The Scrap Tire Problem in Rhode Island: Analysis and Recommendations

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ABSTRACT

The nationwide scrap tire problem, caused by decline of rubber reclamation and tire retreading, has two main components: 2-3 billion tires accumulated in historical piles and 270 million additional tires disposed annually. While Rhode Island has reduced its historical piles to 500,000 tires, 1 million tires are disposed annually. Tire piles present health and fire hazards, but they are classified as municipal solid waste under Resource Conservation Recovery (RCRA) act of 1976. Tires, like other municipal solid wastes, are regulated at the state level. In Rhode Island, RIGL § 23-63 regulates tire storage and recycling. The Comprehensive Solid Waste Management Plan guides this storage and recycling. This study analyzes the current state of scrap tire management in Rhode Island and finds that the state is too dependent on tire combustion, specifically on one plant operated by Oxford Energy Corporation. Further, this study concludes that pursuing more diverse markets for tires will stabilize the long-term tire disposal practices. An analyses of these markets based on environmental and economic soundness concludes that Rhode Island should pursue in this order: increased reuse and retreading, whole tire and shredded applications and crumb rubber applications in addition to current combustion/energy recovery application. Another market, chemical alteration is not suitable for Rhode Island to pursue. Other disposal options, landfilling and monofilling (single-use storage) should be discouraged due to their negative impacts. Economic and non-economic barriers to entering the suggested markets are discussed. A preliminary analysis of the feasibility of overcoming those barriers via policy changes is included. Recommendations based on other states' tire policies are presented and their possible applications in Rhode Island are discussed. Current state scrap tire laws include (1) funding sources for tire pile remediation; (2) mandates to clean up tire dumps; (3) scrap tire management procedures; (4) market development incentives; and (5) regulations regarding landfilling of tires. Coordination with neighboring states is critical to the successful implementation of these laws. Possible innovative solutions include tradable credits, tax incentives, technology forcing statutes, and the extended producer accountability model. The study concludes that integrating several of these options is the best way to take serious aim at solving the waste tire problem in the State.

INTRODUCTION

Every man, woman, and child in Rhode Island disposes of one tire a year on average. In some ways, this is the story of our automobile crazed State beginning to face the dark consequences of its disposable culture. It is the story of the scrap tire problem in Rhode Island, and the quest for solutions to that problem.

Automotive engineer Robert Snyder expressed the hope, "the large and rapidly growing accumulation of piles of scrap tires… exists chiefly because of a lack of markets for scrap tires."[1] The following study begins to address Dr. Snyder's concerns in the context of Rhode Island. The study is an analysis of the scrap tire problem; including a survey of current disposal methods and a preliminary feasibility analysis of market based solutions. The study explores the feasibility of the various market-based solutions and it enumerates the barriers to implementing those solutions. The study concludes with policy suggestions that may be helpful to overcome the barriers in Rhode Island. A helpful way to approach this study is in terms of seeking answers to certain fundamental questions, namely:

- Is there a scrap tire problem in Rhode Island?
- If so, how does Rhode Island manage its scrap tires?
- Are there more cost effective and environmentally sound alternatives for management of scrap tires?
- What barriers to implementing those alternatives exist in Rhode Island?
- What policy measures have other states taken to overcome barriers to incorporate tire disposal alternatives?

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[1] Snyder, Robert H, *Scrap Tires Disposal and Reuse*. (Warrendale: Society of Automotive Engineers, Inc., 1998), 1.

I. ASSESSMENT OF THE PRESENT SITUATION

(a) rise of the scrap tire problem: demise of rubber reclamation

From the beginning of the automotive industry, vehicles have been equipped with rubber tires. It can be argued that the modern automobile would not have been possible without Robert Dunlop's invention of the pneumatic tire and its subsequent development. In the 1920's tires would only last a few thousand miles, in contrast to the 40,000 to 50,000 mile treadlife expectancy of today's tires.[2] Modern textiles and improved rubber compounds have also permitted substantial decreases in tire size and increases in load-carrying capacity of tires.[3]

During most of automobile history, scrap tire problems did not exist. The problem began in the early 1960's and has only become acute during the last 15 years.[4] Before World War II, tires were constructed from cotton textile cords, natural rubber, and steel wire beads. The rubber, which came from the Indies, had to undergo substantial processing before it was ready for the calendaring[5] and extrusion[6] processes required to assemble the raw tire before vulcanization[7]- expensive and time consuming operations. Fortunately, the processing of natural rubber compounds was expedited by the use of substantial amounts of previously vulcanized but reclaimed rubber compounds. [8]

One of the properties of natural rubber compounds is its ability to slowly devulcanize when heated strongly. For tires or other rubber articles in service, this property is clearly a defect, however this defect becomes an advantage in rubber reclaiming. Reversing the vulcanization process[9] produces smaller, modified rubber molecules that can be recompounded and revulcanized to produce rubber articles with reasonably good properties, though not as good as those articles made from virgin rubber. However, the devulcanized rubber compound (reclaimed rubber) can be added to new natural rubber to yield compounds with minimal loss of quality.

Due to the effectiveness and profitability of reclaiming rubber, processes were developed to accelerate the reaction to produce reclaimed rubber of high value at low cost. Prior to World War II, tires were collected and reclaimed in hundreds of facilities throughout the

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[2] Blumenthal, Michael, "Scrap Tire Industry: A Retrospective and Prospective View," *Scrap Tire News, 15:2* (Feb 2001): 3.
[3] Tire and Rubber Recycling- Scrap Tire Disposal and Recycling. Retreived January 25, 2000, from the World Wide Web: http://www.recycle.net/recycle/rubber/scrap
[4] Blumenthal, 5.
[5] Calendaring is the process in which extended sheets of uniform films are produces by squeezing rubber or plastic between counter rotating rolls.
[6] In extrusion, thick shaped pieces are prepared by forcing the material through a die under pressure from a rotating screw.
[7] Vulcanization is the process in which sulfur is combined with rubber or plastic in a chemical operation that links the polymer chains, thereby increasing strength, stability, and elasticity of the polymer.
[8] Here, reclamation refers to a process by which a vulcanized rubber object is devulcanized or otherwise degraded back to a plastic mass.
[9] Commonly called devulcanization

United States. At that time, all of the major U.S. tire companies operated reclaiming plants.

Scarcity and unpredictability of cost of natural rubber during World War II necessitated the development of synthetic rubber. Several times within a decade, the price of natural rubber fluctuated from $0.05/lb to more than $1/lb.[10] These price swings for a commodity with markets thousands of miles away led to manufacturers losing money on rubber inventories, and thus drove down demand for natural rubber.[11] While inferior at first, synthetic rubber eventually supplanted natural rubber in tires because of price stability and another advantage, extended treadlife.

Polymer chemists continued to develop synthetic rubber technology, allowing them to produce increasingly processable materials at decreasing costs. In 1950, synthetic rubber was approximately $0.04/lb while reclaimed rubber, or reclaim, was $0.14/lb.[12] This price advantage buoyed the synthetic rubber market and led the rubber reclaiming industry into slow and steady decline. While the 1960 peak rubber reclamation industry produced 278,000 long tons of rubber, by 1996 no commercial operation was reclaiming tire rubber domestically.[13]

It is important to note that even at the height of the industry, it was only possible to use 20 percent reclaim in tires without serious loss of quality.[14] Tires produced entirely from reclaim would not have passed commercial standards. Accordingly, it was not possible to reclaim all of the tires discarded in any year and reuse them as tires the following year – in other words 100% recycling of tires back to tires. However many articles utilized reclaimed rubber during the thriving years of the industry that no longer use reclaim today. Polyvinyl chloride (PVC) and polyethylene, among other modern day plastics, now replace markets that previously used reclaimed rubber.

In addition to the technical reasons noted, two additional factors are important in the demise of reclaim markets. The first is the decline in the use of snow tires. All-season tires have virtually displaced conventional snow tires, which usually contained substantial amounts of reclaim, in the marketplace. Second, the adoption of radial tires and enhanced service requirements, such as low rolling resistance, created a situation where the tire manufacturer “must use recipes providing highly controlled sets of properties from virgin materials of narrow product variability.”[15] In other words, increasingly demanding tire specifications prevented large percentages of reclaim usage per tire.

[10] Snyder, xi.
[11] Snyder, xii.
[12] Snyder, xiii.
[13] Synder, xi
[14] Blumenthal, 5.
[15] Snyder, xiii.

The decline of the rubber reclaiming industry is the major cause of the contemporary scrap tire problem. If all 278,000 tons of reclaim used in 1960 had been produced from scrap tires, more than 50 million scrap tires would have been required.[16]

(b) rise of the scrap tire problem: decline in passenger retreads

A secondary cause of the present scrap tire problem is the recent and continuing declining in the passenger tire retread industry. For most of the 1960's it was common for one of every four worn-out tires to be retreaded.[17] As late as 1970, 35 million passenger tires were retreaded annually, compared to the new passenger tire sales of 169 million in that year. From 1982 to 1997, that number has dropped significantly. In that same period, medium truck tire retreading actually increased. TABLE 1 shows these trends.

Retreading a tire does not eliminate it from contributing to the scrap tire problem because the retreaded tire will eventually wear our. However, retreading defers the appearance of those casings on the scrap heap and thus materially reduces the number of scrap tires as compared to if they had not been retreaded.

Three reasons can be cited for the decline in passenger tire retreading. The first, as previously noted, was the decline in the use of snow tires. All-season tires have virtually eliminated the need for these snow tires, a high proportion of which were retreads.

The second reason was the appearance of steel-belted radial ply tires, which presented two problems.[18] Primarily, their design did not allow them to be retreaded using the processes and equipment that were used to retread previous tires. Also, the quality of steel-belted radial ply tires supplied at the outset by many domestic manufacturers was not particularly suitable for retreading. Together with the equipment problem, this factor eliminated many retreaders from the business, since it was no longer financially profitable.

The third factor to damage the passenger tire retreading industry was the importing of large numbers of low-cost, new radial ply tires, chiefly from the Asian basin.[19] These tires are generally of satisfactory quality for replacement tires, have the perceived advantage to the consumer of being new tires, and are priced at levels close to the price of quality retreaded casings.

(c) perception of the scrap tire problem

As the number of scrap tires nationwide has grown, so too has the attention to the problem. It is important to note that the scrap tire problem is relatively modern, and that

[16] Since other rubber items were commonly reclaimed in 1960, we know that not all reclaim was derived from tires, although they were a chief component.
[17] Tire Retread Information Bureau. Retreived January 25, 2000 from the World Wide Web: http://www.retread.org
[18] Synder, xv.
[19] Snyder, xv.

tires only compose a small percentage of the total national waste stream.[20] Tires are however, very much in the public eye and therefore garner a disproportionate amount of attention. High profile tire piles receiving national attention have focused the issue in the minds of Americans.

To gain perspective, consider the annual production figures for two familiar plastics, polyethylene and polypropylene. In 1996, 26.5 billion lbs. of polyethylene and 11.9 billion lbs. of polypropylene were disposed.[21] Comparing those figures to an estimated 270 million tires at 25 lbs per tire or 675 million lb total, it becomes apparent that the nation disposes five times as much polyethylene and polypropylene as it does tires. Assuming their scrap rates have similar ratios, the plastics enter the waste stream fivefold more than tires, yet do so inconspicuously. The plastics are equally non-degradable in a landfill, but admittedly do not present the same fire or health hazards as tires do.

It is important not to minimize the perception of the scrap tire problem, but to keep it in its proper perspective. It is important to realize that most of the scrap tire markets are unsaturated, that is they could absorb many more tires.

(d) generation of waste tires

Since there is no industry group or governmental agency that monitors tire disposal in the United States, the best estimates that can be made are based on tire production. The Rubber Manufacturers Association (RMA) records the number of original equipment, replacement, and export tires that are shipped each year in the United States. According to RMA, a total of 298 million tires were shipped in 2000 alone.[22] Using certain basic simplifying assumptions given by the US Environmental Protection Agency (EPA), one can derive a good approximation of the number of tires discarded each year.[23] According to these assumptions, in 2000, 273 million scrap tires were discarded in America at a rate of about 0.97 tires per person per year.[24] Other estimates range from 250-280 million scrap tires, in agreement with the EPA estimate.[25]

Additionally there are approximately 33.5 million tires annually that are re-treaded and another estimated 10 million that are reused each year as second hand tires without being

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[20] According to the Rubber Manufacturers Association, scrap tires compose less than 2 percent of the national solid waste stream. Cited from Snyder, xx.
[21] Snyder, 42.
[22] The RMA data include new tire imports, but not imported used tires.
[23] Five fundamental assumptions: (1) One tire is discarded for each replacement tire shipped. (2) Original equipment tires are not discarded in the year they are produced. (3) Exported tires are not discarded in the USA. (4) Four tires are discarded for each automobile when it is taken out of service. (5) Retreads and reused tires are put back into service the same calendar year as they are taken out.
[24] EPA Municipal Solid Waste Management: Tires. Retrieved March 1, 2001, from the World Wide Web: http://www.epa.gov/epaoswer/non-hw/muncpl/tires.htm
[25] JaiTire Industries (among others) estimate 250 million. Retrieved November 11, 2000 from the World Wide Web: http://www.jaitire.com. The Energy Efficiency and Renewable Energy Network (EREN) estimates 280 million. Retrieved October 10, 2000 from the World Wide Web: http://www.eren.doe.gov/consumerinfo/refbriefs/ee9.html

re-treaded.[26] It is estimated that 7 percent of the discarded tires are currently being recycled into new products and 11 percent are converted to energy.[27] Nearly 78 percent are being landfilled, stockpiled or illegally dumped with the remainder being exported.[28]

As with many other components of the total waste stream, source reduction and recycling measures are not being fully implemented, instead landfilling is still the most common practice. In addition to legal landfilling, there are historical stockpiles around the nation. An estimated 2-3 billion tires are scattered nationwide in these stockpiles.[29] FIGURE 1 diagrams the U.S. waste stream, including these stockpiles and the annual throughflow.

(e) distribution dynamics of scrap tires

The distribution of scrap tires is uneven from a geographical standpoint. Since tires are worn out by the people and industries that use them, it follows that worn-out tires appear in greater concentration where people and industries are more concentrated. Demography thus influences the distribution of scrap tires. Note that tires are usually anchored to their original locations chiefly by their high cost of transportation.[30] Tires also have awkward handling characteristics, as they resist handing by conventional material handling techniques, increasing their immobility.[31]

(f) dual nature of the scrap tire problem

Two separate and distinct problems exist. The first problem is the present, above-ground, uncovered accumulation of scrap tires. The second is the ongoing generation and throughflow of scrap tires before their aggregation into large collections. The second problem usually can be broken down into commercial tires, or those disposed of at commercial tire dealers, and municipal tires, those tires that are governmental responsibility by virtue of curbside collection. Both the historical scrap tire pile and annual throughflow problems require solutions, but they require different treatment.

(g) statement of the issue in RI

The issue in Rhode Island largely reflects the issue at the national level. In this State, approximately 1 tire per capita is also produced, and therefore assumed to be disposed. FIGURE 2 shows a graphical representation of RMA shipment data for the State. In comparison with census population data for same years, Rhode Island seems to have a steady yield of approximately 1 tire per capita. According to RIRRC officials, The estimated 1 million tire annual throughflow is about 80 percent commercial (800,000

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[26] Tire Retread Information Bureau website.
[27] Clark, Meardon, and Russell, *Scrap Tire Technology and Markets*. (Washington, D.C.: US Environmental Protection Agency, Office of Solid Waste, 1993), 9. A 3 billion estimate comes from the EREN website.
[28] Clark, 9.
[29] Clark, 8 estimates 2 billion. The EREN website estimates 3 billion.
[30] Snyder, 6.
[31] Tire Retread Information Bureau website.

tires) and 20 percent municipal (200,000 tires).[32] There are about 530,000 tires in 14 piles statewide.[33] TABLE 2 depicts the complete list of known existing tire piles in the state. The Attorney General called one pile in Olneyville a potential "environmental nightmare."[34] FIGURE 3 diagrams the Rhode Island waste stream and its responsible parties.

