is one of two CalRecycle tire market development priorities.

The other priority is civil engineering, which used about 5,800 tons or just over 1 percent of 2012 waste tire generation (significant growth is expected in 2013 due to several specific projects). Civil engineering applications, mainly in landfills and road or rail projects, offer relatively low pricing and has been slow to expand, but was established as a priority because of the theoretically high potential for growth and demonstrated use in certain other states.

Two low-priority markets (as identified by CalRecycle) are use of tires as alternative daily cover (ADC) in landfills and as tire-derived fuel (TDF), mainly by cement kilns. ADC consumed about 10,500 tons, or just more than 2 percent of tires generated in 2012, and is often a negative price application in which disposal costs may be reduced. TDF consumed more than 77,000 tons, or 17 percent of tires generated in 2012. TDF is a well-established market across the nation that offers stable pricing (though much lower than for crumb rubber) for material that is relatively low-cost to produce (compared to crumb rubber). TDF is a low priority because CalRecycle is statutorily prohibited from promoting its use.

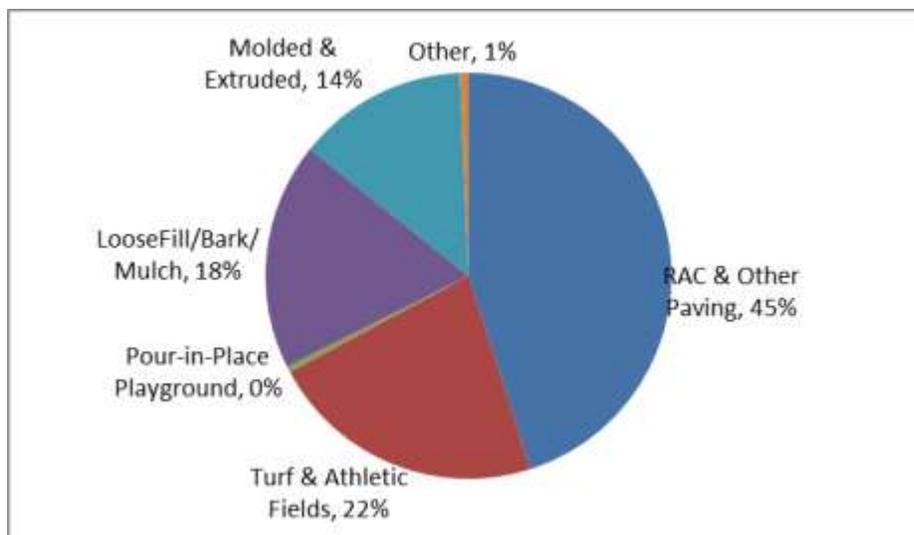
Lastly, export of waste tires and TDF, mainly to Asian nations, has been the dominant trend in California tire recycling markets for several years, with nearly 153,000 tons, or 34 percent of all tires generated exported in 2012 (this includes export of used tires, a long-standing practice which comprised 4 percent of all tires generated). Over the past several years, and especially in 2012, exports grew rapidly and had many disrupting impacts on the state's established waste tire industry; however, waste tire export volumes appear to have stabilized in recent years although they have the potential to abruptly increase. Export of TDF and used tires is expected to remain robust for the foreseeable future.

**Figure 1 California Waste Tire End-Use Trends**



Feedstock conversion and new TDP development are focused mainly on the use of crumb rubber, a raw material that can be used in a variety of manufacturing processes to make a diverse range of products. In 2012, SAIC estimates that California firms produced about 137 million pounds of crumb rubber, which flowed to the markets identified in Figure 2 below. It is important to note that the statistics in Figures 1 and 2 estimate the amount of California-generated tires and California-produced crumb rubber, respectively, flowing to each market, not the overall size of the market.

**Figure 2  
Estimated California Ground Rubber Shipments by Market Category (2012)**



Source: 2012 California Waste Tire Market Report

As shown in Figure 2, the three largest uses for California's crumb rubber are Rubberized Asphalt Concrete (RAC) and other paving applications, synthetic turf infill and coarse crumb rubber nuggets used as mulch or loose-fill playground surfaces. And a small amount is used in pour-in-place surfacing.

Feedstock conversion is primarily focused on the remaining market segment, molded and extruded products. Currently, this category uses about 14 percent of California crumb rubber, or about 18.6 million pounds. Products include a variety of flooring, roofing, mats, tiles, parking stops, and landscaping products, among many others.

Feedstock conversion is an important tire market development strategy because it holds the potential to diversify waste tire markets into a wide range of industries and niches, which can help safeguard against abrupt changes in any one market segment. By focusing on uses for crumb rubber, feedstock conversion also can provide profitable business opportunities for waste tire processors and product manufacturers. While reuse offers the best pricing to processors with low operating costs, crumb rubber offers better pricing, albeit with higher production costs, than other high-volume uses such as civil engineering, ADC, export and TDF (which is a well-established and profitable market segment). On the down side, crumb rubber production is highly competitive and has been impacted by the export trend, subsidies in certain U.S. states and Canadian provinces, and the expansion of production capacity across North America. Feedstock conversion can help address these issues by increasing crumb rubber demand. In the long run, feedstock conversion and new TDP development may be essential to sustaining high waste tire diversion rates as generation grows.

# CalRecycle Support for Feedstock Conversion

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As described in the Background section, CalRecycle's Tire-Derived Product Business Assistance Program has directly supported at least 10 firms involved in feedstock conversion or new product development. In addition, CalRecycle operates or is developing several programs that have or could potentially support feedstock conversion. This section describes these ongoing and potential future activities.

## ***Tire-Derived Product Business Assistance Program***

TBAP started in June 2006 with the overall goal of expanding and diversifying California's markets for waste tires by strengthening the operations of waste tire processors and TDP producers/vendors through customized assistance services. The program also includes industry-wide services involving market research, outreach and education, and technical services targeting one or more market segments. TBAP grant services are set to end in August 2013, while select industry-wide activities will continue under the Tire Outreach and Market Analysis (TOMA) program.

Four "cycles" of TBAP grants have been awarded: Cycle 1 in August 2006, Cycle 2 in May 2007, Cycle 3 in August 2009, and Cycle 4 in September 2011. TBAP grants provide services only and do not make direct monetary reimbursements of any kind to grantees. In the last scheduled program cycle (Cycle 4), 22 individual company TBAP grants totaling \$2.5 million were awarded in September 2011, and of those, eight grants totaling \$793,625 (approximately 32 percent of funds awarded) were awarded to feedstock conversion companies.

