EVALUATION OF TIRE CHIPS AS A SUBSTITUTE FOR GRAVEL IN THE TRENCHES OF SEPTIC SYSTEMS

Aziz Amoozegar and Wayne P. Robarge

Soil Science Department
North Carolina Agricultural Research Service
College of Agriculture and Life Sciences
North Carolina State University
Raleigh, North Carolina 27695-7619

Final Report Submitted to:

Division of Pollution Prevention and Environmental Assistance
Department of Environment and Natural Resources

and

Chatham County Board of Commissioners

The research on which this report is based was financed in part by the Office of Waste Reduction, North Carolina Department of Environment and Natural Resources, and with cooperation from the Chatham County Government. The contents of this publication do not necessarily reflect the views and policies of the North Carolina Department of Environment and Natural Resources or the Chatham County Government.

ACKNOWLEDGMENT

Many individuals were instrumental in the successful completion of this study. We would like to extend our appreciations to Mr. Joe McClees and Ms. Karla Guatney from McClees Consulting, New Bern, NC; Mr. Jimmy Collins, from Chatham County Health Department; Mr. Steven Steinbeck and Mr. Steven Berkowitz, from the On-Site Wastewater Section; Mr. Gary Hunt, Mr. John Nelms, and Mr. Gerry Sutton, from the Division of Pollution Prevention and Environmental Assistance (formerly Office of Waste Reduction); and Mr. Bill Meyer and Mr. Larry Rose, from the Office of Solid Waste for their support and assistance during the course of the study. Special thank you is extended to Mr. and Mrs. Charlie Bouldin, from Chatham County, who allowed the use of their property to conduct the field study and to Mr. Bob Johnson, from U.S. Tire Recycling Company, Concord, NC, who provided tire chips for the study. Two individuals from the North Carolina State University, Mr. Wallace Baker and Mr. Stewart Starr provided space for large column study and we thank them for that. Christopher Niewoehner, an Agricultural Research Technician in the Soil Science Department at North Carolina State University, deserves special recognition for his dedication and hard work throughout the study. Gardner Prabel conducted most of the laboratory experiments and Mr. Guillermo Ramirez analyzed some of the samples, for which we thank them. We also extend our appreciations to the staff at the North Carolina Public Health Laboratory, as well as the staff in the Department of Soil Science Analytical Service Laboratory for their assistance in analyzing samples. Last, but not the least, we would like to thank the Office of Waste Reduction, North Carolina Department of Environment and Natural Resources, for the financial support, and the Chatham County Board of Commissioners, who graciously accepted to cooperate with this project.

INTRODUCTION

Management of used or scrap tires is a major problem facing many local and state governmental agencies. The Rubber Manufacturers Association (RMA, 1998) has reported that in the United States approximately 266 millions scrap tires were generated in 1996, and that approximately 800 millions scrap tires are currently stored in stock piles waiting for proper reuse or disposal. According to the RMA, 84% of the scrap tires are passenger car tires, 15% are light and heavy truck tires and the remaining 1% are heavy equipment, off-road, and aircraft tires. Disposing of whole tires in a municipal landfill not only results in decreasing the useful capacity of the landfill (due to the large volume to mass ratio for whole tires and their non-compressibility), but also results in damage to the top cap when the tires rise (float) to the surface (Eleazer et al., 1992).

As part of the North Carolina Scrap Tire Disposal Act, disposal of whole tires in sanitary landfills was banned in 1989 (NCDENR, 1997, Appendix A). Major legislative changes in North Carolina were inacted in 1993 to address the problem of illegal tire dumping (see the General Assembly of North Carolina, 1977 Session -- S.L. 1997-209, Senate Bill 153, in Appendix B). To encourage collection of scrap tires by individual counties, the tire disposal tax was increased, and landfill disposal fees for scrap tires were eliminated effective January 1, 1994. According to a report filled by the Solid Waste Section of the North Carolina Department of Environment and Natural Resources (NCDENR, 1997), in the Fiscal Year 1996-1997 the 100 counties in North Carolina reported managing approximately 8.9 million scrap tires while the estimated number of tires generated by the citizens of the state (based on one tire per person per year) was 7.3 million. Of the 8.9 million scrap tires collected by the counties, 8.5 million were shipped to six recycling firms within North Carolina and 0.4 million were placed in landfills or shipped out-of-state. In addition, approximately 0.6 million tires generated in North Carolina were taken directly to various recycling firms by individuals and commercial entities, and 1.4 million tires were collected from nuisance tire dump sites in the state. Tire recycling firms within the state also received an estimated 4.0 million tires from out-of-state disposers in the Fiscal Year 1996-1997. Of the 10.5 million tires collected by the recycling firms from sources in North Carolina, approximately 4.7 million (or 45%) of the tires were diverted from landfills.

The most commonly used methods for recycling/reusing scrap tires in North Carolina are (NCDENR, 1997):

- Tire reuse, re-manufactured, retreading -- An estimated 473,000 or 5%
- Tire-derived fuel (TDF) -- Approximately 426,000 or 4% (shipped to out-of-state facilities since there are no TDF facilities in North Carolina)
- Crumb rubber -- Approximately 909,000 or 9%
- Agricultural and miscellaneous products -- Approximately 776,000 or 7%
- Civil engineering applications -- Approximately 2,119,000 or 20% (including tire chips used in place of gravel in the trenches of septic systems in South Carolina)
- Landfill disposal or stockpiling (monofill landfills)-- Approximately 5.8 million or 55%

In addition to unsightliness, the two major problems associated with stockpiling whole tires are the potential for fire and mosquitoes. Eleazer et al. (1992) reported that 14 emergency departments were required to extinguish a fire in a 50,000-tire stockpile on April 7, 1990 in Johnston County, NC. In addition to dense smoke, tire fires produce hydrocarbon liquids (oil) that can infiltrate the soil and result in contamination of ground and surface water resources.

Water that collects in whole or half tires discarded in stockpiles can serve as a breeding ground for mosquitoes. According to the report filed by NCDENR (see Appendix A), the introduction of the Asian Tiger Mosquito to North Carolina was aided by the presence of illegally dumped tires.

USES FOR SCRAP TIRES

Except for recapping and use for low speed, non-highway farm equipment, worn-out tires can no longer be recycled for use with cars and trucks, but there are a number of other potential uses for scrap tires. Energy recovery is perhaps the most widely used means of recycling used tires. Natural rubber, synthetic rubber and carbon black produced from crude oil, petrochemicals, extender oils, and organic fabrics are all products with energy value that can be burned to generate heat. Whole or cut tires are used for the construction of artificial reefs, retaining walls, loading dock bumpers, and crash barriers. Cut or shredded tires are also used as road fill, subgrade, in landfill leachate collection systems, and crumb tires are used in sport and playground surfaces. In recent years, interest has also developed in using scrap tire pieces in place of gravel in the trenches of septic systems. Currently, there are a number of states (e.g., South Carolina, Texas, Virginia) that have developed regulations and permit the use of tire chips in the trenches of septic systems (see Appendix C). However, it appears that these states have relied on a limited number of studies concerning the leachability of tire components, and have developed standards based on the limited amount of data currently available.

TIRE COMPOSITION

The Goodyear Tire Company describes the manufacturing of tires as a one way process in which carbon and sulfur in rubber are inseparably bounded together (Goodyear Tire Company, 1998a). The RMA (1998) reports that the average weight for passenger car tires is approximately 20 lbs (9 kg), and the amount of steel in a steel belted radial passenger car tire is approximately 2.5 lbs (1.13 kg). According to the Goodyear Tire Company, tires currently being manufactured are composed of carbon black, several different types of natural and synthetic rubber (hundreds of polymer types), fabric, and steel. The composition of a typical tire is presented in Table 1. On a mass basis, an average radial passenger tire is composed of 28% carbon black, 27% synthetic rubber, 14% natural rubber, 10% steel wire, 4% organic fabric, 10% extender oil, 4% other petrochemicals, and 3% sulfur, zinc oxide and other compounds (Goodyear Tire Company, 1998a). One of Goodyear's popular size all-season passenger tires weighs 21 lbs (9.5 kg) and is composed of 5.5 lbs of 30 different types of

Table 1. Typical composition of a tire (after RMA, 1998)

Synthetic Rubber
Natural Rubber
Sulfur and Sulfur Compounds
Silica
Phenolic Resin
Oil: Aromatic, Napthenic, Paraffinic
Fabric: Polyester, Nylon, etc.
Petroleum Waxes
Pigments: Zinc Oxide, Titanium Dioxide, etc.
Carbon Black
Fatty Acids
Inert Materials
Steel Wire

synthetic rubber, 4.5 lbs of 8 types of natural rubber, 5 lbs of 8 types of carbon black, 1.5 lbs of steel cord for belts, one lb of polyester and nylon, 0.5 lb of steel bead wire, and 3 lbs of 40 different kinds of chemicals, waxes, oils, pigment and other products (Goodyear Tire Company, 1998b).

SCRAP TIRE CHARACTERISTICS

The specific gravity of rubber tires is reported as 1.15 g/cm^3 (RMA, 1998). The bulk density of 2-inch and 1.5-inch shredded tire pieces are reported in Table 2. Hall (1990) reported a bulk density value of 1250 lbs/yd^3, and Envirologic (1990) estimated 800 lbs/yd^3 as the bulk density for tire chips in the trenches of septic systems.

Table 2. Bulk density of packed tire chips.

CONDITION	lbs/yd^3	lbs/ft^3	g/cm^3
Loosely Packed†			
2-in shred	850 to 950	31.5 to 35.2	0.50 to 0.56
1.5-in shred	1,000 to 1,100	37.0 to 70.7	0.59 to 0.65
Densely Packed†			
2-in shred	1,350 to 1,450	50.0 to 53.7	0.80 to 0.86
1.5-in shred	1,500 to 1,600	55.6 to 59.3	0.89 to 0.95
Packed Under Load‡			
lbs/ft^2 (psf)			
0		58.2	0.93
2,500		47.3 to 62.6	0.76 to 1.00
5,000		51.5 to 66.7	0.83 to 1.07
10,000		59.0 to 71.0	0.95 to 1.14
15,000		63.3 to 74.2	1.11 to 1.19
20,000		65.1 to 79.6	1.04 to 1.28

† RMA (1998)
‡ J&L Testing Company (1989)

As we indicated before, the currently manufactured tires are composed of a number of organic and inorganic chemicals bound together to form a relatively inert and durable product. To show the diversity in the composition of tires the elemental analysis of scrap tire ash for passenger, truck and a blend of passenger/truck tires are reported in Table 3. Note that the oxides of Si, Al, Ti, Fe, and Zn each make up more than 10% of the mass of tire ash for passenger tires. Other compounds found in substantial quantities in tire ash are Ca and S. Minor quantities of other elements, such as Na, K, Cr, and Pb are also found in scrap tires.

Table 3. Inorganic content of scrap tire ash (RMA, 1998).

CHEMICAL	PASSENGER	TRUCK	80/20 BLEND
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SiO_2	22.96	23.83	23.13
Al_2O_3	17.11	3.65	14.42
TiO_2	10.14	0.13	8.14
Fe_2O_3	15.04	19.16	15.86
CaO	2.52	2.45	2.51
MgO	0.63	0.76	0.66
Na_2O	0.91	0.61	0.85
K_2O	1.00	0.90	0.98
P_2O_5	0.64	0.75	0.66
SO_3	4.20	5.94	4.55
ZnO	29.30	34.6	30.36
BaO	0.02	0.012	0.014
CdO	0.00	0.001	0.002
Chlorine	0.00	0.00	0.00
Cr_2O_3	0.03	0.029	0.029
PbO	0.03	0.062	0.00
Flourine	0.00	0.002	0.004
Se (mg/kg)	0.00	0.00	0.00

LEACHABILITY OF TIRE CHIPS

In general, tires are considered to be relatively benign (Zelibor, 1991), but due to their complex chemistry, there is a concern regarding the potential for the release of undesirable materials under conditions which would promote prolonged leaching of scrap tires. Unfortunately, the number of studies assessing the potential leaching of various organic and inorganic chemicals from tires is limited. The most cited study related to the potential leaching of pollutants from tires is the Radian Corporation's Toxicity Characterization Leaching Procedure (TCLP) of different rubber products (Radian Corporation, 1989). This study was funded by the Rubber Manufacturing Association (RMA), and tested seven products from tire manufacturers. The different tires used were four types of passenger tires, two types of light truck tires, and one type of heavy truck tires. The study was conducted following the Toxicity Characterization Leaching Procedure outlined by the EPA (based on the procedure defined by EPA, see Federal Register, 1993. Pt. 261, App1 -- 40 CFR Ch. 1). The following organic compounds and inorganic elements were detected in the leachates from some or all of the seven types of tires: carbon disulfide, methyl ethyl ketone, toluene, 1,1,1-trichloroethane, and phenol; and the inorganic elements As, Ba, Cr, Pb, and Hg. According to the report, however, the levels of various chemicals detected in the leachates were significantly lower than the prevailing TCLP regulatory limits.

In another study, using leachate from a landfill, the permeability and leachability of tire chips were assessed (J&L Testing Company, 1989). The purpose of this study was to evaluate the potential use of tire chips as the lower drainage medium for sanitary landfills (i.e., as part of the leachate collection system for landfills). In this study, tire chips were packed in columns (8-

inch diameter and 48-inch long), and each column was leached with 45 gallons (170 L) of leachate from a landfill over a 90-day period. Separate studies were conducted at two different constant temperatures (23 and 50 degrees Celsius). Raw leachate (i.e., landfill leachate) and leachate samples coming through each column were collected every 30, 60, and 90 days after the initiation of leaching and analyzed for pH, cyanide (CN), and S reactivity, and elemental As, Ba, Cd, Cr, Pb, Hg, Se, and Si content. Overall, the results showed no substantial increase in the level of each of the chemicals in the leachate samples collected from the columns as compared to the inflow leachate samples from the landfill. As for permeability, packed tire chips demonstrated a high rate of water flow even under a load of 20,000 lbs/ft^2.

Another study was conducted to determine the toxicity of contaminants leached from tires on fish and *Daphnia* (B.A.R. Environmental, 1992). New tires, scrap tires, and tires from an existing floating tire breakwater were placed in separate glass aquariums each containing 300 L of filtered and sterilized natural ground water for a period of up to 40 days. Rainbow trout and *Daphnia magna* were exposed to water samples that were removed from each tank at the end of 5, 10, 20, or 40 days of contact with tires. The liquids removed from new and used tires after five days of exposure were toxic to rainbow trout. Exposure of these tires to water from 5 to up to 40 days did not increase the toxicity of the leachates. Leachates generated from breakwater tires after 5, 10, 20, or 40 days of exposure, on the other hand, were not acutely lethal to any of the marine species tested. Although these results showed that substances contributing to the toxicity of the leachate are water soluble, the study did not specify the contaminants or the cause contributing to the toxicity of water exposed to new and used tires.

Kershaw and Pamukcu (1997) reported on the ability of ground tire to adsorb petroleum chemicals and discussed the use of ground tire rubber in reactive permeable barriers to remove BTEX (benzene, toluene, ethylbenzene, and xylene) from contaminated ground water. Citing other research studies, they indicated that the potential for the leaching of toxic chemicals from scrap tire is minimal. For one of these studies they reported that trace levels of Ba, Cr, Pb, and Hg were detected in leachate generated as part of a TCLP study of the leachability of various types of tires under different conditions, and that carbon disulfide at concentrations of up to 0.067 mg/L and toluene at a concentration of 0.007 to 0.19 mg/L were detected in the tire leachate.

Humphrey et al. (1997) conducted two field studies to assess the potential leaching of organic and inorganic chemicals from tire chips placed above the ground water table under roads in Maine. In the first study, tire chips were placed at different thicknesses below a section of a road, and ground water samples were collected from the shoulder of the road at a distance of 1 and 2 m from the edge of tire chip fill. Ground water samples were collected on a regular basis from all the wells and analyzed for total dissolved Al, Ba, Ca, Cd, Cu, Cr, Fe, Pb, Mg, Mn, Se, Na, Zn, Cl, and sulfate. Their results indicated that for filtered samples, the concentrations of cations and anions in the well samples collected adjacent to the tire chip fill sections were similar to the corresponding concentrations in the samples from the control area. Except for Al, Fe, and Mn, the concentrations of individual cations and anions in the filtered and unfiltered samples were similar. They attributed the higher concentrations of Al, Fe, and Mn in the unfiltered samples to the natural presence of these cations in the soil in the area. In a second study, Humphrey et al. (1997) collected drainage water samples from the tire chip fill areas directly beneath the fill layers. In addition to metals, the leachate samples were analyzed for selected volatile organics

(VOC) and semi-volatile organics (SVOC). In general, the primary drinking water standard chemicals (Ba, Cd, Cr, Cu, Pb, and Se) were below the applicable regulatory levels. The levels for Ba, Pb, and Cr in some of the samples collected from the control section were higher than the samples from tire chip fill sections. This indicated the natural occurrence of these chemicals in leachates from under the roads. This study also found no evidence to indicate that tire chips increased the level of Al or Zn in the leachates, and that the secondary drinking water standard chemicals (Al, Fe, Mn, and Zn) were already present in the leachate from the control area. In fact, the concentrations of Zn in the control samples were generally higher at different times during the 2.5 years of study than the corresponding concentrations for various tire chip treatments. The concentrations of Fe and Mn were consistently higher for the tire chip leachates, indicating that under right conditions the amount of iron and manganese could be increased in the shallow ground water beneath the tire chip fill materials. Humphrey et al. (1997) also analyzed leachate samples for organic compounds and found that the amount of organic constituents in the water samples were below the detection limit for the respective analytical procedures.

The leachability of tire chips installed in the trenches of a septic system has also been tested. A septic system using tire chips in place of gravel in two 3-ft wide and 25-ft long trenches, and standard (presumably based on local regulations) stone gravel in one 150-ft long trench was installed at a contractor's residence in Indiana in 1987 (Envirologic, 1990). Wastewater was applied alternatively to the two tire chip- and gravel-filled trenches, and wastewater samples from the trenches were collected and analyzed for a number of years. Unfortunately, no formal report has been prepared for this study (Personal Communication, Lisa Kaufman, Indiana Department of Health, 1998), but the results for over 2-yrs of analyses were compiled and presented by Envirologic (1990). Based on this report, acetone and tetrachloroethane were detected in the wastewater collected from both tire chips and gravel and benzene was detected only in the wastewater from the tire chip trenches. Of the metals, Ba, Cr, Cu, Fe, Pb, Ni, and Zn were detected in wastewater from both tire chip- and gravel-filled trenches. Surprisingly, in all cases, the concentrations of these metals were higher in the wastewater from the gravel trenches than the samples collected from the tire chip-filled trenches. The Envirologic (1990) report contributes the higher concentrations in leachates from the gravel aggregate to the quality of wastewater and the composition of the parent rock for the gravel.

In another study addressing the use of scrap tire as a substitute for gravel in the trenches of septic systems, Burnell and McOmber (1997) constructed an experimental drainfield at a regional landfill in southern Idaho region. They used the wastewater from the landfill's main office, scale house, and public restroom, and applied septic tank effluent to three individual trenches. One trench was filled with 12 inches of standard gravel, one trench was filled with 12 inches of tire chips (0.5 to 2.5 inches in dimension), and one trench was constructed by placing half-tires in a row to form a long chamber in the trench similar to the systems that use a chamber in place of gravel aggregate in the trenches. Each trench was equipped with one observation well and two monitoring wells. After a four-week start-up period, samples were collected from the trenches and analyzed by a certified private laboratory for a limited number of organic compounds and selected metals and sulfate. For the organic compounds, their results indicated no difference between the tire chips, half tires, and gravel-filled trenches. For inorganic chemicals, only the sulfate level of wastewater collected from the tire chip-filled trench was higher than the dosing chamber, but this level was substantially lower than the drinking water standards. Cadmium, Cr, and Pb levels for all three trenches and the dosing chamber were below the detection limits. The level of Cu in the tire chip-filled trench was only slightly higher than the level in the dosing chamber, and the levels of Fe and Zn were the highest in the tire chip-filled trench among all the trenches. Higher than the dosing chamber levels of Fe and Zn were also detected in the control (gravel-filled) trench. With this limited study, Burnell and McOmber (1997) concluded that elevated levels of Fe, Zn, and sulfate were observed in the trench filled with tire chips, and that placement of half-tires in trenches to form a dome chamber results in less leaching than using cut tire chips in place of gravel aggregate. They recommended that further study and long-term monitoring be conducted to determine the fate and transport of contaminants from tire chips before accepting tire chips as a substitute for gravel in the trenches of septic systems.

Perhaps the most comprehensive published evaluation of tire chips for use in septic systems is the study conducted by the College of Engineering at Florida State University (Lerner et al, 1993). In this study three different sizes of tire chips (approximately 4- by 4-inch, 2- by 2-inch, and 1- by 1-inch) were subjected to nine different aqueous solutions in a series of laboratory experiments. Tire chips smaller than 0.5- by 0.5-inch were used in an aggressive extraction test using a batch testing technique. All the tire chips used in this study were from a tire stockpile, and were rinsed with water to remove sand, grit, vegetation and other foreign materials. In addition, an experimental septic system, composed of tire chip- and gravel-filled trenches was studied for a period of 101 days.

The study by Lerner et al. (1993) used two aggressive test solutions with pH levels of 2.1 and 12.1 applied in triplicate to the small tire chips in glass jars. Two separate glass jars, each containing one of the pH solutions, but no tire chips, were used to generate blanks for the two pH solutions. Phosphate solutions at concentrations of 0.4 and 0.1 mol/L were used to buffer the 2.1 and 12.1 pH solutions, respectively, and the time of contact was set at 38 days. For the other laboratory study, different amounts of two or three acids, bases, and salts (H_3PO4, Na_2HPO_4, NaCl, $NaHCO_3$, HCL, $Na_2B_4O_7.10H_2O$, and NaOH) were combined in ultrapure water to obtain nine different aqueous solutions with pH levels of 5.4, 7 and 8.6, and with three total dissolved solid values of 100, 500, and 2,500 mg/L (equivalent to electrical conductivity, EC, values of 0.15, 0.8, and 3.5 dS/m, respectively). Total time of contact for this study was 91 days with samples drawn from tire chip-aqueous suspension at 7, 14, 28 or 30, 63, and 91 days of exposure. For the field study, two small trenches, one filled with 1- to 2-inch pieces of tire chips and one filled with commonly used gravel aggregate, were added to an existing septic system. Two solution collection pipes, draining into individual sumps, were installed below and on the side of each trench. Aqueous solution samples were collected and analyzed at predetermined times from the distribution box and the four sumps.