The number of tires disposed of in piles across the state has dwindled dramatically from 6.5 million in 1990 due to the removal of the enormous Davis tire pile.[35]

<u>(h) the davis pile</u>

At one point, the Davis tire pile contained 6 million tires, or 90 percent of the total tire pile inventory of Rhode Island.[36] Called "the largest scrap-tire dump in the Northeast… and east of the Mississippi,"[37] by DEM officials, this "environmental nightmare"[38] was located in Smithfield, RI, less than 15 miles from the state capital Providence. The tire pile site, spread over 15 acres, was also a Superfund site[39] containing hundreds of drums of "solvents, acids, pesticides, phenols, metals, and laboratory pharmaceuticals." Davis was paid to accept the tires beginning in the 1970's[40] perhaps thinking that oil shortages would one day cause his tires to be a commodity. In 1990, if the site would have caught fire, it could potentially have released over 1 million gallons of oil runoff.[41] The site had a hydrologic connection to Narragansett Bay.[42]

Since passage of the 1992 Vehicle Tire Storage Act,[43] Davis has been barred from accepting more scrap tires. In 1997, after years of studies, cleanup efforts were launched.[44] The last tires were removed in a ceremony including officials from all three

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[32] Ionata, Dante, representative of the Rhode Island Resource Recovery Corporation. Interview by author, Johnston, RI, November 20, 2000.
[33] Existing Tire Pile Sites, compiled by Environmental Advocacy Unit, Office of the Attorney General of Rhode Island, revised March 2000.
[34] Attorney General Wants Thousands of Tires Removed. Providence Journal, 2-23-00.
[35] DEM Announces More Tires To Be Removed From Davis Pile Beginning Today. (RI Department of Environmental Management, March 4, 1999) Retreived October 2, 2000 from the World Wide Web: http://www.state.ri.us/dem/pr/0304991.htm
[36] Witham, Drake. Officials Keeping Fingers Crossed on Smithfield Tire Dump. Providence Journal. October 19, 1997.
[37] Holmstrom, David. Rhode Islanders Tire of Tire Piles. Christian Science Monitor, March 3, 1998. Retrieved October 2, 2000 from the World Wide Web: http://www.csmonitor.com/durable/1998/03/03/feat/feat.1.html
[38] Holstrom.
[39] According to the EPA, Superfund sites are "uncontrolled or abandoned places where hazardous waste is located, possibly affecting local ecosystems or people." The Superfund site co-mingled with the Davis Tire Site was officially called it the Davis Liquid Waste Site. Retrieved April 25, 2001 via World Wide Web: http://www.epa.gov/superfund/sites/index.htm
[40] Davis Property: Chronology of Events and Proceedings 1974-1990. (Office of the Attorney General of Rhode Island, September 1990).
[41] Projo.com slideshow: A look back at the Davis tire pile. Retrieved March 16, 2000 from the World Wide Web: http://www.projo.com/cgi-bin/include.pl/news/extra/tires/tires2.htm
[42] Tierney, Terrence, assistant Attorney General. Interview by author. Providence, RI, October 16, 2000.
[43] RIGL § 23-63
[44] Lord, Peter B. 6 Million Tires Removed From Smithfield Site. Providence Journal. December 20, 2000.

branches of government on December 20, 2000.[45] Removal of the tires allows the EPA to complete the estimated $55 million cleanup of the chemical dump buried underneath.[46]

The cleanup of the tire pile cost approximately $1 per tire, or $6 million[47]. TABLE 3 offers an accounting sheet of the funding sources of the cleanup of what was once called the "largest single environmental threat in Rhode Island."[48] Note that the final $2.1 million dollars of the costs were covered by the Oil Spill Prevention and Remediation Fund (OSPAR)[49] A more detailed explanation the allowance of OSPAR to remediate the Davis site requires an understanding of environmental problems with waste tire stockpiles.

<u>(i) environmental problems associated with waste tire stockpiles</u>

Tires are difficult to landfill. Whole tires do not compact well, and they tend to work their way up through the soil to the top.[50] Tires are also undesirable landfill components because of their low bulk density and the fact that they are shifting and unstable base for possible future building construction above landfills.[51] Accordingly, many landfills have banned whole tires; others, like Rhode Island, have banned tires all together. TABLE 4 provides state-by-state landfill tire regulations in the United States.[52]

As a result of landfill difficulties, tire stockpiles have sprung up all over the country. As previously noted, it is estimated that 2-3 billion tires are stockpiled in the U.S. at present. Tires stockpiles are unsightly and are a threat to public health and safety. Not only are tire piles excellent breeding grounds for rodents and mosquitoes, but they can also be fire hazards. Other problems include the propensity for tires to comingle with hazardous wastes on sites that contain both and the slow rate of decomposition of tires.[53]

Due to the shape and impermeability of tires, they may hold water for long periods of time providing sites for mosquito larvae development.[54] Because tires hold water, they have contributed to the introduction of non-native mosquito species when used tires are imported to the United States. The new species are often more difficult to control and are able to spread exotic diseases. Cases of encephalitis have been traced to specific colonies in tire piles; the Lacrosse encephalitis strain was named after a tire pile in Wisconsin where it originated.[55] The main solution that has been offered is tire shredding. This

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[45] Morgan, Thomas J. At Last, Davis Dump Is All Tired Out. Providence Journal. December 21, 2000.
[46] Projo.com slideshow.
[47] Lord, Peter B. Tiring of the Tremendous Pile – Oil Fund Tapped for the Davis Dump. Providence Journal December 18, 1999. Retrieved Ocotber 2, 2000 from the World Wide Web: http://www.projo.com/display.cgi?id=39d8db48a207
[48] DEM's Annual Report Shows Progress Toward Meeting Environmental Goals.
[49] Davis Property: Chronology of Events and Proceedings 1974-1990.
[50] Snyder, 1.
[51] Snyder, 2.
[52] State by State regulations cited from Scrap Tire Management Council.
[53] Ionata.
[54] Snyder, 3.
[55] Snyder, 4.

guarantees that no water will be held for breeding sites. Further preventative measures could require all shipped tires and all stockpiles to be fumigated.[56]

With regard to flammability, tires behave as though they are a mixture of "jellied petroleum" and carbon.[57] They are not subject to spontaneous combustion and are not easily ignited. However, once they catch fire they burn vigorously. Tire fires are particularly difficult to extinguish, by some accounts "virtually inextinguishable."[58] Due to the 75 percent void space present in whole scrap tires, fires are difficult to quench with water and it is difficult to cut off their oxygen supply.[59] Water on tire fires often increases the supply of pyrolytic oil and provides a mode of transportation to carry the oils off-site and speed up the contamination of soils and water.[60]

The potential fire hazards presented by waste tire stockpiles have been realized a number of times. Several stockpiles have burned until their tire supplies were exhausted, depending on weather conditions, burning from a few days to more than a year. On September 24, 1999, a 35-acre site containing 8 million tires in Stanislaus County, CA caught fire and burned for 14 months.[61]

In the open, tires burn with a "hot, sooty, and maldrous flame."[62] In doing so, they emit an entire spectrum of undesirable chemicals. Air pollutants from tire fires include dense black smoke, which impairs visibility and soils painted surfaces.[63] Toxic gas emissions include polyaromatic hydrocarbons (PAHs), CO, SO_2, NO_2, and HCl.[64] The Stanislaus County fire released an estimated 323,000 tons of benzene into the air.[65] In addition, the fierce heat from fire produces pyrolysis of adjacent tires in the pile. Substantial quantities of petroleum oil are produced and can create a runoff problem. Unchecked, this oil runoff can enter neighboring streams or percolate through the soil, thereby contaminating the groundwater.

Following tire pile fires, oils, soot, and other materials are left on site.[66] These byproducts, besides being unsightly, may cause contamination to surface and subsurface

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[56] "DEP Fact Sheet: Minimizing Waste Tire Generation." Commonwealth of Pennsylvania Department of Environmental Protection. Harrisburg, 1998.
[57] Jellied petroleum is semi-solidified petroleum. Cited from Snyder, 2.
[58] Snyder, 2.
[59] Green, Jay. The Science of Tire Fires. Environmental Sciences International Inc. (Technical Bulletin #7).
[60] Came, Barry. "The Fire Mountain: Battling the Blaze at Quebec Tire Dump." Maclean's. (1990 Jun 29; Vol. 103 no. 22), 83.
[61] Seven Million Tires Ablaze in California. Environment News Service, September 23 1999. Retrieved October 10, 2000 from the World Wide Web: http://www.ens.lycos.com/ens/sep99/1999L-09-23-03.html
[62] Snyder, 2.
[63] Green.
[64] Reisman, Joel I. Air Emissions From Scrap Tire Combustion. Clean Air Technology Center of the US Environmental Protection Agency, Washington D.C., Environmental Protection Agency, October 1997. Retrieved March 3, 2000 from the World Wide Web: http://www.epa.gov/ttncatc1/dir1/tire_eng.pdf
[65] Fire is Officially Out. Stanislaus County – Tire Fire Updates, October 1999. Retrieved March 3, 2000 from the World Wide Web: http://www.co.stanislaus.ca.us/tirefire/index.htm
[66] Stofferahn, Jeffey A. and Simon, Verneta. Emergency Response to a Large Tire Fire: Reducing Impacts to Public Health and the Environment. Haztech International (Pudvan) Conference, St. Louis, August 26-28, 1987.

water as well as the soils on which the tires were located. If tire piles have an established hydrologic connection, like the Davis pile, then a tire fire may result in a potential oil spill into a water body. As previously noted, the Rhode Island DEM was able to draw funds to remediate the Davis site from OSPAR as a result.

Careful monitoring of stockpiles can reduce fire hazard. Shredded tires pose less of a fire hazard. Tire shreds behave differently than whole tires when burning and because they have less air space, they can be extinguished more easily. Other provisions that may reduce the fire hazards of stockpiles are mandatory fire lanes and fire plans so that a fire can be attended to as quickly as possible.[67]

Ultimately, the best solution to the problems of waste tires as fire hazards and mosquito breeding grounds is to eliminate stockpiles. At the least, the number of tires in a stockpile should be minimized, thus reducing the number of breeding sites for mosquitoes and fuel for fires. To date, EPA has not identified scrap tires as a hazardous substance.[68] Instead, the EPA advocates source reduction on tires.

(j) source reduction of waste tires

There are two options for reducing the number of tires landfilled, stockpiled and dumped. The first is to increase recovery. The other is to reduce the number of tires generated, a strategy called source reduction.[69] Potential source reduction measures for tires include retreading, which is the application of a new tread to a worn tire that still has a good casing. Other source reduction measures include design of longer-lived tires and reuse of tires removed from vehicles.[70] These practices all extend the useful life of tires before they are discarded, thus reducing tire waste at the source.

Retreading extends the usable life of a tire from 60-80 percent to 300 percent and therefore reduces the number of tires scrapped.[71] There are nearly two thousand retreaders in the United States and Canada,[72] although that number is shrinking because of the decreased markets for passenger retreads. The National Tire Dealers and Retreaders Association claims that properly inspected retreaded tires have lifetimes and failure rates comparable to new tires.[73] Mileage guarantees and warranties are often similar or identical to new tire warranties.

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[67] Stofferahn, Jeffey A. and Simon, Verneta.

68 Cotsworth, Elizabeth A. Letter from Director of EPA Office of Solid Waste to Mr. Christopher Harris. Retrieved March 10, 2001 from the World Wide Web: http://www.yosemite.epa.gov/osw/rcra.nsf/documents/db5b7ea3aabb56c4852569c90064a378

[69] DEP Fact Sheet: Minimizing Waste Tire Generation.

[70] Pennsylvania Department of Environmental Protection Waste Tire Recycling Homepage. Retrieved November 11, 2000 from the World Wide Web: http://www.dep.state.pa.us/dep/deputate/airwaste/wm/mrw/Tires/Tires.htm

[71] 60 – 80 percent refers to an automobile tire with one retread and 300 percent refers to a truck with three retreads.

[72] Tire Retread Information Bureau Website.

[73] Tire Retread Information Bureau Website.

In terms of design modifications, currently steel belted radial tires have an average treadlife of 40,000 miles.[74] According to the EPA, “further increases in life would require higher pressures, thicker treads, or less flexible materials. Each of these methods would result in more gas consumption, higher cost, and or rougher rides.”[75] Accordingly, major design modifications are not planned in the near future.

Another way to reduce this waste at the source is to reuse the tires themselves. Frequently, when one or two tires of a set are worn, the entire set is replaced. Tires with reusable tread can then be sorted out and reld for farm equipment, second cars, or exported to other nations for reuse.

[74] Clark, 1.
[75] Clark, 13.

II. DISPOSAL AND CURRENT TIRE ECONOMICS IN RI

(a) tire jurisdiction

Congress enacted the Solid Waste Disposal Act of 1965 [42 U.S.C. 6901-6991k] to address the growing quantity of waste generated in the US and to ensure its proper management. A subsequent amendment to that Act, the Resource Conservation Recovery (RCRA) act of 1976, [U.S.C.A. §6901-6922(k)], regulates tire disposal. Tire disposal is regulated as a solid waste under subtitle D of RCRA as non-hazardous municipal solid waste: "Municipal solid waste is a subset of [non-hazardous] solid waste…" and among these wastes are "durable goods such as appliances, tire, batteries…" RCRA mandates that the federal government take a non-regulatory approach to solid waste management, and thus tire management.

The US Environmental Protection Agency, which implements RCRA, has left the regulation of solid wastes, including tires, predominantly to state and local governments. At the federal level, it has suggested an "integrated hierarchical approach to waste management with four components: source reduction, recycling, combustion, and landfilling… The goal of EPA's approach is to use these methods to safely and effectively manage municipal solid waste." The critical element is that EPA merely suggests this management strategy; there is no federal mandate to reduce, recycle, combust, or landfill tires. That responsibility, excluded from federal jurisdiction, has been charged to states.

Rhode Island General Law § 23-63 regulates Vehicle Tire Storage and Recycling. This law declares storage of tires is "an unacceptable risk to the public health and safety, and that it is necessary to control disposal and promote safe recycling or recovery of the tires." Section 1 of RIGL § 23-63 acknowledges that (1) that the stockpiling of whole vehicle tires poses unacceptable risks to the environment and public health, (2) that the haphazard dumping of vehicle tires in Rhode Island is both unsightly and environmentally unsound, (3) that used vehicle tires represent a form of recyclable waste which should, for the purpose of reuse, be fully segregated from solid waste, and (4) that the state should take every reasonable step to ensure that recycling is pursued as the preferred method of handling waste tires. Accordingly, RIGL 23-63 bans burning, restricts storage of over 400 tires, and licenses tire recyclers.

The RI Department of Environmental Management (DEM), in accordance with Section 4002(b) of RCRA, has prepared a Comprehensive Solid Waste Management Plan (CSWMP), which is State Guide Plan Element 171. Section 7 (Management of Special Wastes), Part 2 of the CSWMP addresses tires specifically; it outlines the potential environmental or health impacts, composition of the waste stream, quantity, state of the waste industry, and current management practices.

The state of Rhode Island has also created the Rhode Island Resource Recovery Corporation (RIRRC), which is charged with "providing environmentally responsible and economically sound waste management options to meet community needs using public and private systems, programs, and facilities." RIRRC is responsible for non-commercial tire disposal in the state. RIRRC gets enforcement assistance from the Rhode Island Attorney General, specifically from the Office of Environmental Advocacy.[76]

(b) tire jockeys in RI

When worn tires go from the end user to the dealer, the disposal process begins. The tire dealers subcontract the actual removal and disposal of tires. A "tire jockey" or a solid waste hauler generally performs the removal of waste tires from a dealer's property.[77] While some hauling is done by tire users, tire dealers, or retreaders, the majority of tires go by way of a hauler who is paid to remove waste tires from the dealer's property.