### **TBAP Feedstock Conversion Focus**

CalRecycle staff and the TBAP contractor team conduct outreach to potential applicants in advance of each program cycle. For Cycle 3 (in 2009) and Cycle 4 (in 2011), this outreach specifically included targeting potential feedstock conversion applicants. In Cycle 2, one grantee was involved in feedstock conversion activities. For Cycle 3, feedstock conversion was established as a priority, and in August 2009, six new feedstock conversion grants were awarded, in addition to a grant to the returning sole feedstock conversion grantee in Cycle 2. In Cycle 4 in August 2011, the program marketing effort was relatively small due to time and budget constraints, but nevertheless led to two new grantees involved in feedstock conversion and one new grantee involved in new product development, in addition to five returning feedstock conversion grantees from Cycle 3 who reapplied for assistance.

Identifying candidate feedstock conversion firms and familiarizing decision makers with the opportunity and assistance available, and securing a firm, lasting commitment to pursue conversion projects, proved time-consuming and complex. This important feedstock conversion barrier is described further in the Barriers section.

### **Types of TBAP Assistance Services**

Working with the 10 TBAP feedstock conversion grantees provided an opportunity to learn about the many challenges inherent in changing established manufacturing operations. All eligible TBAP applicants receive a Needs Assessment based on review of company documents and a site

visit, which is used to validate and refine services requested by grantees. TBAP provided four categories of assistance: general business, marketing, product testing, and technical assistance.

Feedstock conversion grantees received a wide variety of services generally aimed at establishing production capacity using crumb rubber, facilitating raw material sourcing from crumb rubber producers and compounders, and developing marketing strategies, collateral, and other resources needed to expand sales of these products. Examples of the assistance provided are provided in Table 1. Grantees were often less interested in general assistance as they felt they could address general business operational needs in-house, despite TBAP assessments in some cases that indicated fundamental issues with the basic business information and management systems.

**Table 1  
Examples of TBAP Assistance by Category**

General	Marketing	Product Testing and Certification	Technical Assistance
<ul style="list-style-type: none"> <li>• Business planning and strategy development</li> <li>• Pricing strategies</li> <li>• Financial/operational performance benchmarking</li> <li>• Inventory management control systems</li> <li>• Accounting system and controls</li> <li>• Strategic partnership development</li> <li>• Financing strategies and assistance</li> <li>• Customized training</li> </ul>	<ul style="list-style-type: none"> <li>• TDP market research</li> <li>• Branding, marketing and sales strategy and planning</li> <li>• Customer satisfaction and retention strategies</li> <li>• Product pricing</li> <li>• Customer relations management and sales systems</li> <li>• Website and collateral design, programming and printing</li> <li>• E-commerce Solutions</li> </ul>	<ul style="list-style-type: none"> <li>• Product testing for safety, fire resistance, performance, etc.</li> <li>• Product prototype analysis</li> <li>• Documentation of recycled content use and other product attributes</li> </ul>	<ul style="list-style-type: none"> <li>• Developing and sourcing crumb rubber feedstocks</li> <li>• Manufacturing systems review</li> <li>• Process evaluation/optimization</li> <li>• Energy audits</li> <li>• Product quality evaluation and systems</li> <li>• Troubleshooting product performance issues</li> <li>• Evaluating/implementing new technologies</li> </ul>

### **TBAP Feedstock Conversion Participants**

This report focuses on 10 firms that each received one or more TBAP grants to pursue feedstock conversion, as listed in Table 2. Overall, these 10 firms received a total of 16 TBAP service grants with a combined total of \$1,729,365. Across all feedstock conversion grantees, approximately 60 percent of services by dollar value involved marketing, with the remainder mostly split between technical assistance and product testing. While some companies other than TBAP grantees have undertaken product development or other activities related to feedstock conversion, SAIC feels the firms listed in Table 2 comprise the vast majority of TBAP feedstock conversion assistance efforts and embody the key lessons learned to date.

**Table 2  
Major Feedstock Conversion TBAP Participants**

<b>Company</b>	<b>Grant Cycle and Grant Amounts</b>	<b>Services Received</b>	<b>Feedstock Conversion Focus</b>
Crossfield Product Corp.	Cycle 3, \$175,000 Cycle 4, \$50,000	<ul style="list-style-type: none"> <li>• Marketing</li> <li>• Testing</li> <li>• Technical assistance</li> </ul>	Increase product performance benefits and expand sales of a permeable membrane used for waterproofing and protecting concrete, masonry, and other materials. Develop other deck and floor sealants.
Deccofelt	Cycle 3, \$50,000 Cycle 4, \$50,000	<ul style="list-style-type: none"> <li>• Marketing</li> <li>• Testing</li> <li>• Technical assistance</li> </ul>	Develop an advanced waterproofing material using a patented self-adhering rubber asphalt compound. Integrate the resilience, flexibility, and waterproofing properties of tire rubber into waterproofing membranes and flashings.
Holz Rubber	Cycle 2, \$175,000 Cycle 3, \$36,000	<ul style="list-style-type: none"> <li>• General</li> <li>• Technical assistance</li> </ul>	Help the firm to evaluate and increase use of compounds containing crumb rubber (replacing virgin rubber) in its line of diverse industrial equipment parts and Original Equipment Manufacturer products.
Hyperseal	Cycle 3, \$100,000	<ul style="list-style-type: none"> <li>• General</li> <li>• Testing</li> <li>• Technical assistance</li> </ul>	Assist in commercializing a rubberized coatings product used in roofing and other applications.
Kirkhill Manufacturing	Cycle 3, \$175,000 Cycle 4, \$125,000	<ul style="list-style-type: none"> <li>• General</li> <li>• Testing</li> <li>• Marketing</li> <li>• Technical assistance</li> </ul>	Develop and take to market a “shake style” roofing shingle that contains recycled tire rubber. Help firm use more recycled tire rubber in manufacturing off-the-road (OTR) retread material.
MB Technology	Cycle 3, \$50,000 Cycle 4, \$50,000	<ul style="list-style-type: none"> <li>• Testing</li> <li>• Marketing</li> </ul>	Developed a new torch-applied roofing membrane that incorporates recycled tires into styrene-butadiene-styrene (SBS) modified bitumen.
PolymeRight, Inc.	Cycle 4, \$50,000	<ul style="list-style-type: none"> <li>• Marketing</li> <li>• Testing</li> <li>• Technical assistance</li> </ul>	Refine and take to market a simulated, devulcanized crumb rubber raw material that can be used by various existing rubber product manufacturers.
reRubber	Cycle 4, \$175,000	<ul style="list-style-type: none"> <li>• Marketing</li> <li>• Testing</li> <li>• Technical assistance</li> </ul>	Produce a more effective, sustainable, and permanent tire sealant using crumb rubber in place of alternative chemicals. Develop protective coatings and sealants for a variety of applications (e.g. flooring, roofing, automotive, waterproofing), making use of crumb rubber beneficial properties.
Swisstrax	Cycle 3, \$175,000	<ul style="list-style-type: none"> <li>• Testing</li> <li>• Marketing</li> </ul>	Assist in developing and refining a modular flooring product line made with recycled tire