For the aggressive extraction test, Lerner et al. (1993) reported that benzene, toluene, m/p xylene, 1,2,3-trimethylbenzene, and dimethyl phthalate were found in both the high and low pH tire chip suspension, but only benzene and 1,2,3-trimethylbenzene were found at high enough concentrations to be of interest. For the inorganic constituents only As was found to be significantly (at 5% probability) higher than the control. The concentrations of Zn in the three replications for each of the two pH solutions were highly variable. As a result, although the concentration for individual replications was substantially higher than the corresponding control (from 2.4 to over 16.5 times), the difference between the tire leachates and the corresponding control (blank) value for each solution was determined to be statistically insignificant. Lerner et al. (1993) did observe the formation of a precipitate in some of the suspensions.

For the other laboratory experiment using three tire chip sizes and nine different solutions, benzene and a ketone (believed to be methyl isobutyl ketone according to Lerner et al., 1993) were reported to be present at relatively high concentrations in some of the suspensions. The concentration of benzene in the leachates decreased with time indicating the depletion of leachable benzene from tire chips or its degradation by an increase in the number of microorganisms in the tire chip suspensions. Other volatile organic compounds noted in one or more of the leachates at concentrations above detection limits were toluene, m/p xylene, o-xylene, ethylbenzene, 2-ethyltoluene, propylbenzene, 1,2,3-trimethylbenzene, and 1,2,4-trimethylbenzene. Except for toluene, the concentrations of the above chemicals in the tire leachates ranged from 0.7 to 6.4 µg/L. Lerner et al. (1993) also reported that some semi-volatile organic compounds were detected in many of the tire leachate samples, but their results are not conclusive because some of the compounds were also detected in the control samples.

Lerner et al. (1993) reported that a hydrogen sulfide-like odor was detected during the 91 days of leaching study in many of the containers containing tire chips and solutions. Although no microbial analysis was performed on any of the leachates, they suspect that microbial activities are responsible for biodegradation of organic compounds in the matrix of tire chips and for the production of acids that tend to depress the pH of the tire chip suspensions. The concentration of soluble metals in the leachates from tire chips generally decreased with time, indicating a depletion of readily leachable metals or uptake and precipitation of metals. Similar to the aggressive leaching study, only As and Zn were consistently higher than the detection limits in the leachates.

The concentration of each of these ions, however, was considerably less than drinking water standards of 50 µg/L for As and 5,000 µg/L for Zn. No selenium was detected in any of the leachates, but Cd, Cr, and Pb were often detected in trace amounts.

Lerner et al. (1993) analyzed samples from the experimental septic system for 46 base/neutral compounds, 11 acid compounds, 16 pesticides and semi-volatile organic compounds, and a series of volatile organic compounds. Their results for the semi-volatile organics generally showed lower concentrations in the samples collected from the tire chip-filled trench than samples from gravel-filled trench or the blanks. As for the volatile organics, higher concentrations for 1,2,3-trimethylbenzene was observed in the samples from the gravel-filled trench than the tire chip-filled trench. The concentrations for 3-ethyltoluene, and o-xylene in the trenches were similar to the corresponding concentrations in the distribution box of the septic system, indicating no net contribution of these chemicals from the tire chips. In contrast, 1,3,5-trimethylbenzene and methyl isobuthyle ketone were not present in the samples of septic tank effluent (collected at the distribution box for the system), but were found sporadically at low concentrations only in the samples from tire chip-filled trench. Both these compounds in the tire chip-filled trench were not detected during the early stages of the study, or consistently after the first detection, suggesting that they were leached from the tire chips after exposure to septic tank effluent and only in response to certain unspecified conditions (e.g., presence of certain chemicals in the wastewater passing through the distribution box between sampling periods). As for the inorganic elements, Cr, Pb, Sn, and Zn were detected in the samples from the trenches, but their concentrations were at the corresponding detection limits. Higher than detection limit concentrations were observed in samples from tire chip-filled trench as well as samples from gravel-filled trench and the septic tank effluent. These data, however, showed no consistent trend and do not indicate any potential leaching from tire chips.

Lerner et al. (1993) concluded that organic compounds and metals were leached from tire chips, and indicated that the majority of compounds identified in the study are used in the manufacturing of tires. They found that pH and electrical conductivity (dissolved solutes) have little to no impact on leachability of chemicals from tire chips. The size of tire chips, on the other hand, affects the leaching of organic compounds, but the leachability was specifically related to each organic compound detected. They also concluded that tire chips tend to drive the pH of the leachate from acidic and neutral toward alkaline conditions. A number of recommendations, including more study of the leaching of organic and inorganic chemicals from tire chips under different aquatic environments, was made by Lerner et al. (1993). Specifically, they recommended that the long-term impact of tire shreds used in septic systems, including soil analysis, needs to be evaluated. They stated that, "... shredded tires should be carefully evaluated for longer periods of time and in demonstration projects carefully designed and monitored prior to uncontrolled environmental usage."

USE OF TIRE CHIPS IN SEPTIC SYSTEMS

According to the 1990 census data (Bureau of Census, 1993), approximately 50% of the population of North Carolina in rural areas as well as in areas around large municipalities uses septic systems for managing domestic wastewater. Based on a survey study reported by Hoover and Amoozegar (1988), the number of septic systems installed annually in North Carolina is estimated to be approximately 50,000. Due to economic development in the state, and the desire to live in rural areas not served by public sewage systems, there will continue to be a high demand for housing development with individual on-site wastewater management systems (i.e., a septic system).

Currently, there are a number of states that allow the use of tire chips in place of gravel in the trenches of septic systems. South Carolina has been permitting the use of tire chips for a number of years (the standards adapted by the South Carolina Department of Health and Environmental Control are presented in Appendix C), and Texas and Virginia (see Appendix C) have recently begun to allow installation of septic systems using tire chips in place of gravel. Iowa (see Appendix C) allows the use of tire chips in septic system under the Administrative Code of Beneficial Uses of Waste Tires. For the past few years, there has been an interest in using tire chips in place of gravel in the trenches of septic systems in North Carolina. Due to a lack of published information, the Office of Waste Reduction, North Carolina Department of Environment and Natural Resources, in cooperation with the Chatham County Government provided funding to conduct this study to assess the potential use of tire chips in the trenches of septic systems.

Objectives

The objectives of this study reported here were:

1. Quantitative and qualitative identification of a number of inorganic elements that can be leached from tire chips under a range of pH conditions,
2. Determination of the effect of tire chip leachate on the hydraulic conductivity and porosity of soils,
3. Evaluation of the physical behavior of tire chips in simulated drainlines, and
4. Assessment of short-term (one year) performance of tire chips in the trenches of septic systems.

MATERIALS AND METHODS

Laboratory Studies

Three different sets of bench-top experiments were conducted to leach tire chips and two types of gravel aggregate. In the first two series of experiments, movement of selected cations and anions (metals and non-metals) from tire chips and the two types of gravel aggregate under continuous and intermittent saturated conditions were assessed. The continuous leaching part of the study was carried out in a non-air-conditioned building (a large barn) at North Carolina State University Unit I Research Farm located near Raleigh, NC. The intermittent leaching was conducted in a laboratory on the main campus of the North Carolina State University in Raleigh, NC. The third set of experiments for evaluating potential leaching of selected organic compounds and inorganic chemicals from tire chips under continuous saturation was also conduced in the above laboratory. Each of these experiments will be described separately.

Physical Assessment of Tire Chips

The amount of small particles (including fines) in the tire chips was assessed by washing the tire chips and evaluating the fine material content of the rinse water. For the leaching experiments, however, the tire chips were not rinsed because in practice, tire chips are not generally washed before their placement in septic tank drainlines.

The particle density of tire chips was evaluated by determining the volume of water displaced in a graduated cylinder by various sizes of tire chip pieces. The mass of individual tire chip pieces ranged between 20 and 70.3 g. The content of the cylinder (i.e., tire chips emersed in water) was agitated to remove the air bubbles from tire chip surfaces. No other procedure, such as heating, was followed to remove the air bubbles from the tire chips. The packing density of tire chips was evaluated by measuring the mass of tire chips that could be packed in the lower 30.5 cm (1 ft) of a 25 by 50 by 40 cm wooden box (approximately 38,125 cm^3). (NOTE: Because of the size of tire chips it is difficult to precisely determine the depth of packed tire pieces in a box. Therefore, the volume of tire chips in a box was determined based on an estimate rather than actual measurement of the depth of tire chips in the box.)

Leaching Solutions

Five different leaching solutions were selected for the study. These were deionized water; an acidic solution containing organic and inorganic acids; a basic solution containing a commercial liquid drain opener; simulated laundry wastewater containing laundry detergent, bleach and fabric softener; and simulated wastewater containing various household cleaning products. These leaching liquids were selected to cover a wide range of wastewater characteristics. The composition and selected characteristics of the five leaching liquids are presented in Table 4.

Tire Chips and Gravel Aggregate

The U.S. Tire Recycling, L.P., in Concord, NC, agreed to provide the tire chips that were used in this study. Since there are no specifications regarding tire chips as a substitute for gravel in North Carolina regulations, the South Carolina specifications were selected as the criteria for the tire chip size and steel content for the study. The original standards developed by the South Carolina Department of Health and Environmental Control required that at least 95% of the tire chips for use in septic systems to be a nominal 2-inch in size, with a range between 1/2 to a maximum of 4 inches in any one direction, and with no steel wire protruding

Table 4. General characteristics of the five solutions[†] used for leaching tire chips and two types of rock aggregate.

SOLUTION	SOURCE	FORMULATION
Water	Distilled and deionized	
Acid Solution	Glacial acetic acid (concentrated)	20 mL/100 L
(pH 3.1)	Nitric acid (concentrated)	2.5 mL/100 L
Base Solution	Commercial household drain opener	3.077 L/100 L
(pH 12.1)	Recharged with sodium hydroxide	
Laundry Wastewater	Laundry detergent in powder form	192.3 g/100 L
(Simulated)	Liquid fabric softener	65.4 mL/100L
	Liquid bleach	500 mL/100 L
Household	Dishwashing (machine) detergent in powder form	230.8 g/100 L
Chemical Solution	Heavy duty cleaner with ammonia	1.538 L/100 L
	All purpose ammonia cleaner with lemon scent	1.923 L/100 L
	Liquid dishwashing detergent	38.5 mL/100 L
	Anti-bacterial liquid hand soap	80.8 mL/100 L
	Liquid hair shampoo with aloa vera	15.4 mL/100 L
	Regular hair conditioner (liquid form)	15.4 mL/100 L

† Trade names of the commercial products are not given.

more than 1/8th-inch from the tire chips (see Appendix C). The same standards also required the tire chips to be free from fine materials. In reality, it is impractical to obtain tire chips that have no fine sized particles (e.g., soil materials, ground tire and fiber), and it would be difficult to consistently produce tire chips with no steel wire protruding more than one-eighth of an inch from the side of the chip pieces. The South Carolina Department of Health and Environmental Control modified their original standards in December, 1995, by increasing the maximum length of steel wires protruding from the side of tire chips from 1/8th of an inch to 1/2 of an inch, and decreasing the percent of tire chips meeting the standards from 95% to 90% (see Appendix C).

Tire chips were transported from the U.S. Tire Recycling facility in Concord to Raleigh and were stored on a tarp in a large barn at North Carolina State University Unit I Research Farm. In general, the tire chips obtained from the U.S. Tire Recycling Company for this study contained some large pieces, relatively long wire protruding from the sides of some chips, and some fine materials composed of tire pieces, fibers, and dirt. The tire chips were sorted, and large rubber pieces and tire chips with long steel wires were separated by hand and discarded before placing the tire chips in containers and columns for the leaching studies.

Two types of rock aggregate, granite and limestone, were used in the laboratory leaching experiments. The granite rock was #5 aggregate that is commonly used in the Piedmont region of North Carolina, and was purchased in Raleigh. The limestone rock aggregate, commonly used in the Coastal Plain region of North Carolina, was purchased in Wilmington, NC, and transported to Raleigh for the study. Both types of rock aggregate were of the size permitted for septic systems in North Carolina (NCDENR, 1998). Both batches of rock aggregate contained the usual amounts of fines commonly found in the gravel aggregate used for septic systems. The rocks were stored at the barn used for the large column study.

Continuous Leaching Experiment

A set of large wooden boxes lined with polyvinyl chloride (PVC) sheets were constructed for continuous leaching portion of the study. To prevent leakage, the joints between the PVC sheets were sealed with a durable calk. The inside dimensions of the boxes were 50 cm (19e in) long, 25 cm (9f in) wide and 40 cm (15f in) deep. Each box was equipped with a PVC hinged top for access, and three barb adapters that were connected together through a piece of plastic (Tygon) tubing with a clamp at its end for draining and sampling the liquid content of the box. Seventeen (17) kg of tire chips was loosely packed in each of the 15 PVC lined wooden boxes. The height of packed tire chips in each box was approximately 30 cm (12 in), resulting in a packed bulk density of approximately 0.45 g/cm^3 (equivalent to 28.3 lbs/ft^3).

Considering the environment in which these boxes were used, and the concern regarding the potential loosening of the sealant at joints resulting in leakage from the boxes, large plastic containers equipped with removable tops were used for leaching the two types of gravel aggregate. The plastic containers were 31 by 46 cm at the bottom, 36 by 51 cm on top, and 30 cm deep. Two overlapping doors covered the top of the box. An access tube was installed in each gravel-filled box for collecting samples and draining the liquid content of the box from the top. For the granite gravel, 63 kg of rock aggregate was packed in the lower 22 to 25 cm of each of 15 boxes with a perforated sampling port in the middle. For the lime stone gravel, 40 kg of aggregate was packed in approximately the same height in each of 15 boxes.

Twenty-eight (28) L of each of the five leaching solutions was added to three boxes (three replications) to completely cover the tire chips. For complete submergence, the granite gravel and lime stone aggregate required 25 and 22 L of each solution, respectively. For each aggregate-solution combination, all the tire and gravel pieces were submerged with 5 to 6 cm of free solution above them in each box. The tire chips were maintained under saturated conditions ranging approximately from 100 to 180 days for the individual solutions. The granite stone gravel was covered by the five solutions for 90 to 120 days, and the lime stone gravel was covered by all solutions for approximately 90 days.

At various times during the saturation period, three different sub-samples were obtained from the top, middle, and the lower portion of each box and analyzed for pH. The liquid from each box was then drained and agitated to obtain a uniform solution, and a sub-sample of the homogenized liquid (composite sample) for each replication was collected for analysis. At this time, the pH for each of the acid and drain opener (basic) solutions was adjusted by the addition of acid or NaOH, respectively. After adding an amount of the original solution equal to the volume of all the subsamples drawn during the process to each homogenized liquid, the entire volume of the liquid was reapplied to its respective box from the top for maximum contact and mixing with tire chips or gravel pieces. For tire chips, 6 to 10 sub-samples were collected from each box during the course of the study with a final sample collected at the end of the contact period. For granite aggregate, 8 or 9 samples were collected from each box and for lime stone aggregate only four samples were collected from each box for analysis over the 90 days of continuous saturation. The solution samples obtained at various stages of the experiments and the samples collected at the termination of the saturation period were filtered and analyzed for a set of cations and anions using ion-coupled plasma (ICP) emission spectroscopy (hereafter referred to as ICP). In addition to analyzing the solution samples, a subsample from each tire chip leachate was treated with concentrated nitric acid and heated to dissolve the iron that had precipitated. These samples were also filtered and analyzed for the same set of cations and anions by ICP.

Intermittent Leaching Experiment

For this portion of the study, 45 columns were constructed from 30 cm (11.8 inch) long and approximately 15 cm (6 in) diameter sections of Schedule 40 PVC pipe. The bottom part of each column was sealed with a PVC plate equipped with a plastic barb attached to a section of plastic (Tygon) tubing with a clamp. The columns were divided in three groups (each containing 15 columns). Tire chips, granite, and lime stone aggregate were packed in the lower 22 to 25 cm of the columns in each group leaving a 5 to 8 cm of head space for completely submerging the aggregate. The mass of tire chips, granite, and lime stone aggregate in each of the respective columns was 2.25, 6.25, and 5.25 kg, respectively. The bulk densities for the tire chips and lime stone gravel were comparable to those packed for the continuous leaching, but for the granite aggregate the packing bulk density for intermittent leaching was lower than the bulk density that was achieved for the larger leaching boxes. The leaching liquid was applied to each tire chip- or gravel-filled column from the top and the liquid content of the column was sampled or drained using the bottom opening. The volumes of solutions required to saturate the aggregate were 3.1 L for the tire chips, 2.6 L for the granite, and 2.8 L for the lime stone gravel.

Each aggregate was maintained under saturated conditions for three periods of saturation each ranging between 14 to 18 days followed by a period of drainage ranging between 8 and 14 days. A sample of the effluent drained from each column was collected and analyzed for its inorganic chemical content.

Continuous Saturation of Tire Chips for Organic Compound Analysis

For determining movement of selected organic compounds and inorganic chemicals from tire chips, 350 g of hand selected tire chips were packed in each of 20 one-L wide-mouth glass jars. The tire chips were hand sorted to separate large pieces and pieces with long protruding steel wires. The jars were separated into five groups of four, and 600 mL of each solution was applied to each of four tire-filled jars in its respective group. In addition, one jar containing only the solution without any tire chips was added to each group. A piece of flat Teflon sheet was used to loosely cover the top of each glass jar to minimize evaporation from the jar in the air conditioned laboratory. The jars were not tightly sealed because, like gravel aggregate, the tire chips placed in the trenches of septic systems are exposed to the atmosphere through the pore spaces in the soil above them in the trenches. The tire chips were maintained saturated for 160 days, during which the glass jars were occasionally agitated to minimize the layering of the solution inside the jars and deionized water was added to each jar to maintain the original depth of solution (i.e., to compensate for evaporation losses).

At the end of 160 days of continuous saturation, the solution from each of the one-L glass jars was drained into a clean, empty glass container. The tire chips in the jar were then rinsed once with an additional 100 mL of the original solution saturating the tire chips, and the resulting solution was combined with the original solution from the respective jar (for a total of 700 mL of leachate). After completely mixing the leachate and the rinse solution from each jar, a subsample from each mixture and the five blank solutions was collected in a clean special bottles tightly fitted with a Teflon coated cap. These 25 sub-samples were submitted to the State Laboratory of Public Health for North Carolina through the NC Division of Solid Waste Management for analysis for selected organic compounds. The remaining liquid for each of the 25 leachates and blanks was divided into two parts in clean containers and submitted to the NC State Public Health Laboratory and the Department of Soil Science Analytical Service Laboratory for inorganic chemical analyses. The samples submitted to the Soil Science Department Laboratory were filtered, but not treated with acid. The samples submitted to the State Laboratory were prepared and analyzed by the respective procedures employed by the laboratory for ground water analysis. Table 5 presents the list of organic compounds and inorganic constituents of tire chip leachates that were analyzed by the State Public Health Laboratory.

Hydraulic Conductivity Measurements

Intact samples (6.5 cm diameter, >10 cm long) were collected from the Bt horizon at a site located on the Unit I Research Station near Raleigh. For measuring saturated hydraulic conductivity (K_{sat}), these samples were prepared in the laboratory to form 10 cm long intact cores by the procedure described by Amoozegar (1988). Saturated hydraulic conductivity of three cores for each of the original solutions and tire leachate generated by the solutions was measured under a constant head (Klute and Dirksen, 1986) over a few days. A final hydraulic conductivity was determined for each core.

Field Study

A research site was located at a private residence of a dairy farmer in Chatham County, NC. The site was visited and a preliminary evaluation of the soil near the residential dwelling on the farm was conducted to determine the suitability of the soil for installation of a septic system. After obtaining the necessary permits, an experimental septic system composed of

Table 5. List of organic compounds in tire leachates analyzed by the NC State Public Health Laboratory, and inorganic elements measured in the leachates from tire chips and rock aggregate.

Organic Compounds:

CHLOROMETHANE	VINYL CHLORIDE	BROMOMETHANE
CLOROETHANE	TRICHLOROFLUOROMETHANE	ACETONE
1,1-DICHLOROETHENE	IODOMETHANE	2-BUTANONE
CARBON DISULFIDE	TRANS- 1,2-DICHLOROETHENE	ACRYLONITRILE
1,1-DICHLOROETHANE	METHYLNE CHLORIDE	CHLOROFORM
CIS- 1,2-DICHLOROETHENE	1,1,1-TRICHLOROETHANE	BENZENE
CARBON TETRACHLORIDE	1,2-DICHLOROETHANE	TRICHLOROETHENE
1,2-DICHLOROPROPANE	BROMODICHLOROMETHANE	DIBROMOMETHANE
4-METHYL-2-PENTANONE	CIS-1,3-DICHLOROPROPENE	TOLUENE
TRANS- 1,3-DICHLOROPROPENE	1,1,2,2-TETRACHLOROETHANE	2-HEXANONE
1,1,2-TRICHLOROETHANE	DIBROMOCHLOROMETHANE	CHLOROBENZENE
TETRACHLOROETHENE	ETHYLENE DIUBROMIDE	ETHYL BENZENE
1,1,1,2-TETRACHLOROETHANE	XYLENE	STYRENE
TRANS- 1,4-DICHLORO-2-BUTENE	1,2,3-TRICHLOROPROPANE	BROMOFORM
1,4-DICHLOROBENZENE	1,2-DICHLOROBENZENE	VINYL ACETATE
1,2-DIBROMO-3-CHLOROPROPANE		

Inorganic Elements:

ANTIMONY (Sb)	ALUMINUM (Al)	ARSENIC (As)
BARIUM (Ba)	BERYLLIUM (Be)	CADMIUM(Cd)
CALCIUM (Ca)	CHROMIUM (Cr)	COBALT (Co)
COPPER(Cu)	IRON (Fe)	LEAD (Pb)
MANGANESE (Mn)	MAGNESIUM (Mg)	MERCURY (Hg)
NICKLE (Ni)	PHOSPHOROUS (P)	POTASSIUM (K)
SELENIUM (Se)	SILVER (Ag)	SODIUM (Na)
SULFUR (S)	THALLIUM (Tl)	VANADIUM (V)
ZINC (Zn)		

four 20-ft (7 m) long trenches was constructed at the residence site on the farm. The original septic system for the home was a gravity fed, conventional septic system. A 1200-gallon concrete tank (pump tank) was installed adjacent to the original septic tank. This pump tank intercepted the single line carrying the effluent from the septic tank to its original drainfield (located at a distance of greater than 100 ft from the septic tank). The pump tank was connected to the septic tank on one side and to the effluent carrying line to the original drainfield on the opposite side. The connections to the septic tank and the drainfield were sealed to prevent leakage from the tanks. This type of installation allowed the wastewater in excess of the daily application to the experimental field to move into the original drainfield by gravity flow. A submerged pump for handling sewage effluent was installed in the tank and connected to electrical outlet through a digital timer.