In Rhode Island, tire jockeys typically charge the dealers about $.50 per tire as a tipping fee. [78] For this payment, the tire jockey then takes and sorts the tires. The tire jockey removes tires that can be resold, making his role invaluable in source reduction. Resalable tires include tires sold as second hand tires as well as those that can be sold to a retreader. [79] On the negative side, the tire jockey still has some genuine scrap tires of which he must dispose. If jockeys dispose of the tires legally, they must pay a fee at a landfill or processing facility. If they stockpile the tires illegally or dump them, the tires create serious hazards, as described earlier.[80]

The tire jockey responsible for removing all municipal waste tires from RIRRC is Meridian Tire.[81] They pick up tires from the central facility in Johnston and sort out tires with ¼ inch of tread for re-sale, mostly to Russia and South America.[82] This sorting process accounts for only 5 percent of the 200,000 municipal tires. The remainder goes to a tire-to-energy plant in Sterling, CT. FIGURE 4 shows the disposition of scrap tires in RI's municipal tire stream in detail.

In Rhode Island, two tire jockeys are responsible for 85-90 percent of commercial tire business (700,000 to 750,000 tires): Bob's Tire and Lakin Tire East.[83] They sort out nearly 10 percent of tires for resell and retread, and send the rest to Sterling, CT.[84]

The tire jockey responsible for most of the historical pile removal (on the Davis pile) is Casella, Inc. of Maine.[85] They were able to sort out relatively few tires due to the poor

[76] Tierney
[77] Snyder, 9.
[78] Drop-off Recycling at the Central Landfill. (Johnston: Rhode Island Resource Recovery Corporation. 1999).
[79] The basic definition of a worn-out tire is one that has less than 1/16 in remaining tread depth. In Rhode Island tire jockeys look for tires with more than ¼ inch of tread.
[80] For details on environmental problems associated with waste tire stockpiles, refer to section on
[81] Ionata.
[82] Ionata.
[83] Inter-East Tires Incorporated – Tire Recycling. Retrieved November 20, 2000 from the World Wide Web: http://www.recycle.net/lakintire and verified by Ionata.
[84] Ionata
[85] DEM Announces More Tires To Be Removed From Davis Pile Beginning Today.

conditions of tires on the Davis site. Their tires were sent for use as tire derived fuel to a paper mill in Bucksport, Maine.[86] FIGURE 5 shows the RI historical stockpile waste stream in detail.

Although there has been and continues to be use of whole tires as fuel as a practical matter, any other effectual use of tires requires them to be chopped up into uniform pieces. Shredding of tires is becoming increasingly common as part of the disposal process. Shredding eliminates the buoyancy problem and makes tires into a material that can be easily landfilled. Shredding reduces the tire's volume up to 75 percent.[87] This volume reduction can also reduce transportation costs 30 to 60 percent.[88] Processing tires is not without its problems, however.

(c) difficulties in processing tires

Modern tires are not just made of rubber. In fact, the composition of a typical passenger tire is only 14 percent natural rubber. A typical passenger tire is composed of 27 percent synthetic rubber, 28 percent carbon black, 14 percent steel, and 17 percent fabric, fillers, etc. FIGURE 6 depicts graphically the composition of a typical passenger tire. FIGURE 6 also depicts how elements are arranged within a tire.

The presence of multiple elements adds difficulty to the processing of tires. Primarily, the rubber and wire, each in its own way, resist cutting. Tire wire is medium carbon steel effectively hardened by several steps. Machine edges hard enough to cut the wire repetitively tend to be brittle and chip. Softer edges require frequent typically expensive replacement. Rubber compounds are also difficult to cut due to frictional forces build quickly on the sides of the blade when the knife-edge begins to penetrate rubber.[89] Secondarily, tire rubber compounds are abrasive. Heavy frictional contact with a piece of tire rubber quickly dulls even the sharpest edges. In tire manufacturing operations, even the knives that cut soft, unvulcanized rubber need frequent sharpening.[90]

While tire processing is difficult, commercial markets for tire chips and crumb rubber dictate that tires be processed multiple times. The current markets utilize particle sizes from 1 inch down to 80 mesh.[91] A cutting process, to approximately 0.25 inch, best achieves the upper range of particle sizes. For intermediate re-chopping of tires chips (smaller than 1 inch and greater than 0.25 inch) granulators are emerging as the preferred machine.[92] Granulators resemble reel-type lawnmowers in their action and have set of long straight knives mounted on a common axle rotating at high speeds and at close clearances past a stream of tire chips.

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[86] Davis Property: Chronology of Events and Proceedings 1974-1990.
[87] Amos, John M. Estimated Costs, Throughputs, and Chip Size in Shredding Scrap Tires. University of Missouri-Rolla, 1993.
[88] Amos, John M. Estimated Costs, Throughputs, and Chip Size in Shredding Scrap Tires.
[89] Snyder, 19.
[90] Snyder, 20.
[91] Snyder, 31.
[92] Snyder, 31.

Below this size, grinding processes are more effective. Due to their elastic nature, rubber particles resist grinding even more than they resist cutting. Ambient grinding, which involves repetitive grinding of rubber chips at room temperature, is most widely used.[93] A newer technology called cryogenic grinding involves taking approximately 3 inch tire chips and freezing them using liquid nitrogen at -195°C (-319°F).[94] Freezing converts the tough elastic particles to brittle glassy state in which they are easily shattered, often with a hammermill. This process is limited by the prices of liquid nitrogen, which is hard to transport. For asphalt extension, ambient ground crumb rubber is preferred; for recycling into virgin rubber compounds, cryogenic material, when available, is preferable.[95] In addition to these two methods, several proprietary methods of wet grinding are being tested currently; while production is relatively low, very small particle sizes (400 to 500 mesh) can be obtained.[96]

The main disadvantage of shredding before landfilling is that an extra processing step is required, which increases costs. Shredder companies charge approximately $75 per ton of ambient shredded scrap tires, and more for the other processes.[97]

(d) significance of tire source

While tires in general present processing problems, certain tires present more of a problem than others. Recall that tires brought to a processor from an outdoor pile may contain water or ice, dirt, or other scrap materials. Additionally, they may be pressed down by the weight of neighboring tires.[98] For convenience and cost reasons, a tire recycler will prefer to receive tires directly from a jockey than from long standing piles. This preference highlights the need to remove existing piles of scrap tires. No tire processor will willingly collect those dirty tires at their own expense until the supply of fresh, clean scrap tires is used up.

(e) removal costs for historical scrap piles

An associated removal cost of approximately $1.00 each tire directly from site exists for tires in stockpiles. The removal fee is approximately 70 cents if the tires are delivered to recycler.[99]

In 1989, tires were added to the RI Hard-to-Dispose law[100], carrying a 50-cent tax per tire. That was supplanted by a 75-cent tax collected through retail sales beginning in 1992 to start the “Tire Remediation Fund” to be administered by DEM. After tire dealers complained, the general assembly rescinded that tax and it was soon exhausted.

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[93] Snyder, 34.
[94] Snyder, 35.
[95] Snyder, 36.
[96] Snyder, 37.
[97] Amos, John M. Estimated Costs, Throughputs, and Chip Size in Shredding Scrap Tires.
[98] Tires in the Davis pile, for instance were pressed down with so much force that tires on the bottom retained no recyclable value.
[99] National Recycled Rubber Association.
[100] RIGL 37-15.1

Temporarily, the Rhode Island general fund paid. Also temporarily, there was a $5 refundable deposit charged on each tire. That deposit too was lobbied off the books. [101]

The Oil Spill Prevention and Remediation Fund (OSPAR) paid for removal of two major sites that had hydrological connections to the Narragansett Bay (Davis site and another pile near the Woonasquatucket River) arguing that the removal of piles was in fact a viable prevention of a potential oil spill.[102] While there are currently no active piles with hydrological connections, future OSPAR use is currently being contested by: ExxonMobil Corp., Motiva Enterprises LLC, and Sunoco INC on behalf of Davis. The RI Attorney General is arguing on behalf of DEM for the future right to use OSPAR for this purpose.[103] The funding for removal of future scrap tire piles is in question. For an accounting sheet of this process, refer back to TABLE 3.

<u>(f) disposal economics for municipal tires</u>

All tires incur an associated disposal fee. First, consider the economics of the municipal tire situation: Tires brought directly to the landfill are charged at $3 per tire or $52 per ton in large segregated loads. RIRRC, the responsible agency, has worked out a deal and pays Oxford Energy only $40 per ton, instead of the fair market price $65 per ton charged to commercial jockeys to dispose of those tires.[104]

In exchange for discounted prices on all its 200,000 municipal tires a year to Oxford Energy, the state accepts 30,000 tons of residue ash. This ash includes the bottom ash and fly ash produced from all 10 million tires across all ten states that use the Oxford Energy Facility. The state uses this ash for landfill cover, since according to state law it must cover each day's fill with 6 inches of cover. A typical landfill cover, topsoil, costs $12 per ton at current market prices.[105] For 30,000 tons the assumed savings is $360,000 in avoided costs. Refer to FIGURE 7 for a schematic presentation of economics for municipal tire disposal.

The state of Rhode Island can only receive the ash if it is "neutralized" so that metals are "fixed" [106] and are no longer available, and thus the ash is safe. Scientist Jon Campbell of *Essential Dioxin-L* says that some tests that ash can pass are "rigged," and that the "idea of using ash as landfill cover is outrageous."[107] While neutralization and fixation data for Oxford Energy is unavailable, RIRRC accepts the ash for its landfills. An

[101] The refundable deposit was charged from January 1994- July 1996. Cited from Providence Journal, December 20, 2000.
[102] Tierney.
[103] RI Supreme Ct C.A. No. 2000010.
[104] Ionata.
[105] Solid Waste Association of North America. Retreived 10 April 2001 from the World Wide Web: www.swana.org
[106] Terms cited from Campell, Jon. "Re: Bottom/fly Ash as Landfill Cover." *Essential Dioxin-L Listserv*. Retrieved March 3, 20001 from the World Wide Web: http://lists.essential.org/dioxinl/msg00234.html
[107] Campbell.

official at RIRRC estimates that it would cost Sterling $100/ton, or $3 million/year to dispose of the hazardous ash properly.[108]

Essentially, RI is assuming this $3 million liability for a $360,000 / year assumed savings in landfill cover and the $25/ton ($79,000/year) for a total of approximately $439,000 /year it saves in disposal fees. Assuming the 3 million disposal cost is actually paid, this is a net loss for state of RI of $2,561,000 per annum, for 200,000 tires, nearly $12 a tire. TABLE 5 presents the economics of municipal tire flow. FIGURE 7 presents the same information in schematic form.

(g) disposal economics for commercial tires[109]

Recall that there are 800,000 passenger vehicle tires in the Rhode Island commercial tire stream. End-user retail sites such as Sears or Firestone charge consumers anywhere from $3 to $6 based on competition alone (e.g. no regulations). The weighted average is approximately $5 a tire, or approximately $315 per ton. In RI, retail removal of scrap tires is a $3.5 – 3.75 million dollar business (gross). Expenses involved for retail sites are: mechanic labor, other overhead costs, and the fee of the tire jockey.

The aggregate fee of RI tire jockeys is $50 per ton, that costs the commercial disposers $552,500 - $592,500 annually.

Sterling charges jockeys $30 per ton to incinerate the tires or between $331,500 – 355,500. The middlemen make whatever money they can from re-usable tires and the difference in disposal fees ($221,000-237,000).

Meanwhile Sterling receives the total 900,000 –950,000 tires from municipal and commercial sources, they produce between an estimated 133 MWh and 140.5 MWh, and sell electricity at 3.5 cents/kWh for a gross profit of $4,663,000 - $4,920,000. In addition, remember Sterling makes between $331,500 – 355,500 from disposal fees. Sterling grosses $4,994,500 – $5,275,500

In addition to this gross profit, Oxford Energy saves $100/ton ($3 million a year) in ash disposal costs because of the agreement with RIRRC.

(h) problems with a predominantly single market system

RI's tire economy relies almost solely on the tire to energy market. Evidence as to why that is not prudent can be found in Oregon. That state's recovery rate fell from 98% in 1994 to less than 30% in 1999. Oregon experienced such a drop in recovery rate because it relied almost exclusively on 2 paper mills and a cement kiln to buy its scrap tires.

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[108] Ionata.

[109] Extrapolated from data from Bob's Tire and Lakin Tire East, which control a dominant 85-90 percent of the commercial business in RI.

When markets shifted, those mills stopped using tires as part of their fuel source, leaving Oregon with a disposal dilemma.[110]

Rhode Island may face a similar situation if Oxford Energy goes out of business or raises its fees dramatically. Thus, Rhode Island must begin to diversify its scrap tire disposal economy. Due to the single market nature of the scrap tire disposal economy and its inequitable exchanges with Oxford Energy, it can be concluded that the current tire economics of the state are sub-optimal.

[110] Blumenthal.

III. MARKET BASED SOLUTIONS AND ANALYSIS

(a) unique properties of scrap tires

Understanding the nuances of the status quo waste tire disposal requires consideration of what can be done to tires once tire jockeys dispose of them. In order to understand the range of utilization alternatives available for scrap tires, it is important to discuss further the unique properties of scrap tires.

The primary difficulty with tires is that in each of the many particle size ranges, tire chips have somewhat different engineering properties than other materials in that same size range and in most instances do not qualify as direct replacements for materials to which they seem comparable. TABLE 6 provides a detailed look at the engineering properties of rubber particulates.

To illustrate the uniqueness of tire particulates, consider one characteristic example. Theoretically, the hydrocarbon property and high heat of combustion of tire chips should make them an ideal solid fuel replacement for coal.[111] However, the absence of high ash levels precludes their use as a total replacement for coal in a conventional boiler where the coal ash serves the necessary function of protecting the grate from the high combustion temperatures. Rubber chips are limited to approximately a 15 percent mixture when used as a supplementary fuel to coal to avoid the problem of burned-out gates. In this way many theoretical applications of scrap tires become complicated.

(b) cost considerations

In further considering utilization alternatives of tire chips or crumb rubber, the cost is a key factor. The cost of the rubber particulate will depend on the amount of chopping or grinding necessary to achieve the desired particle size. In chopping chips, new surfaces are generated. As the size of rubber chips is reduced, the ratio of surface to volume increases, which raises process costs. In reducing 2-inch chips to 1-inch chips, the surface to volume ratio doubles, and cost increases accordingly.

Another cost consideration is the expense of the starting material, or the cost of the scrap tire at the door of the recycling plant. Today that cost is negative, that is to say recycling plants are paid to process tires. The current existence of a tipping fee reflects public view of tires as a waste material. It is vital to note that the conditions of the present system are not guaranteed. As late as 1986, one major private brand dealer was able to sell its worn-out tires, rather than pay to dispose of them.[112] That is to say, the conditions of the market then precluded a tipping fee, instead the dealers were paid for their scrap tires. While the present circumstance is not likely to revert in the next few years, the State

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[111] Reschner, Kurt. **"**Scrap Tire Recycling: A Summary of Prevalent Scrap Tire.
Disposal and Rubber Recycling Methods." Retrieved 2 November 2000 from the World Wide Web: http://home.snafu.de/kurtr/str/recy_en.html

[112] "Recommendations For Addressing Used Tires in California." USEPA Region 9 with Assistance from California Integrated Waste Management Board. July 2000.

should be aware that the possibility exists. To that end, reliance on subsidy to recyclers via tipping fees is not a stable long-term solution to the scrap tire problem.

(c) tire recycling activities.

Tire recycling activities, as noted, include the reuse or retread of the tire. There are a multitude of other creative uses for scrap tires. Whole tires may be used for things such as artificial reefs and breakwaters, playground equipment, erosion control and highway crash barriers, among other things.

Tire processing includes punching, splitting, or cutting tires into products; processing tires into crumb rubber for use in rubber or plastic products, railroad crossings, rubber reclaim, or asphalt paving; and chopping tires into small pieces or chips for use as gravel or wood chip substitutes. Processed tire products include mats and other rubber products, rubberized asphalt, playground gravel substitute, and bulking agent for sludge composting, among other things.