Company	Grant Cycle and Grant Amounts	Services Received	Feedstock Conversion Focus
	Cycle 4, \$143,625	<ul style="list-style-type: none"> <li>• General</li> <li>• Technical assistance</li> </ul>	rubber. (Other Swisstrax product lines utilize recycled rubber tire rubber and plastic.)
WWIR/Delamo Mfg.	Cycle 4, \$150,000	<ul style="list-style-type: none"> <li>• Marketing</li> <li>• Testing</li> <li>• Technical assistance</li> </ul>	Develop a new line of janitorial tool products that are manufactured with recycled tire rubber.

### Feedstock Conversion Grantee Results

Overall, the 10 grantees have generally made steady but slow progress toward establishing the sustained demand for California crumb rubber in their new and established products. Eight of the 10 grantees are currently marketing, producing and selling the targeted products listed in Table 2 above, while one is conducting additional testing prior to fully launching marketing efforts and one is still developing production capacity.

While demand for California crumb rubber through these firms is expected to grow steadily, reaching the full promise of these products is likely to play out over several years. It is very challenging to estimate the potential demand in tonnage terms and when it may materialize, given the many variables affecting each firm and each product. Based on information provided by the firms, SAIC estimates that in the short term (i.e., one or two years), they are poised to use approximately 1 million to 1.5 million pounds of crumb rubber a year (including buffings), or 5 – 8 percent of the 18.6 million pounds currently flowing to the molded and extruded product category. In five years they could be using 3 million to 5 million pounds of crumb rubber and buffings. This is most likely demand that would not have occurred without CalRecycle support. Moreover, TBAP feedstock conversion activities also resulted in raising awareness and interest in feedstock conversion by compounders, which could benefit future feedstock conversion efforts.

The firms are also making slow but steady progress in terms of securing adequate long-term supplies of California-produced crumb rubber. In many cases raw materials are provided by a compounder who combines crumb rubber with other additives. Several firms began production with a waiver from CalRecycle that allowed them to purchase fine crumb rubber from out-of-state sources, because such fine crumb rubber (i.e., of 80 – 200 mesh in size) was not available in California. In Cycle 4 however, with support from the TBAP program in collaborating with compounders and crumb rubber producers, three of these grantees were able to shift to using California-made crumb rubber, which is larger in size (i.e., 30-50 mesh) and lower in price. One additional firm currently using a source with limited quantity available was able to secure additional California sources. Four of the firms are still using crumb rubber sourced from out-of-state suppliers, although two of these are actively working to shift to California sources and appear to have the potential to do so in the short term. Shifting feedstock suppliers and specifications requires an investment in time and energy that can be difficult for some firms to make, especially without outside support as was provided through TBAP. Two California crumb rubber suppliers can provide fine mesh material of 30-50 mesh, but depending on the specification, the material is typically a by-product generated through the production of crumb rubber with other specifications. This feedstock supply issue is addressed in more depth in the Feedstock Conversion Barriers section.

## **Other Types of CalRecycle Support**

As discussed above, the current TBAP grant cycle closes in August 2013, and no further application cycles are currently scheduled. However, the following CalRecycle activities have, or potentially could, support feedstock conversion efforts:

- ***TBAP Industry-Wide Activities.*** This includes the 2009 Feedstock Conversion Project Report that provided initial research into the topic; ongoing outreach and education activities designed to raise awareness of all types of tire-derived products produced in California among potential customer groups; and promotion of best management practices to improve feedstock and TDP quality.
- ***TDP and Rubberized Pavement Grants.*** This program offsets the purchase price of products made from California waste tires. To date, use of grants for molded and extruded products has been somewhat limited, but CalRecycle staff are actively exploring how the program could better support feedstock conversion products.
- ***Recycling Market Development Zone Loan Program.*** The Recycling Market Development Zone Loan Program encourages California-based recycling businesses located within California to site new manufacturing facilities and expand existing operations. This program provides low-interest loans for the purchase of equipment and other relevant business costs. The intent of the Recycling Market Development Zone Loan Program is to help California manufacturers increase their processing capabilities and create additional markets for recycled-content products. According to CalRecycle program staff, businesses involved in feedstock conversion activities could qualify as long as they meet minimum financial strength criteria, including demonstrating an adequate market for their product. For new or reformulated products, this may require providing written documentation demonstrating demand. While the program does not fund new product development per se, it can potentially fund equipment and other costs related to producing tire-derived products. Use of California-generated tires would be a strict requirement.
- ***Tire Incentive Program (TIP).*** CalRecycle staff is currently developing a pilot program that would provide monetary payments to processors, TDP manufacturers, and/or compounders using California waste tires.
- ***Plastics Market Development Programs.*** Some feedstock conversion and TDP development involves products made from both recycled rubber and recycled plastic, and in such cases two CalRecycle programs focused on recycled plastics could potentially provide support. The Beverage Container Recycling Market Development and Expansion Grants Program offers grants specifically to boost demand for recycled beverage containers. The program is currently on hold due to lack of available budget, but may be offered in the future. And, the California Plastics Market Development Incentive Program provides a monetary per-ton payment to reclaimers (i.e., processors of recycled plastic containers) and recycled product manufacturers who use California recycled plastic as feedstock.

As discussed, one key lesson from the TBAP feedstock conversion experience is the need for ongoing, tangible support and encouragement to manufacturers engaged in feedstock conversion.

Providing an adequate incentive to research, develop, test, and launch new products, in addition to adapting marketing and sales systems, requires that managers adjust priorities and accept a variety of costs. CalRecycle staff is currently evaluating how existing and new programs can best be tailored to provide a sufficient incentive for firms to overcome such barriers.