Granite gravel aggregate was purchased from a source in Chatham County and tire chips were obtained from the U.S. Tire Recycling Company in Concord, NC. A septic tank installer was hired to install the pump tank, the drainlines and the necessary connections. A 10 by 10 m (approximately 30 by 30 ft) area was marked for the installation of the drainfield for the experimental septic system. After installing the pump tank, four 3 ft (90 cm) wide, 2 ft (60 cm) deep, and 20 ft (7 m) long trenches were dug with a spacing of 6 ft (120 cm) between the walls of the adjoining trenches. After installing three observation/sampling wells in each trench, the trenches from North to South (Fig. 1) were alternately filled to a depth of approximately 6 inches (15 cm) with tire chips and gravel. Similar to the gravel aggregate, the tire chips were poured into the trenches with the front loader of a backhoe. After flattening the

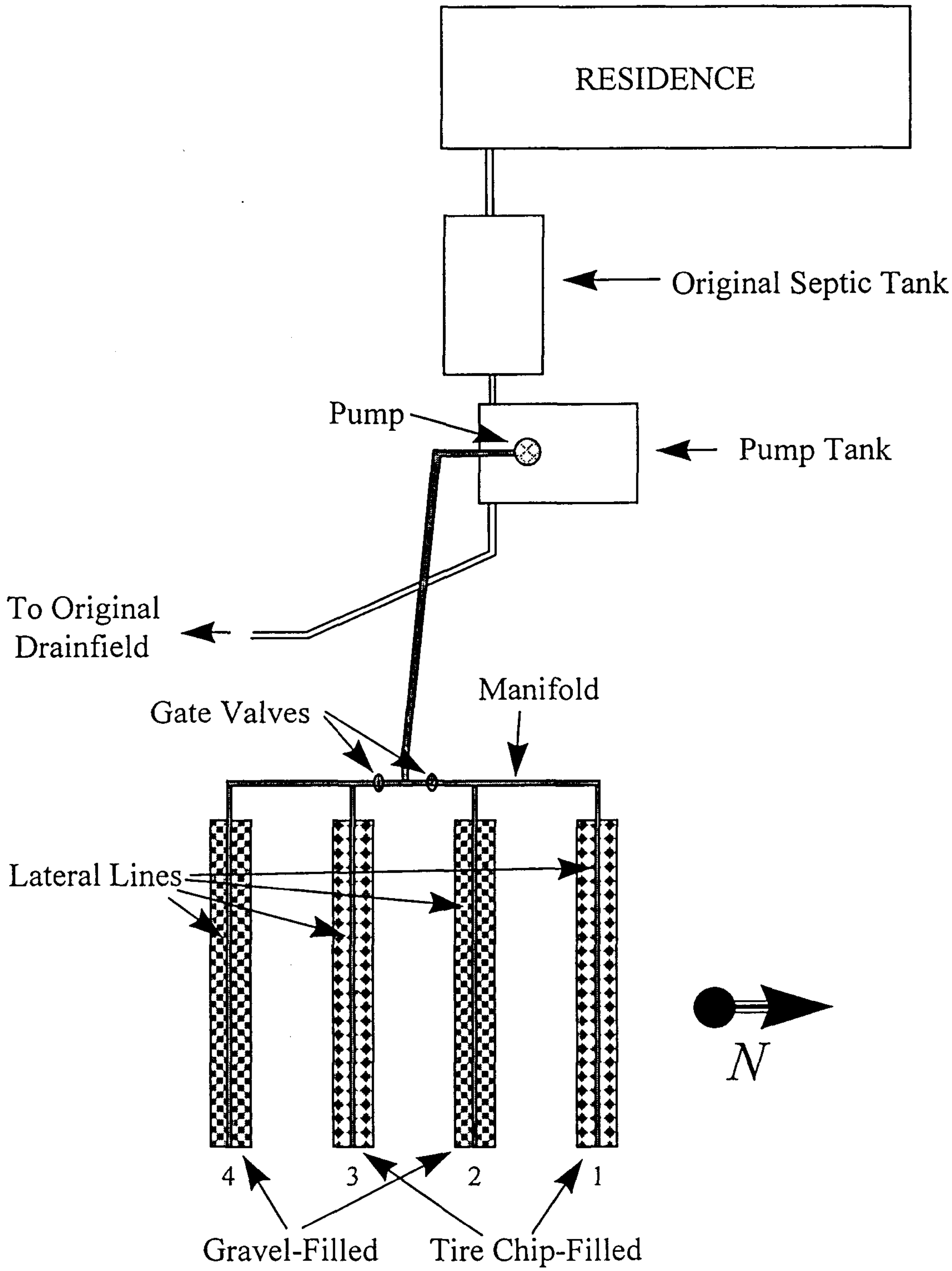

Figure 1. Schematic diagram of the areal view of the experimental septic system.

gravel aggregate and tire chips in the trenches, a section of perforated corrugated 4-inch drainage pipe was placed on top of the gravel or tire chips along the center line of each trench. Four 5/32nd-inch holes were drilled on each of four 20 ft long sections of 1¼-inch PVC pipe used as lateral lines. The perforated lateral lines were then installed inside the corrugated 4-inch pipe sections in the trenches. The lateral lines in the top two adjoining trenches (one filled with tire chips and one filled with gravel aggregate) and the lateral lines in the bottom two adjoining trenches were connected to the manifold through two separate gate valves. Each of the four lateral lines was equipped with a turn-up with a screw cap at the end. An additional 6-inch (15 cm) thick layer of gravel aggregate or tire chips was placed on top and around the 4-inch perforated drainage pipe in each of the respective trenches. After leveling the gravel aggregate and tire chips in the trenches, a layer of geotextile fabric was placed over the aggregate, the trenches were backfilled with the soil that was dug from the trenches, and the drainfield area was leveled using hand rakes. The area was then seeded with grass seed and covered with straw to allow seed germination.

The pump in the pump tank was connected to electric power through an electronic timer. The gate valves on the manifold were adjusted to operate the system at approximately 3 ft (90 cm) of pressure head in the lateral lines. Then, using the level of drawdown in the pump tank, the timer was set to apply approximately 50 gallons (190 L) of wastewater to the system once every day for an effective loading rate of 0.2 gal/ft^2/day (0.8 cm/d). This loading rate was based on the total trench bottom area as required for conventional septic systems in North Carolina (NCDENR, 1998).

Soil samples were collected from five locations across the drainfield area for particle size analysis. Particle size distribution of the samples was determined by the pipet method (Gee and Bauder, 1986). Saturated hydraulic conductivity (K_{sat}) of the soil at 60 to 75 cm depth was measured *in situ* at fifteen locations on three parallel transects going across the drainfield area by the constant head well permeameter technique (Amoozegar and Warrick, 1986) using the Compact Constant Head Permeameter (Amoozegar, 1992). Using a hydraulic probe, 20 intact core samples were also collected from 25 to 90 cm depth interval from seven locations in the perimeter of the drainfield. These samples were prepared in the laboratory by the method described by Amoozegar (1988), and then they were analyzed for saturated hydraulic conductivity under a constant head (Klute and Dirksen, 1986) and soil water retention (Klute, 1986) in the laboratory. Figure 2 shows a schematic diagram of the areal view of the relative locations of the soil samples and K_{sat} measurements.

A continuous water level recorder was installed on the pump tank to monitor the volume of and frequency of effluent application to the drainfield. The site was visited biweekly and the rate of infiltration of wastewater in the trenches was determined frequently. For this purpose, a known quantity of wastewater was applied to the drainfield by manually triggering the pump. Wastewater level in the trenches was then measured with time through the observation wells.

After approximately 11 months of operation, soil samples were collected from four 5-cm depth intervals at the bottom of all four trenches through each of the three sampling wells, and from 60 to 80 cm depth interval at two location outside of the drainfield (background samples). The samples were air dried in the laboratory. The air dried samples were passed

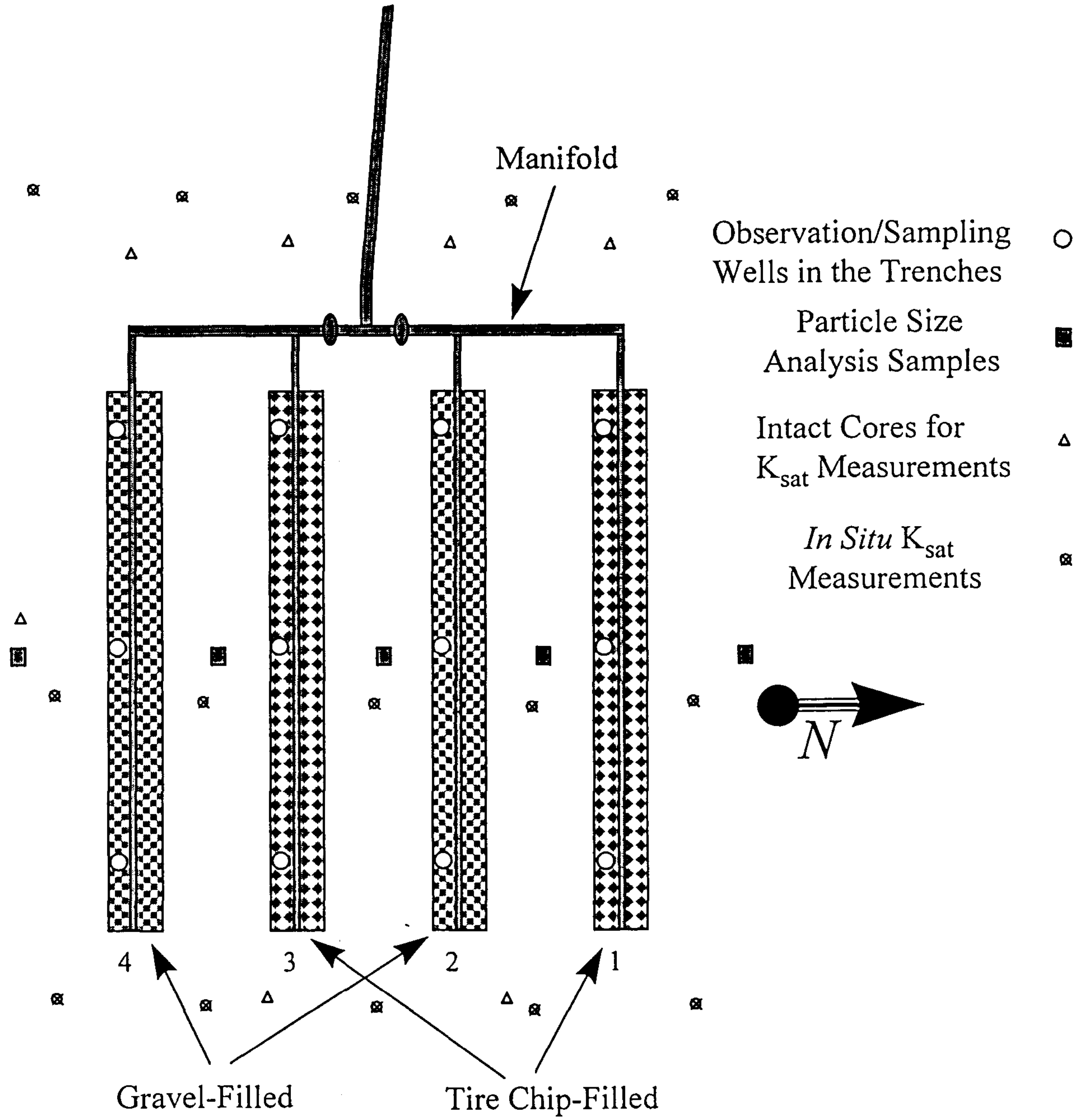

Figure 2. Schematic diagram of the areal view of the drainfield area showing the relative locations of the soil samples and *in situ* saturated hydraulic conductivity measurements.

through a 2-mm sieve, and 4.0 g of each sample was placed into a centrifuge tube for extraction. First, each of the 4.0 g subsamples (average gravimetric water content of 3%) was extracted three consecutive times with 0.016M NaH_2PO_4. For each extraction, 20 mL of the extractant was mixed with soil, and the mixture was shaken on a mechanical shaker for 30 minutes, followed by centrifuging at 1500 RPM for 10 minutes. After decanting the supernatant into a 100 mL volumetric flask, the above steps were repeated two more times. After the third extraction, the extract in the flask was brought to volume (i.e., 100 mL), and then the extract was passed through a filter paper before analyses. These extracts were analyzed for nitrate (NO_3^-) and sulfate (SO_4^{2-}). Using the same subsample of the soil, the extraction procedure was repeated using a one-N HCl as extractant. After bringing the volume of the extract to 100 mL and filtering, the extracts were analyzed for a set of inorganic elements by ICP emission spectroscopy. A sample of the septic tank effluent was also analyzed for the metals and S by ICP.

RESULTS AND DISCUSSION

Physical Characteristics of Tire Chips

The tire chips obtained from the U.S. Tire Recycling Company in Concord were visually inspected for size, steel wire length, and fine material content. Overall, the tire chips contained some fine particles, large sections of steel wire, large tire pieces, and long protruding wires from the side of some tire chips. Although these tire chips could not meet the original South Carolina Standards, they were within an acceptable limit based on the latest South Carolina regulations. South Carolina Standards are presented in Appendix C.

The density for a large number of tire chip pieces obtained from the U.S. Tire Recycling Company measured in the laboratory ranged between 1.05 and 1.27 g/cm^3 with an average value of 1.14 g/cm^3. The differences in the density of individual tire pieces is probably related to the heterogeneity among the tire chips, the positions of the tire chip pieces on the original whole tire (e.g., sidewall, crown of tire), and the amount of steel and other types of belt materials imbedded in the tire. The average bulk density of loosely packed tire chip pieces was 0.46 g/cm^3 (approximately 29 lbs/ft^3). Based on this estimated bulk density, the total porosity of loosely packed tire chips was estimated at 60%. Envirologic (1990) also estimated the porosity of tire chips with wires to be 60%. Due to the potential of air entrapment and incomplete wetting of the entire surface of tire pieces, however, the effective porosity for tire chips packed in wooden boxes in our study was perhaps between 50 and 60%.

Continuous Saturation

Leaching of Organic Compounds

Not all the organic compounds that were analyzed for by the NC State Laboratory of Public Health (see Table 5) were detected in the leachates from tire chips. Table 6 presents the concentrations of the organic compounds that were detected in the leachates from tire chips and the original (blank) solutions along with the detection limits for the respective compounds. Several of the concentration values reported by the NC State Public Health Laboratory are only estimates and are below the stated detection limit for that compound. These values are identified by the letter "J" in Table 6. Some of the results are also identified only as "trace" amounts by the NC State Public Health Laboratory, indicating that the compound was identified at low level below the respective detection limit without specifying a value (Personal Communication, John Neal, NC State Public Health Laboratory, 1998). In most cases, the individual organic compounds under consideration were not detected in all four replicate leachates for a test solution. The means and standard deviations for compounds measured above the listed detection limit in all four replicates are presented in the table as mean/standard deviation. For those compounds that were not detected in all four replicates, only the mean for the detected values and the number of detected values (identified by the # sign) are given. The net amount of each organic compound (in µg) leached from one kg of tire chips is given in Table 7. These numbers are based on the blank-corrected mean for each separate compound times the total volume of leachate (0.7 L) divided by the total mass of tire chips (0.35 kg).

In almost all cases, an estimated value for acetone concentration was reported by the NC State Public Health Laboratory for leachates and blank solutions. The source of this

Table 6. Concentration of selected organic compounds present in the leachates of tire chips for five test solutions (4 replications) after 160 days of continuous contact. All values are in µg/L (ppb). Chemical analyses were performed by the North Carolina State Public Health Laboratory.

COMPOUND	Water Blank	Water Tire	Acid Blank	Acid Tire	Base Blank	Base Tire	Laundry Blank	Laundry Tire	Cleaner Blank	Cleaner Tire
Acetone DT[†]= 20	15 J[‡]	220.5[§]/ 70.0	43.0	275.0/ 192.0	95.0	402.0/ 40.5	0	93.75/ 88.3	196	424.5/ 246.2
1,1-Dichloroethene DT = 5	U[¶]	U		U	U	2.75/ 2.22	U	U	U	U
Methyl Chloride DT = 5	U	2 J #1[††]	U	U	4 J	6 J	U	U	20 J	26 #1
2-Butane DT = 20	2 J	U	U	28 J #1	U	30 J #1	U	U	U	U
Chloroform DT = 5	Trace	Trace #2	Trace	Trace	131	1026.2/ 152.3	372	237.5/ 65.0	8 J	85 #1 3 J #3
Carbon Tetrachloride DT = 5	U	U	U	U	U	1 J	U	U	U	U
Benzene DT = 5	U	13.2/ 10.7	U	59.75/ 10.0	U	3 J	U	27.2 12.0	U	Trace
Bromochloromethane DT = 5	U	U	U	U	2 J	887.7/ 71.5	Trace	Trace	U	U
4-Methyl-2-Pentanone DT = 10	U	7 J #1	Trace	6 J #1	7 J	168.2/ 47.0	U	42.0/ 13.2	3 JC	45.5/ 5.3
Dibromochloromethane DT = 5	U	U	U	U	U	803.0/ 170.5	U	U	U	U
Chlorobenzene DT = 5	U	U	U	U	Trace	22.2/ 3.0	U	U	U	U
Styrene DT = 5	U	U	U	U	Trace	7.25/1.5	U	Trace	U	U

Table 6. Continued

COMPOUND	Water Blank	Water Tire	Acid Blank	Acid Tire	Base Blank	Base Tire	Laundry Blank	Laundry Tire	Cleaner Blank	Cleaner Tire
Toluene DT = 5	Trace	Trace	Trace	Trace	Trace	Trace	U	Trace	2 J	U
Bromoform DT = 10	U	U	U	U	U	209.2/ 101.4	U	U	U	U
1.4-Dichlorobenzene DT = 5	U	U	U	U	U	1.5 J	U	U	U	U
2-Hexanone DT = 10	U	U	Trace	Trace	Trace	Trace	Trace	Trace	U	U
Tetrachloroethene DT =5	U	Trace #1	Trace	1 J #1	U	Trace	U	Trace #1	U	U
Xylene DT = 5	U	U	U	U	Trace	U	U	U	Trace	U
Trichloroethene DT = 5	U	U	U	U	U	Trace #1	U	U	U	U
Dibromoethene DT = 5	U	Trace #1	U	U	U	Trace	U	U	U	U
1,2-Dichlorobenzene DT = 5	U	U	U	U	U	Trace	U	U	U	U
Trichlorofluromethene DT = 10	U	U	U	U	U	U	U	U	U	3 J #1
Carbon Disulfide DT = 5	U	Trace	U	U	U	U	U	U	Trace	U

† DT -- Detection Limit.
‡ J -- Estimated value.
§ Mean/Standard Deviation (number of observations N = 4).
¶ U -- Compound was analyzed for but not detected.
†† # -- Number of samples with the level given and the others being below detection limit.
††† Trace -- Identified at low level below the detection limit without specifying a value.

Table 7. Amount of organic compounds leached from tire chips by the test solutions under continuous saturation.

Test Solution COMPOUND	Water	Acid	Drain Opener (Base)	Laundry Wastewater	Household Cleaning
	- - - - - - - - -	- - - - - - - - -	µg/kg	- - - - - - - - -	- - - - - - - - -
1.1-Dichloroethene	--	--	5.5	--	--
Chloroform	--	--	1790	--	--
Benzene	26.4	119.5	--	54.4	--
Bromochloromethane	--	--	1775	--	--
4-Methyl-2-Pentanone	--	--	336	84.0	91.0
Dibromochloromethane	--	--	1606	--	--
Chlorobenzene	--	--	44.4	--	--
Styrene	--	--	14.5	--	--
Bromoform	--	--	418	--	--

acetone is unknown. Acetone, however, is highly volatile, and its presence in the blanks as well as all leachates suggests an external source of contamination during the sample collection or sample preparation steps and analysis.

With water as the test solution, benzene was measured above the stated detection limit for three of the replicates and trace amounts was identified as being present in the fourth replicate. The State Public Health Laboratory also reported detectable amounts of a number of other organic compounds for leachates generated by saturating tire chips in water (Table 6). Trace amounts of chloroform, toluene, and 2-butanone were detected in the blank sample for water. Since the detection limits for these compounds are 5, 5, and 20 µg/L (ppb), their presence at trace or very low levels in water used for leaching the tire chips could be due to cross contamination in the laboratory. Overall, the amounts of organic compounds leached by water from tire chips is not substantial (see Table 7).

Only one of the four replicate leachate solutions for household cleaning solution was found to contain methyl chloride (Table 6). This same solution was also found to contain chloroform, as did the blank solution of household cleaners. The other three replicate leachate solutions of household chemicals did not contain chloroform above the detection limit and were identified as potentially contaminated in the laboratory by the State Public Health Laboratory. Trace levels of benzene and xylene were identified as being present in some of the replicate leachate solutions of the household cleaning solution. Only 4-methyl-2-penthanone was detected in substantial amounts in the household cleaning product leachates for all four replicates (see Tables 6 and 7).

Substantial amounts of chloroform were reported in the tire leachates for the laundry wastewater. The amount of this compound detected in the blank laundry wastewater, however, was substantially greater than the amount found in the tire leachates. The disappearance of chloroform measured in the original test solution could be due to the potential adsorption of this chemical by tire chips. No benzene was detected in the blank solution, but four to over 8 times the detection limit was present in the four replicates of laundry wastewater-tire chip leachates. Similarly, substantial amount of 4-methyl-2-penthanone was leached from tire chips by the laundry wastewater (see Tables 6 and 7). Trace amounts of bromochloroethane and 2-hexanone were identified in the laundry wastewater blank with trace amounts in some of the associated tire chip leachates. Styrene was detected in trace amounts for four replicates of laundry wastewater test solution in contact with tire chips.

Only benzene was removed in substantial quantities from tire chips leached with the acid test solution. Trace amounts of chloroform was detected in the blank as well as the tire chip leachate for the acid solution. Trace amounts of some other organic compounds were also reported in the blank acid solution and some of the replications by the State Public Health Laboratory (Table 6).