Various rubber products can be manufactured using rubber from scrap tires to replace some or all of the other virgin rubber material in the product. While the primary focus is the reuse of the rubber from the tires, the fabric and steel may also be recycled.

Tires may also be used for energy sources, either as shredded or whole tires. Tires are often used for combustion in paper mills, cement kilns, or dedicated tire-to-energy plants like the one that Rhode Island uses in Sterling, CT. In paper mills or cement kilns, tires undergo combustion and the result is tire-derived fuel. In dedicated tire incineration plants, the product is usually energy. Newer technologies involve altering the chemical structure of tire for re-use. TABLE 7 presents a detailed, but not comprehensive, list of various potential uses for scrap tires. The economic value of these potential uses is explored in further chapters.

(d) detail on oxford energy tire-to-energy plant

As noted previously, Oxford Energy operates a 10-million tire-a-year energy facility 20 miles from the Rhode Island border. In technical terms, it is a "base loading electric co-generating plant"[113] and it serves ten states across New England and the Eastern seaboard.[114] The operations of the plant recover 70 percent of the fuels from tires at an average of 3 gallons of oil per tire. The remaining 30 percent by volume are hazardous byproducts known as fly ash and bottom ash, referred to collectively as residue ash.[115]

While Oxford Energy has obtained permits to generate this ash and other visible pollutants, it has been charged with violations of its permits in the past. In 1996, the

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113 Ionata.

114 Namely, the Sterling plant takes tires from CT, NH, NJ, NY, MA, ME, RI and VT.

115 Montague, Peter. "New Study Shows Incinerator Ash More Dangerous Than We Realized." Rachel's Enviornment and Health Weekly #92. Retrieved 3 March 2001 from the World Wide Web: http://www.rachel.org/bulletin/bulletin.cfm?Issue_ID=1053&bulletin_ID=48

Connecticut Attorney General filed a "lawsuit that alleged 222 violations of its permits for two waste tire incinerators in Sterling."[116] The alleged violations included more than 100 occasions from April 1994 to March 1996 when the carbon monoxide emissions were higher than allowed and 13 occasions in which the facility exceeded the allowed level of ash pollutants. Under the stipulated judgment, Exeter Energy is prohibited from violating its permits or air pollution regulations, must pay the state $75,000 and is required to make improvements to the incinerator facility that cost about $300,000.[117] In the last five years, Oxford Energy has not violated its legal incineration limits, however its waste ash was no longer accepted by Connecticut landfills after the 1996 settlement. Research attempting to determine whether those landfills reject the ash because of the potentially harmful content or negative publicity fallout following the settlement was inconclusive. However, the ash definitively contains increased levels of heavy metals, dioxins and other toxics potentially harmful to humans.[118] TABLE 8 details the heavy metals contained in a generic sample of residue ash. The data in TABLE 8 is not taken from Oxford Energy ash, and therefore can only provide a representative sample. This data does not implicate Oxford Energy, it merely just to suggest that if its ash heavy metal/dioxin contents are typical, they may be harmful to humans.

(e) overview of utilization alternatives

Knowing that a variety of alternatives exist for tires after they have been expended as useful vehicle tires, it is useful to create categories of these alternatives for further analysis:

- Re-use and retreading – using tires or casings again as tires or casings
- Whole and shredded tire applications – using rubber tires or shreds as rubber in various applications
- Crumb rubber applications – using smaller uniform pieces of rubber in applications
- Fuel uses (tire-to-energy and tire derived fuel) – using tires for energy or as fuel supplements
- Technologies using chemical alteration – using tires by altering their physical structure via chemical process

(f) re-use and retreading[119]

- common applications: retreads
- 1998 National Usage: est. 26 million tires
- efficiency: very high, it takes 1/3 the amount of petroleum to re-tread as it does for a new tire that lasts just as long.

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[116] Connecticut Attorney General's Office. Retrieved May 1, 2001 from the World Wide Web: http://www.cslib.org/attygenl/mainlinks/tabindex1.htm
[117] Connecticut Attorney General's Office website.
[118] Increased levels of heavy metals result from burning of steel belted radials. Cited from Montague, New Study Shows Incinerator Ash More Dangerous Than We Realized.
[119] Tire Retread Information Bureau.

- market value: worth 1/3 to 1/2 the cost of a new tire (usually $8-25 per tire, potentially $800-2500 per ton).

Drawbacks to re-use and retreading involve the public perception that these tires are of the same quality as new tires. Also, retreading machines for radial steel-belted tires are expensive. As noted, the retreading industry for passenger tires in general has been in decline. Possible solutions to these drawbacks include consumer education.   Users must be educated to realize the value and safety of retreads. There must be incentives for producers and consumers to support the production and purchase of re-used and re-treaded tires.

(g) whole and shredded tire applications[120]

- common applications: civil engineering (e.g. wall barriers), leachate collection systems, artificial reefs, erosion control, road base.
- 1998 National Usage: over 30 million tires[121]
- efficiency: high
- market value: $100-300 per ton

(h) crumb rubber applications[122]

- common applications: transportation uses (rubberized asphalt)[123] mats, playturf, equestrian use, sewage sludge composting and soil amendments, molded rubber/plastic products
- 1998 National Usage: less than 30 million tires[124]
- efficiency: medium to high, rubberized asphalt lasts longer than regular asphalt
- market value: transportation uses: $100/ton; other uses: $250-500/ton[125]

Measures to implement crumb rubber applications have been introduced in the past. In 1991, Congress passed the Intermodal Surface Transport Efficiency Act (ISTEA).[126] Section 1038(d) of ISTEA mandated the use of asphalt rubber in federally funded highways beginning in 1994 at the level of 5 percent, increasing to 20 percent for all federally funded highways in 1997.[127] This action, in response to a growing national concern about the scrap tire problem, provoked a strong protest from many states that had no experience or insufficient experience with asphalt rubber.

In response to these objections, Rep. Carr of Michigan introduced an amendment to the Appropriations Bill for 1994 forbidding the Federal Highway Administration from using

[120] Snyder.
[121] In 1994, less than 3 million used, so usage has dramatically increased in last few years.
[122] Scrap Tire Management Council.
[123] Rubberized asphalt is a promising high value use.
[124] Scrap Tire Management Council.
[125] Snyder.
[126] Plater, Abrams, Goldfarb, et al.
[127] Plater, Abrams, Goldfarb, et al.

its funds to implement, administer, or enforce the provisions of Section 1038(d) on the basis that it was an unproven technology.[128] It appears as if Congress will not require adoptions of rubber-extended asphalt but it remains in a position to do so as the technology is refined. It also appears that the states will only widely adopt the terms of section 1038(d) if rubber-modified asphalt becomes cost effective.

(i) combustion/energy recovery applications (tire-to-energy and tire derived fuel)

- common applications: shredded or whole tires used for combustion in paper mills, cement kilns, dedicated tire to energy plants like the one run by Oxford Energy, or as tire derived fuel (TDF).
- 1998 National Usage: 115 million tires
- efficiency: low to medium, the least positive value of the four categories of utilization alternatives, however is the fastest most accessible use and is an efficient fuel compared to other common fuel sources -- TABLE 9 shows the fuel efficiency of common fuel sources[129]
- Market value: over $40 per ton

Fuel uses are the most accessible and most utilized category in Rhode Island. It is important to burn tires in a controlled fashion, harnessing the energy rather than allowing them to burn uncontrolled, creating a public health hazard. The most undesirable consequence of uncontrolled burning of tires arises primarily from incomplete combustion. Black carbon particles and many chemical products escape the combustion zone after incomplete combustion. In a proper boiler, tires receive a larger combustion zone, so they can burn completely with adequate oxygen. Under these conditions, they emit normal combustion gases including sulfur dioxide.[130]

The drawbacks to combustion include significant environmental and health risks. The hazardous fly ash and bottom ash and the disposal thereof present significant drawbacks. In addition there is smoke emitted from the stacks of these plants, so neighbors are exposed to potentially toxic air contaminants. There is also the Not In My Backyard (NIMBY) objection to these plants, in which people value the recycling of tires but do not want the plants in their vicinity due to the real and perceived health risks.

A classic example of the NIMBY objection involves the residents of Foster, Rhode Island. Foster is the town closest to the Sterling, CT plant and it no longer wanted to live in the shadow of the operations of the Oxford Energy tire-to-energy incinerator. As a result, the residents successfully lobbied to get a section added to the 1989 Vehicle Tire Storage and Recycling Act[131] that said waste tires could not be sent to another state for disposal. In 1992, the Rhode Island General Assembly repealed that prohibition and tires

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[128] "Market Status Report: Waste Tires." California Integrated Waste Management Board. Retrieved 14 March 2001 from the World Wide Web: http://www.ciwmb.ca.gov/markets/statusrpts/tires.htm
[129] Amos.
[130] Snyder, 47.
[131] RIGL § 23-63-2.

resumed going to Sterling, much to the chagrin of Foster residents.[132] With its lack of political clout,[133] Foster was unable to maintain political pressure on the State General Assembly.

(j) chemical alteration applications[134]

- common applications: tire pyrolisis, devulcanization, reverse polymerization, gasification, etc.[135]
- 1998 National Usage: 0 tires
- These markets are just developing; there is no large-scale usage and thus no established market values or efficiency data.

Pyrolysis, or destructive distillation is the process of heating tires, or more conveniently tire chips, to temperatures of over 315° C (600° F) in a confined space. At these temperatures, the tire rubber begins to decompose, generating an assortment of gas and liquid products. Devulcanization is a proprietary technology. One recycler, TRC industries, offers a process that "breaks the cured cross-link chain in reclaimed material."[136] This allows the reclaimed rubber to be incorporated at higher levels than other reclaimed materials. Furthermore, the entire process is accomplished without the use of chemicals or other reclaiming agents. Devulcanization is just beginning to gain field use. Reverse Polymerization is another proprietary process currently in minimal use by the Environmental Waste Management Corporation (EWMC).[137] The process involves the chemical breakdown of bonds that provide rubber with structural integrity. The "Tire Reduction System Model 3000" supposedly breaks down tires into three products: oil, carbon black, and steel.[138] Gasification was a short lived technology that turned a portion of a tire into saleable gas, but left 60 percent of the tire as hazardous

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[132] Tierney.

[133] Rhode Island Economic Development Corporation describes Foster as "sparsely settled town with almost four-fifths of the town's 52.2 square miles being hilly, and 88.2 percent of the land being forested." Cited from RIEDC website, retrieved April 24, 2001 from the World Wide Web: http://www.riedc.com/startframe.html

[134] Pennsylvania Department of Environmental Protection Waste Tire Recycling Homepage.

[135] California Waste Tire Management Program 1999 Annual Report. Retrieved March 8, 2001 from the World Wide Web: http://www.ciwmb.ca.gov/publications/Tires/62000006.doc

[136] "Market Status Report: Waste Tires." California Integrated Waste Management Board.

[137] EWMC - Environmental Waste Management Corporation Website. Reverse Polymerization via the Tire Reduction System Model 3000. Retrieved November 20, 2000 from the World Wide Web: http://www.ewmc.com/home/ewmc/real%20solutions.htm.

[138] In reverse polymerization, tires enter the processing area and proceed up the inclined tire feed into the dry-feed tower. They pass a series of shutters and land on the diverting conveyor, which send tires alternately to the two process lines. Vapor manifold piping systems draw process gases from the chambers to condensers where the oil is condensed. A scrubber to remove the hydrogen sulphide then processes any incondensable vapours. The remaining vapor is utilized to run a gas generator. The carbon crusher crumbles the reduced tire and assists in separating the carbon from the steel belts. After passing through the reverse polymerization trap, the main conveyor dips down into a solids separator water tank where the carbon is collected and transferred to the carbon processor. The steel is washed and falls off the end of the conveyor into a storage bin.

waste byproduct. This technology was found to have little practical application as aggregate byproduct disposal costs outweighed the value of the saleable gas.[139]

These technologies are not yet developed for large-scale usage. Most methods involving chemical alteration are in their early stages of development.

(k) optimal hierarchy of scrap tire utilization

Below is a ranking the five utilization categories with attention focused on environmental and economic soundness. The option of landfilling or monofilling tires is less desirable than all the utilization options on this list:

- Use **Product** for its originally intended purpose
  (re-use, re-tread) - maintain ½ - 1/3 of original value
  [$500+/ton]

- Use **Material** for its originally intended purpose
  (whole/ shredded tire) – civil engineering uses, erosion control, fill
  [$100-500/ton]

- Use **Processed Scrap** for its originally intended purpose
  (crumb rubber) – rubberized asphalt, molded products, etc.
  [$100-300/ton]

- Use tires for **Energy Recovery**
  (tire-to-energy and TDF) -- burn as fuel supplement in a variety of ways
  [less than $40/ton]

- **Alter chemical** structure of scrap tires and use
  (Pyrolysis, de-vulcanization)
  [no current sustainable markets]

- **Landfill or Monofill**[140] tires
  [negative economic and environmental value]

(l) actual tire usage nationwide and in rhode island (1998)[141]

- *US: Tires as energy: 115 million tires (42%); RI 900,000 tires (90%)*

- US: Landfilled or monofilled: 70 million tires (26%); RI >1000 tires (>1%)

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[139] California Waste Management Board.
[140] Monofilling is single use storage of waste substance for possible re-use later. Monofills are not co-mingled with other wastes as landfills are.
[141] Scrap Tire Management Council.

- US: Processed Material: Over 30 million tires (11%); RI >1000 tires (>1%)
- US: Whole Material: Less than 30 million tires (10%) RI >1000 tires (>1%)
- US: Retread: Over 20 million (>8%); RI 100,000 tires (10%)
- Chemical alteration: negligible relative to other uses

(m) discussion

Consider the optimal hierarchy of uses for scrap tires and derivatives, based on the conventional wisdom: "reduce, reuse, recycle."[142] At the top of the utilization hierarchy is retreading or re-use of tires. This option reduces the flow of tires into the waste stream and so represents the greatest environmental benefit. Retread and re-use of scrap tires also represents the consumer use of most value—1/3 to ½ the original value.

Excluding chemical alteration, which is a developing category, the lowest positive value is the use of scrap tires as fuel. As noted earlier, fuel uses currently comprise a dominant portion of Rhode Island's scrap tire disposal economy. Except for the steel and small amount of inorganic matter, the remainder of the tire can be considered petroleum derived with black carbon particles suspended therein. These tires can be reassigned to the fuel use with relatively high fuel efficiency.[143]

Tires have relatively high fuel efficiency when compared to other materials used to produce fuel. TABLE 9 compares the fuel efficiency of some common fuel sources. The average tire contains more than 3 gallons of fuel oil that can be extruded, making the fuel value of tires roughly $40 per ton. For comparison, a barrel of oil costs about $19.[144] If the chopped tire is used as a coal replacement, the value is slightly less because the value of coal is slightly less to begin with.

If the material from scrap tires can also be used as an asphalt extender, the tire is worth the same as the asphalt it extends, about $100 per ton. Alternatively, if the tire is ground into fine particles and incorporated into virgin rubber products or blended with certain plastics, the value can rise to $250 to $500 per ton depending on the value of plastics substituted.

Clearly, the least desirable thing to do with tires is to landfill them or monofill[145] them, as they produce a negative impact, environmentally and economically. These options take up valuable fill space and do not capitalize on any of the intrinsic properties of scrap

[142] Reduce, reuse, recycle are the fundamental tenets of RCRA
[143] When undergoing complete combustion, tires produce energy as high as 15,000 BTU/lb, a higher value than most other common fuel sources. For detailed treatment see Table 9.
[144] In the post World War II era oil prices have averaged $19.27 per barrel in 1996 dollars. Cited from "Market Status Report: Waste Tires." California Integrated Waste Management Board website.
[145] Monofilling is single use storage with potential retrieval capabilities.

tires. Of the two disposal options, monofills are slightly more desirable than landfills because they have the potential to be used for positive value later.