# Feedstock Conversion Opportunities

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The 2009 Feedstock Conversion Project Report indicates that there are a number of rubber products for which crumb rubber from waste tires could potentially add value compared to virgin rubber raw materials. In addition, the report notes that crumb rubber can be used in combination with plastics in certain products currently made from plastic only. Examples of products include:

- Window and door seals/gaskets
- Automotive mud flaps
- Wheel well spray sealants
- Floor mats
- Carpet underlay
- Flooring and tiles
- Industrial belts and rollers
- Vibration pads
- Wheel chocks
- Drains and downspouts
- Soaker hose
- Floating docks
- Dock bumpers
- Rubberized asphalt
- Crack sealant
- Sports/playground surfacing
- Expansion joints
- Sound barriers
- Guard rail components
- Roofing shingles

The starting point for evaluating specific feedstock conversion opportunities is customer needs, and determining how use of crumb rubber can add value to current practices to satisfy them and drive sales. In practice, this may involve working closely with manufacturers, crumb rubber suppliers, and compounders to develop and validate through product testing hypotheses about the potential benefits of using crumb rubber as feedstock.

Some of the opportunities for benefits that have driven California firms to undertake feedstock conversion projects include:

**Reducing Production Cost.** In many cases, replacing a percentage of virgin rubber or plastic with recycled tire rubber can reduce costs. This benefit is of course dependent on market and pricing trends for conventional materials like natural or synthetic virgin rubber or plastic resins, which vary with the price of petroleum and related by-products. The cost savings also depends on the percentage conversion and amount used in each product. Feedstock conversion involves new costs as well, especially during the evaluation and testing stage.

**Enhancing Product Performance.** Crumb rubber can provide certain product performance benefits that can drive feedstock conversion. Performance is influenced by particle size, particle size distribution, rubber chemistry, and surface morphology. And, depending on the type of compounds used, the manufacturing process and the type of product, performance benefits may include: durability, flexibility, water resistance, slip resistance, tensile strength, cushioning, and sound or vibration dampening. It is important to identify the critical benefits, then implement a program to ensure that the appropriate crumb rubber characteristics are managed to produce a suitable and consistent product. Some of the material characteristics that should be considered, and potential benefits, are listed in Figure 3.

**Figure 3**  
**Examples of Crumb Rubber Characteristics and Potential Product Benefit**

*Sales Expansion.* If a manufacturer can successfully collaborate with raw material suppliers (e.g., crumb rubber producers and compounders) to enhance the performance, cost or other product attributes through crumb rubber use, then there is an opportunity to expand sales. This, of course, requires investing in new or refined marketing materials, as well as training distributors and

Crumb Rubber Attribute	Crumb Rubber Feature	Potential TDP Performance Benefits
Tire chemistry →	Elastomeric Resilience →	Abrasion Resistance Impact Resistance Crack Resistance Vibration Damping Sound Damping
	Strength & Toughness →	Abrasion Resistance Impact Resistance Crack Resistance Vibration Damping Flexibility Cohesion Crack Bridging Tear Strength Flexural Strength
	Non-conductive →	Thermal Insulation Sound Insulation Electrical Resistivity
	Chemical Inertness Water Resistance →	Resistant to acids and Moisture and Water Weatherability
	Durability →	Aging
Particle Size →	Adhesion →	Abrasion Resistance Crack Resistance Flexibility Cohesion Flexural Strength Crack Bridging Tear Strength
Particle size distribution →	Adhesion →	Abrasion Resistance Crack Resistance Flexibility Cohesion Flexural Strength Crack Bridging Tear Strength
Surface morphology →	Adhesion →	Abrasion Resistance Crack Resistance Flexibility Cohesion Flexural Strength Crack Bridging Tear Strength

others involved in customer outreach and sales to ensure they understand the product benefits and how they meet customer needs.

**Green Marketing.** Some manufacturers have focused on branding products made with recycled tire rubber as “green.” Experience shows that green marketing can drive sales to a degree in some markets and for some products, but that the products must make sense on a business basis as well to thrive. That is, the products must have clear price, performance, or other benefits to drive sales over the long-term, and it is risky for manufacturers to depend too heavily on “green” marketing strategies.

**Additional Opportunities.** Depending on the manufacturer’s niche and positioning within the marketplace, some manufacturers may see additional opportunities for pursuing feedstock conversion, such as:

- Advancing corporate sustainability practices
- Supporting the local economy through “green” job creation
- Promoting “Made in the U.S.A.” brand certification for products that may otherwise be made with conventional virgin materials and imported into the United States

Again, however, experience to date shows that fundamental business and market principles must drive successful feedstock conversion opportunities. That is, manufacturers must collaborate with suppliers to meet clear customer needs in a manner that provides benefits in cost, performance, or other areas through conversion to crumb rubber.

The 2009 Feedstock Conversion Project Report concluded that a plausible goal would be for California manufacturers to collectively use about 52 million pounds of crumb rubber per year in making such products. It is based on data on California manufacturers in ThomasNet business registry (<http://www.thomasnet.com/>) and assumes, among other things, that one-third of California rubber and plastics manufacturers could benefit from feedstock conversion, and that 25 percent of these actually pursue and succeed in converting, on average, 20 percent of their raw material needs to recycled tire rubber. This is a very rough estimate that was derived based on a number of assumptions, in order to develop a plausible goal.

While not a precise estimate of potential feedstock conversion demand, this rough estimate of 52 million pounds of potential demand was intended to provide a conservative estimate for the purposes of evaluating alternative feedstock conversion activities. In practice, there are many variables to consider that complicate such an estimate, such as the types of products assumed to use crumb rubber, the percentage of feedstock that can be converted to crumb rubber, current and potential demand for each targeted product, and the market share that can be captured by California manufacturers.

Because of these variables and a lack of data, the 52 million pound estimate of potential demand should be used for illustrative purposes only. However, achieving this level of demand through feedstock conversion would be equivalent to a 38 percent increase in current production of crumb rubber, or a 280 percent increase over the current use of crumb rubber in molded and extruded products. Another way of looking at it is that this level would increase the number of California waste tires being used in crumb rubber for molded and extruded products from 1.3 million PTE to 3.7 million, or just over 8 percent of the amount generated in 2012. In short, achieving such an increase would represent a significant expansion in the state’s crumb rubber and TDP manufacturing infrastructure, but would not in and of itself “solve” the state’s need for waste tire markets.