The highest quantity and the most number of organic compounds were identified in the leachates for the drain opener (basic) solution (see Tables 6 and 7). The level of chloroform in the blank solution was more than 65 times the detection limit. The amounts measured in the tire chip leachates were 6 to 9 times greater than the amount found in the blank solution. Similarly, substantially higher amounts of bromochloromethane, 4-methyl-2-penthanone, dibromochloromethane, and bromoform were detected in the drain opener leachate. The average concentration of chlorobenzene in the leachates was more than five times the detection limit and the average styrene concentration was 1.5 times its respective detection limit. Other organic compounds were found at low levels or trace amounts in both the blank and leachate solutions. The results suggest that strong alkaline solutions (high pH, such as drain openers) have a much greater potential for removing organic compounds from tire chips than acid and selected simulated wastewater solutions.

Leaching of Inorganic Constituents of Tire Chips and Gravel Aggregate

Saturating Tire Chips in Glass Jars: Two sets of samples were collected from the leachates of tire chip suspensions after 160 days of contact with the respective test solutions. One set of samples was submitted for analysis to the North Carolina Public Health Laboratory and the second set was analyzed by the Department of Soil Science Analytical Service Laboratory. Tables 8 and 9 list the results of the analyses for inorganic constituents in the blank solutions and the tire chip leachates analyzed by the two laboratories. We should note that the two laboratories did not analyze for the same set of elements, and that the purpose of analyses by the two laboratories was not to compare analytical methodologies.

The following elements were not detected in the leachate samples analyzed by the NC State Public Health Laboratory (Table 8): As, Be, Cd, Cr, Co, Cu, Se, Ag, Tl, and V. Given the listed detection limits, these elements can be considered as not being present in substantial amounts in the leachate solutions. Barium was detected only in one replicate leachate solution in each of water and laundry wastewater. Barium is one of the elements that are found in relatively small amounts in tires (see Table 3). Lead was detected in the leachates generated after soaking tire chips in basic and laundry wastewater solutions. Significant amounts of Pb may still be present adjacent to roadbeds due to the use of leaded gasoline prior to its ban in the United States. The amount of iron in the blank solutions was below the detection limit, but relatively high amounts of Fe were removed from the tire chips by all five solutions. This is understandable because tire chips contain steel wires that can dissolve in each of the solutions. The highest amount of iron was measured in the leachates from laundry wastewater. Zinc was also measured in the leachates for all five solutions. Similar to iron, the highest amount of Zn was measured in the leachate generated by laundry wastewater followed by the acid solution. The household cleaner and the drain opener (basic) solutions contained Mg. Magnesium, however, was found in the leachates generated by all five solutions, but the levels of Mg in

Table 8. Concentration of selected elements in leachates from tire chips for five solutions after 160 days of continuous saturation. All values are in mg/L (ppm). Chemical analyses were performed by the North Carolina Public Health Laboratory.

COMPOUND	Water Blank	Water Tire	Acid Blank	Acid Tire	Base Blank	Base Tire	Laundry Blank	Laundry Tire	Cleaner Blank	Cleaner Tire
Arsenic (As)	<0.1[†]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Barium (Ba)	<0.1	0.1 #1[‡]	<0.1	<0.1	<0.1	<0.1	<0.1	0.1 #2	<0.1	<0.1
Beryllium (Be)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cadmium (Cd)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chromium (Cr)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt (Co)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Copper (Cu)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Iron (Fe)	<0.5	28.5[§]/18	<0.5	29.5/17.0	<0.5	17.8/1.0	<0.5	43.5/8.8	<0.5	9.2/3.7
Lead (Pb)	<0.05	<0.05	<0.05	<0.05	<0.05	0.06 #2	<0.05	0.1/0.02	<0.05	<0.05
Magnesium (Mg)	<0.5	1.35/0.21	<0.5	2.2/0.14	0.8	1.1/0.0	<0.5	0.9/0.1	3.4	3.1/0.9
Manganese (Mn)	<0.3	0.85/0.22	<0.3	1. 3/0.0	<0.3	0.3 #2	<0.3	0.45/0.06	<0.3	<0.3
Nickel (Ni)	<0.5	<0.5	<0.5	<0.5	<0.5	0.5 #1	<0.5	<0.5	<0.5	<0.5
Selenium (Se)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silver (Ag)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Thallium (Tl)	<0.02	<0.02	<0.02	<0.02	<0.04	<0.04	<0.02	<0.02	<0.02	<0.02
Vanadium (V)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc (Zn)	<0.5	12.0 /2.2	<0.5	16.8/2.5	<0.5	12.8/1.5	<0.5	21.3/1.2	<0.5	13.0/1.4

† < -- The given value is the minimum amount that the analysis could detect. All values less than the detectable value could be taken as insignificant.

‡ # -- number of replicates with the given value with the remaining replicates being below the detection limit.

§ Mean/Standard Deviation.

Table 9. Mean concentration values for selected inorganic constituents of tire chip leachate after 160 days of continuous saturation. The analyses were performed at the Department of Soil Science Analytical Service Laboratory. All values are in mg/L (ppm).

COMPOUND	Water Blank	Water Tire	Acid Blank	Acid Tire	Base Blank	Base Tire	Laundry Blank	Laundry Tire	Cleaner Blank	Cleaner Tire
Barium (Ba)	U†	0.06§/0.02	0.01	0.06/0.01	0.01	0.04/0.0	U	U	0.04	0.01 #1‡
Calcium (Ca)	0.17	8.77/0.19	0.74	12.13/1.03	1.6	4.2/2.7	0.9	2.85/0.46	2.4	2.05/0.15
Cadmium (Cd)	U	U	U	U	U	U	U	U	U	U
Chromium (Cr)	U	U	U	U	U	U	U	U	U	U
Cobalt (Co)	U	U	U	U	U	0.02/0.0	U	U	U	U
Copper (Cu)	U	0.03 #1	U	U	U	0.2/0.11	0.031	0.07/0.01	0.035	0.12/0.03
Iron (Fe)	U	4.3/4.57	U	0.53/0.33	0.09	8.8/1.55	0.08	19.2/6.89	0.12	0.82/0.68
Lead (Pb)	U	U	U	U	U	0.1/0.11	U	0.11 #2	U	0.12 #1
Magnesium (Mg)	U	0.98/0.17	0.07	1.68/0.13	0.7	0.58/0.11	0.1	U	4.2	2.08/0.11
Manganese (Mn)	0.017	0.73/0.13	0.023	1.14/0.04	U	0.21/0.04	0.005	0.21/0.04	0.005	0.07/0.02
Nickel (Ni)	U	0.02 #1	U	U	U	0.02 #1	U	0.2/0	U	0.09 #1
Potassium (K)	U	14.0 /2.75	U	15.4/1.2	1.9	24.4/3.34	1.5	19.0/2.02	203.9	206.4.73
Selenium (Se)	U	0.08 #1	U	U	U	U	U	U	U	U
Silver (Ag)	U	U	U	U	U	0.02 #1	U	U	U	U
Sodium (Na)	1.22	9.11/0.82	3.21	10.4 /0.57	>1000	1301/745	495	556/12.9	835	828/13.5
Sulfur (S)	0.4	10.6/4.18	1.3	8.28/0.4	4.2	31.7/0.42	133.3	145./4.86	421.5	428./5.76
Zinc (Zn)	U	4.82/3.68	0.645	6.96/0.97	0.013	9.8/1.4	0.028	9.53/4.22	0.043	5.19/1.11

† U -- Below detection limit.
‡ # -- number of replicates with the given value with the remaining replicates being below the detection limit.
§ Mean/Standard Deviation.

The absolute concentrations reported by the Department of Soil Science Analytical Laboratory were numerically different than the results reported by the NC Public Health Laboratory. The pattern of the results for respective elements, however, were similar for the two sets of data. The discrepancies between the two sets of data are most likely due to the nature of the samples. Although the two samples for each replication were collected from the same jar, their contents could have varied due to the presence of precipitating particles floating in the solution. Also, we should note that the blank water and acid solutions should not have contained any of the inorganic elements listed in Table 9. The reported values for Ca and other elements in these two leaching solutions are perhaps due to carry over or cross contamination during the laboratory analysis by ICP. Iron was measured in substantial quantities in the leachates generated by all five solutions with the laundry wastewater removing the highest quantity of Fe from tire chips (Table 9). Similarly, substantial amounts of Zn was removed from the tire chips by all five solutions (see Table 9). Manganese was detected in small quantities in the leachates for all five solutions, and Mg was measured in the blank solutions for both the basic and household cleaning wastewater. Except for the laundry wastewater, small quantities of Ba were detected in the tire leachates. Small quantities of Cu were measured in some of the leachates and the laundry and household cleaning solutions. Calcium, K, and Na were measured in substantial quantities in all five leachates. Some of the blank solutions also contained appreciable amounts of these basic cations. The simulated wastewater containing household cleaning chemicals contained high level of K, and the basic solution (drain opening wastewater), the laundry wastewater, and the household cleaning solution had high levels of Na. Overall, the net amount of Ca, K, and Na removed from tire chips does not seem to be significant. The level of S in the blank solutions was highest in the household cleaning solution followed by the laundry wastewater. The average level of

S in each leachate was higher than the corresponding blank solution, indicating a net leaching of S from tire chips. Sulfur is one of the main ingredients in tires.

Saturating Tire Chips in Large Boxes: As we indicated before, 17 kg of tire chips were maintained saturated under 28 L of each of the five different solutions for periods ranging from 102 to 180 days. During the saturation period, the tire chips were drained and after agitating the drained liquid from each box to obtain a homogenized solution, a 100-mL sample was collected from the leachate and analyzed for pH. The drained liquid was recharged and placed back over the tire chips in the box to keep the tire chips saturated. At the termination of the saturation period, the tire chips were drained completely and after homogenizing the leachate by agitation, a final leachate sample was collected for analysis. All these leachate samples were analyzed by the Soil Science Department Analytical Service Laboratory. Table 10 presents the mean and standard deviation for the concentration of individual elements in the final leachate of the three replications for each solution. To calculate the total amount of each element removed from the tire chips (Table 11), the amount of that element removed from each box during the periodic sampling (concentration × 0.1 L × number of samples) was added to the total amount that was measured in the leachate at the end of the saturation period (concentration × 28 L). A blank in Table 11 indicates no measured amount in the leachate.

The amounts of Ca, K, and Na in the leachate generated using water were greater than 10 mg/L. These cations are commonly found in soils and the salt applied to roads during winter. The other elements detected in the leachate were Fe, Mg, Mn, S and Zn. No other

Table 10. Mean concentration of various elements in the leachates from tire chips at the end of the continuous saturation period. All analyses were performed by the Department of Soil Science Analytical Service Laboratory. All values are in mg/L (ppm).

COMPOUND	Water Blank	Water Tire	Acid Blank	Acid Tire	Base Blank	Base Tire	Laundry Blank	Laundry Tire	Cleaner Blank	Cleaner Tire
Number of Days of Saturation		102		180		170		170		180
Arsenic (As)	U†	U	U	0.26	U	U	U	U	U	U
Barium (Ba)	U	U	U	0.3	U	U	U	U	U	U
Calcium (Ca)	U	12.8	U	38.2	0.1	1.15	2.23	2.4	0.4	3.0
Cadmium (Cd)	U	U	U	0.166	U	U	U	U	U	U
Cobalt (Co)	U	U	U	0.32	U	U	U	U	U	U
Copper (Cu)	U	U	U	0.4	U	0.37	U	0.1	U	0.4
Iron (Fe)	U	1.6	U	>350	U	0.7	0.3	21.8	U	2.5
Lead (Pb)	U	U	U	0.12	U	U	U	U	U	U
Magnesium (Mg)	U	0.86	U	1.9	0.16	0.16	0.4	0.4	3.0	1.5
Manganese (Mn)	U	1.03	U	27.6	U	U	U	0.2	U	0.1
Nickel (Ni)	U	U	U	0.83	U	U	U	U	U	U
Phosphorous (P)	U	U	U	4.8	U	6.6	0.1	1.2	146	131
Potassium (K)	U	19.2	U	19.9	2.3	30.8	2.9	20.2	180	203
Sodium (Na)	U	11.4	U	10.4	--	--	543	572	744	729
Sulfur (S)	U	3.9	U	3.9	5.7	51.3	134	134	352	365
Thallium (Tl)	U	U	U	0.35	U	U	U	U	U	U
Vanadium (V)	U	U	U	0.6	U	U	U	U	U	U
Zinc (Zn)	U	1.48	U	37.9	U	0.59	0.08	3.7	0.1	5.6

† U -- Below detection limit.

Table 11. The amount of inorganic elements removed from tire chips†. All values are in mg/kg.

COMPOUND	Water	Acid	Base	Laundry Wastewater	Household cleaner
Number of Days of Saturation	102	180	170	170	180
Arsenic (As)		0.4			
Barium (Ba)		0.4			
Calcium (Ca)	21.6	64.5	2.1	0.2	4.4
Cadmium (Cd)		0.3			
Cobalt (Co)		0.5			
Copper (Cu)		0.6	0.8	0.17	0.6
Iron (Fe)	2.7	>600	1.4	36.8	4.2
Lead (Pb)		0.2			
Magnesium (Mg)	1.4	3.3			
Manganese (Mn)	1.7	46.4			0.2
Nickel (Ni)		1.4			
Phosphorous (P)		8.1	13.6	1.9	
Potassium (K)	32.5	33.8	58.8	29.1	38.9
Sodium (Na)	19.3	17.7	E‡	49.1	
Sulfur (S)	6.6	6.7	93.4		20.8
Thallium (Tl)		0.6			
Vanadium (V)		1.0			
Zinc (Zn)	2.5	63.9	1.4	6.22	9.4

† The reported value for each element includes the amount removed by the intermediate samples used for pH measurement. A blank indicates no net removal from tire chips.
‡ E -- Excessive amount in the original leaching solution.

element that was analyzed for was measured or detected in the water drained from tire chips after 102 days of continuous saturation. In general, there was no substantial change in the concentration of the inorganic constituent in the saturating water with time. This indicates that most of the inorganic constituents leached from the tire chips were present at the surface of the tire aggregates, and that they dissolved in water during the early stages of saturation. Figure 3 presents the concentration of S, Fe, and Mn in the leachates in excess of the original solution (i.e., concentration in the leachate minus the concentration in the original solution) for water and other four solutions. Zero or negative values indicate no measurable leaching from the tire chips.

Tire chips were maintained saturated with the laundry wastewater for 180 days. The concentration of Fe (see Fig. 3) and K in individual samples collected periodically during the saturation period showed a general increase with time. There was no substantial change in the concentrations of other elements in the periodic samples (see Fig. 3). The laundry solution contained a relatively high amount of S and Na. The concentrations of S in the leachates from the large boxes (Table 10) was comparable with the concentration of the solution saturating the tire chips for 160 days in glass jars, as reported in Table 9. Overall, other than the common salts, Fe was the main element leached by the laundry solution from tire chips followed equally by S and Zn (see Table 11).

The highest amount of Fe, Zn, and some other elements were leached from tire chips by the acid solution. Most of S was removed from the tire chips within the first few weeks of saturation (see Fig. 3). The concentrations of Fe, Mn, Ca, P, and Zn in the acid solution in

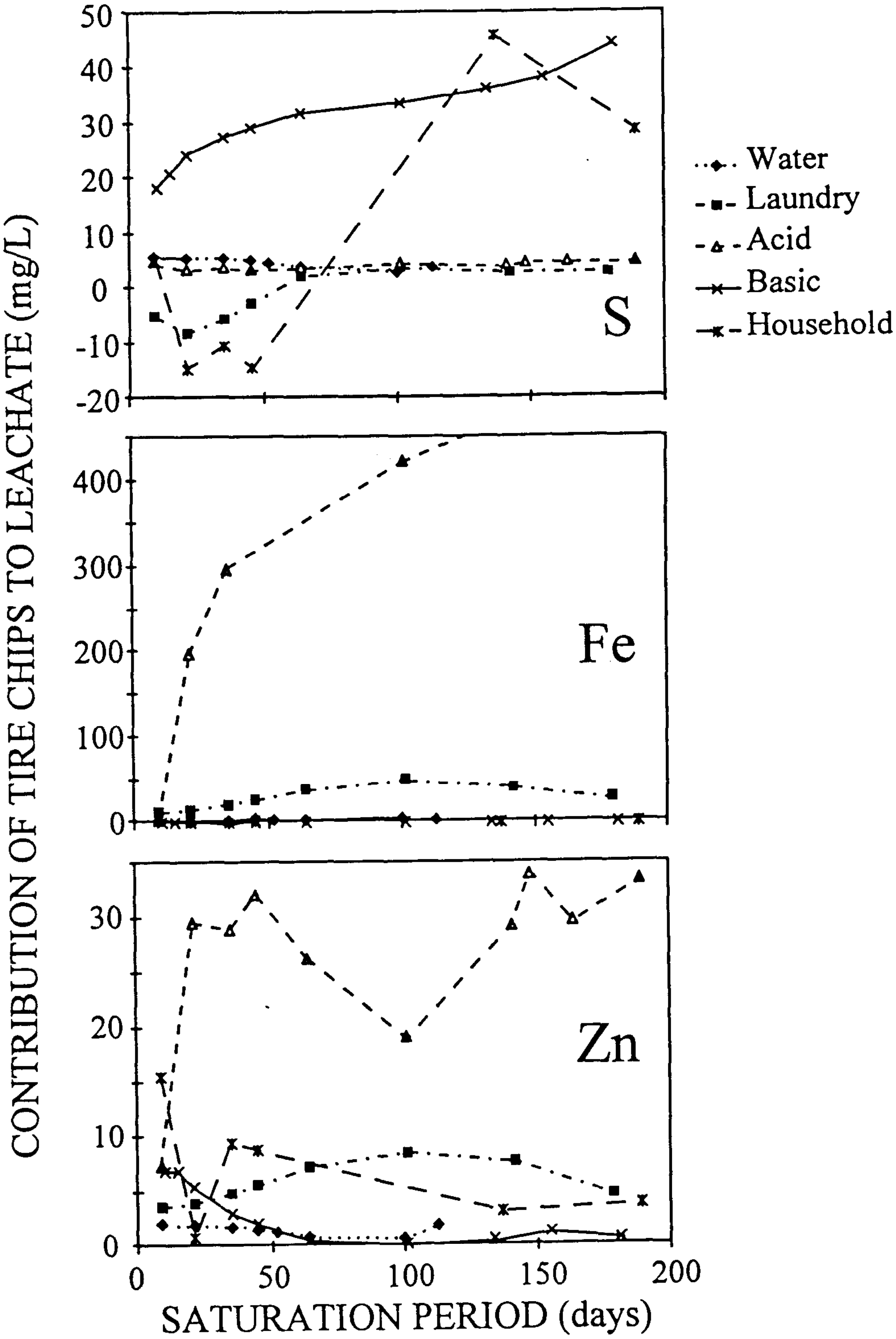

Figure 3. Concentrations of S, Fe and Zn in the leachates in excess of the corresponding original solution. Negative values indicate no net leaching of the element from tire chips.

contact with tire chips increased with time. The concentrations of Ba, Mg, and Na remained relatively constant from the beginning to the end of saturation period. No Cd, As, Co, Ti, Ni, V, Cu and Pb was measured above the detection limits during the initial stages of saturation. After approximately three months of saturation, the above elements were measured in the acid leachates.

Tire chips were kept saturated with the drain opener solution for 170 days. The amount of S removed from tire chips increased with time while little Fe was measured in the tire chip leachates (see Fig. 3). Initially, Zn was detected at more than 5 mg/L in the leachate, but its concentrations decreased with time to a final concentration value of 0.6 mg/L. The highest concentration was for Na, which was mainly in the blank solution. Overall, the caustic solution removed more S than any of the other solutions. A relatively small quantity of Cu was leached from the tire chips, but no Pb, Ni, Cd, and a host of other elements beyond the detection limit of the instrument (0.1 mg/L) were detected in the leachates.

Similar to the caustic solution, the household chemicals removed a substantial amount of S, but little Fe was removed from the tire chips with this solution (see Fig. 3). The amount of Zn removed from the tire chips was also relatively high compared to other elements.

Acid digestion of the leachate samples resulted in higher concentration values for Fe and to some extent for Zn. In all experiments, we observed the formation of visible rust-like materials in the leachates. Because of high concentration of Fe, and due to presence of Ca and other elements or compounds, iron could precipitate with time. Digestion of the leachate samples by strong acid allows some of the iron and other elements to dissolve back into the solution. Otherwise, the results for digested and undigested samples were similar.

Saturating Granite Aggregates: Saturation of the granite gravel aggregate with various solutions resulted the leaching of some inorganic chemicals (Table 12). Overall, the levels of various elements in leachates generated from the granite gravel aggregate were low. When leached with water, relatively small quantities of S, Mg, Ca, and Na were leached. Similar results were obtained when the gravel pieces were leached with the other four solutions. As for the other elements, small quantities were detected in some of the samples collected from the three replications throughout the study. Due to lack of consistency among the replications for each solution, we believe the values for these elements are below the detection limit of the instrument and conclude that granite gravel, with exception of common cations and S do not contribute any of the cations listed in Table 12 beyond the levels that occur naturally in soils. Saturating Limestone Aggregates: The lime-stone gravel aggregate leached with water released S, Mg, Ca, Na, and K at a concentration greater than 10 mg/L in the leachate (Table 13). The amounts of other elements detected in the leachates from the three replications were generally zero or less than 0.1 mg/L. In general, the results for other solutions resembled the results for water. For all practical purposes, we can assume that the lime stone gravel aggregate does not release any heavy metals beyond the natural soil background levels.

Intermittent Saturation

The average concentration of selected inorganic constituents in the leachates of tire chips generated by the five solutions for three saturation-drainage periods are presented in Table 14 through 17. In general, the concentrations of all the elements measured in the leachates generated using water decreased with time. The trend was almost the same for the

Table 12. Mean concentration of various elements in the leachates collected from granite aggregates at the end of the continuous saturation. All analyses were performed by the Department of Soil Science Analytical Service Laboratory. All values are in mg/L (ppm).

COMPOUND	Water Blank	Water Gravel	Acid Blank	Acid Gravel	Base Blank	Base Gravel	Laundry Blank	Laundry Gravel	Cleaner Blank	Cleaner Gravel
Number of Days of Saturation		130		100		130		130		130
Calcium (Ca)	U	40.2	U	253.4	U	2.47	0.2	36.1	0.7	19.2
Iron (Fe)	U	U	U	U	U	U	U	0.49	0.18	4.4
Lead (Pb)	U	0.25	U	U	U	0.04	U	U	U	U
Magnesium (Mg)	U	12.7	U	53.7	U	3.83	U	8.4	3.5	8.3
Manganese (Mn)	U	U	U	0.35	U	U	U	0.36	U	0.7
Phosphorous (P)	U	U	U	U	U	U	U	0.2	150	110
Potassium (K)	U	0	U	6.9	4.1	16.9	3.2	7.5	252	150
Sodium (Na)	0.7	5.6	U	4.5	1584	1510	568	515	634	716
Sulfur (S)	U	2.6	U	0.37	2.9	9.3	139	152.5	354	443
Thallium (Tl)	U	U	U	U	U	U	U	U	0.15	0.08
Vanadium (V)	U	U	U	U	U	U	U	U	U	U
Zinc (Zn)	U	U	U	U	U	U	U	0.28	U	0.32

† U -- Below detection limit.