One conclusion from this priority ranking is that fuel uses are the fastest and most accessible for scrap tires, but they do not present optimal environmental and economic soundness. Other potentially high volume uses exist and the development of those markets should be pursued by the State. Another conclusion derived from comparing optimal use with actual use is that current market conditions in Rhode Island have prevented all of the usable scrap tires from entering scrap tire markets, in other words the scrap tire market uptake is less than 100 percent.

For the State, pursuing aggressive re-use and retread of tires policies makes sense. In addition, the state should pursue whole and shredded tire applications and crumb rubber application. Of these applications, the greatest potential volume utilization for the State is crumb rubber. Ideally the State would diversify its tire economy by shifting its operations to optimize its scrap tire use environmentally and economically. However, there are substantial barriers to such utilization. The next section explains these barriers.

IV. BARRIERS TO MARKET BASED SOLUTIONS

(a) economic and non-economic barriers

There are substantial barriers to utilization of scrap tires. For clarity, it helps to classify these barriers into two main types: economic and non-economic. Economic barriers refer to the high costs or limited revenues associated with various waste tire utilization methods, which make them unprofitable.[146] No tire processor will invest time or capital unless there is a sufficient rate of return to justify the efforts.

Non-economic barriers refer to a number of constraints on utilization. These include technical concerns such as lack of information or concerns regarding the quality of products or processes. These barriers also include the reluctance of consumers, processors, and regulators to employ new approaches or technologies for aesthetic or other reasons. They also include constraints on utilization for health, safety, and environmental reasons as well as laws and regulations.

The strength and persistence of these barriers is evident from the continuing buildup of tire stockpiles and illegal dumps over the last several years. TABLE 10 summarizes the economic and non-economic barriers that the EPA has identified for each of the tire utilization options. A common economic factor that affects all technologies is the low tipping fees for all solid wastes, which are subsidized by the RI General Assembly. Although landfills charge a premium for tires, disposal costs are generally much lower than the costs for alternate means of managing scrap tires such as recycling and incineration for energy recovery.

(b) case studies on three market based solutions

Currently, the State relies heavily on combustion technologies. Rubberized asphalt is the most promising new application on the basis of environmental soundness, economic feasibility, and State controlled volume assurance. It is helpful to analyze the feasibility of three technologies spread across the spectrum of viability: rubberized asphalt (promising future application), combustion (status quo) and pyrolysis (developing potential application):

In analyzing the economics of tire utilization, it is helpful to consider each situation where cost data are available in terms of the profit per tire. Common sense dictates that entrepreneurs will launch a tire processing facility only if the potential profit is high enough.

(c) crumb rubber applications case study: rubberized asphalt

The following is an economic analysis of rubberized asphalt, which was mandated nationally by ISTEA for five years from 1992-1997. The economic barrier to its implementation in Rhode Island is the high initial capital cost to the highway departments

[146] EPA, Scrap Tire Technology and Markets.

for purchase of different equipment. Data is unavailable at this time on the capital investment needed to convert an asphalt operation to add rubber. However, the Asphalt Rubber Producers Group (ARPG) claims that the installation of rubber asphalt pavements will cost about 2 times as much as standard asphalt.[147] In tests, the maximum pavement lifetime is also doubled. Therefore, over the lifetime of the road, the aggregate costs to the State would be the same.

The Rhode Island government, like others, has expressed concern that the two most proven forms of rubberized asphalt are patented and that may be keeping prices artificially high. The APRG estimates that royalty charges add nearly 35 percent to the current prices of asphalt-rubber.[148] In time, these proprietary technologies will become more widely produced, reducing costs.

One of the major non-economic barriers to rubber usage in paving systems has been the lack of long-term test results. Presenting another barrier, the ability to recycle pavements containing rubber needs to be tested. Given the similarity to conventional asphalt, a recyclable substance, the testing should be on how, not whether, the rubberized asphalt can be recycled. Another barrier is the lack of standard national specifications for pavements containing rubber.[149]

<u>(d) combustion/energy recovery applications case studies: (1) tire-to-energy and (2) tire derived fuel</u>

Since tires have a higher BTU value than coal[150], they are economically attractive as a fuel source in some situations. An analysis of the two types of tire combustion follows: (1) tire-to-energy power plant, such as the Oxford Energy plant, and (2) tire derived fuel (TDF) used in cement kilns and pulp and paper mills. The fundamental barrier to these technologies is the launching of facilities-- entrepreneurs will launch a tire processing facility only if they can be certain potential profit is high enough.

To analyze potential tire combustion facility profits, the EPA has established a profit-per-tire formula.[151] Applying this formula to economic conditions in Rhode Island, one can test the feasibility of tire combustion in the State.

$$P = F + R - C - T - D$$

Where

P is the profit per tire
F is the tipping fee collected per tire
R is the revenue received per processed tire

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[147] Tire and Rubber Recycling – Scrap Tire Disposal and Recycling website.
[148] Tire and Rubber Recycling – Scrap Tire Disposal and Recycling website.
[149] “EPA Municipal Solid Waste Management: Tires. website.
[150] Refer to Table of Fuel Efficiency of Common Fuel Sources.
[151] Clark.

C is the processing cost per tire for the operating facility
T is the transportation cost to bring in the tires
D is the disposal cost for waste products

Remember that there must be a high enough profit-per-tire to motivate entrepreneurs to remain in or enter the market. Thus, if the EPA equation yields a zero or negative value, there will be no profit or losses and thus no economic incentive.

(1) tire-to-energy power plant

The key economic factor for a tire-to-energy plant is the electricity buy-back rate granted by the utility.[152] This rate reflects the avoided cost or the cost per kilowatt-hour that the utility would incur if they built a plant themselves to generate additional power. For Oxford Energy, the rate is now $0.035 per kilowatt-hour (kWh).[153]

In analyzing the economics of the Oxford Energy power plant, the tire profit equation can be used. The initial buy-back rate fixed at $0.067 per kWh by Connecticut state legislation yielded revenue of $1.64 per tire. Assuming the same revenue rate, the current buy-back rate of $0.035 per kWh yields a per tire revenue of approximately **R= $0.86** per tire revenue. The EPA estimates the plant consumes 9.5 million tires per year, and it generates 26.5 MWh of electricity. Processing costs are assumed to be **C = $0.50.**[154] Costs of disposal to the Sterling plant are **D = zero** for the plant because of a special deal the plant has worked out with RIRRC to accept all its fly ash, gypsum, and bottom ash. *(See scenario below with an assumed $100 per ton disposal cost if RI rescinds this agreement.)* The tipping fee at Sterling is $60 a ton, which works out to nearly $0.60 a tire (assuming 100 tires a ton). The average transport cost is $3 per ton or $0.05 per tire

Substituting these values:

P = $0.60 + $0.86 + $ 0.50 - $ 0.05 - $ 0.00
= $0.91 per tire

Processing 10 million tires brings a gross profit of $9.10 million per year.

Consider the following hypothetical scenario where RIRRC no longer accepts the ash and Oxford Energy cannot find another State to take it-- Oxford Energy would have to assume the $100 per ton cost for its entire 30,000 tons of ash. The plant would assume a $3 million per year liability and have gross post-disposal profits of only $6.10 million per year. Officials at RIRRC hypothesize that $6.10 million would NOT be enough gross profit for the Oxford Energy plant to remain viable.[155] Therefore, RIRRC is faced with a difficult choice: continue to accept the residue ash or change its agreement with Oxford

[152] Snyder, 180.
[153] Ionata.
[154] While data is unavailable for the Sterling plant, processing costs are assumed based on data from the Modesto, California sister plant which has similar processing costs.
[155] Ionata.

Energy and risk the plant becoming unviable and potentially face a serious disposal dilemma. Rhode Island's scrap tire recovery rates would drop sharply in the absence of the dominant scrap tire market, as did Oregon's in the mid 1990's. This hypothetical scenario underscores the instability of the State's predominantly single market scrap tire disposal economy.

Note in both tire-to-energy power plant scenarios the critical factor is the utility buy-back rate. The buy-back rate is the primary economic factor in determining a new plant's feasibility and an existing plant's stability.

(2) tire derived fuel (TDF)

We can use similar analysis to test the viability of a TDF market in the Rhode Island area. Here the main economic barrier is the price of the competing fuel.[156] In areas of the country where cheaper fuel sources, such as petroleum coke[157] are available locally, such as Texas and Louisiana[158], TDF cannot gain market share. In Rhode Island, the primary competitive fuel would be coal. Since TDF is currently only slightly less expensive than coal,[159] it is hard to justify the high capital expenditure necessary to enter the market. TDF would become a more attractive alternative if current energy prices were to increase.

To further illustrate the point, consider the hypothetical scenario where the State buys out all the commercial tires and centralizes tire combustion services in a brand new $1 million facility to shred its 1 million tires annually. If the state can sell the TDF for $20 per ton[160], then assuming 100 tires per ton **R = $0.20**. Assume the tipping fee is $60 per ton[161], then **F = $0.60**. To maintain the steady flow of tires, an average transportation cost of **T = $0.05** is assumed. For the projected shredding operation the processing costs will be approximately **C = $0.40.** If the state sells TDF to cement kilns, the wire and beads do not need to be separated out and disposal cost for waste products is negligible, **D = 0.**

In this hypothetical, then:

P = $0.60 + $0.20 - $0.40 - $0.05 - $0

= $0.35 per tire profit

With the profit per tire of $0.35, the gross annual profit is $0.35 * 1 million tires, or $350,000.

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[156] Clark.
[157] Petroleum coke is a waste product from the petroleum refining process.
[158] Clark.
[159] Average Real Price of Coal Delivered to Electric Utilities in New England based on census data was $38.10 real dollars per short ton. A typical price for one ton of tire for use as tire derived fuel is $20.
[160] $20 is the typical rate per ton of tdf.
[161] $60 per ton is status quo in Rhode Island.

This analysis shows that TDF in Rhode Island (given the assumed constants and conditions reflect reality) is a fairly stable business proposition, with a 35 percent annual return on the initial $1 million investment. However, be advised that the stability of this deal is highly dependent on maintaining at least the same tipping fees as are charged today and a continuing demand for TDF at $20 per ton. In the absence of either of these conditions, the venture would not be financially feasible. However, in the event that coal prices rise dramatically, a TDF plant is an option worth considering.

Of course, building a new TDF plant is not as efficient as financing minor equipment changes to a nearby pulp or paper mill. In Rhode Island, Central Paper is one family owned, wholesale paper merchant.[162] While most cement kilns operate in the American Midwest, Rhode Island may build a cooperative relationship with the Cement Kiln Recycling Coalition (CKRC), an association with members throughout the United States.[163] Members include most major cement companies that use hazardous waste-derived fuel.

Since pulp and paper mill boilers are often equipped to burn hog-fuel, very little equipment modification is needed to burn TDF.[164] Often the competing fuel for the boiler is hog-fuel[165], which is sometimes more expensive than TDF on a dollar per million BTU basis. For instance, at $30 per ton for wire free tdf, the equivalent cost per tire consumed is about $0.30. The cost for the same fuel value of hog-fuel can be as high as $0.45 when hog-fuel is in short supply.[166] If the costs of handling, transportation, and disposal remain constant, the fuel cost saving realized would be $0.15 per tire.

Continuing this hypothetical scenario, if the pulp paper mill consumes 500,000 tires per year as TDF, then the annual fuel cost saving is $0.15 * 500,000 yielding a total of $75,000. If a hypothetical $150,000 in equipment changes were needed to handle TDF initially, the payback period would be 2 years. Clearly, pulp and paper mills have the potential to burn TDF efficiently and recover overhead costs quickly, although they are dependent on competing fuel prices.

The summary of economic barriers to scrap tire combustion markets follows: tire-to-energy plants are dependent on buy-back rate for electricity and to a lesser extent competing fuels; similarly TDF consumed at cement kilns or pulp and paper mills depend on cost savings over competing fuels.

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[162] Central paper operates in an 80,000 square foot warehouse located in Pawtucket, Rhode Island, and has dozens of nearby operating facilities. Cited from Central Paper Website, retrieved from the World Wide Web May 1, 2001: http://www.centralpaper.com

[163] Cement Kiln Recycling Coalition website. Retrieved from the World Wide Web, May 1, 2001: http://www.ckrc.org

[164] Clark.

[165] Hog-fuel is made by grinding waste wood in a hog; a mix of wood residues such as sawdust, planer shavings, and sometimes coarsely broken-down bark and solid wood chunks produced in the manufacture of wood products and normally used as fuel. Cited from Cement Kiln Recycling Coalition website.

[166] Clark.

There are non-economic barriers to scrap tire combustion as well. The chief concern to building a new TDF plant in Rhode Island is the possible siting of a new facility and related environmental concerns. Here, as in other aspects of tire combustion, the NIMBY objection occurs. Parties opposed to new combustion plants will stress the existence of the Oxford Energy plant 20 miles from the Rhode Island border, claiming any new combustion plant within the state is inefficient. In terms of updating existing Rhode Island pulp and paper mills to include tire combustion capability, considerable permitting delays are certain.[167]

(e) chemical alteration applications case study: pyrolysis

As noted earlier, at this time there has been limited commercial operation of pyrolysis plants in the United States. The primary barriers are economic and technical.[168] In particular, there has yet to be a commercial demonstration of a process to economically upgrade the carbon black residue to a high-quality profitable by-product.[169]

Upon preliminary inspection, pyrolysis does not appear to be an economically viable option for the state. First of all, if the state were to pyrolyze a ton of tire chips into gas, oil, and carbon residue that must be sold as fuel, the BTU level of the products would be less than that if tire chips were burned as fuel.[170] Accordingly, the economic value of the products produced from that ton of tires is less than the value of the chips in today's markets. Furthermore, to achieve this undesirable result, the state would have to make a large capital investment to build a pyrolysis plant as one does not exist in the region. Until sustained commercial operation occurs elsewhere in the nation, the state should not engage in commercial pyrolysis.

[167] For pulp and paper plants, air pollution tests are necessary, and for pulp and paper mills, emissions tests must be conducted.
[168] Pennsylvania Department of Environmental Protection Waste Tire Recycling website.
[169] Pennsylvania Department of Environmental Protection Waste Tire Recycling website.
[170] Refer to Table of Fuel Efficiency of Common Fuel Sources.

V. POLICY RECCOMENDATIONS TO MITIGATE THE SCRAP TIRE PROBLEM IN RHODE ISLAND

(a) overview

Specifically, Rhode Island depends too heavily on combustion, and not enough on the other available disposal options. The options that make the most sense for the state to pursue are whole and shredded tire applications and retreading. These options should be given preference in the state legislation that governs tires. As noted, earlier Rhode Island General Law § 23-63 governs tire storage and recycling. For full text of this statute, refer to TABLE 11. Other state scrap tire are similar to Rhode Island's however they all offer certain fundamental regulations: (1) funding sources for stockpile remediation; (2) mandates to clean up tire dumps; (3) scrap tire management procedures; (4) market development incentives; and (5) regulations regarding landfilling of tires. Since the size and shape of the scrap tire problem in the United States is greatly influenced by demography, wide variations in the ways individual states deal with the problem are expected. Nonetheless, a surprising amount of commonality exists between regulations.

(b) funding sources for stockpile remediation

Most states with scrap tire laws obtain funding for stockpile remediation through taxes or fees on vehicle registrations or on the tires themselves. States have taxes or fees on vehicle titles. These range from $0.50 to $2.00.[171] The advantage is that the government collects these fees, therefore it does not add administrative burden to tire dealers. A disadvantage is that the tax is not directly on tires.