# Feedstock Conversion Barriers

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As described in the previous sections, feedstock conversion is an important component of CalRecycle's overall tire market development program, and steady progress is being made, albeit slowly. Experience through the TBAP program shows there are several barriers that must be addressed for feedstock conversion to succeed in expanding and diversifying crumb rubber demand. Following is a brief summary of some of the most critical challenges.

## ***Identifying and Recruiting Candidates for Feedstock Conversion***

Outreach to prospective feedstock conversion firms for TBAP Cycles 3 and 4 showed how time-consuming and challenging it can be to find and motivate firms well positioned for success. SAIC started with a list of 345 California manufacturers for Cycle 3 and prioritized them based on their apparent use of rubber or plastic and interest in green/recycled content production (based on current involvement with recycling, to the extent information was available). About 220 of these firms were contacted by mail, and 48 of these were identified as priorities and called by phone. Direct calls were time-consuming, as manufacturing managers were understandably skeptical of a cold call advocating for significant changes in their practices, even when the team was able to describe the potential for them to receive up to \$175,000 in services through the TBAP program. However, this effort did result in seven feedstock conversion applications in TBAP Cycle 3. Outreach conducted for TBAP Cycle 4 was far more modest due to time and budget constraints but still resulted in two eligible feedstock conversion applicants.

## ***Need for a Timeline and Objectives Tailored to the Firm's Specific Customer Requirements and Market Positioning***

Every firm that considers feedstock conversion will have a unique set of considerations. Above all, the effort must be driven by market considerations and the firm's positioning to leverage the potential benefits of using crumb rubber as feedstock. In addressing the general barriers described below, it is helpful to define up front, to the extent possible, the firm's objectives for feedstock conversion and a reasonable timeline for the effort. The objectives should be grounded in the firm's markets, including which products to focus on and why, specific benefits that will be attractive to customers, what the firm will need to do to adjust marketing, and sales practices to expand sales of the newly reformulated products. The objectives should also consider the firm's internal and external constraints, especially related to determining specific feedstock needs and sources, and the need to refine and prove the ability to produce high-quality products using crumb rubber. Some of these considerations can be controlled by the firm itself internally, but most will require collaborating with other firms such as suppliers, customers, testing facilities, and/or other experts. These challenges are described more in the remainder of this section.

## ***Defining Feedstock Needs and Securing Suppliers***

Establishing specific feedstock specifications for a particular product must be done concurrently with refinement of production capabilities and evaluation to ensure that targeted attributes are being achieved. Although feedstock sourcing and production capacity are described separately, in practice they must be addressed at the same time in an iterative fashion until the manufacturer is confident that they "have it right" and have identified suppliers who can provide needed raw materials at an acceptable price and meeting minimum quality standards on a consistent basis.

There are several specific considerations related to defining and sourcing raw materials containing crumb rubber, including:

**Mesh Size.** When the 2009 Feedstock Conversion Project Report was prepared, SAIC believed that very fine crumb rubber of 200-300 mesh size may be required for most products. This presented a challenge because the only suppliers of such material are located in the Eastern United States and do not use California tires (an explicit requirement for CalRecycle’s program). Experience through the TBAP program working with grantees since then has shown that larger-size crumb rubber in the 30-50 mesh range can often be used. At least two California crumb rubber producers can provide such material, although they do not have established, dedicated production lines for such material. In one case the material is derived from the fines by-product resulting from production of other crumb rubber sizes, and in the other case it is derived from 50-80 mesh material that includes a wide range of mesh sizes. In the long term, expanding California production capacity for fine crumb rubber may be needed to facilitate feedstock conversion efforts, as currently most available supply is produced as a by-product in the production of crumb rubber of smaller mesh sizes. In the short run, this presents a sort of “chicken-and-egg” dilemma in that sufficient demand must first be established to trigger further investment in fine crumb rubber capacity, even while building demand is complicated by a lack of supply. Feedstock conversion firms may at times continue to require imported crumb rubber until they are able to make the investment of time and energy needed to identify, test, and negotiate new supply deals.

**Other Crumb Rubber Characteristics.** Depending on the product and production equipment/process, other crumb rubber characteristics may be critical. These include: amount of wire, fiber, or other contaminants in the material; the shape of the crumb rubber particles (which is influenced by the production method: for example, whether it is produced cryogenically or at ambient temperatures); the chemical composition of the rubber, which varies with the type of tires used to produce the crumb rubber; moisture content; and the specific distribution of mesh sizes.

**Compounded Raw Materials.** Compounders are responsible for providing specialized raw material mixes to manufacturers such as crumb rubber combined with other additives needed to provide specific attributes and to ensure smooth production, given the manufacturer’s equipment, process, and needed product specifications. Through the TBAP grant services described above, the contractor team worked with grantees and crumb producers to identify California compounders and raise awareness about opportunities to work with crumb rubber produced from waste tires. As a result, at least four compounders are now either actively supplying crumb rubber-derived raw materials, or ready to consider doing so when the opportunity arises. It is possible that additional or refined compounding capacity may be required as feedstock conversion efforts continue. Generally, the type of compounder required in the production of tire derived products is dependent on the type of product being made and the equipment used. For example, compounders may specialize in thermoplastics and utilize a twin extruder to be able to compound the plastic and rubber into a pellet-size feedstock. Other compounders may specialize in compression molding.

**Industry Standards.** Industry standards for crumb rubber are established, but some industry members say they need to be reviewed and refined, especially for fine mesh crumb rubber. ASTM D5603 and D5644 focus on particle size, particle size distribution, and rubber chemistry. In addition to these two standards, there are other material characteristics that may be as important or even more important depending on how the crumb rubber is being used and what benefits it is providing to the final product. There are several methods for producing crumb rubber that yield crumb rubber with different material characteristics. A report on Best Management Practices for developing TDPs was recently prepared under the TBAP program that

suggests procedures for identifying and meeting quality standards for raw materials and new TDPs. This report will be posted on the CalRecycle website.