Table 13. Mean concentration of selected elements in the leachates from granite aggregates collected at the end of the continuous saturation. All analyses were performed by Department of Soil Science Analytical Service Laboratory. All values are in mg/L (ppm).

COMPOUND	Water Blank	Water Gravel	Acid Blank	Acid Gravel	Base Blank	Base Gravel	Laundry Blank	Laundry Gravel	Cleaner Blank	Cleaner Gravel
Number of Days of Saturation		90		90		90		90		130
Barium (Ba)	U[†]	U	U	U	U	0.1	0.1	0.05	U	U
Calcium (Ca)	U	188.5	0.4	1140	0.2	20.7U	0.1	74.8	0.6	15.5
Iron (Fe)	U	U	U	U	U	U	0.46	0.28	0.08	0.21
Lead (Pb)	U	U	0.06	0.09	U	U	U	4.0	0.12	0.08
Nickel (Ni)	0.02	0.06	U	0.16	U	U	U	0.28	U	0.16
Magnesium (Mg)	U	10.1	U	29.3	0.3	1.8	U	U	3.3	3.2
Manganese (Mn)	U	U	U	0.7	U	U	U	U	U	0.11
Phosphorous (P)	U	U	U	U	0.1	0.1	0.1	0.1	153	63
Potassium (K)	0.3	29.3	0.1	58.1	5.0	56.9	2.4	38.4	205	200.7
Sodium (Na)	0.2	23.4	0.3	29.9	463	173	525	471	636	638
Sulfur (S)	0.1	148.4	0.4	99.5	2.2	197.6	130	252	311	477
Thallium (Tl)	U	U	U	U	U	U	U	U	0.16	0.15
Vanadium (V)	U	U	U	U	U	U	U	U	U	0.15
Zinc (Zn)	U	U	U	U	U	U	0.06	0.12	U	0.14

† U -- Below detection limit.

Table 14. Average concentration of selected elements in leachates from tire chips generated with water for the three saturation-drainage periods. All analyses were performed by the Department of Soil Science Analytical Service Laboratory.

COMPOUND	Blank	SATURATION PERIOD First	Second	Third
	-----------------	mg/L	-----------------	
Barium (Ba)	U†	0.2	0.4	0.0
Calcium (Ca)	U	9.0	4.4	1.8
Iron (Fe)	U	6.1	0.6	0.7
Magnesium (Mg)	U	0.9	0.3	0.2
Manganese (Mn)	U	1.0	0.8	0.5
Potassium (K)	U	15.9	3.1	3.8
Sodium (Na)	U	12.2	2.3	3.3
Sulfur (S)	U	8.9	2.9	1.3
Thallium (Tl)	U	0.1	0.04	0.09
Zinc (Zn)	U	2.1	1.0	0.2

† U -- Below detection limit.

Table 15. Average concentration of selected elements in leachates from tire chips generated with laundry wastewater for the three saturation-drainage periods. All analyses were performed by the Department of Soil Science Analytical Service Laboratory.

COMPOUND	Blank	SATURATION PERIOD First	Second	Third
	-----------------	mg/L	-----------------	
Aluminum (Al)	1.2	6.3	8.8	7.4
Barium (Ba)	U†	0.1	U	U
Calcium (Ca)	0.2	3.2	0.7	0.4
Copper (Cu)	U	0.3	0.2	0.2
Iron (Fe)	U	55.8	16.5	20.6
Magnesium (Mg)	U	0.3	U	0.1
Manganese (Mn)	U	0.3	0.2	0.1
Phosphorous (P)	U	1.1	0.4	0.3
Potassium (K)	2.4	25.4	7.7	5.0
Sodium (Na)	490	470	473	473
Sulfur (S)	130.4	129.9	132.5	134.8
Zinc (Zn)	U	9.9	2.9	2.6

† U -- Below detection limit.

Table 16. Average concentration of selected elements in leachates from tire chips generated with acid solution for the three saturation-drainage periods. All analyses were performed by the Department of Soil Science Analytical Service Laboratory.

		SATURATION PERIOD		
COMPOUND	Blank	First	Second	Third
	- - - - - - - -	mg/L	- - - - - - - -	
Aluminum (Al)				
Barium (Ba)	U†	0.3	0.9	0.7
Calcium (Ca)	0.3	19.5	4.9	1.8
Iron (Fe)	U	3.0	3.3	1.3
Magnesium (Mg)	U	1.4	0.4	0.2
Manganese (Mn)	U	2.8	2.2	1.9
Phosphorous (P)	U	0.1	0.1	U
Potassium (K)	0.6	14.5	2.9	1.1
Sodium (Na)	0.4	6.1	1.1	1.1
Sulfur (S)	U	8.2	2.5	1.9
Zinc (Zn)	U	17.5	7.1	2.0

† U -- Below detection limit

Table 17. Average concentration of selected elements in leachates from tire chips generated with drain opener solution for the three saturation-drainage periods. All analyses were performed by the Department of Soil Science Analytical Service Laboratory.

		SATURATION PERIOD		
COMPOUND	Blank	First	Second	Third
	- - - - - - - -	mg/L	- - - - - - - -	
Aluminum (Al)				
Barium (Ba)	U†	0.3	0.2	U
Calcium (Ca)	0.4	1.8	0.6	0.5
Copper (Cu)	U	0.7	0.3	0.2
Iron (Fe)	0.1	10.1	1.8	1.9
Magnesium (Mg)	0.9	0.8	0.3	0.1
Manganese (Mn)	U	0.3	0.1	0.2
Phosphorous (P)	U	4.2	2.0	0.9
Potassium (K)	4.6	52.3	16.0	18.7
Sodium (Na)	--	1326	1336	1377
Sulfur (S)	2.2	31.4	22.0	18.0
Zinc (Zn)	U	9.0	1.8	1.1

† U -- Below detection limit.

other solutions. Sulfur, Zn, Fe, Mn, Mg, Ca, Na, and K were the major elements measured in the leachates from tire chips. In addition, other elements were detected in small quantities in the leachates. In most cases, there were little consistencies among the results for the three replications. Overall, the low levels of some of the elements were either below the detection limit for the element or could be due to cross contamination in the laboratory. The total amounts of S, Fe, and Zn leached from tire chips for the five solutions are presented in Table 18. Based on our laboratory analysis of the leachates, only common elements generally found in soils are leached from tire chips during consecutive short term saturation-drainage periods.

Intermittent leaching did not result in substantial movement of inorganic chemicals from either of the two types of gravel. Sulfur, Mg, Ca, K, and Na were the major elements consistently found in the leachates of gravel aggregate for all five solutions. Other elements detected in some of the leachates were generally low and could be considered as insignificant.

Table 18. Total amounts of S, Fe, and Zn leached from tire chips after three saturation-drainage periods.

SOLUTION	S	Fe	Zn
	- - - - - - - - - - - - - -	mg/kg	- - - - - - - - - - - - - -
Water	16.7	9.1	4.2
Laundry Wastewater	0	123	20.3
Acid Solution	15.4	10.2	34.6
Drain Opener	77.8	15.7	13.5
Household Chemical	15.5	4.3	96.6

The mean concentration of the inorganic elements in the leachates generated during the first and third saturation period for the granite and limestone rocks are presented in Tables 19 and 20, respectively.

Impact of Wastewater and Tire Leachates on Soil Hydraulic Conductivity

One of the objectives of the study was to assess the impact of wastewater and tire leachates on the soil hydraulic properties. To achieve this objective K_{sat} of a set of intact soil cores was measured in the laboratory using blank and tire chip leachate solutions with three replicates for each measurement (Table 21). The intact samples were collected from the Bt horizon of a soil mapped as Cecil and contained approximately 57% clay and 26% sand (textural class of clay). Amoozegar (1998) conducted a field and laboratory study and determined that soil K_{sat} and infiltration rate decrease substantially when laundry and other wastewaters are applied to the soil. A similar type of results were observed for the blank solutions in this study. Due to the substantial impact that the quality of wastewater/leachate has on the K_{sat} of soils, the results of our laboratory measurement of this property are inconclusive. Measurement of the levels of wastewater applied to trenches filled with tire chips and gravel aggregate showed no adverse impact on the infiltration rate of wastewater in tire chip-filled trenches. No further assessment of the impact of tire chip leachate on soil physical properties will be presented here.

Field Evaluation

The soil at the site of the experimental septic system was characterized with respect to texture, hydraulic conductivity, and water retention at various depths and locations. Table 22 presents the average clay and sand content from the surface to 90 cm depth along a transect

Table 19. Mean concentration for selected elements in the treatment solution and the leachates of granite aggregate for the first and third saturation periods. All values are in mg/L. All analyses were performed by the Department of Soil Science Analytical laboratory.

COMPOUND	Water Blank	Water 1st/3rd	Acid Blank	Acid 1st/3rd	Base Blank	Base 1st/3rd	Laundry Blank	Laundry 1st/3rd	Cleaner Blank	Cleaner 1st/3rd
Aluminum (Al)	U†	U/U	U	U/U	0.55	U/0.25	1.23	2.74/0.64	0.18	U/U
Arsenic (As)	U	U/U	0.25	U/U	U	U/U	U	U/U	U	0.19/0.16
Calcium (Ca)	0.11	26.5/16.4	0.32	48.4/69.9	0.2	9.0 /2.4	0.15	23.5/7.67	0.6	18.5/26.4
Copper (Cu)	U	U/U	U	U/ U	U	U/U	U	U/U	U	0.07/0.08
Iron (Fe)	U	U/U	U	U/U	U	U/U	U	0.15/0.03	0.1	0.38/0.91
Lead (Pb)	0.22	U/U	U	U/U	U	0.09/0.06	U	U/U	U	U/U
Magnesium (Mg)	U	6.0/4.95	U	10.0/9.4	0.5	0.55/0.1	0.05	5.87/2.07	3.3	14.3/7.1
Manganese (Mn)	U	U/U	U	U/0.15	U	U/U	U	0.08/U	U	0.25/0.28
Nickel (Ni)	U	U/U	U	U/U	U	U/U	U	0.06/U	U	U/U
Phosphorous (P)	U	U/U	U	U/U	0.05	0.43/U	U	0.17/0.07	153	106/154
Potassium (K)	U	3.7/U	0.3	4.13/0.63	4.7	20.2/8.4	1.95	11.3/3.1	190	157/126
Sodium (Na)	0.31	3.03/3.1	0.35	1.88/1.55	323	1243/ 1308	512	495/479	707	615/670
Sulfur (S)	0.2	1.87/0.53	0.2	0.93/0.23	2.0	5.7 /3.9	133	134/160	360	377/338
Thallium (Tl)	U	U/U	U	U/U	U	U/U	U	U/U	0.15	0.11/0.03
Zinc (Zn)	U	U/U	U	U/U	U	U/U	U	0.21/U	U	0.6/0.73

† U -- Below detection limit.

Table 20. Mean concentration for selected elements in the treatment solutions and in the leachates of the limestone aggregate for three consecutive soaking periods. All analyses were performed by the Department of Soil Science Analytical Service Laboratory.

COMPOUND	Water Blank	Water 1st/3rd	Acid Blank	Acid 1st/3rd	Base Blank	Base 1st/3rd	Laundry Blank	Laundry 1st/3rd	Cleaner Blank	Cleaner 1st/3rd
Aluminum (Al)	U†	U/U	U	U/U	U	U/0.04	1.24	0.86/0.99	0.18	0.08/U
Arsenic (As)	U	U/U	0.25	0.160.17	U	U/U	U	U/U	U	0.22/0.07
Calcium (Ca)	0.11	146/58.8	0.32	161/92.6	0.4	3.6/0.73	0.15	55.7/22.8	0.6	12.0/26.2
Iron (Fe)	U	U/U	U	U/U	U	U/U	U	1.0/0.44	0.1	0.57/0.1
Lead (Pb)	0.22	0.09/0.17	U	0.04/0.04	U	0.04/0.1	U	U/U	U	0.04/U
Magnesium (Mg)	U	5.5/1.60	U	7.05/3.73	0.5	0.83/0.1	0.05	2.63/0.73	3.3	2.0/4.33
Manganese (Mn)	U	U/U	U	U/U	U	U/U	U	U/U	U	U/0.15
Nickel (Ni)	U	U/U	U	U/U	U	U/U	U	0.15/U	U	U/U
Phosphorous (P)	U	U/U	U	U/U	0.05	0.17/U	U	0.1/0.1	154	89/159
Potassium (K)	U	24.7/4.5	U	27.9/7.07	4.7	59.6/18.6	U	31.7/9.43	190	213/145
Sodium (Na)	0.31	10.3/3.04	0.35	10.0/4.0	323	919/1430	512	465/470	707	628/705
Sulfur (S)	0.2	88.8/29.5	0.2	87.2/38.4	2.0	128/59.9	133	207/156	360	437/367
Thallium (Tl)	U	U/U	U	U/U	U	U/U	U	U/U	0.15	0.12/0.04
Vanadium (V)	U	U/U	U	U/U	U	U/U	U	0.22/0.20	U	U/U

† U -- Below detection limit.

Table 21. Mean and standard deviations for the saturated hydraulic conductivity of the soil for various solutions and tire chip leachates produced using these solutions.

SOLUTIONS	BLANK SOLUTIONS Mean	BLANK SOLUTIONS Standard Deviation	TIRE LEACHATES Mean	TIRE LEACHATES Standard Deviation
	- - - - - - - - - - - - - - -	cm/d	- - - - - - - - - - - - - - - -	
Water	4.8	1.8	2.4	2.4
Acid	7.0	3.6	6.7	2.2
Drain Opener	0.3	0.2	0.4	0.4
Laundry	--	--	0.3	0.1
Household Chemicals	0.08	0.06	0.3	0.4

Table 22. Average clay and sand content and textural classes as identified from the USDA Textural Triangle at six depths for five locations across the drainfield area.

DEPTH	CLAY	SAND	TEXTURAL CLASS
	- - - - - - - - %	- - - - - - - - -	
0-15	30.0	9.9	scl
15-30	31.0	10.6	scl
30-45	47.2	5.9	c, sc, scl
45-60	56.9	3.8	c, sc
60-75	57.5	3.7	c, sc
75-90	52.8	4.3	c, sc

perpendicular to the drainlines in the middle of the drainfield (see Fig. 2). In general, the clay content increased from an average of approximately 30% at 30 cm depth to 50% at 60 cm. Below 60 cm the clay content remained relatively constant. Figure 4 shows the distribution of clay with depth for five locations along the transect.

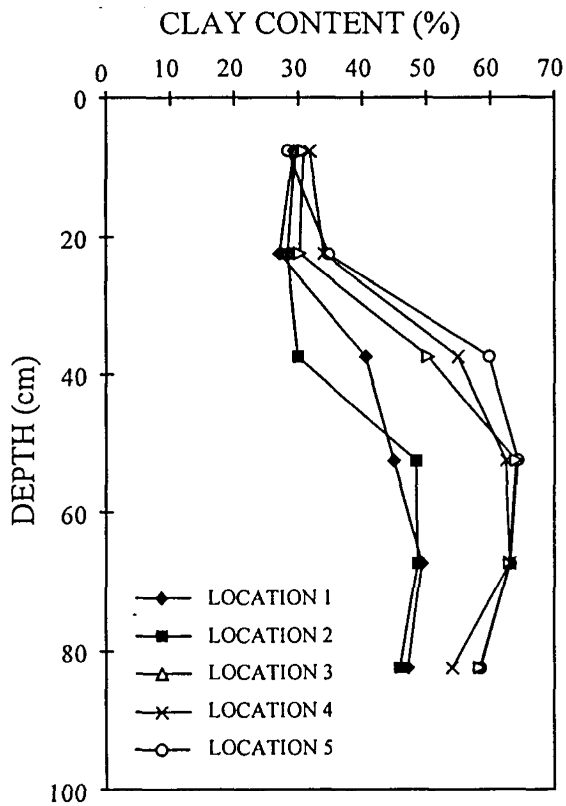

Figure 4. Distribution of clay content with depth for five locations across the drainfield.

The trenches of the septic system were 60 cm deep and the depth of gravel and tire chips in the trenches was approximately 30 cm. The *in situ* saturated hydraulic conductivity was measured between 60 and 75 cm depth (to represent the conductivity of the soil below the bottom of the trenches) along three transects perpendicular to the drainlines (see Fig. 2). Transect 1 was near the manifold, transect 2 went through the center of the drainfield, and transect 3 was at the end of the drainlines. The results of K_{sat} for 14 locations on the transects are given in Table 23. At one location, the flow rate of water from the hole into the soil was greater than 200 cm^3/min, which is abnormally high for the type of soil found at the site. This

Table 23. *In situ* saturated hydraulic conductivity between 60 and 75 cm depth at 14 locations in the drainfield area of the experimental septic system.

TRANSECT POSITION	LATERAL LINES 1	2	3	4	
	- - - - - - - - - -	- - - - cm/d - - - -	- - - - - - - - - -		
End of Trench	10.6	H†	6.2	26.6	21.6
Middle of Trench	53.0	12.7	10.1	25.4	24.2
Beginning of Trench	94.3	18.5	13.7	31.7	41.5

† Higher than 12 cm/h.

high value could have been due to a large macropore (e.g., large root channel) intercepting the auger hole. No K_{sat} value is presented for this location. The mean and standard deviation for the *in situ* K_{sat} values are 27.85 and 23.05 cm/d, respectively. Overall, the hydraulic conductivity of the soil decreased from the manifold side to the end of the drainlines. The center of the drainfield also had the lowest K_{sat} values compared to its neighboring locations. Overall, the design loading rate, 0.2 gal/(ft^2 d) or 0.8 cm/d, represented less than 3% of the average K_{sat} for the entire drainfield and less than 15% of the lowest measured K_{sat} values (6.3 cm/d) in the area. The distribution of the K_{sat} of 20 intact cores collected from 25 to 90 cm depth is presented in Fig. 5. The K_{sat} values for the 20 cores ranged between 0.1 to 227 cm/d

with an arithmetic mean and standard deviation of 25.4 and 53.1 cm/d, respectively. Note the high standard deviation and the distribution of Ksat values with depth indicate a high degree of variability within the upper 90 cm of the soil in the drainfield area.

The soil water characteristics for the 20 intact soil samples collected from around the drainfield were assessed for 0 to -400 cm soil water pressure head. The mean and standard

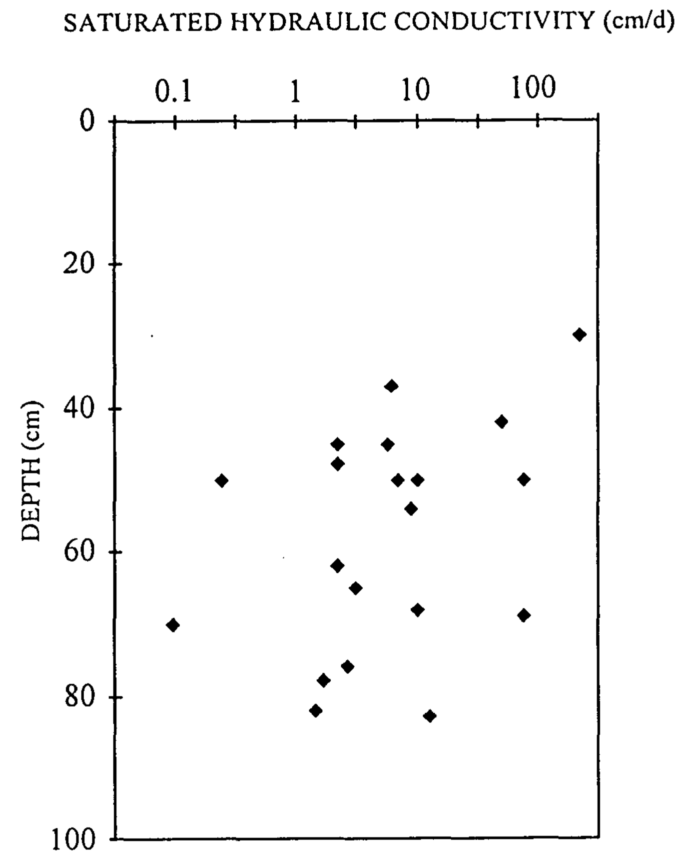

Figure 5. Distribution of saturated hydraulic conductivity with depth in the drainfield area.

deviation for soil water content at zero pressure head (i.e., at saturation) for the 20 samples were 46.25 and 1.63, respectively. At -100 and -400 cm soil water pressure heads the mean values for water content were 44.16 and 42.42 m^3/m^3, respectively. The gradual decrease in the soil water content with decreasing pressure head indicates that the pores in the soil in the 25 to 90 cm depth interval are relatively small and that the drainable porosity of the soil is relatively small.

Wastewater Infiltration

The late fall and winter of 1997-1998 and the spring of 1998 were relatively wet. Due to ponding in the trenches, wastewater application to the experimental septic system was ceased for approximately 50 days during January and February, 1998, to prevent potential surfacing of effluent and damage to the system. Figure 6 presents the level of wastewater in the two trenches filled with tire chips and Fig. 7 presents the same data for the gravel aggregate filled trenches. Note that with some exceptions the trenches for both tire chips and granite aggregate were remained partially saturated for an extended period of time with similar patterns. Overall, during the early stages of the study, less ponding was observed in the tire chip-filled trenches than the ones for gravel aggregate. Even during the wet season, higher levels of ponding were observed in gravel aggregate trenches than the tire chip-filled trenches. After May, 1998, no ponding was observed in any of the locations within the four trenches.