Many states have taxes on the sale of new tires, and some states have fees on the disposal of waste tires. Taxes on the sale of new tires range from 1 to 2 percent and fees range from $0.50 to $1.00 per tire.[172] Disposal fees on tires range from $0.25 to $1.00 per tire.[173] Advantages to these types of taxes or fees are that they are assessed directly on tire retail sales. A disadvantage is that the tire dealer often collects them so there are administrative costs incurred by these intermediaries before the state government collects the money. Some states arrange for dealers to retain a designated percentage of taxes to defray their administrative costs.[174]

c. identify and clean up stockpiles

Most state laws set aside a certain proportion of the funds for cleaning up major abandoned dumps.[175] As in Rhode Island's case, states identify and prioritize their tire pile sites. Rhode Island uses criteria such as the number of tires on a site, proximity to public facilities, potential for significant environmental damage, and accessibility in the

[171] $1.50-2.00 range cited from Scrap Tire Management Council.
[172] EPA Municipal Solid Waste Management: Tires website.
[173] Clark, 82.
[174] EPA Municipal Solid Waste Management: Tires website.
[175] "State Scrap Tire Management Programs." 1995 Legislative, Regulatory, Market Development Review, 8th Annual Report. Suffield, CT: Research Recycling Institute, 1996.

event of a fire.[176] While clean up of these sites is usually expensive, it is less expensive than the cost of fighting a tire fire and associated environmental reparations.

d. methods for managing current tire disposal

Most states have developed regulations to manage tire stockpile and processing operations. A number of states have also addressed requirements for tire haulers in their regulations.[177]

In terms of stockpile regulation, state regulations generally limit the size of stockpiles. In RI, the storage of more than 4,000 tires at one location without a permit is illegal according to § RIGL 23-63.[178] States usually limit the length of storage, require fire lanes, and require that stockpiles be fenced in.[179] Rhode Island prohibits burning of tires and establishes guidelines for fire lanes - § 23-63-4 mandates licensing for all tire recyclers in Rhode Island.

Many states have regulations for processors. States may require processors to obtain permits or simply register. Generally, these regulations limit stockpile size, and establish tire management practices. Most states also have regulations on tire jockeys, providing for a state-supplied identification number and record keeping requirements.[180]

e. market development incentives

States have developed laws incorporating market development incentives for scrap tires. These fall into three general categories: (1) Rebates for tire recyclers and users of tires for fuel, (2) grants and loans to encourage businesses to recycle tires or use them for fuel, and (3) funds for testing innovative uses of scrap tires.

In 1987, Oregon was the first state to establish a rebate program[181], with many other states soon following. Some monies collected by states for management programs is returned to entrepreneurs who recycle tires or use them for energy recovery. At a minimum, reimbursement is made available at a rate of 1 cent per pound of tire utilized.[182] Oregon's program provides rebates to end-users of tires, specifically recyclers and those utilizing tires as fuel.[183] Some uses, such as paving projects using crumb rubber, are reimbursed at a higher rate, in order to make that use competitive to the use of conventional asphalt. Utah provides rebates to end-users but not to processors of

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[176] *Existing Tire Pile Sites*, Office of the Attorney General.
[177] State Scrap Tire Management Programs.
[178] The storage of less than 4000 tires is also regulated by RI DEM.
[179] Clark.
[180] Overview Report on California's Waste Tire Program, October 1998. Retrieved from the World Wide Web 8 March 2001: http://www.ciwmb.ca.gov/publications/Tires/54098007.doc
[181] Wise, Barry. "Scrappy New Programs for Tire Recycling," 11.
[182] Clark.
[183] State Scrap Tire Management Programs.

scrap tires.[184] Utah, like Oregon, makes its incentives available to out-of-state users utilizing its state's tires.

An advantage to these rebate programs is that state governments can use them to directly encourage forms of tire recycling and disposal they believe to be most beneficial for helping manage tires that enter the waste stream and for cleaning up tire piles. Representatives from both Oregon and Utah state governments report that their rebate systems have been successful in encouraging additional companies to start using scrap tires, especially for fuel.[185] They believe rebates have made a strong contribution to the success of their programs.

Disadvantages to these programs occur when neighboring states do not offer similar rebates and "leakage" takes effect.[186] Utah's programs have caused difficulties for neighboring states that have not yet implemented such rebate programs. Another disadvantage is lag time; after legislation has passed, it takes time for the funds to accrue; meanwhile entrepreneurs may stockpile tires.

Multiple states have programs that bestow grants or provide low interest loans to tire entrepreneurs or others willing to perform research into uses for tires. The programs are also available to those looking to start or expand a business that utilizes scrap tires. Several states provide funding for feasibility studies to investigate recycling processes and methods, or for feasibility studies regarding new businesses.[187] Grants range from 50 percent to 100 percent of the cost of these studies. Several states have also set aside funds for their own research and development of innovative uses for scrap tires.[188]

Clearly, these grants and loans are advantageous to businesses with the initiative to develop better ways to utilize scrap tires. These grants are often disadvantageous when they are redundant, that is they help businesses that could have succeeded without the extra help. The cost of administering such a program is also a disadvantage.

f. regulations regarding landfilling tires

Many states have passed laws regulating the landfilling of tires. Some states require that tires be split, others require tires be shredded before landfilling.[189] Other states have banned tires entirely from landfills. Some states only allow single use monofilling of scrap tires. TABLE 6 details these landfill regulations.

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[184] 1993 Audit: Waste Tire Recycling [in Utah]. Retrieved October 10, 2000 from the World Wide Web: http://www.le.state.ut.us/audit/ad3_93.htm

[185] State Scrap Tire Management Programs.

[186] Leakage is the phenomenon which may occur when neighboring law making bodies have inconsistent rules and interested parties seek out the law making body with the most favorable laws. In this case, Utah placed a burden on neighboring states by offering rebate programs which its neighbors did not.

[187] Clark.

[188] State Scrap Tire Management Programs.

[189] Pennsylvania Department of Environmental Protection Waste Tire Recycling website.

The advantages from regulation of landfilled tires are apparent-- they discourage landfilling. Hopefully, this will spur the tire industry to develop and improve means of using waste tires. However, if these alternate methods do not become available soon, there may be an incentive created to dump tires illegally.

g. other regulatory and non-regulatory strategies overview

The Resource Conservation Recovery Act (RCRA) mandated that EPA prepare guidelines for the purchase of retreaded tires for Federal agencies and for agencies using Federal funds to procure supplies. Accordingly, the General Services Administration (GSA) has developed specifications for retreaded tires and has developed protocols for testing tires. Of the 365 contracts awarded for supplying tires to the Federal Government in 1996, only 75 went to retread manufacturers.[190] The State should pursue similar or greater use of its purchasing power to encourage recycled tire products.

h. further research

Funding levels for research have fluctuated over the past two decades. The Department of Energy (DOE)[191] has researched recycling of tires, incineration and pyrolysis. The Federal Highway Administration (FHA) and the EPA have funded research on the use of rubber in pavements.[192] Many states' highway departments have also funded research. The National Research Council (NRC), the FHA, and the American Association of State Highway and Transportation Officials (AASHTO) are presently funding a five-year joint research project on rubberized asphalt in the wake of the complete repeal of ISTEA in 1997.[193] Rhode Island, which had a general assembly committed to ISTEA during its brief existence, will be well served by this research and will likely reassess using rubberized asphalt when the study concludes.[194] Multiple similarly themed research projects have also been sponsored by state and federal agencies. Rhode Island should consider undertaking or financing further research.

i. additional coordination among states and municipalities

States and communities must work together to address the scrap tire problem. They can pool resources so that studies of the use of rubber in pavements and other studies could be done on larger scales leading to more useful results. Pooling resources is especially important for a small state such as Rhode Island.[195] Also, tires tend to migrate to the

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[190] Tire Retread Information Bureau Website

[191] The Department of Energy's mission is to "foster a secure and reliable energy system that is environmentally and economically sustainable, to be a responsible steward of the Nation's nuclear weapons, to clean up our own facilities and to support continued United States leadership in science and technology." Cited from Clark, 107.

[192] Clark, 108.

[193] EPA Municipal Solid Waste Management: Tires website.

[194] ISTEA was introduced in the Senate by the Late Senator Chaffee from Rhode Island, and he rallied support from the state General Assembly for ISTEA.

[195] Hockenstein, et al. *Crafting the Next Generation of Market Based Tools*. (Environment 39:13, 1997) 18.

least expensive use or disposal option. Neighboring jurisdictions can work together in planning their policies so that there are consistent economic incentives to send the tires to a location where they can be utilized. In this way, neighboring jurisdictions can avoid the effect of leakage.

j. education and promotion

Education and promotion is an important component of any program to alleviate the problems of waste tires. Varied audiences need to be informed about different facets of the scrap tire problem. Informed citizens are the first step to preventing illegal tire dumping, especially in the rural parts of Rhode Island. Citizens can be educated about source reduction alternatives. Similarly, governments and companies operating fleets of vehicles can be educated on the harms of improper disposal and the economic and environmental benefits of reuse and retreading.

Tire dealers need ready access to information on reputable or licensed tire jockeys. They should also be informed on companies that sell used tires and that retread tires. Dissemination of available information regarding environmental controls and emissions is helpful in ensuring that industrial users of scrap tires implement environmentally sound practices.

Suppliers of scrap-tire derived products ought to be informed on the requirements of their potential product users.[196] This information, in turn can help to develop and expand markets for tire-derived material.

Information on all potential uses of tires for recycled products should be widely distributed. This education and promotion can take several forms. Sources useful to the author include reports and studies, which were supplemented by books, newspapers, newsletters, fact sheets, hotlines, and conferences on scrap tires. Also of use were computerized databases and government and quasi-governmental clearinghouses. Since the field of scrap tire recycling is changing rapidly, multiple means of communication are vital.

k. tradable credits

Congress has been considering numerous pieces of legislation that pertain to the management of solid wastes, including scrap tires.[197] One innovative suggestion is a credit system that would allow manufacturers to produce a new tire only upon recovery of an existing tire.[198]

In this hypothetical system, ¼ credit may be granted for shredding one tire. ¼ credit may be granted for burning a shredded tire. ½ credit may be granted for burning a whole tire. ¾ credit could be granted for reusing or recycling a shredded tire. Finally, one credit

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[196] Facilities that can use tire derived fuel may need this fuel supplied with uniform, consistent quality.
[197] Snyder, 186.
[198] California Waste Tire Program Evaluation and Recommendations Final Report, June 30, 1999.

could be granted for reusing or recycling one whole tire.[199] Under this system, manufacturers would be free to buy, sell, or trade their accrued credits. The Federal Government would work with the state government to administer this program.

l. tax incentives

Tax incentives were utilized as part of the financing package to build the Oxford Energy tire-to-energy plant. Tax-free municipal bonds were issued to borrow the money to finance the project. Entrepreneurs show clear responses to tax incentives when undertaking major projects, such as building a new tire derived fuel facility. Another form of tax incentive, the reinstatement of the higher utility buy-back rate for the Oxford Energy plant, would theoretically provide Oxford Energy enough money to dispose of its hazardous ash commercially at a cost of $3 million and still remain viable. Similarly, the Federal and State governments should consider reducing subsidies on the virgin rubber industry, assuming they still have such subsidies.

m. technology forcing statutes

Another option is to name tires as a hazardous waste by a fixed date. In this way, tire manufacturers will be forced to pursue technological innovations on the production end. This model, similar to the model used in the Clean Air Act, can be implemented most effectively at the Federal level.

n. extended producer accountability model

A final option is to make manufacturers responsible for the tires throughout the lifetime of the tires. Obligating manufacturers to take responsibility for the disposal of tires will likely force innovations on the production end. Perhaps producers will place greater efforts into making more recyclable tires if they are fiscally responsibly for their disposal costs. Similar measures are taking place in Europe, however the extended producer reliability model has not been applied to scrap tires yet. The feasibility of such a system remains in question.[200]

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[199] California Waste Tire Program Evaluation and Recommendations Final Report, June 30, 1999.
[200] Raymond, M. *Will European Producer Systems Work Here?* Resource Recycling. 1998.

CONCLUSION

The scrap tire problem in the State of Rhode Island has its genesis in the demise of the rubber reclamation industry and the decline of passenger retreads. It appears as both historical stockpiles and annual throughflow. With the remediation of the Davis Tire Site, most of the historical stockpiles in the State have been removed. Yet the perceived threat of new stockpiles and the reality of annual throughflow keep the issue alive and in the public eye.

The lack of Federal involvement necessitates State involvement. The State agencies responsible for tires must acknowledge the current scrap tire disposal economy is too narrow and therefore sub-optimal. Those agencies must further realize that other viable markets exist and they should begin to develop those markets. In developing those markets, the State must take into account the barriers to those utilization alternatives, and turn its attention to various options to begin to overcome those barriers.

Specifically, Rhode Island depends too heavily on combustion, and not enough on the other available disposal options. The options that make the most sense for the state to pursue are whole and shredded tire applications and retreading. These options should be given preference in the state legislation that governs tires (RIGL § 23-63).

Other states have attempted many ways to integrate disposal preferences via potential mitigating legislation. Some of the attempts have been successful, while others have not. Fortunately, Rhode Island has the benefit of collective knowledge of these efforts to rely on when developing its own solution to the scrap tire problem. This collective knowledge will allow the State to avoid the pitfalls of other States and adopt their successes for use in Rhode Island.

An important point to remember when attempting to incorporate these solutions is that none are all encompassing. In fact, exploring several of the options together is the best way to take serious aim at solving the waste tire problem in the State. Proper disposal techniques must be employed for all tires that are not recycled or incinerated and the approaches to the problem must be both regulatory and non-regulatory. An integrated approach involving government, industry, and the citizenry is needed to find a complete solution to the scrap tire problem in Rhode Island.

APPENDIX

TABLE 1: DECLINE OF TIRE RETREADS 1982-1997 (MILLIONS)

Year	Passenger	Medium Truck
1982	25.5	--
1985	15.5	13.1
1988	15.1	14.1
1991	8.4	14.8
1993	6.6	15.4
1994	5.9	15.9
1995	5.0	16.0
1996	4.2	16.5
1997	3.9	16.7

Source: Snyder, *Scrap Tires: Disposal and Reuse*, 1998.

TABLE 2: KNOWN EXISTING TIRE PILES IN RHODE ISLAND

Priority Ranking Number:

1. Number of Tires on a site
2. Proximity to Public Facilities
3. Potential For Significant Environmental Damage
4. Accessibility in Case of Fire

	OWNER	ADDRESS	TIRES (est)	STATUS
1	Mario Libutti	Railroad Ave., Johnston Plat 36, Lot 38; Plat 36, Lot 8	250,000	Unremediated
2	George Melidossian	Opposite 78 Belfield Dr., Johnston	125,000	Remediation initiated
3	Metals Recycling	Celia St., Johnston	50,000	No written response
4	James Brassard	Old Hope/ Old Kent Rd., Scituate Plat 48 Lot 81, 79 Coolridge Rd.; Plat 48 Lot 82, 79 Coolridge Rd. Plat 48 Lot 83, 195 Danielson Pk.	20,000 – 30,000	Unremediated
5	Oak Hill Auto Salvage	381 Oak Hill Ave., North Kingstown	30,000	Remediation in progress- trailer onsite
6	Gold Auto Wrecking	113 Fenner Rd., Middletown	10,000	Remediation in progress
7	Perry’s Auto Salvage	Chase Rd., Hopkinton	5,000 – 6,000	Remediation in progress
8	Exeter Salvage	575 Nooseneck Rd., Exeter	3,000	Unremediated, new site
9	Snake Den State Park	Access from 772 Greenville Ave., Johnston	15,000 – 20,000	Recently discovered
10	Charles Bargamian II (ABC Auto Truck & Bus Part)	Plympton St., North Providence	2,000 – 3,000	Unremediated, owner indicated cooperation
11	Foster Auto Parts	40 Mill Rd., Foster	1,000 – 1,500	Remediation in progress
12	Blanche Frenning	312 West Main Rd., Little Compton	500	Unremediated
13	Old Exeter Landfill	Off Rt. 102, Exeter. Plat 22 Block 2 Lot 3	300-400	Unremediated
14	Albert Ursillo	115 Railroad Avenue, Johnston	300	Remediation in progress

Source: Rhode Island Attorney General, March 2000

TABLE 3: FUNDING FOR REMOVAL OF TIRES FROM SCRAP TIRE PILES

SOURCE	FEE	YEARS	TOTAL $
Hard to Dispose *[RIGL § 37-15.1]*	$0.50/user tax assessed at retail	1989 –1992	1.5 million total
Tire Remediation Fund *[RIGL § 23-63-4.1]*	$0.75/user tax assessed at retail	1992 –1997	2.0 million total
RI General Assembly	---	1997 –1999	400,000 total
Oil Spill Prevention and Remediation Fund *[RIGL § 46-12.7-1]*	5 cents/barrel on oil purchases charged to retail gasoline vendors*	1999-current	2.1 million total

TOTAL COLLECTED (est). = $6.0 million

Source: "Davis Property: Chronology of Events and Proceedings 1974-1990." Office of the Attorney General Of Rhode Island. September 1990.