***Ensuring Crumb Rubber Is Made from California Waste Tires.*** While this is not necessarily a concern for the manufacturer, it is a critical concern to CalRecycle, since the point of feedstock conversion is to expand and diversify markets for waste tires generated in the state. Out-of-state rubber may sometimes be more appealing to manufacturers because of specifications (e.g., very high mesh sizes), pricing, established relationships, or other considerations. Some out-of-state crumb rubber producers receive subsidies that some say allow them to offer very low prices compared to California producers. Another related issue is that waste rubber may be derived not from tires, but from other rubber manufacturing processes or products. While use of these other waste materials is consistent with CalRecycle's overall mission to expand recycling, it does not satisfy the specific needs of their waste tire market development program and the dedicated funding source that fuels it (i.e., a \$1.75 fee on each new tire sold).

### ***Refining Production Capabilities***

As noted above, manufacturers pursuing feedstock conversion must simultaneously work on feedstock sourcing while refining production capabilities. Depending on the manufacturer's existing equipment, raw materials, products, and desired product attributes, developing production capacity may require extensive experimentation and refinement of previously established practices, potentially including purchase of new equipment.

Production issues may involve: odor, color, adaptation or need for new types of equipment (e.g., for injection molding, industrial sheet extrusion and thermoforming, profile extrusion or protrusion, or compression molding and/or structural foam molding). In many cases adjusting the particle size and/or compound additives can alleviate such issues. In others, production lines may need to be thoroughly shut down and cleaned prior to and after running crumb rubber raw materials.

Storage needs and space limitations can sometimes complicate efforts. New raw material supplies, production lines, and product inventory all require suitable space, which can be challenging in some manufacturing facilities, especially if objectives call for significantly increasing production levels.

In many cases, there is a need for independent, external product testing to document product performance and attributes. In other cases, there may be established certifications that must or should be obtained to support marketing and sales efforts. Sometimes such testing and documentation can be provided in-house, if the firm has sufficient expertise available and independent documentation is not required to meet regulatory or market needs.

The process of refining raw material and production practices can be time-consuming and costly. In addition to potentially needing to shut down existing production to test new formulations, there are costs for staff time and attention, raw materials purchasing, research product needs and issues, and collaborating with potential suppliers and customers. As mentioned above, a report on Best Management Practices for developing TDPs was recently prepared under the TBAP program that suggests procedures for identifying and meeting quality standards for raw materials and new TDPs.

## ***Refining Marketing and Sales Systems***

Since feedstock conversion by definition leads to new or reformulated products, there is usually a need to adjust or develop new strategies, materials, or practices related to branding, marketing, and sales. As emphasized above, customer needs should drive the feedstock conversion initiative.

This may involve researching preferences and demand trends for existing and new customers, which can and should inform the design of new or reformulated products. Therefore, such research should be conducted early in the process as overall objectives and timelines are developed.

While some firms have explicitly adopted a “green” marketing strategy that leverages the use of recycled tires, experience indicates that products should make sense in the marketplace based on price and performance. Any “green” marketing advantages then complement the sales base in place.

A related issue is that some feedstock conversion companies have historically been producing custom or private-label products or compounds but have expanded to manufacture a new product that they intend to market directly, or that is to be marketed using a different venue than they are used to. In such cases, developing marketing and sales systems may entail more cost than cases where existing systems can be adapted.

As mentioned above, addressing customer needs sometimes requires providing independent product testing results or certifications. In other cases however, independent analysis may not be required.

## ***Organizational Constraints, Costs, and the Need for a Sustained Commitment***

As the above discussion of barriers makes clear, pursuing feedstock conversion requires time and commitment of monetary and staffing resources over time that may be difficult to predict. Most TBAP grantees, including the 10 feedstock conversion companies, are considered small businesses by most established standards. As such, owners, managers and staff often wear many hats, and it may be difficult to allocate the resources needed for feedstock conversion. Also, the firm may require outside expertise that is costly and/or difficult to find. Since the main priority will be to maintain ongoing profitable production and sales, allocating time, space, production capacity, etc. to feedstock conversion may require tradeoffs with ongoing operations that are difficult to justify. This is yet another reason why it is so important to establish clear objectives and a timeline at the beginning of the effort, and to revisit the timeline and approach from time to time. The objectives should quantify the potential sales or other measures that make the effort worthwhile to the firm, in order to help motivate and sustain the commitment through to project success.

In addition to the above opportunity costs of reallocating scarce resources to feedstock conversion, there are hard costs as well. Some potential costs include:

- Purchasing crumb rubber and other additives for testing purposes.
- Enhanced sales and marketing expenses and staff resources.
- Research and testing of new products.

- Staff time spent to evaluate opportunities such as formulating, testing, and proving production processes; establishing acceptable crumb rubber and/or compound specifications, sources and pricing terms; and conducting product testing and refining marketing materials and sales processes.
- Potential investments in molds, new or adapted production equipment, plant layout adjustments, and adjustments to electrical and/or other hard infrastructure.
- Reduced production of established products when capacity is shifted to development and testing of feedstock conversion products.
- Space constraints for storing adequate supplies of crumb (on both the processor and product manufacturer side).

While the specific costs vary across companies and market niches, the time commitments alone guarantee that cost will almost always be a major consideration.

Overall, feedstock conversion advocates should expect successful efforts to take time and unfold slowly, but steadily. Establishing a timeline can be a helpful way to drive efforts, but the timeline will most likely need to be revisited as the project unfolds and the firm addresses the challenges described above. Above all, a sustained effort, ideally with tangible support in the form of funding or technical assistance or product promotion, may be needed to monitor progress and continually encourage candidate firms to remain committed to the effort.

# Conclusions and Recommendations

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Feedstock conversion is an attractive waste tire market development strategy because it yields new demand, over and above existing crumb rubber markets like RAC, synthetic turf infill, and mulch, within a very diverse range of established product niches. There is a widely acknowledged need for new markets for waste tires to safeguard against sudden weakening of any one market. Feedstock conversion, while perhaps a long-term approach, holds the promise of diversifying tire recycling markets far more than they have been to date, while providing a high price market that can strengthen California crumb rubber producers and fuel expansion of TDP manufacturing firms. Opportunities for feedstock conversion abound, with a wide variety of products that can potentially use crumb rubber, and potentially new products yet to be conceived.

Unfortunately, there are a number of significant barriers to feedstock conversion that must be addressed, including feedstock sourcing, refinement of production capacity, and refinement of company marketing and sales systems. Experience with TBAP grantees shows that these barriers can be overcome, but that it requires investments of monetary and staff resources that can be challenging for small businesses to make. Most importantly, successful feedstock conversion requires a sustained commitment by firms and advocates over time. SAIC suggests that firms establish clear objectives and a timeline early on, and directly tie all efforts to their customer needs and their positioning in the market spaces in which they operate.