As we explained earlier, trenches 1 and 3 were filled with tire chips and trenches 2 and 4 were filled with granite gravel. Trenches 1 and 2 were connected to one side of the manifold and trenches 3 and 4 were connected to other side of the manifold. A gate valve on each side of the manifold was used to set the pressure in the upper two and lower two drainlines. Because the distribution lines in the four trenches were identical and placed inside a section of 4-inch corrugated drainage pipe in each trench, we assume that all four trenches received an equal amount of wastewater during each dosing period. In general, the depth of wastewater in the trenches immediately after wastewater application to the two tire chip-filled trenches were fairly identical. The differences between the gravel-filled and tire chip-filled trenches, however, are substantial. Overall, higher wastewater levels after wastewater application were

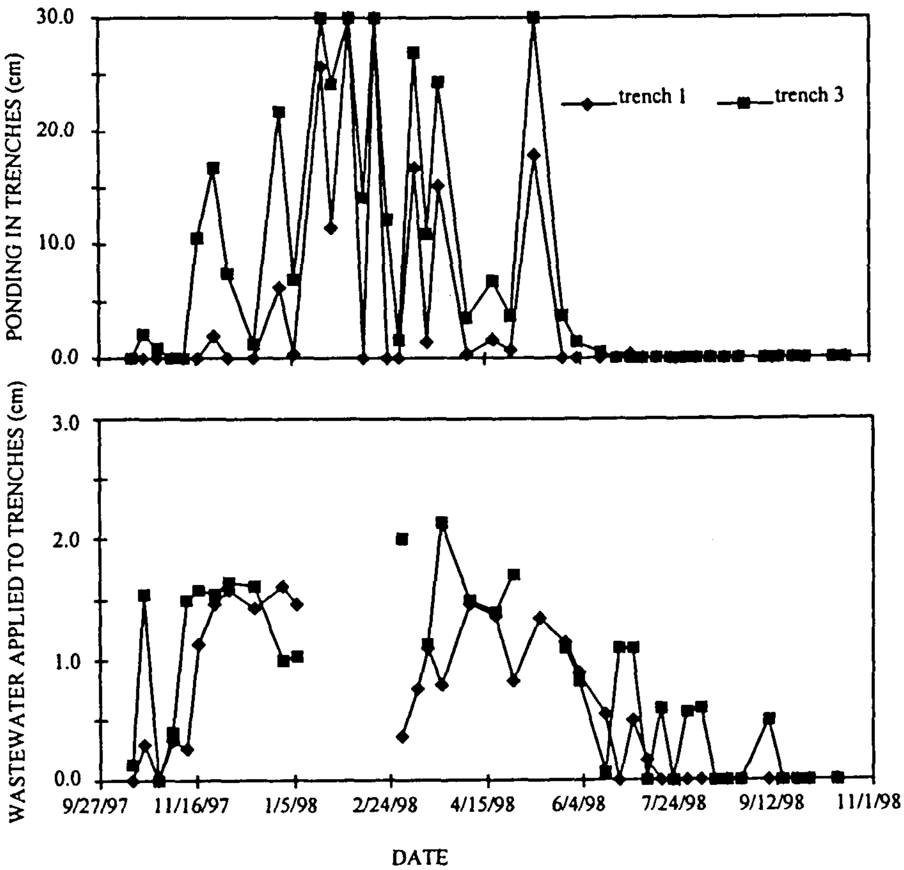

Figure 6. Average of wastewater ponding prior to dosing and the amount of wastewater measured at three locations immediately after dosing for the trenches filled with tire chips.

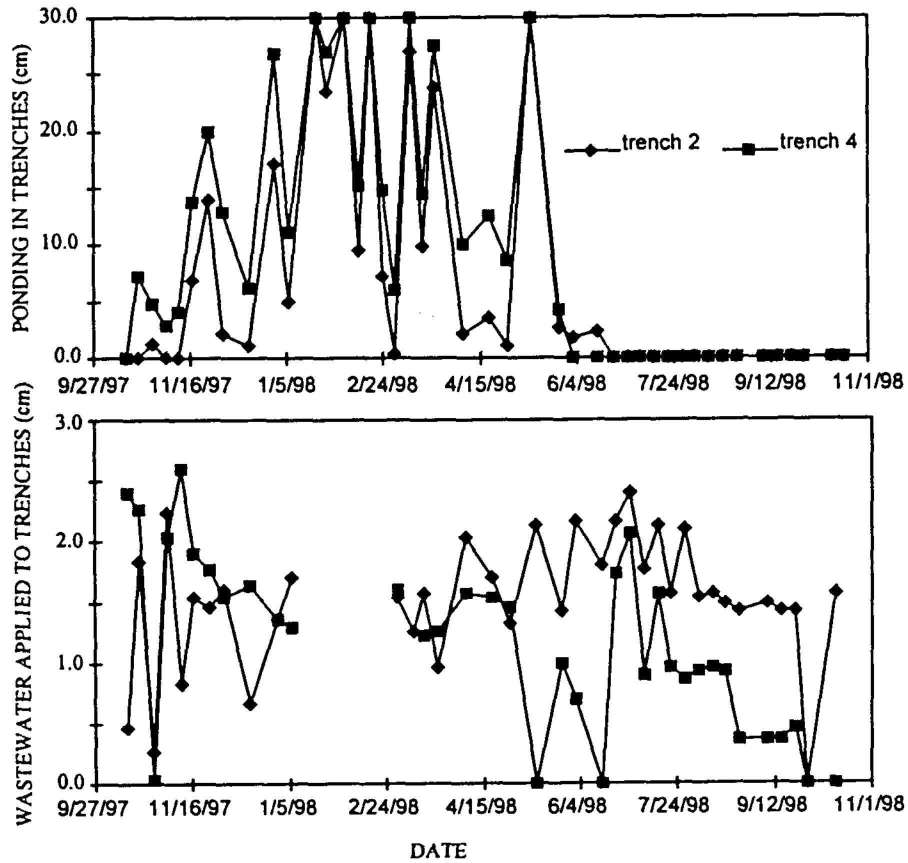

Figure 7. Average of wastewater ponding prior to dosing and the amount of wastewater measured at three locations immediately after dosing for the trenches filled with gravel.

observed in the gravel-filled trenches than the tire chip-filled trenches. This indicates that wastewater infiltrated the soil in the tire chip-filled trenches faster than the gravel-filled trenches. For the last few months of the monitoring program, wastewater was found in the two tire chip-filled trenches for only a few hours after wastewater application, whereas for gravel aggregate, wastewater was observed in the trenches for a longer period of time following wastewater application. Measurement of wastewater ponding immediately after wastewater application and one hour after wastewater application showed no negative impact of the tire chips in the trenches of the septic system. In general, the data regarding wastewater levels in the trenches indicated that placement of tire chips in the trenches instead of gravel aggregate does not negatively impact the infiltration of wastewater into the soil and the soil hydraulic conductivity below and around trenches. Visual inspection of the tire chips at one locations of the drainfield after 13 months of operation showed no deterioration of the tire chips and no sign of soil failure at the bottom of the trench.

Analyses of soil samples collected from the bottom of the trenches and outside the drainfield area showed no substantial accumulation of inorganic elements beyond the natural level of the these elements in the soil samples collected from the area. Table 23 presents the average level of NO_3^- and SO_4^{2-} in the background soil samples collected from 60 to 80 cm depth at two locations outside the drainfield and from the 20 cm depth interval below the bottom of the trenches at three locations within each of the four trenches. The levels of nitrate (NO_3^-) in the extract of background samples was below the detection limit while the average SO_4^{2-} content of eight samples from 60 to 80 cm depth interval outside the drainfield area was

669 mg/kg soil. Inside the trenches the average concentration of nitrate for all the samples

Table 23. Average nitrate (NO_3^-) and sulfate (SO_4^{2-}) in the background soil samples and in the soil at the bottom of the trenches. The levels of nitrate and sulfate in the septic tank effluent are also given.

TRENCH NUMBER	DEPTH INTERVAL	NITRATE	SULFATE
	cm	- - - - - - - - mg/kg	- - - - - -
1	0 to 5	36.9	585
	5 to 10	35.8	531
	10 to 15	24.1	412
	15 to 20	22.8	
2	0 to 5	62.7	431
	5 to 10	67.9	553
	10 to 15	43.8	720
	15 to 20	37.8	758
3	0 to 5	136.6	551
	5 to 10	101.4	745
	10 to 15	70.4	943
	15 to 20	51.6	1125
4	0 to 5	70.4	582
	5 to 10	63.6	977
	10 to 15	51.5	1223
	15 to 20	51.5	1021
Background	0 to 5	U	549
	5 to 10	U	665
	10 to 15	U	726
	15 to 20	U	737
		- - - - - - - - mg/L	- - - - - - -
Septic Tank Effluent		0.13	1.98

(47 samples) was 56.4 mg/kg soil. This shows that all the locations within each of the tire chip-filled and gravel-filled trenches received wastewater during the study period. The average SO_4^{2-} contents of the soil samples for the four trenches ranged between 505 and 951 mg/kg soil. Note that the level of SO_4^{2-} increased with depth for background as well as for samples collected from inside the trenches. Also, there was a general increase in the SO_4^{2-} content of the soil from trench 1 to trench 4 across the drainfield area. These results show that tire chips did not contribute any significant amount of sulfate to the soil.

With the exception of common cations and anions generally found in septic tank effluent, the concentrations of the inorganic elements in the septic tank effluent at the site were generally low. The highest measured concentration (0.112 mg/L) was for Zn in one of the two samples from the pump tank. For the soil samples collected from the bottom of the trenches and from the background area, Zn content of the upper 5 cm of the soil inside the trenches filled with tire chips increased substantially above the corresponding background level (Table 24). At other depth intervals, Zn concentration did not change substantially above the background level. Higher levels of Se were also observed in the upper 5 cm of the soil below the bottom of the tire chip-filled trenches as compared to gravel-filled trenches and background samples. The levels of Ni were somewhat higher than the background level with no consistency among the trench bottom samples for tire chips or rock aggregate. As for the other elements, V was detected in all the samples from the trenches and from background samples. There was no consistency among the samples, and it appears that tire chips or gravel do not contribute V in the trenches of septic systems. Overall, during the short time of monitoring, it appears that the level of contribution of tire chips to the inorganic constituents of the soil is limited.

Table 24. Inorganic element content of the extracts of the soil inside the trenches and at 60 to 80 depth outside the drainfield area.

TRENCH NUMBER	DEPTH INTERVAL	ELEMENTS Zn	V	Se	Cu	Cr	Ni
	cm	mg/L					
1	0 to 5†	0.87	0.30	0.34	0.27	0.26	0.15
	5 to 10	0.19	0.21	0.9	0.19	0.20	0.15
	10 to 15	0.34	0.19	0.14	0.17	0.13	0.09
	15 to 20	0.23	0.15	0.12	0.22	0.17	0.15
2	0 to 5	0.14	0.41	0.19	0.20	0.10	0.06
	5 to 10	0.07	0.33	0.05	0.15	0.12	0.11
	10 to 15	0.12	0.27	0.11	0.27	0.12	0.08
	15 to 20	0.10	0.23	0.14	0.21	0.19	0.14
3	0 to 5	0.85	0.76	0.41	0.30	0.43	0.26
	5 to 10	0.18	0.67	0.19	0.33	0.13	0.09
	10 to 15	0.14	0.62	0.10	0.23	0.12	0.09
	15 to 20	0.12	0.59	0.08	0.24	0.14	0.20
4	0 to 5	0.18	0.70	0.21	0.35	0.30	0.18
	5 to 10	0.09	0.61	0.08	0.27	0.13	0.11
	10 to 15	0.13	0.60	0.06	0.31	0.19	0.10
	15 to 20	0.10	0.59	0.05	0.25	0.33	0.15
Background	60 to 65	0.14	0.56	0.10	0.21	0.03	0.03
	65 to 70	0.12	0.59	0.08	0.21	0.22	0.07
	75 to 80	0.13	0.59	0.13	0.23	0.10	0.03

† Measured from the bottom of the trenches.
‡ Measured from the soil surface.

SUMMARY AND CONCLUSIONS

Only a limited number of studies have been conducted to assess the potential leaching of organic and inorganic chemicals from tire chips for use in various installations, such as drainfields for septic systems, sub-grading for road beds, or landfill leachate collection systems. In this study, we attempted to bring tire chips and two different types of gravel used in septic systems in contact with a variety of chemicals and commercial products commonly found in septic tank effluent. This was done to assess the potential for leaching of various organic compounds and inorganic elements from tire chips and gravel aggregate under different degree of saturation. The results obtained in this study do not directly match the findings of comparable studies, but they are consistent with general observations and trends relating the leachability of tire chips and gravel aggregate as affected by the properties of the leaching solution.

Today, tires are manufactured using a variety of organic and inorganic chemicals. When tire chips are exposed to an aquatic environment, some of the chemicals start to leach posing a potential environmental problem. Consistent with the findings of other studies, our results show that the concentrations of most chemicals in tire chip leachate decrease with time due to the depletion of readily accessible and soluble compounds at the surface of tire chips. This is significant because it may be economically feasible to wash tire chips and remove some of the harmful chemicals prior to their use in the environment. In our study, we determined that a common drain-opener solution (with pH exceeding 12) and laundry wastewater (containing detergent, fabric softener and bleach) can leach more organic compounds than acidic solutions, household chemicals, or water. A study conducted by Twin City Testing Company in Minnesota for assessing tire chips as sub-grade for road beds concluded that under basic conditions (i.e., high pH) more organic compounds are removed from tire chips than under acidic conditions (Minnesota Pollution Control Agency, 1990). The report also stated that inorganic chemicals leach from tire chips at a higher rate under acidic conditions than under alkaline conditions. Other studies have indicated that low levels of a variety of inorganic chemicals are leached from tire chips. Our results also show that various inorganic elements, such as Ba, Co, Cu, Fe, Mn, Ni, Zn and S can be leached from tire chips. Another similarity between the results of our study and the ones reported by others is the inconsistencies in the concentrations of various chemicals in leachates or soil solution for replicates, sampling points, and gravel vs. tire chips. In some cases, higher levels of organic chemicals were measured in the blank solution than tire chip leachate. In other cases, more of a chemical was found in the rock aggregate than tire chips.

Overall, tire chips appear to retain their integrity during prolonged contact with liquids. Our information regarding the behavior of tire chips under prolonged contact with septic tank effluent, however, is limited to a number of short term studies and assessments. For our field investigation, we inspected tire chips at one location in one of the two trenches in our experimental septic system after one year of operation and detected no deterioration of the tire chips in the trench. Due to funding limitations, we did not assess the movement of organic chemicals from tire chips in our field study. However, the level of selected inorganic chemicals did not increase substantially in the soil immediately under the tire chip-filled trenches.

RECOMMENDATIONS

No recommendation regarding the suitability of tire chips for use in septic system will be made in this report. The suitability of tire chips for use as a substitute for gravel in the trenches of septic systems must be determined by regulatory agencies. The recommendations presented here are based on the results of this study as well as the findings of other reported research.

1. Currently there are a few states that allow the use of tire chips as a substitute for gravel aggregate in the trenches of septic systems. The standards used by the states allowing the use of tire chips should be consulted prior to developing standards for North Carolina.

2. There are different types of machinery and procedures used to produce tire chips. As a result, the quality of tire chips may vary greatly among different tire recycling plants. To assure uniformity among tire chips produced by various tire recycling firms, a set of standards concerning the size (dimensions) of tire chips, length of steel wires protruding from the side of the tire chips, and the amount of foreign objects and fine/small particles (e.g., wire pieces, soil) must be specified. These standards, however, must be achievable with current technology. A selected number of tire recycling firms that intend to produce tire chips for septic systems should be visited, and samples of their finished product should be collected for inspection. These samples should be evaluated for size, length of steel wires protruding from the tire chips, and fraction of foreign objects and fine materials.

3. If possible, a number of septic systems installed in South Carolina with tire chips as a substitute for gravel should be inspected. It is best to locate some of the early systems as well as some of the newly installed systems for inspection. If allowed by the owners, these systems should be partially excavated to assess the integrity of the tire chips and the conditions of the bottom of the trenches.

4. If the North Carolina Department of Environment and Natural Resources determines that tire chips are suitable as a substitute for gravel in the trenches of septic system, only a limited number of septic systems should be allowed to be installed during the initial phase of the program. The septic systems under this program must be carefully designed and be monitored for a number of years before granting wide spread use of tire chips in septic systems. To monitor these systems, observation/sampling wells must be installed in their trenches during construction to allow monitoring of the level and duration of ponding in the trenches, and to allow collection of soil samples from the bottom of the trenches and/or wastewater samples from the bottom section of the trenches. The ideal installation would be to have tire chip-filled and gravel-filled trenches side by side at each site. As an alternative, however, a parallel monitoring program can be initiated to assess the level of ponding in the trenches of comparable septic systems with gravel in their trenches.

5. Periodically, soil samples and/or a wastewater samples from the bottom of the trenches of each system must be collected and analyzed for selected organic and inorganic chemicals. A record of the results should be kept for each system.

6. Due to their elastic nature, tire chips cannot be compressed during the installation of septic system trenches. Septic systems in which tire chips are used should be inspected frequently to determine the degree of settlement that can occur with time due to compaction in the trenches. Compaction could occur as a result of slippage of tire chips against one another and collapse of the voids initially created by the bridging of steel wire pieces. Prolonged contact in the aqueous environment of the trenches will lead to the oxidation and dissolution of the steel wire protruding from the tire chips.

7. In all systems, the contractor must be aware of the potential problems that could arise from

the use of tire chips in the septic system trenches (e.g., unacceptable tire chips, settlement of tire chips in the trenches), and the installer must be familiar with the handling procedure for using tire chips with sharp metal pieces. A detailed description of the system and a schematic diagram identifying the locations of the trenches, septic tank and all other below ground components of the system must be kept on file by the respective health department.

8. The owner or future owner of any system with tire chips as a substitute for gravel in its trenches must be informed about the existence of tire chips in the trenches of the respective septic system.

9. There has been reported instances of spontaneous combustion of tire chips placed as fill materials under roads in Washington State and other locations (Nightingle and Green, 1997). The conditions under which combustion has occurred (see for example WSDOT Home Page, 1998 -- see Appendix C) should be carefully evaluated to assure that similar conditions cannot occur in the trenches of septic systems.

10. We have detected particular odors when tire chips were maintained saturated in laboratory containers. Other reports also mention odors generated by tire chips. In inspecting any drainfield in which tire chips are used for septic systems, particular attention should be devoted in assessing the presence of odors and the integrity of tire chips. The integrity of white wall sections of tire chips should be evaluated.

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LIST OF APPENDICES

Appendix A

SCRAP TIRE MANAGEMENT REPORT

FY 1996-97

North Carolina Department of Environment and Natural Resources

SCRAP TIRE MANAGEMENT REPORT

FY 1996 - 97

PREPARED BY THE

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT
AND NATURAL RESOURCES

DIVISION OF SOLID WASTE MANAGEMENT

SOLID WASTE SECTION

James B. Hunt Jr.
Governor

Wayne McDevitt
Secretary

State of North Carolina
James B. Hunt, Jr., Governor

Department of Environment and Natural Resources
Wayne McDevitt, Secretary

Division of Waste Management
William L. Meyer, Director

Solid Waste Section - Dexter Matthews, Chief
Special Waste Branch - Paul Crissman, Supervisor

Contact: Ernest Lawrence, Environmental Biologist
919-733-0692 ext. 274
Fax: (919) 733-4810

Special thanks to:

County solid waste management officials and other county officials for completion of the FY 1996-97 scrap tire annual report.

Central Carolina Tire Recycling, Envirotire Recycling, Tire Disposal Service, TIRES, Inc, and US Tire Recycling, LP for submission of recycling data.

P.O. Box 29603
Raleigh, NC 27611

SCRAP TIRE MANAGEMENT REPORT

TABLE OF CONTENTS

1) EXECUTIVE SUMMARY AND RECOMMENDATIONS

Executive Summary

The seventh annual Scrap Tire Management Report provides information on the management of scrap tires during FY 1996-97 in North Carolina. This report is based on information provided in waste management annual reports from counties and permitted tire processing facilities.

- While an estimated 7.3 million scrap tires were generated by the citizens of North Carolina - about one per person - the state's 100 counties reported managing approximately 8.9 million scrap tires[1]. Most of the additional tires are assumed to have originated out-of-state.

- Counties incurred an estimated $1 million in expenses for out-of-state tires inappropriately disposed of as North Carolina tires.

- About 45 percent of the scrap tires disposed in North Carolina were diverted from landfills for various uses in FY 1996-97, which was about the same recycling rate as in FY 1995-96. Tires were primarily recycled as used tires or in civil engineering applications.

- An increase in recycling did not occur in FY 1996-97 because fewer tires were taken from nuisance tire sites and recycled. (Cleanup contracts with the Division specified that all tires from nuisance sites be recycled). Also, US Tire, which recycles about 2 million tires per year, preferentially recycled tires from Virginia because of incentives funded by the state of Virginia.

- North Carolina has surplus quantities of recycled tire material due to weak market demand. A new state program will start in 1998 to encourage market demand for processed tire material.

- The average cost for scrap tire management reported by the counties was $90 per ton, which is about 90 cents per passenger car tire or about $4.50 per truck tire.

- The counties received $6,206,045 in direct distribution of the tire tax proceeds. This covered about 88 percent of the reported total expenses of $7,024,340 for tires being generated in the normal course of business.

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[1] Unless otherwise specified, references to numbers of tires are estimates based on the conversion factor of 100 tires per ton.

- A total of about $900,000 was requested from the Scrap Tire Disposal Account by county governments that incurred deficits in their tire programs. About $825,000 was available in the account and provided to counties. Funds available for counties will increase during FY 1997-98 because of legislative changes enacted in 1997.

- Distribution of the tire disposal tax proceeds to counties was based on county populations. Counties received from 28 percent to more than 150 percent of reported costs incurred from their individual scrap tire programs. A total of about $350,000 in surplus funds were received by thirty-seven counties.

- All high priority nuisance tire sites have been cleaned or are under contract. Over the last three years about 4.7 million tires have been removed from nuisance tire sites.

- Illegal dumping of tires has been drastically reduced by the availability of free disposal in all counties. There have been only a few reports of scrap tire dumping since free disposal was required by statute in 1994.

- Nuisance tire sites which were established prior to 1994 continue to be discovered. In order to clean sites as they are discovered the Scrap Tire Disposal Account will provide continued funding for cleanups for the next several years.

Recommendations

- *The state should increase efforts to find and clean up nuisance tire sites.*

- *The state should proceed with implementing the grant program to encourage market demand for processed scrap tire materials.*

- *County tire collection sites should increase efforts to identify out-of-state tires by placing the burden of proof on the scrap tire generators and requiring documented proof of origin.*

- *The time-limited position which provides technical assistance to counties on scrap tire management should be funded as long as free tire disposal is offered by counties.*

2) INTRODUCTION

Detailed scrap tire management data were received from all North Carolina counties and permitted tire processing facilities for FY 1996-97. This was the seventh such annual reporting, which makes it possible to analyze trends in scrap tire management in North Carolina.