State	BANS ALL TIRES	BANS WHOLE TIRES	OPERATORS OPTION	MONOFILL PERMITTED
AL				X
AK			X	
AR				X
AZ	X			X - must be cut
CA		X		
CO		X		
CT		X		
DE		X		
FL		X		
GA		X		
HI		X		
ID	X			
IL		X		
IN		X		
IA		X		
KS		X		
KY		X		
LA		X		
ME	X			
MD	X			
MA		X		
MI				X
MN	X			
MS		X		
MO		X		
MT			X	
NE	X			
NV		X		X - must be cut
NH		X		
NJ				X
NM		X		
NY		X		
NC		X		
ND			X	
OH	X			
OK		X		
OR	X			
PA			X	
RI	***X***			
SC		X		
SD	X			
TN		X		
TX		X		
UT		X		
VT		X		
VA		X		
WA			X	
WV	X			
WI	X			
WY	X			

SOURCE: State Scrap Tire Management Programs, Research Recylcing Institute 1997

TABLE 5: ECONOMICS OF MUNICIPAL TIRE FLOW FROM THE PERSPECTIVE OF RHODE ISLAND (ANNUAL)

Income From Municipalities	**+ $165,000**
Payment to Tire Jockeys for Removal/Disposal	- *$125,000*
Missed Sales of Re-usable Tires	- *$30,000*
*Assumed Savings on Landfill Cover by Accepting Residue Ash**	**+ $360,000**
Opportunity Cost of Missed Energy Production	- *$100,000*
Net Economic Activity/ Net Benefit to Rhode Island	**+ $270,000**

* *Assumed hazardous waste liability = [$ 3 million]*

Source: Rhode Island Attorney General's Office and RI Resource Recovery Corporation.

TABLE 6: ENGINEERING PROPERTIES OF RUBBER PARTICULATES

Black – opaque
Liquid state – low freezing point
Low density (1.15)
Water resistant – nonwicking
Low thermal conductivity- thermal barrier
Low electrical conductivity – insulator
High absorption capabilities for most organics
Elastic and resilient
Flammable
High heat of combustion – low ash
Organic - nonbiodegradable

Source: Snyder, Robert H. *Scrap Tires Disposal and Reuse*. Warrendale: Society of Automotive Engineers, Inc., 1998.

TABLE 7: VARIOUS POTENTIAL USES FOR SCRAP TIRES.

Potential uses	Advantages	Disadvantages	Marketable product
Artificial reefs	Increases fish habitation; long life; ease of configuration.	Costly to install; may move.	Reefs.
Breakwaters	Perform well; durable; low cost.	Limited number of tires used	Breakwater.
Construction	Perform well; low cost.	Limited number of tires	Retaining walls; erosion control; crash attenuation; structural fill material.
Crumb rubber	Marketable commodity; reclaims raw material; marketable applications.	High cost.	Crumb rubber.
Rubberized asphalt	Longer wear; noise buffer.	Mixed test results; requires special equipment; not proven economical.	Asphalt.
Sealants	Proven effective.	Limited number of tires used.	Roof/road sealant.
Railroad crossings	Proven effective; reduces supply.	Limited number of tires used.	Railroad crossings.
Sport surfaces	Better surface; lessens impact.	Limited number of tires used.	Running tracks; playgrounds.
Stampings	Proven effective.	Limited number of tires used; not economical; fragmented market.	Dock bumpers; farm machinery rollers; pipe rollers.
Soil additives	Improves soil quality; improves air circulation.	Limited number of tires used; fixed sales for compost.	Tire chips.
Sheet goods	Proven effective.	Limited uses; limited number of tires used.	Floor mats, carpet pads; mud guards.

Molded products	Wide variety of uses.	Saturated market.	Truck bed liners; pots, buckets, etc.
Tire retreading	Historically proven; reduction of supply.	Declining market.	Retreaded tires.
Dedicated whole tire boilers	Completely disposes tire; produces energy; appears environmentally clean.	Long pay-back period; community acceptance; new boiler construction; requires large stockpile for continuous use.	Energy.
Municipal Solid Waste/Waste to Energy (MSW/WTE)	Reduction of supply; compatible with existing fuels; can boost Btu content.	Limited use; tires may burn too hot; limited MSW/WTE facilities.	Energy.
Pulp/paper plants	Reduction of supply; compatible with existing fuels; can boost Btu content.	Limited use in Illinois; increases air emissions; required stockpiles.	Energy.
Utility boilers	Reduction of supply; compatible with existing fuels.	Requires stockpiles; increases air emissions.	Energy.
Cement kilns	Reduction of supply; compatible with existing fuels.	Requires clean TDF.	Energy.
Fluidized bed boilers	Reduction of supply; compatible with existing fuels.	Requires clean TDF; requires stockpiles; increases air emissions.	Energy.
Pyrolysis	Minimal environmental impacts anticipated.	Unproven markets; requires stockpiles.	Oil and combustible gas; carbon black.

Source: John M. Amos: Engineering Specialist, University of Missouri-Rolla, 1993

TABLE 8: METAL PER TON OF ASH DERIVED FROM TIRE COMBUSTION (LBS)

Metal	Flyash	Bottom ash
Chromium	0.09	0.1
Cadmium	0.56	0.07
Lead	7.9	5.6
Arsenic	0.14	0.2
Dioxin	0.17	0.2

SOURCE: Reisman, Joel I. *Air Emissions From Scrap Tire Combustion*. Clean Air Technology Center of the US Environmental Protection Agency, Washington D.C., Environmental Protection Agency, October 1997. http://www.epa.gov/ttncatc1/dir1/tire_eng.pdf (March 3, 2000).

TABLE 9: FUEL EFFICIENCY OF COMMON FUEL SOURCES (BTU IN THOUSANDS /LB)

Rubber derivative (tires)	16.0
Bituminous coal	12.75
Coke	13.70
Subbituminous coal	10.5
Lignite coal	7.3
Wood	4.375

Source: Amos, John M. *Fuel Efficiencies of Common Fuel Sources*. University of Missouri-Rolla, 1993.

TABLE 11: FULL TEXT OF RI GENERAL LAW § 23-63
(TITLE 23 -HEALTH AND SAFETY, CHAPTER 63: VEHICLE TIRE STORAGE AND RECYCLING)

§ 23-63-1 Legislative findings and policy. – The general assembly finds and declares that accumulation of stored used vehicle tires and the disposal of the tires by land filling present an unacceptable risk to the public health and safety, and that it is necessary to control disposal and promote safe recycling or recovery of the tires. The general assembly also recognizes: (1) that the stockpiling of whole vehicle tires poses unacceptable risks to the environment and public health, (2) that the haphazard dumping of vehicle tires in Rhode Island is both unsightly and environmentally unsound, (3) that used vehicle tires represent a form of recyclable waste which should, for the purpose of reuse, be fully segregated from solid waste, and (4) that the state should take every reasonable step to ensure that recycling is pursued as the preferred method of handling waste tires.
§ 23-63-2 Disposal of used vehicle rubber tires – Burning prohibited – Storage restricted. – (a) No person shall dispose of any vehicle tire within the state except by delivery of the tire to a facility operated by the Rhode Island resource recovery corporation designated for that purpose, or to a privately operated tire storage or tire recycling or recovery facility licensed by the director of environmental management for that purpose or by delivery for transportation to an out-of-state recycling facility. Prior to the delivery of any vehicle tire for export to any tire-burning facility outside the state, and within thirty (30) miles of the Scituate Reservoir watershed, the department of environmental management shall consult with the appropriate state agency regulating such tire-burning facility and shall receive assurances in writing from the agency that the facility meets all applicable state and federal pollution control standards. (2) The burning of used tires within the state is prohibited. (b) No person not licensed under the provisions of § 23-63-4 shall store more than four hundred (400) used vehicle tires at any location within the state. Any person not in compliance with this section on July 11, 1989 shall have one year from that date to effectuate compliance pursuant to the provisions of subsection (a).
§ 23-63-3 Environmental impact statement – Necessity – Approval of director. – No export of tires for burning shall be permitted to a facility which has not submitted to the satisfaction of the director, in accordance with reasonable rules and regulations, an environmental impact statement conforming to the United States environmental protection agency standards. Upon the filing of a satisfactory environmental impact statement, the director shall conduct a public hearing seeking public comment prior to granting final approval of the statement and approval of the export of the tires. The environmental impact statement shall be required regardless of whether it is required at the facility site by the United States environmental protection agency regulations.

§ 23-63-4 Licensing of tire recyclers. – The director shall license any person to engage in the vehicle tire recycling or recovery business if the director finds that the person has the proper equipment and facilities to properly recycle or recover the materials of vehicle tires. The license shall be annually renewable on January 1 of each year upon application by the licensee. The director may revoke the license at any time or refuse to renew the license upon a finding that the licensee has not operated the busienss to safely and properly recycle and recover vehicle tires in a manner causing the lease practicable pollution of the environment. The initial license fee shall be fifty dollars ($50.00) and the fee for annual renewal shall be twenty-five dollars ($25.00). Other than as set forth in this chapter, the license shall be subject to the provisions of the Administrative Procedures Act, chapter 35 of title 42.

§ 23-63-5 Penalty. – Any person who violates §§ 23-6-2, 23-63-3 or 23-63-4 and 23-63-4.9(b) of this chapter shall be fined not more than one thousand dollars ($1,000) per occurrence. Fines collected pursuant to this section shall be remitted to the corporation for deposit in the tire site remediation account. Each day that the violation continues or exists shall constitute a separate occurrence. The provisions of this chapter may also be enforced by an action for injunctive or other relief in the superior court for Providence county to be brought by either the department of environmental management or the attorney general.

§ 23-63-6 Rules and regulations. – The director may promulgate rules and regulations necessary to implement this chapter.

§ 23-63-7 Severability. – If any clause, sentence, paragraph, or part of this chapter or the application thereof to any person or circumstance shall, for any reason, be adjudged by a court of competent jurisdiction to be invalid, such judgment shall not affect, impair, or invalidate the remainder of this chapter or its application to other persons or circumstances.

SOURCE: Rhode Island General Laws, 2001.

Figure 1: US Waste Stream

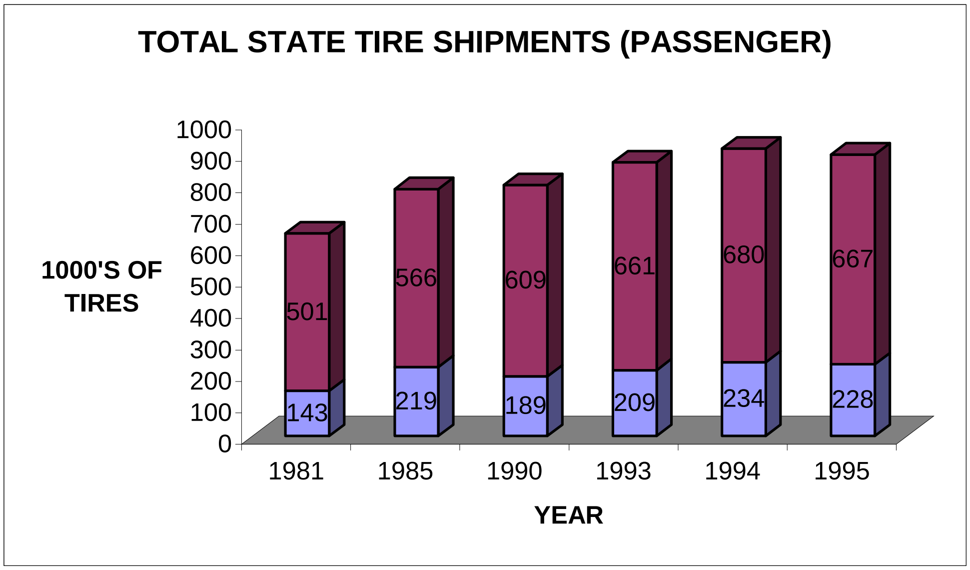
Total U.S. Waste Stream

annual thruflow
250-270 million tires/yr
(1 tire per capita)