The 2009 Feedstock Conversion Project Report concluded that a plausible goal would be for California manufacturers to collectively use about 52 million pounds of crumb rubber per year in making such products. Achieving this level of demand through feedstock conversion would be equivalent to a 38 percent increase in current production of crumb rubber, or a 280 percent increase over the current use of crumb rubber in molded and extruded products. This would increase the number of California waste tires being used in crumb rubber for molded and extruded products from 1.3 million PTE to 3.7 million, or just over 8 percent of the amount generated in 2012. In short, achieving such an increase would represent a significant expansion in the state's crumb rubber and TDP manufacturing infrastructure, but would not in and of itself "solve" the state's need for waste tire markets.

The 10 TBAP grantees involved in feedstock conversion generally have made demonstrable progress and have strong prospects to expand demand in a variety of diverse markets offering relatively high prices for crumb rubber. However, to date this crumb rubber demand has been slow to materialize, despite significant investments by CalRecycle of more than \$1.7 million in grant services. Based on information provided by the firms, SAIC estimates that in the short term (i.e., one or two years), they are poised to use approximately 1 million to 1.5 million pounds of crumb rubber a year (including buffings), or 5 to 8 percent of the 18.6 million pounds currently flowing to the molded and extruded product category. In five years they could be using three-to-five million pounds of crumb rubber and buffings. This is most likely demand that would not have occurred without CalRecycle support. Moreover, TBAP feedstock conversion activities also resulted in raising awareness and interest in feedstock conversion by compounders, which could benefit future feedstock conversion efforts. However, compounders' activity in this arena will be directly dependent upon demand from their customers, i.e., rubber product manufacturers in California, as well as their willingness and ability to conduct research and testing to overcome the production and supply-related feedstock conversion barriers discussed earlier in this report.

Given the important need for new types of products using recycled tire rubber, SAIC believes feedstock conversion is still a very essential component of CalRecycle's tire market development

program, despite the cost and time involved. However, feedstock conversion should be viewed as a long-term effort that holds the promise, over time, to transform crumb rubber markets that currently rely on a few, large relatively low-value markets by creating higher-value demand in a wide variety of niche market segments. In the long run, successful feedstock conversion could literally transform the industry.

To support feedstock conversion, SAIC recommends that CalRecycle consider the following recommendations:

***Provide technical assistance and ongoing monitoring and encouragement.*** The now-discontinued TBAP grant program provided an opportunity to recruit and work closely with firms pursuing feedstock conversion. Short of re-starting TBAP, CalRecycle should consider providing some level of ongoing monitoring and communication with manufacturers and compounders actively engaged in feedstock conversion. This could be done by CalRecycle staff or contractors, and could be as simple as checking in with them on a regular basis and reminding them of commitments and objectives previously discussed. Ideally, some level of direct technical assistance would also be provided to both crumb rubber and TDP manufacturers and compounders, whether through a TBAP-like program or another model, perhaps similar to that provided for civil engineering or RAC.

***Closely monitor rubber supplies used in feedstock conversion efforts.*** CalRecycle's main goal for feedstock conversion is to boost demand for California waste tires used to make crumb rubber. Firms engaged in feedstock conversion, on the other hand, are driven by market growth opportunities and may be less concerned with whether raw materials are derived from California waste tires. Supplies may come from out of state, be derived from other types of industrial rubber by-products and/or may be derived from retreading operations rather than crumb rubber production. While the latter two sources are beneficial from a recycling perspective, they have less of a direct impact on CalRecycle's long-term goals. A related issue is that, in some cases, use of buffings or crumb rubber derived from buffings produced by truck tire retreaders may be the most appropriate supply, due to cost, availability, and/or the relatively high natural rubber content of this material. CalRecycle could consider opening grant programs and other assistance to use of buffings in such feedstock conversion applications.

***Provide monetary support for feedstock conversion efforts.*** CalRecycle's loan program can provide low-cost loans to qualified manufacturers who use California-generated crumb rubber in their product(s). In order to encourage and/or support manufacturer's feedstock conversion efforts, CalRecycle may consider grants or contracts to facilitate the necessary research and development. The initial and ongoing results could yield valuable information to help shape future efforts and provide transferrable performance data for other products. Additionally, CalRecycle may consider an incentive payment supporting higher-volume users of crumb rubber, perhaps targeting higher value-added products. SAIC understands that CalRecycle may be currently exploring these approaches.

***Conduct training and promotion.*** CalRecycle should consider dedicating one or one-half day of its biannual Tire Conference to feedstock conversion. This could involve active recruitment of candidate manufacturing firms and/or providing similar information and encouragement via webinars. The task of identifying and contacting prospective feedstock conversion candidates alone could provide valuable information. A greater understanding of the candidate firms and their unique prospects and challenges could also provide information for crumb rubber demand through feedstock conversion.

***Conduct outreach to customers.*** CalRecycle's Tire Outreach and Market Analysis contract is slated to conduct outreach and education to a range of customer groups through September 2016. CalRecycle should make sure that the full range of available new products developed by feedstock conversion firms is fully included in the effort. And, as customer needs for new recycled tire products are identified, CalRecycle should communicate these needs back to the industry and firms who may be well positioned to meet the needs.

***Develop a feedstock conversion plan.*** CalRecycle has established feedstock conversion as a priority tire market development area, and as discussed above there are several existing and potential new programs and activities that CalRecycle could use to promote it. Past feedstock conversion efforts have largely been conducted through TBAP grants, which are no longer offered. Given this context, SAIC suggests that CalRecycle develop a Feedstock Conversion Plan that identifies goals and activities (including staff and financial resources) to advance feedstock conversion, and that puts potential outcomes in the context of broader goals for expansion and diversification of California waste tire recycling markets. The plan should address both short- and long-term actions and goals, with the expectation that feedstock conversion results will most likely occur incrementally over a period of several years, but if successful could provide lasting benefits for many years to come.

Overall, feedstock conversion is a long-term tire market development strategy that, while costly and slow to yield results, holds the potential to transform crumb rubber markets, benefitting waste tire recycling firms and helping to achieve CalRecycle's waste tire recycling goals.