Scrap tires present unique disposal and environmental problems. Landfill disposal of whole scrap tires was banned in 1989 as part of the Scrap Tire Disposal Act. Whole tires cannot be landfilled satisfactorily because they use large amounts of space, cannot be compacted, and tend to "float" to the surface due to vibration and the presence of trapped gas.

Improper tire management poses serious threats to public health and the environment. A number of illegal dump sites were established due to the lack of readily available disposal sites in some parts of the state and due to efforts to avoid the cost of appropriate disposal. The Scrap Tire Disposal Act requires all counties to provide at least one scrap tire collection site. This ensures that all tire disposers have a readily available site to properly dispose of scrap tires.

However, illegal dumping of tires increased significantly in North Carolina after whole tires were banned from landfill disposal. This ban caused an increase in tire disposal costs due to the costs of tire shredding. Counties passed the increased costs on to tire haulers and disposers as higher disposal fees, creating an economic incentive for illegal dumping of tires.

By 1992 it was apparent that there had been a large increase in illegal tire dumping. Data provided by the counties documented that tire disposal fees were strongly correlated to tire stockpiling and illegal dumping, since counties with higher fees reported fewer tires disposed.

To address these problems associated with variable tipping fees and illegal dumping, major legislative changes were made in the scrap tire program in 1993. The scrap tire disposal tax was increased to 2 percent in October 1993, and landfill disposal fees were prohibited effective January 1, 1994. Also, the Scrap Tire Disposal Account was created which receives twenty-seven percent of the disposal tax proceeds. This account has been used to fund clean up of illegal scrap tire sites and to reimburse counties that incur deficits when providing tire disposal services at no cost to disposers.

The higher disposal tax, prohibition on county tire disposal fees, and Scrap Tire Disposal Account had been scheduled to expire in June 1997. However, legislation in 1997 extended these parts of the program until June 30, 2002. Since most of the nuisance tire sites have been cleaned up more funds will be available to reimburse counties that incur deficits. A temporary time-limited position was created to assist counties in their efforts to avoid providing free disposal for out-of-state tires which are being fraudulently presented as in-state tires. Additionally, the Scrap Tire Disposal Account was amended to provide for grants to encourage tire recycling.

Public Health Hazards Associated With Tire Dumps The Asian Tiger Mosquito was introduced to North Carolina in illegal tire dumps. The rapid proliferation of illegal tire dumps is believed to have played a major role in the spread of the mosquito across North Carolina. The Asian Tiger Mosquito (Aedes albopictus) is an aggressive exotic species which competes with native North Carolina species. It is a container-breeder and thrives in tire dumps across the state.

A study of mosquito species at illegal tire sites was conducted by N.C. State University in 1993.[2] The mosquito was identified in 29 of 38 nuisance tire sites sampled. In some areas of North Carolina the mosquito is not just limited to tire sites, but is now permanently established and breeds in yards and woodlands.

Its potential range includes even the cooler mountainous regions of North Carolina, which have traditionally escaped nuisance problems with aggressive mosquito species.

Not only is the Asian Tiger Mosquito a nuisance for outdoor activity, it is capable of carrying the eastern equine encephalitis (EEE) virus.[3] This deadly disease is currently present in bird populations in eastern North Carolina and is transmitted among birds by mosquitoes. It is not known if the Asian Tiger Mosquito can transmit infectious doses of the EEE virus to humans.

One death occurred due to mosquito-transmitted eastern equine encephalitis in

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[2] 1994. Survey of Mosquitoes and Mosquito-Transmitted Viruses Associated with Tire Disposal Sites in North Carolina. NC State University, Department of Entomology.

[3] 1992. Isolation of eastern equine encephalitis virus from Aedes albopictus in Florida. Science 257:526.

October 1996 in Harnett County. Public health officials advised the public against camping trips to the coastal areas until cold weather reduced mosquito populations. It is not known if the disease was transmitted by mosquitoes breeding at a tire site.

This introduction and establishment of an exotic pest into North Carolina at nuisance tire sites shows that regulatory changes in tire management can have an unexpected adverse effect on the environment.

Fire hazards Nuisance tire sites pose special fire risks because of the difficulty in cutting off the oxygen supply and extinguishing such fires. There is a substantial threat of tire fires at many sites, especially large sites. Tire fires produce hazardous air emissions and toxic liquid run-off. Recent Environmental Protection Agency (EPA) research on uncontrolled tire fires has identified cancer-causing agents in the smoke.

An EPA report[4] states that large amounts of harmful organic compounds may be released at tire fires:

"Considering (a) the relatively high mutagenic potency of the particulate organics, (b) the high mutagenic emission factors, and (c) the presence of many mutagens/carcinogens, especially PAHs, in the effluent from the open burning of tires, such burns pose a genuine environmental and health hazard. Because of the frequent occurrence of unwanted combustion at tire piles, and the potential environmental and health risks posed by such combustion, prudence would suggest that such piles be reduced or eliminated in size and number."

Tire fires in Surry, Stokes, Wayne, Halifax, and other North Carolina counties produced large amounts of emissions of incomplete combustion. Also, liquid run-off to surface waters has caused fish kills.

3) SCRAP TIRE GENERATION IN NORTH CAROLINA

The standard used by the EPA for estimating generation of scrap tires is one tire per person per year.[5] Since the 1997 population of North Carolina was about 7.3 million, it is estimated that an equal number of tires were generated during FY 1996-97.

4Mutagenicity of Emissions from the Simulated Open Burning of Scrap Rubber Tires. July 1992. EPA Air and Energy Research Laboratory and Health Effects Research Laboratory, RTP, NC.

5 Markets for Scrap Tires. 1991. US EPA, Office of Solid Waste. EPA/530-SW-90-074A. Washington, DC.

This standard is representative of tire generation in North Carolina, based on comparisons with tire sales and tax collections in the state.

For purposes of this report, data are reported in automobile tire equivalents, unless indicated otherwise, which is about 20 pounds per tire or 100 tires per ton. Additionally, unless otherwise noted tires managed includes only tires which are being presented for disposal as North Carolina tires.

4) VOLUME OF TIRES DISPOSED IN NORTH CAROLINA

All counties are required to provide facilities for disposal of scrap tires and to report on scrap tire management programs. A summary of this data is presented in the Appendix, Table 1.

Approximately 9.5 million tires, which is 130 percent of the estimated 7.3 million total tires generated in North Carolina, were disposed in 1996-97. These tires were managed by county disposal facilities and private recycling facilities. In comparison, approximately 9.2 million tires were disposed in FY 1995-96, 9.3 million tires were disposed in 1994-95, and 7.6 million tires in FY 1993-94.

The counties reported that they managed about 8.9 million tires of which about 8.5 million were shipped to five private facilities, and about 400,000 tires were disposed in local landfills or shipped to out-of-state recyclers.

The six processing and recycling firms reported that in addition to receiving 8.5 million tires from county tire programs, they received about 600,000 directly from disposers who chose not to participate in the county tire programs. These may be individuals involved in privately funded cleanups not on state records, tire dealers who choose not to participate in a county program, or those who are not aware of the tire program.

North Carolina recycling firms reported receiving about 4 million tires from out-of-state disposers.

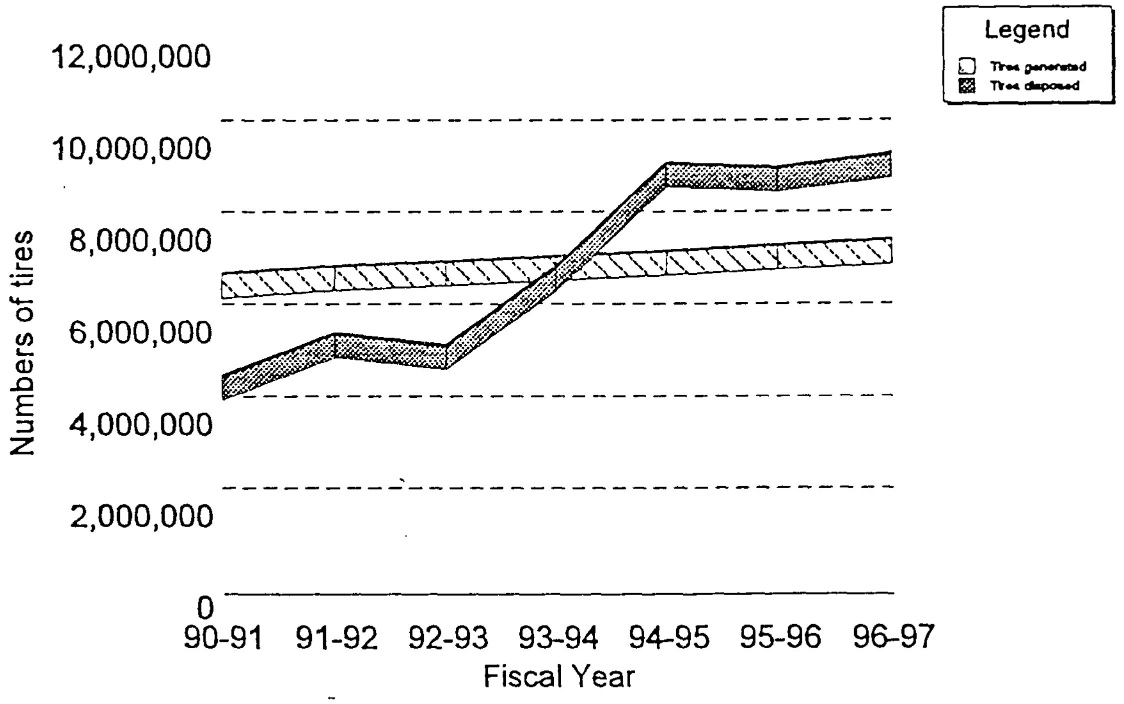
The numbers of tires managed by North Carolina counties and recycling firms can be summarized as follows:

8.5 million tires - Managed by counties and shipped to six recycling firms
0.4 million tires - Managed by counties and landfilled locally or shipped out-of-state
0.6 million tires - Tires taken directly to recycling firms (not managed by counties)
1.4 million tires - Cleaned up from nuisance tire sites.
4.0 million tires - Tires shipped to NC recycling firms from out-of-state disposers.
13.5 million tires - Total tires managed

The increased number of disposed tires over the past seven years reflects the success of the tire program. The program has been more firmly implemented as awareness of the regulations and cooperation of affected parties has increased.

However, the sudden increase in numbers of disposed tires after 1994 highlights a problem with illegal disposal of out-of-state tires at county collection sites. The Solid Waste Section estimates that counties spend about $1,000,000 per year to manage out-of-state tires which are inappropriately disposed as North Carolina tires.

Numbers of tires generated compared with numbers of tires disposed.



Note - Free disposal began January 1, 1994

This estimate is based on the cost of disposal in counties that receive volumes of tires greater than 120 percent of county population. It is assumed that some counties are regional retail centers and would receive a volume of tires up to 120 percent of county population. However, volumes of tires in excess of 120% are assumed to be out-of-state tires.

Counties which have reported receiving a number of tires over 120% of population are:

Bladen	120%	Jackson	168%	Pender	136%
Brunswick	137%	Johnston	252%	Pitt	308%
Burke	178%	Lincoln	159%	Rowan	150%
Carteret	129%	Macon	128%	Rutherford	254%
Chatham	133%	Madison	131%	Scotland	194%
Cherokee	133%	Mcdowell	161%	Stokes	127%
Cleveland	144%	Mecklenburg	168%	Tyrrell	153%
Craven	206%	Mitchell	132%	Vance	201%
Forsyth	164%	Moore	123%	Warren	123%
Gaston	159%	Northampton	132%	Wilkes	175%
Halifax	172%	Onslow	133%	Wilson	167%
Hertford	144%	Pamlico	140%	Yancey	175%
Hoke	149%	Pasquotank	139%		

Haulers in Virginia have complained about competing with North Carolina haulers who haul tires from Virginia tire dealers to North Carolina county collection sites. Since the haulers fraudulently obtain free disposal they can underbid Virginia tire haulers who must pay disposal costs at Virginia facilities.

The Solid Waste Section provides assistance to counties to aid in avoiding fraudulent disposal of out-of-state tires. Assistance to counties has consisted of visiting county collection sites, reviewing the scrap tire programs, reviewing certifications, and making suggestions for improvement. **Efforts being made to avoid abuse is a factor in eligibility for grants** from the Scrap Tire Disposal Account to cover cost over-runs. Scrap tire management legislation passed in 1997 provides a temporary time-limited position to assist counties in their effort to avoid providing free disposal for out-of-state tires.

It is important that counties avoid abuse by implementing policies such as:

- Improving screening of tire loads by requiring complete scrap tire certifications. These forms provide details on the origin of each load;
- Requiring proof of origin of scrap tires to document information claimed on the scrap tire certifications;
- Developing an inventory of all scrap tire disposers using county services;
- Visiting generators to discuss tire program requirements;

- Making spot checks of loads by calling to verify the origin and size of loads brought by haulers;
- Holding meetings with scrap tire disposers to discuss regulations and county requirements; and
- Providing details on county requirements by providing handouts or announcements on tv, radio, and in newspapers.

The Solid Waste Section has assisted a number of counties in avoiding out-of-state tires. Rockingham, Iredell, Duplin, and Buncombe counties have reported significant reductions in tire volumes and costs after aggressively screening for out-of-state tires.

The time-limited position provided for by 1997 legislation will be able to offer assistance to a greater number of counties and can offer more detailed help. *It is recommended that the position be funded as long as free tire disposal is offered by counties.*

5) **TIRE RECYCLING**

The numbers of tires the tire management facilities received from North Carolina counties and from cleanup programs can be summarized as follows:

Facility		Tires Received
US Tire Recycling, LP		3,305,600
Central Carolina Tire Recycling		3,909,700
TIRES, Inc		2,110,500
Envirotire Recycling (Lillington)		256,000
Envirotire Recycling (Kings Mtn)		91,600
Tire Disposal Service		834,400
	Total	10,507,800

North Carolina recycling firms diverted from landfills approximately 4.7 million scrap tires or about 45 percent of the total 10.5 million scrap tires they handled. In FY 1995-96, the recycling firms diverted approximately 4.8 million or 45 percent of the total tires disposed. In FY 1994-95, the recycling firms diverted approximately 4.2 million or 37 percent of the total tires disposed. These tires were used as tire-derived fuel (TDF), asphalt, used tires, retreading, agricultural products, civil engineering products, crumb rubber, and miscellaneous products.

Recycled tire materials are readily available in North Carolina since there is a large number of tire recyclers in the state. However, markets for these materials have not been strong the past seven years and have improved only slightly.

There was no increase in the recycling rate in FY 1996-97 in comparison with FY 1995-96. Part of the increase in the recycling rate in FY 1995-96 was due to recycling of tires removed from nuisance tire sites. State contracts for removal of tires from nuisance sites required that the tires be recycled. Fewer tires were removed from nuisance tire sites under state contract and recycled in FY 1996-97 than in the previous year. Also, US Tire recycled fewer North Carolina tires and recycled more Virginia tires than in the previous year because of incentives funded by the state of Virginia. This shows that improvements in tire recycling rates have been partially dependant on subsidies from state government.

In FY 1997-98 the Division will provide grants to companies that buy recycled tire products. This will enable businesses to make equipment modifications or other changes needed to use tire products. Grant applications will be evaluated by an interagency task force representing the North Carolina Division of Waste Management, the Division of Pollution Prevention and Environmental Assistance, and the Department of Commerce.

This program is authorized by changes made to the Scrap Tire Management Act in the recent legislative session in Senate Bill 153. These changes to GS 130A-309.63 establish a tire recycling market development program by the addition of a new allowed use of the funds in the Scrap Tire Disposal Account with inclusion of the following: "The Department may use up to forty percent of the revenue in the Account to make grants to encourage the use of processed scrap tire materials. These grants may be made to encourage the use of tire derived fuel, crumb rubber, carbon black, or other components of tires for use in products such as fuel, tires, mats, auto parts, gaskets, flooring material, or other applications of processed tire materials."

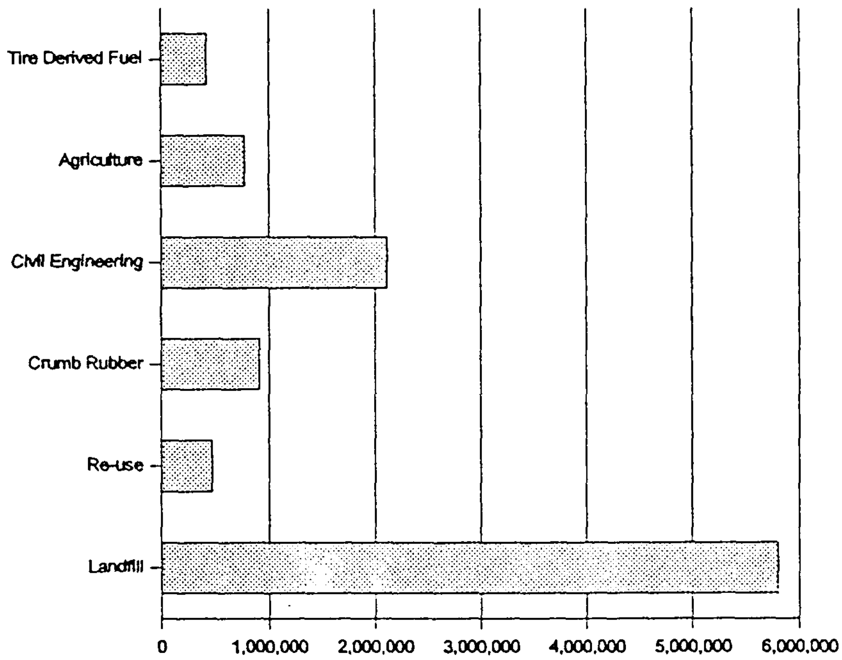
Tire Reuse, Re-manufacturing, and Retreading - 5 percent of North Carolina Tires - An estimated 473,000 scrap tires were diverted from landfills by North Carolina recycling firms for reuse, retreading, or re-manufacturing. Many of these tires had high tread remaining and were sold on the used tire market. This figure does not include the large number of tires that were sold directly as used tires or casings, and were not discarded as scrap tires originally. Tire retreading is a large part of the North Carolina tire industry and significant numbers of tires are imported into the state for retreading.

Tire-derived fuel (TDF) - 4 Percent of North Carolina Tires - Approximately 426,000 tires or approximately 4 percent of the scrap tires disposed in North Carolina were used as tire-derived fuel. These tires were shredded and shipped by TIRES, Inc. and US Tire to out-of-state markets. There are currently no users of TDF in North Carolina.

Crumb Rubber - 9 Percent of North Carolina Tires - About 909,000 tires were processed into crumb rubber and related products by TIRES, Inc. and Envirotire in FY 1996-97.

According to North Carolina tire recyclers, supply of crumb rubber exceeds demand nationally. Crumb rubber 40-mesh may become a commodity and may eventually have value as a substitute for plastics and other polymers in manufacturing products in the plastics industry.

END USES OF 10.6 MILLION TIRES DISPOSED IN NC IN FY 1996-97



Agricultural and Miscellaneous Products - 7 Percent of North Carolina Tires
Central Carolina sold about 776,000 tires for agricultural and other miscellaneous applications. Agricultural products include livestock bedding mats. Other items include mats, solid rubber wheels, barricades, and loading dock stops.

Civil Engineering Applications - 20 Percent of North Carolina Tires - TIRES, Inc. and US Tire shredded and sold 2,119,000 tires for civil engineering applications. This includes tire chips for construction of road beds and embankments. The tire chips used are 1 inch to 6 inches, and do not require the more expensive processing required to produce 10-to-40 mesh crumb rubber. This also includes tire chips for construction of septic tank drainfields in South Carolina.

Landfill Disposal - 55 Percent of North Carolina Tires - Approximately 5.8 million tires were landfilled or stockpiled. US Tire and Central Carolina operate tire monofills. Both facilities shred tires prior to landfilling and can recover or "mine" the landfilled tires for future recycling markets.

The tire monofills provide an essential service to the 100 counties by providing a low cost disposal option for tires that cannot be economically recycled. If landfilling of tires were banned counties would incur significant cost increases. If counties were allowed to pass such costs on to tire haulers and disposers, tire dumping would again endanger the environment and public health.

6) COUNTY COSTS OF TIRE DISPOSAL

The counties reported spending a total of $7,198,865 for scrap tire disposal. (Appendix, Table 1) A total of $7,031,045 was provided to counties through direct distribution by the Department of Revenue or Scrap Tire Disposal Account grants.

Costs per tire for disposal The reported costs for scrap tire disposal (Appendix, Table 2) varied greatly and ranged from 34 cents to $2.38 per tire ($34.00 to $238.00 per ton).

Tire disposal costs charged by recyclers are very competitive in North Carolina. Recyclers in North Carolina report that their contracts with counties typically charge 60 - 70 cents per tire, which includes transportation and trailer rental costs. Counties which are not near recycling facilities may pay as much as 70 - 90 cents per tire.

Some of the fluctuation among counties is probably due to errors in recordkeeping and reporting by the counties. Some counties are inefficient in their management of tires. For example, counties which allow citizens to dispose tires in "green boxes" incur subsequent labor costs for recovering the tires and loading into a trailer.

During the past five years the reported costs per tire have fluctuated. The average reported costs were:

Fiscal year	Average cost per tire	Average cost per ton
1990-91	$0.87	$87.00
1991-92	$0.88	$88.00
1992-93	$0.89	$89.00
1993-94	$0.78	$78.00
1994-95	$0.72	$72.00
1995-96	$0.81	$81.00
1996-97	$0.90	$90.00

The average tire disposal cost in FY 1996-97 was 90 cents per tire. The number of county programs totaled 97 since there are two regional programs which include Chowan, Perquimans, and Gates counties and Mitchell and Yancey counties.

<u>Types of tires received at county tire collection sites</u> In FY 1996-97 counties reported receiving tires in three size categories in the following percentages: 81 percent passenger car tires, 16 percent truck tires, and 3 percent off-road tires (large tires from tractors and other large off-road equipment).

Some counties have expressed concern about the tax rate being lower on truck tires than on passenger car tires, since larger tires are more expensive to dispose. An analysis of revenue and costs of disposal was presented in the FY 1994-95 report. At an estimated weight of 20 pounds per auto tire, 100 pounds per truck tire and 500 pounds per off-road tire, the costs of disposal were $0.72 per passenger tire, $3.60 per truck tire and $37.50 per off-road tire.

Total disposal costs for passenger car tires are less than tax revenues collected from the sale of new replacement tires. Total disposal costs for truck tires and off-road tires exceed tax revenues collected from the sale of new replacement tires.