scrap tire piles
2 - 3 billion tires

FIGURE 2: TOTAL RHODE ISLAND TIRE SHIPMENTS

LEGEND: BOTTOM FIGURE = ORIGINIAL EQUIPMENT; TOP FIGURE = REPLACEMENT



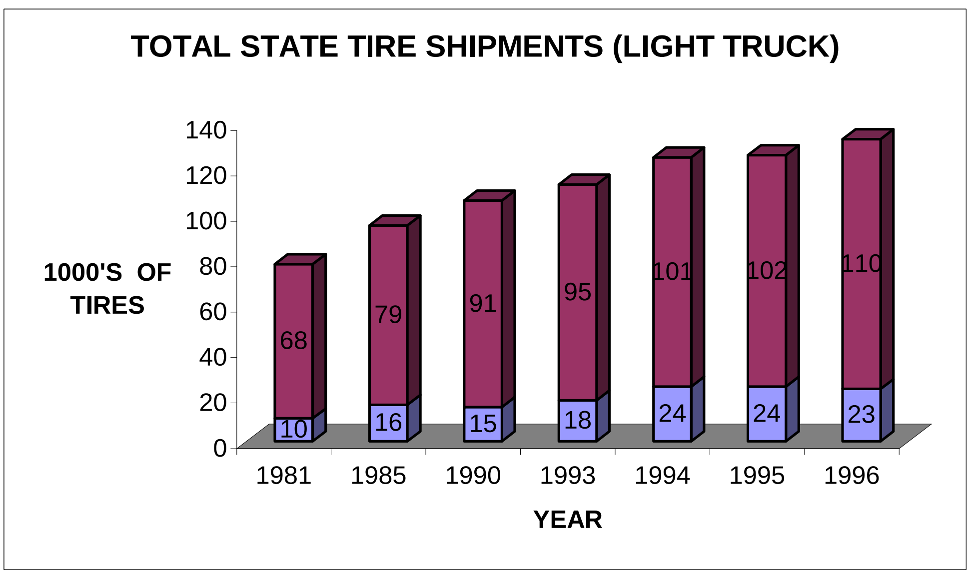


Figure 3: R.I. Waste Stream and Responsible Parties

RIGL § 23-63 : Vehicle Tire Storage and Recycling

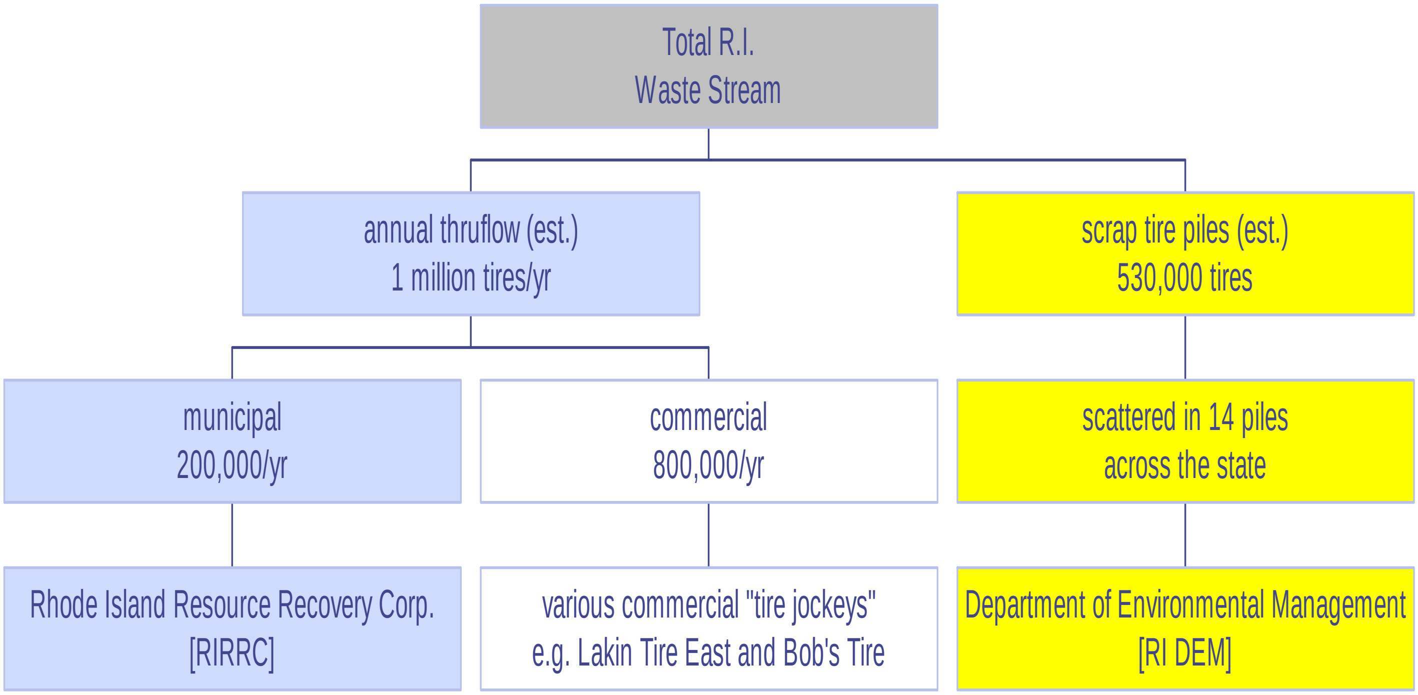


Figure 4: Disposition of Scrap Tires in R.I. Municipal Tire Stream

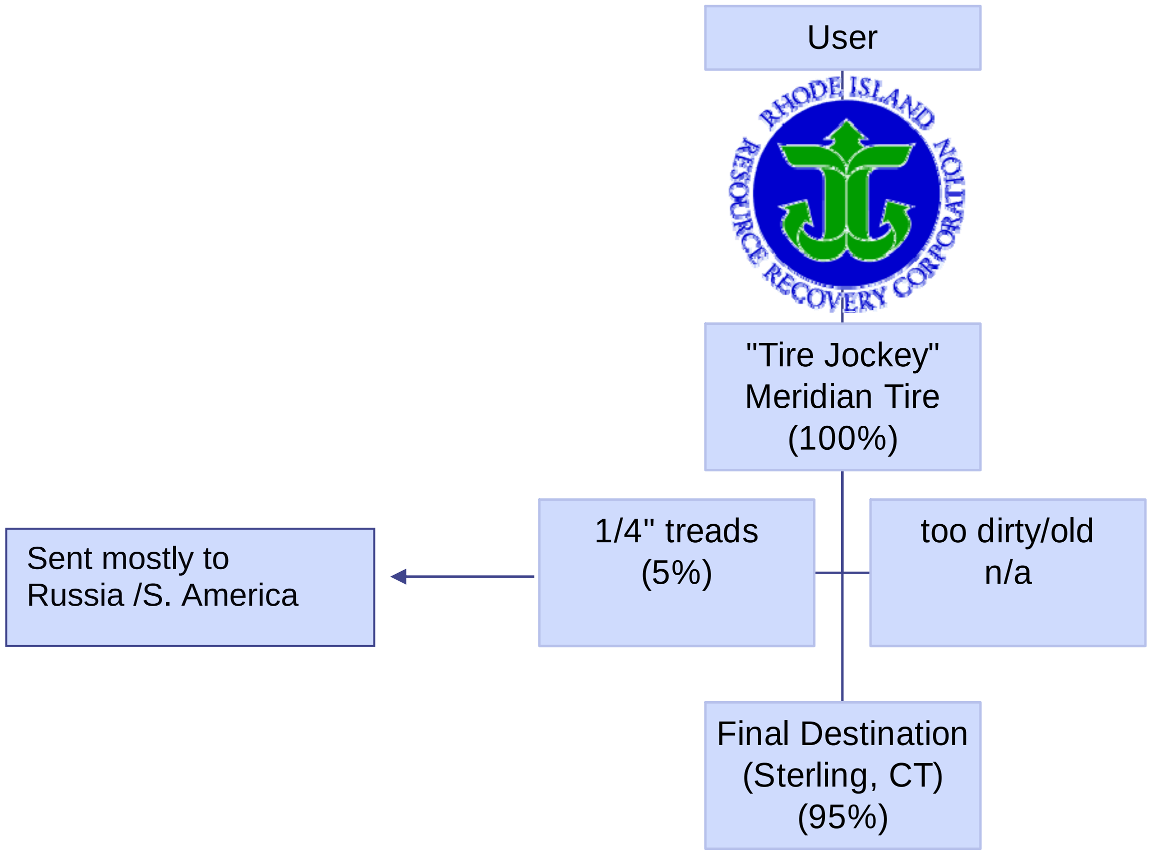


Figure 5: Disposition of Scrap Tires in R.I. Historic Piles

[RI Comprehensive Solid Waste Mgmt Plan 171-7-2]
[RIGL § 23-63-4.2]

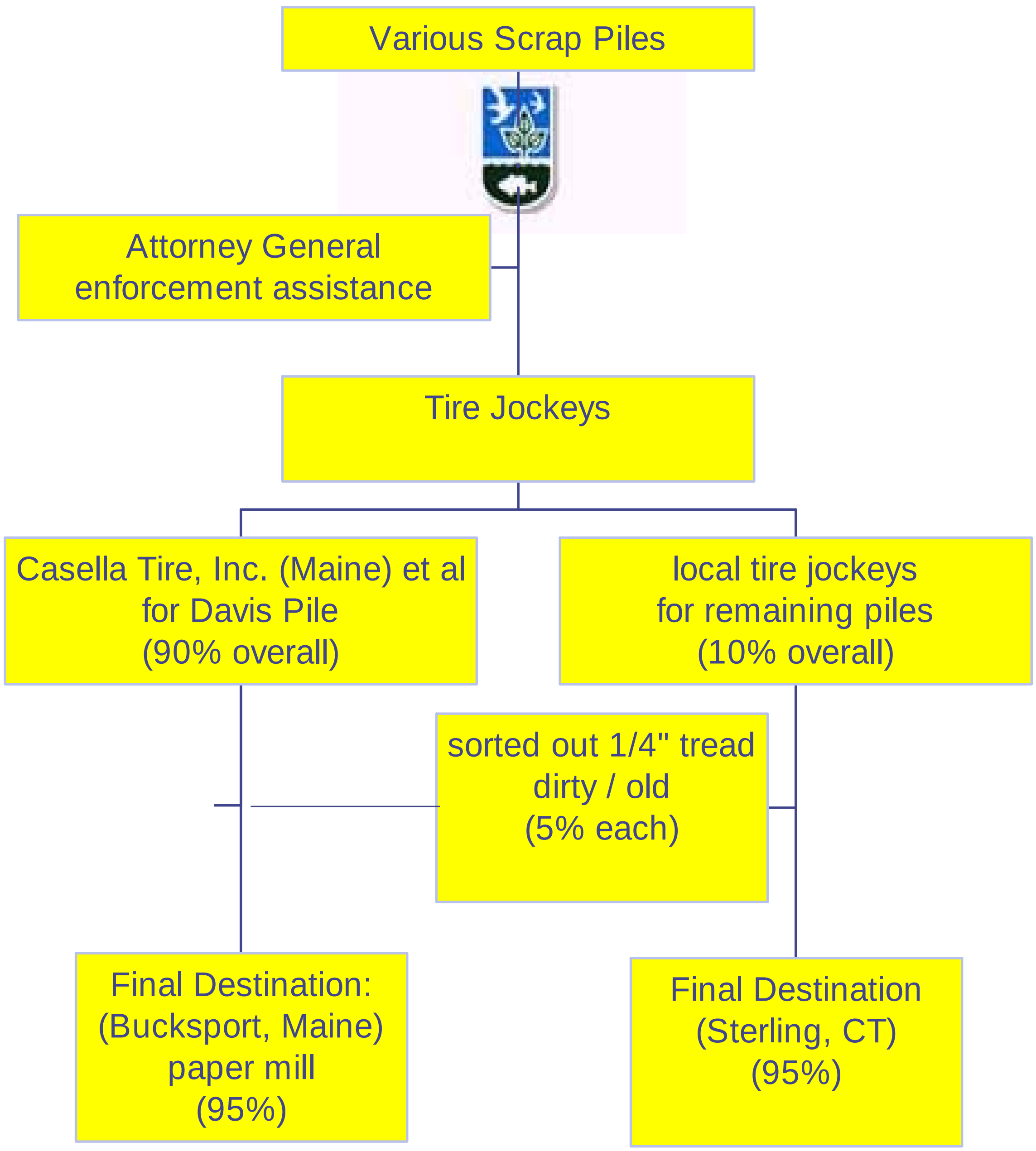
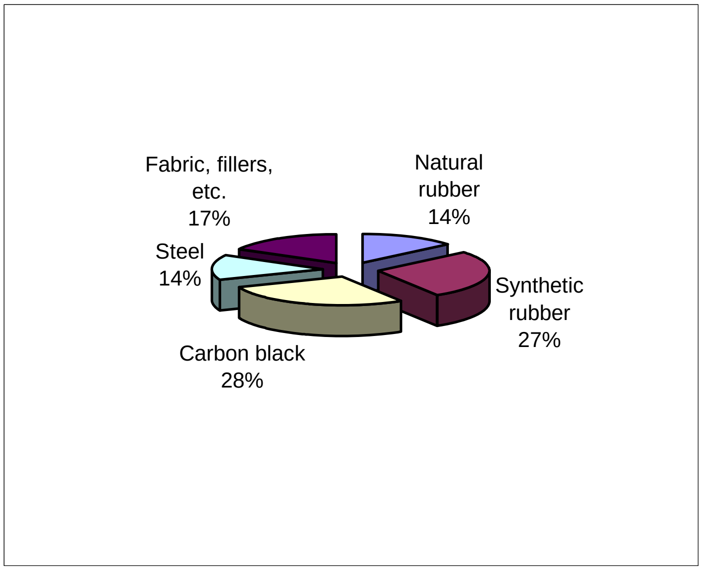
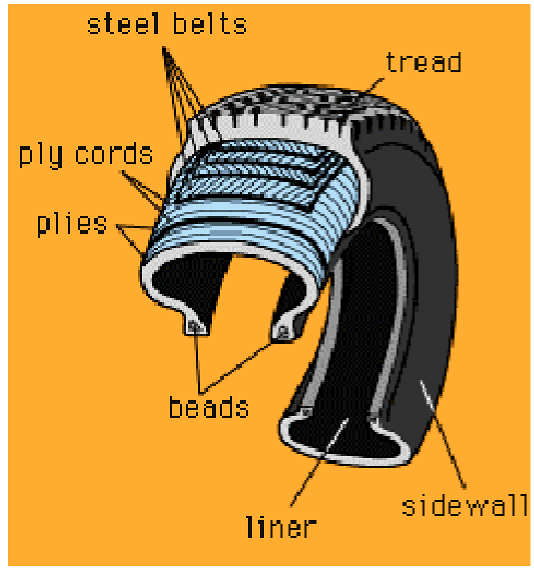


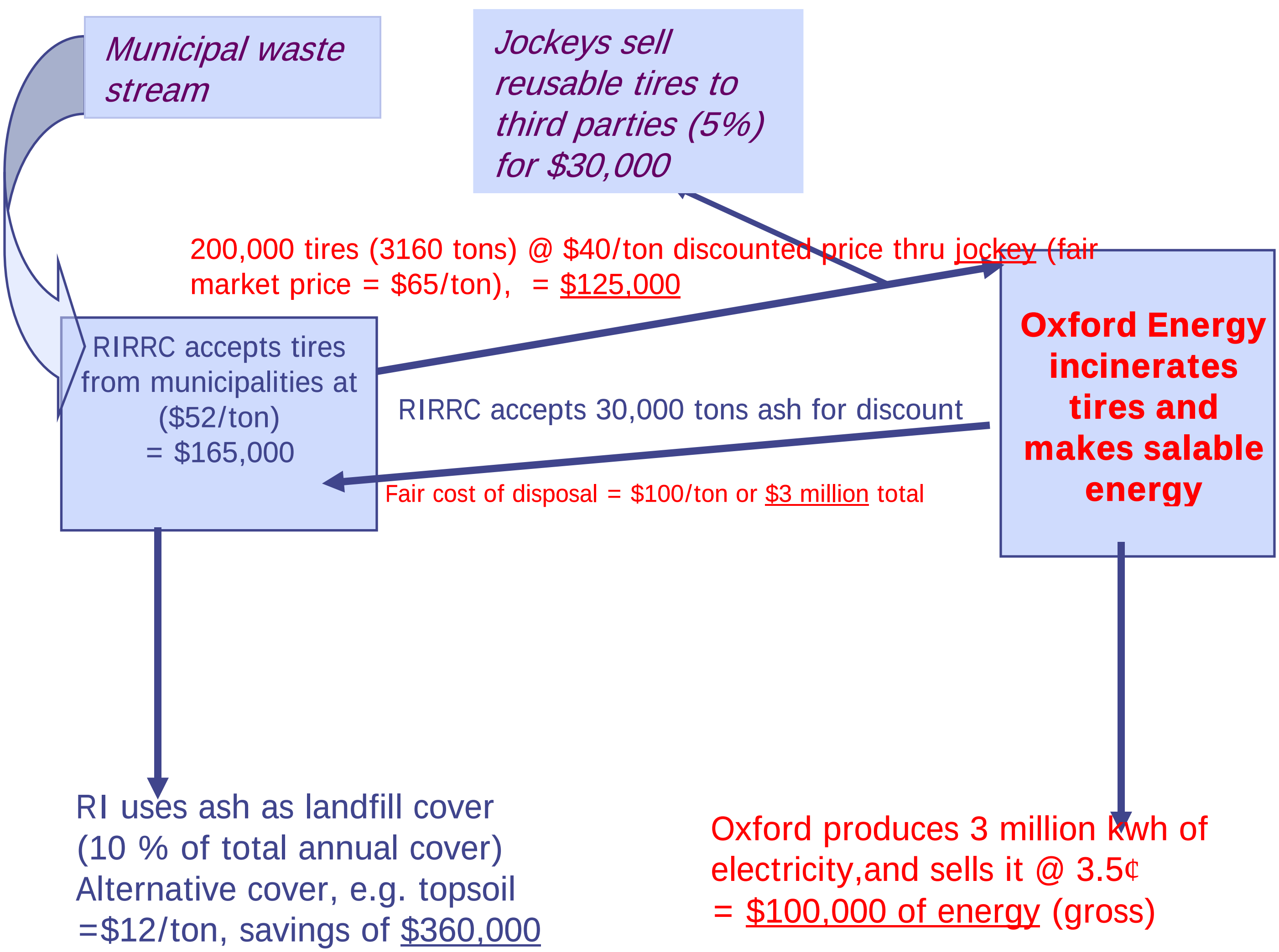
Figure 6: Typical Passenger Tire Structural Composition





Source: "EPA Municipal Solid Waste Management: Tires." http://www.epa.gov/epaoswer/non-hw/muncpl/tires.htm (March 1, 2001).

Figure 7: Economics of Municipal Tire Flow in R.I. *(annual)*



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