# Appendix A Glossary

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**Alternative Daily Cover (ADC)**—The U.S. Resource Conservation and Recovery Act Subtitle D underwent a major revision in 1991 to ensure human health and the environment were protected. A major change was the requirement to cover disposed solid waste with 6 inches of earthen material at the end of each operating day, or at more frequent intervals if necessary. Materials other than, or in combination with, earthen materials, including shredded tires, collectively referred to as Alternative Daily Cover, may be used to achieve the same function. Permission must be granted by the enforcement agency for the landfill with concurrence by CalRecycle.

**Asphalt-Rubber**—A blend of asphalt cement, ground tire rubber, and additives in which the rubber component is at least 15 percent by weight and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles.

**Buffings**—High-quality scrap tire rubber, often elongated, that is a by-product from the conditioning of tire carcasses to remove worn/used tread from a tire in preparation for re-treading. Buffings contain essentially no metal or fiber.

**Chip Seal**—A pavement surface treatment formed by evenly distributing a thin base of hot asphalt or asphalt-rubber onto an existing pavement and then embedding finely graded aggregate into it.

**Civil Engineering (CE)**—Use applications for shredded tires in public works construction applications where defined properties are needed, including use in roadways and transportation systems, landfill systems, as lightweight fill in retaining wall applications, or levee projects.

**Tire Consumer**—Individual consumers who purchase tires from tire dealers.

**TDP Consumer**—Individuals and companies that purchase finished products containing recycled tire rubber, including individual consumers purchasing tire-derived products (TDPs) from retailers, businesses purchasing TDPs for use in other manufacturing, construction or installation of products such as turf or playground surfacing; and facilities that purchase tire-derived aggregate for use in CE projects.

**Crumb Rubber**—Rubber granules derived from a waste tire that are less than or equal to 1/4 inch or 6 millimeters in size. (30 Public Resources Code (PRC) §42801.7). Imported crumb rubber refers to material imported into California from other states or countries.

**End User**—User of processed tires, including TDP manufacturers making products from crumb rubber, installers of playground surfacing or artificial turf fields, tire-derived fuel (TDF) users producing cement or electricity, contractors and engineers leading CE projects, landfills accepting tires as ADC or for disposal, and exporters. There is some ambiguity in how this term is used across different programs, with many state incentive programs defining crumb rubber producers as end-users. In this report, crumb rubber producers are considered a type of processor.

**Incentive Policy**—As used in this report, incentive policy means a program that provides standardized payments to companies engaged in specified activities, based on the volume of materials handled (e.g., a specified amount of money per ton of tires processed that are sold to an eligible end-use market).

**Installer**—A firm that purchases crumb rubber or coarse ground rubber among other raw materials, and engages in the installation of applications such as playground surfacing, synthetic

sports fields or other turf applications. Installers sometimes are owners of recycled tire product brands who engage in marketing and sales of such product applications. Other times installers are contractors who provide installation services on behalf of brand owners marketing products.

**Passenger Tire Equivalent (PTE)**—Historically, measurement of the quantities of waste tires were based on number of tires and not weight. Because waste tires come in a variety of sizes and weights (especially when passenger and light truck tires are compared to heavy commercial tires), it is useful to use a standard unit of measure to convert numbers of tires to weight and number of large tires to equivalent number of small tires, and vice versa. This factor is called the Passenger Tire Equivalent—the average scrap passenger tire historically has been commonly held to weigh 20.0 pounds. Furthermore, 14 CCR §17225.770 defines a “passenger tire equivalent” (PTE) as the total weight of altered waste tires, in pounds, divided by 20 pounds. 1 PTE = 1 Waste Tire.

**Processor**—A facility that accepts whole tires for processing, including culling of reusable tires, shredding, baling, chipping and/or production of crumb rubber or coarse ground rubber. In some programs, crumb rubber producers are considered end-users instead of, or in addition to, being considered processors.

**Rubberized Asphalt Concrete (RAC)**—A pavement material that consists of crumb rubber mixed into regular asphalt concrete (a mixture of asphalt binder and mineral aggregate). Since 2007 the California Department of Transportation (Caltrans) has replaced the term Rubberized Asphalt Concrete with the term Rubber Hot Mix Asphalt, which is an equivalent term that Caltrans feels is more consistent with industry usage.

**Rubber Hot Mix Asphalt (RHMA)**—See the definition of Rubberized Asphalt Concrete.

**Scrap Tire**—A worn, damaged, or defective tire that is not a repairable tire. (30 PRC §42805.6).

**Tire Business Assistance Program (TBAP)**—A California program that provides services and resources for businesses who either process used tires or produce tire-derived products using California waste tires

**Tire-Derived Aggregate (TDA)**—Pieces of scrap tires that have a basic geometrical shape and are generally between 12 mm and 305 mm in size and are intended for use in CE applications.

**Tire-Derived Fuel (TDF)**—The combustion of whole or shredded tires in an oxygenated environment to extract the energy value embodied in the tire for use in an industrial process or to generate electricity.

**Tire-Derived Material (TDM)**—Processed material (crumb, shreds, aggregate, etc.) derived from scrap tires, typically used as a feedstock in further processing, or used as is in a CE, turf infill, or other type of application.

**Tire-Derived Product(s) (TDP)**—Material that meets both of the following requirements (30 PRC §42805.7):

1. Is derived from a process using whole tires as a feedstock. A process using whole tires includes, but is not limited to, shredding, crumbing, or chipping.
2. Has been sold and removed from the processing facility.

**Used Tire**—A tire that meets both of the following requirements:

1. The tire is no longer mounted on a vehicle but is still suitable for use as a vehicle tire.

2. The tire meets the applicable requirements of the Vehicle Code and of Title 13 of the California Code of Regulations.

**Tire-Derived Product Manufacturer (TDP Manufacturer)**--For the purposes of this report, this term refers to facilities that purchase processed or whole tires for the purpose of making a product. Elsewhere, this term is sometimes defined narrowly to mean a firm that produces products from crumb rubber. However, in this report, the term is used broadly to include firms that purchase processed tires for use as TDF (the product being electricity or heat), firms that use TDA in CE applications (the product being the finished project, whether a road embankment or other). For the purposes of this report, TDP manufacturer is a type of end-user.

**Waste Tire**--A tire that is no longer mounted on a vehicle and is no longer suitable for use as a vehicle tire due to wear, damage, or deviation from the manufacturer's original specifications. A waste tire includes a repairable tire, scrap tire, and altered waste tire, but does not include a tire-derived product, crumb rubber, or a used tire. (30 PRC §42807)