7) TIRE DISPOSAL TAX REVENUE DISTRIBUTION

The state's 2 percent tire disposal tax revenue (initiated October 1993) was distributed to the counties on a per capita basis. This subsidized the counties for tire disposal costs, but did not cover total expenses in many counties. The counties received $6,206,045 which was about 7 percent more than in the previous year.

FISCAL YEAR	DISTRIBUTION OF PROCEEDS OF DISPOSAL TAX TO THE 100 COUNTIES
FY 1990-91	$2,814,337
FY 1991-92	$3,637,903
FY 1992-93	$3,478,739
FY 1993-94	$4,045,702
FY 1994-95	$5,675,341
FY 1995-96	$5,818,752
FY 1996-97	$6,206,045

The total distributed to the counties represented 91 percent of the total reported disposal costs of $7,198,866. (Appendix, Table 3) This provided an average of 69 cents for each of the 9.0 million scrap tires handled by the counties.

On January 1, 1994, counties discontinued charging tipping fees for disposal of tires that were certified as generated in North Carolina, in accordance with G.S. 130A-309.58. Counties may charge a fee for tires presented for disposal without an accompanying scrap tire certification form certifying that the tires were generated in North Carolina. The large increase in volume of tires being managed is the reason most counties reporting a deficit have insufficient funds.

8) SCRAP TIRE DISPOSAL ACCOUNT

The General Assembly created the Scrap Tire Disposal Account effective October 1, 1993. It consists of 27 percent of the net tax proceeds of the 2 percent disposal tax. Effective, July 1, 1997 new legislation allows up to 50 percent of the account to fund grants to counties that incur losses in their tire management programs each six months (GS 130A-309.63). Forty percent can be used for grants to encourage increased recycling market demand for processed tire material, and the remainder may be used to clean up nuisance tire sites.

Total grant requests from the Scrap Tire Disposal Account the past four years has been $3,388,561.53 and grant awards have totalled $1,952,320.48.

Grant requests from the Scrap Tire Disposal Account for the two most recent six-month periods were as follows:

	April - Sept 1996	Oct 1996 - Mar 1997
Number of applicants -	30 counties	36 counties
Requested funds -	$ 509,885	$ 395,822
Total funds available -	$ 314,640	$ 301,479

The grants awarded by county for the two periods are presented in Tables 4 and 5 in the appendix. The legislation establishing the grants for county reimbursement requires the department to take into consideration the following when making grant awards: financial ability to provide for scrap tire disposal, the severity of the county's scrap tire disposal problem, efforts made to ensure that only tires generated in North Carolina in the normal course of business are given free disposal, and the efforts made by a county to provide for scrap tire disposal within the resources available to it.

9) NUISANCE TIRE SITE CLEANUPS

The Nuisance Tire Site Cleanup Program is funded from the Scrap Tire Disposal Account, which made initial allocations of funds in 1994. Since that time approximately 6 million tires at 300 sites has been cleaned up.

Seven of the eight highest priority sites in North Carolina, each having more than 100,000 tires, have been cleaned up under state contract. The contracts required the nuisance tires to be recycled into reusable products like crumb rubber, civil engineering materials, tire-derived fuel, as well as for reuse as used tires and recapped tires. The remaining site in Greene County is scheduled for completion in the spring of 1998.

These eight sites represent about 50 percent of the known nuisance tires found in the state and were located in Richmond, Pender, Greene, Brunswick, Chatham, Iredell and two sites in Harnett counties. The status of these sites are shown in the following table.

SITE #	COUNTY	REMAINING TIRES	CLEARED TIRES	FINISH DATE
90	PENDER	0	538,730	JUNE 1995
133	RICHMOND	0	550,210	JUNE 1996
160	BRUNSWICK	0	64,197	FEBRUARY 1996
101	GREENE	482,000*	318,073*	DECEMBER 1997
129	HARNETT	0	166,263	NOVEMBER 1996
118	IREDELL	0	209,163	JULY 1997
130	HARNETT	0	118,693**	NOVEMBER 1997
137	CHATHAM	0	350,861	AUGUST 1997

* All tires baled; awaiting transport to end use ** All tires removed;erosion control to be finished

The effort to clean up smaller high priority nuisance tire sites is also underway at 40 nuisance tire sites in 18 counties at this time. These cleanup actions use each county's current generation scrap tire contractor for recycling the tires, and more than half of the cleanups are using minimum security inmate labor under an agreement between the Solid Waste Section, the county, and the North Carolina Division of Prisons. Inmates have assisted in removing more than 550,000 tires. Inmates load the tires onto contractor-supplied trucks, and the Solid Waste Section uses funds from the Scrap Tire Disposal Account to pay for processing of the tires.

As the Nuisance Tire Site Cleanup Program has progressed, and more funds for cleanup became available, counties were asked to locate any and all collection points of scrap tires for removal using cleanup funds. This "good news" program has been well received and has allowed more than half of the counties in the state to rid themselves of all of their nuisance tire sites. So far, 35 counties have cleaned up more than 1000 sites of about 180,000 nuisance tires since the section began this project in November 1995. Additionally, 11 smaller sites being cleared by responsible parties are expected to be completed by early 1998.

There have been 38 new nuisance tire sites discovered in the last 12 months. These sites collectively contained more than 295,000 nuisance tires. Already, 20 of these newly discovered sites have been cleared of more than 185,000 tires. Since the Nuisance Tire Site Cleanup Program was initiated on June 1, 1993, there have been 138 new sites discovered, which brings the overall current total of known tire sites to 293.

TABLE 1. COUNTY REPORTS OF TIRE DISPOSAL ACTIVITIES IN FY 1996-97.					
COUNTY	2% TAX REVENUE	NUMBER TIRES DISPOSED	TOTAL EXPENSES	NET SURPLUS OR NET LOSS	MEANS OF TIRE DISPOSAL
ALAMANCE	$99,458.19	156,490	$117,946.09	($18,487.90)	CENTRAL CAROLINA
ALEXANDER	$26,024.19	33,103	$24,457.75	$1,566.44	TIRES INC
ALLEGHANY	$8,296.86	10,556	$12,974.93	($4,678.07)	US TIRE
ANSON	$20,555.05	30,531	$19,845.15	$709.90	TIRE DISPOSAL
ASHE	$19,833.83	29,787	$47,549.51	($27,715.68)	TIRES INC
AVERY	$13,100.09	11,460	$9,073.66	$4,026.43	US TIRE
BEAUFORT	$37,378.27	48,025	$51,207.31	($13,829.04)	CENTRAL CAROLINA
BERTIE	$17,803.16	20,031	$17,803.16	$0.00	EAST MOBILE RECYCLER
BLADEN	$25,698.05	31,977	$21,862.80	$3,835.25	CENTRAL CAROLINA
BRUNSWICK	$52,395.97	122,040	$86,663.80	($34,267.83)	CENTRAL CAROLINA
BUNCOMBE	$162,811.43	159,298	$127,200.16	$35,611.27	US TIRE
BURKE	$70,253.48	109,112	$78,096.16	($7,842.68)	US TIRE
CABARRUS	$95,182.11	119,600	$46,357.59	$48,824.52	US TIRE
CALDWELL	$63,599.05	71,095	$62,208.50	$1,390.55	US TIRE
CAMDEN	$5,448.41	3,848	$38.50	$5,409.91	ATLANTIC OPERATIONS
CARTERET	$49,698.50	146,901	$174,526.14	($124,827.64)	CENTRAL CAROLINA
CASWELL	$18,436.36	7,737	$18,392.20	$44.16	CENTRAL CAROLINA
CATAWBA	$108,899.84	228,114	$150,519.74	($41,619.90)	US TIRE
CHATHAM	$37,019.37	44,102	$30,972.00	$6,047.37	CENTRAL CAROLINA
CHEROKEE	$18,826.28	13,303	$14,000.00	$4,826.28	US TIRE
CLAY	$6,669.94	8,720	$10,030.00	($3,360.06)	US TIRE
CLEVELAND	$76,892.40	134,319	$128,940.94	($52,048.54)	US TIRE
COLUMBUS	$44,225.89	51,947	$37,401.76	$6,824.13	CENTRAL CAROLINA
CRAVEN	$74,028.37	146,901	$174,526.14	($100,497.77)	CENTRAL CAROLINA
CUMBERLAND	$253,625.11	343,000	$281,242.93	($27,617.82)	CENTRAL CAROLINA
CURRITUCK	$13,645.23	14,718	$17,311.00	($3,665.77)	WEEMS, VA
DARE	$22,219.94	26,285	$18,162.37	$4,057.57	Landfill and SPSA
DAVIDSON	$117,840.19	163,021	$98,278.21	$19,561.98	US TIRE
DAVIE	$25,650.64	30,300	$22,908.00	$2,742.64	TIRES INC
DUPLIN	$36,896.87	49,870	$45,297.85	($8,400.98)	CENTRAL CAROLINA
DURHAM	$166,408.63	177,015	$157,870.70	$8,537.93	CENTRAL CAROLINA
EDGECOMBE	$49,007.52	73,459	$68,459.85	($19,452.33)	CENTRAL CAROLINA
FORSYTH	$241,456.67	584,635	$352,917.47	($111,460.80)	TIRES INC
FRANKLIN	$35,928.16	36,308	$43,787.38	($7,859.22)	CENTRAL CAROLINA
GASTON	$153,931.37	220,730	$169,043.60	($15,112.23)	US TIRE
GRAHAM	$6,440.44	5,383	$4,200.00	$2,240.44	RCC CONTRACTING
GRANVILLE	$35,480.46	35,883	$26,714.94	$8,765.52	CENTRAL CAROLINA
GREENE	$14,487.21	14,223	$11,438.22	$3,048.99	CENTRAL CAROLINA
GUILFORD	$320,986.13	630,178	$407,831.66	($86,845.53)	TIRES INC
HALIFAX	$49,574.25	25,225	$50,650.00	($1,075.75)	US TIRE
HARNETT	$66,388.86	90,775	$62,489.51	$3,899.35	CENTRAL CAROLINA
HAYWOOD	$43,085.46	46,866	$61,750.15	($18,664.69)	WASTE RECOVERY
HENDERSON	$65,776.38	77,100	$101,484.23	($35,707.85)	TIRES INC
HERTFORD	$19,381.79	19,399	$29,750.00	($10,368.21)	CENTRAL CAROLINA
HOKE	$23,579.43	26,751	$19,552.00	$4,027.43	CENTRAL CAROLINA
HYDE	$4,495.23	13,174	$12,773.17	($8,277.94)	CENTRAL CAROLINA
IREDELL	$89,250.56	158,900	$154,583.00	($65,332.44)	US TIRE
JACKSON	$24,842.36	19,299	$26,053.65	($1,211.29)	WASTE RECOVERY
JOHNSTON	$82,307.17	107,426	no data	$82,307.17	CENTRAL CAROLINA
JONES	$8,196.81	28,668	$18,920.76	($10,723.95)	CENTRAL CAROLINA
LEE	$39,693.55	46,765	$34,732.09	$4,961.46	CENTRAL CAROLINA
LENOIR	$50,967.40	80,399	$54,878.76	($3,911.36)	CENTRAL CAROLINA
LINCOLN	$47,955.97	78,800	$57,965.15	($10,009.18)	ENVIROTIRE, KINGS MTN
MACON	$22,673.66	36,100	$39,900.00	($17,226.34)	US TIRE
MADISON	$15,336.00	18,128	$23,615.85	($8,279.85)	US TIRE
MARTIN	$22,292.36	27,163	$20,101.00	$2,191.36	CENTRAL CAROLINA
MCDOWELL	$32,128.21	47,003	$42,064.88	($9,936.67)	US TIRE
MECKLENBURG	$498,157.04	783,326	$498,675.00	($517.96)	TIRE DISPOSAL SERVICE
MITCHELL	$12,799.84	24,687	$23,190.00	($10,390.16)	TIRES INC
MONTGOMERY	$20,555.05	39,366	$23,592.96	($3,037.91)	CENTRAL CAROLINA
MOORE	$57,503.66	51,787	$60,321.58	($2,817.92)	CENTRAL CAROLINA
NASH	$72,432.48	98,679	$85,109.50	($12,677.02)	TIRES INC

TABLE 1. COUNTY REPORTS OF TIRE DISPOSAL ACTIVITIES IN FY 1996-97.

COUNTY	2% TAX REVENUE	NUMBER TIRES DISPOSED	TOTAL EXPENSES	NET SURPLUS OR NET LOSS	MEANS OF TIRE DISPOSAL
NEW HANOVER	$120,404.84	241,417	$194,084.00	($73,679.16)	ENVIROTIRE
NORTHAMPTON	$17,879.11	30,000	$27,705.00	($9,825.89)	US TIRE
ONSLOW	$127,594.98	135,293	$109,807.48	$17,787.50	CENTRAL CAROLINA
ORANGE	$91,285.51	105,500	$91,918.00	($632.49)	US TIRE
PAMLICO	$10,238.67	No data	No data	$10,238.67	No data
PASQUOTANK	$28,717.30	55,602	$62,304.66	($33,587.36)	ATLANTIC OPERATIONS
PENDER	$29,908.61	37,200	$49,115.00	($19,206.39)	CENTRAL CAROLINA
PE/CH/GA*	$29,742.98	23,884	$41,424.35	($11,681.37)	ATLANTIC WASTE DISPOSAL
PERSON	$27,724.46	38,076	$27,902.00	($177.54)	CENTRAL CAROLINA
PITT	$101,291.28	171,431	$113,887.00	($12,595.72)	CENTRAL CAROLINA
POLK	$13,580.56	17,347	$0.00	$13,580.56	US TIRE
RANDOLPH	$99,676.46	153,700	$98,262.91	$1,413.55	CENTRAL CAROLINA
RICHMOND	$39,167.34	62,765	$27,618.00	$11,549.34	CENTRAL CAROLINA
ROCKINGHAM	$95,744.50	107,256	$96,737.25	($992.75)	CENTRAL CAROLINA
ROBESON	$76,200.55	70,780	$78,800.00	($2,599.45)	ROBESON CO LANDFILL
ROWAN	$102,546.45	98,663	$114,762.50	($12,216.05)	TIRES INC/US TIRE
RUTHERFORD	$50,966.59	104,075	$83,684.54	($32,717.95)	US TIRE
SAMPSON	$43,583.20	35,556	$30,706.39	$12,876.81	CENTRAL CAROLINA
SCOTLAND	$29,949.19	48,967	$31,484.88	($1,535.69)	CENTRAL CAROLINA
STANLY	$46,396.26	83,710	$77,947.22	($31,550.96)	US TIRE
STOKES	$35,429.51	37,594	$26,734.32	$8,695.19	TIRES INC
SURRY	$56,137.21	115,413	$39,552.30	$16,584.91	SURRY CO LANDFILL
SWAIN	$9,979.01	12,331	$15,000.00	($5,020.99)	WASTE RECOVERY
TRANSYLVANIA	$23,436.25	27,780	$21,948.00	$1,488.25	US TIRE
TYRRELL	$3,288.39	5,838	$4,538.85	($1,250.46)	ATLANTIC OPERATIONS
UNION	$84,704.44	120,764	$96,611.20	($11,906.76)	TIRE DISPOSAL SERVICE
VANCE	$34,540.98	42,972	$35,483.50	($942.52)	CENTRAL CAROLINA
WAKE	$447,081.87	467,605	$530,833.54	($83,751.67)	CENTRAL CAROLINA
WARREN	$15,645.75	15,846	$15,210.00	$435.75	CENTRAL CAROLINA
WASHINGTON	$11,875.14	23,167	$10,000.00	$1,875.14	CENTRAL CAROLINA
WATAUGA	$34,620.36	36,482	$34,441.24	$179.12	US TIRE
WAYNE	$95,768.71	115,322	$98,250.00	($2,481.29)	CENTRAL CAROLINA
WILKES	$53,532.04	83,310	$78,368.62	($24,836.58)	US TIRE
WILSON	$58,520.71	137,600	$89,457.00	($30,936.29)	CENTRAL CAROLINA
YADKIN	$29,046.84	26,776	$26,747.54	$2,299.30	TIRES INC
YANCEY	$13,925.63	25,876	$27,327.22	($13,401.59)	US TIRE
TOTALS	$6,206,044.86	9,005,689	$7,198,865.92	($992,821.06)	
AVERAGES		92,842	74,988	(10,131)	

TABLE 2. EXPENSES INCURRED BY NORTH CAROLINA COUNTIES FOR TIRE DISPOSAL IN 1991 - 1997.										
	---------FY 1992-93----------		---------FY 1993-94---------		---------FY 1994-95---------		---------FY 1995-96---------		---------FY 1996-97---------	
COUNTY	TOTAL COSTS	COST PER TIRE	TOTAL COSTS	COST PER TIRE	TOTAL COSTS	COST PER TIRE	TOTAL COSTS	COST PER TIRE	TOTAL COSTS	COST PER TIRE
ALAMANCE	$113,220.00	$1.01	$123,599.00	$0.96	$145,500.00	$0.95	$96,534.13	$0.66	$117,946.09	$0.75
ALEXANDER	$19,722.55	$1.07	$18,646.47	$0.95	$19,761.01	$0.93	$25,393.55	$1.02	$24,457.75	$0.74
ALLEGHANY	$5,893.60	$0.96	$7,041.80	$0.81	$7,910.00	$0.90	$7,500.00	$1.20	$12,974.93	$1.23
ANSON	$15,674.50	$0.81	$26,490.85	$1.08	$24,197.94	$1.96	No data	No data	$19,845.15	$0.65
ASHE	$16,523.00	$1.30	$15,611.50	$0.60	$21,558.97	$0.71	$29,399.70	$0.98	$47,549.51	$1.60
AVERY	$10,820.00	$1.46	No data	$1.00	$12,165.00	$0.83	$13,000.00	No data	$9,073.66	$0.79
BEAUFORT	$56,542.00	$0.89	$64,933.00	$0.56	$65,000.00	$0.30	$75,054.00	$1.01	$51,207.31	$1.07
BERTIE	$13,227.62	$18.90	$11,838.00	No data	$0.00	$0.00	No data	No data	$17,803.16	$0.89
BLADEN	$19,548.44	$0.64	$30,028.25	$0.57	$11,844.30	$0.30	$38,790.20	$1.24	$21,862.80	$0.68
BRUNSWICK	$37,452.00	$0.65	$57,202.90	$0.97	$59,716.35	$0.83	$65,606.14	$0.72	$86,663.80	$0.71
BUNCOMBE	$134,317.00	$0.60	$121,330.00	$0.49	$170,768.42	$0.71	$196,708.42	$0.93	$127,200.16	$0.80
BURKE	$51,000.00	$1.28	$65,000.00	$0.98	$63,944.00	$0.84	$89,838.96	$0.67	$78,096.16	$0.72
CABARRUS	$51,419.62	$0.42	$63,658.57	$9.76	$70,591.36	$0.42	$51,851.95	$0.56	$46,357.59	$0.39
CALDWELL	$46,604.50	$0.43	$54,676.06	$0.71	$56,055.74	$0.76	$59,205.50	$0.81	$62,208.50	$0.88
CAMDEN	$2,713.00	$0.77	$2,978.25	$0.88	$4,144.00	$1.27	$183.70	$0.05	$38.50	$0.01
CARTERET	$28,593.00	$1.28	$37,820.00	$1.61	$11,900.00	$0.32	$45,429.94	$1.15	$174,526.14	$1.19
CASWELL	$12,465.00	$0.63	$18,878.34	$0.99	$17,752.00	$1.30	$23,186.00	$2.50	$18,392.20	$2.38
CATAWBA	$112,514.00	$0.82	$164,683.00	$0.72	$144,022.00	$0.74	$170,305.83	$0.68	$150,519.74	$0.66
CHATHAM	$30,703.00	$1.42	$28,067.43	$0.78	$31,827.83	$0.91	$35,236.00	$0.82	$30,972.00	$0.70
CHEROKEE	$13,230.00	$1.38	$16,725.00	$1.05	$10,375.00	$1.30	$14,000.00	$1.06	$14,000.00	$1.05
CLAY	$3,014.00	$1.02	$5,279.00	$1.31	$6,663.25	$1.33	$7,330.00	$1.15	$10,030.00	$1.15
CLEVELAND	$99,127.59	$1.04	$101,972.38	$0.98	$100,099.29	$0.85	$105,795.82	$0.99	$128,940.94	$0.96
COLUMBUS	$33,609.70	$0.56	$26,885.00	$6.72	$52,728.00	$0.82	$49,273.00	$0.71	$37,401.76	$0.72
CRAVEN	$70,550.00	$1.50	$60,350.00	$1.71	$90,950.00	$1.17	$82,600.00	$1.15	$174,526.14	$1.19
CUMBERLAND	$184,722.00	$1.21	$150,188.00	$0.74	$221,981.00	$0.81	$164,510.00	$0.71	$281,242.93	$0.82
CURRITUCK	$11,964.64	$2.19	$14,750.82	$1.61	$12,210.78	$0.18	$12,327.42	$1.12	$17,311.00	$1.18
DARE	$20,880.85	$0.87	$21,940.00	$1.07	$15,725.00	$0.74	$17,297.50	$0.72	$18,162.37	$0.69
DAVIDSON	$81,653.72	$0.83	$73,000.00	$0.60	$114,607.45	$0.69	$129,629.11	$0.78	$98,278.21	$0.60
DAVIE	$22,600.30	$2.68	$11,947.37	$0.47	$38,969.71	$2.40	$16,759.01	$0.64	$22,908.00	$0.76
DUPLIN	$32,195.73	$1.77	$63,413.96	$0.75	$48,100.23	$0.88	$41,804.89	$0.87	$45,297.85	$0.91
DURHAM	$130,505.63	$0.92	$114,663.37	$0.74	$110,969.84	$0.84	$158,888.00	$0.90	$157,870.70	$0.89
EDGECOMBE	$31,000.00	$0.71	$44,773.00	$0.55	$51,500.00	$1.01	$50,000.56	$1.03	$68,459.85	$0.93
FORSYTH	$163,949.13	$0.46	$219,890.76	No data	$337,574.00	$0.53	$387,000.00	$0.65	$352,917.47	$0.60
FRANKLIN	$24,989.70	$0.68	$38,027.05	$0.90	$34,293.08	$0.79	$36,275.00	$1.20	$43,787.38	$1.21
GASTON	$122,892.00	$1.25	$134,478.60	$0.78	$153,777.30	$0.80	$127,149.80	$1.17	$169,043.60	$0.77
GRAHAM	$8,085.00	$1.13	$9,832.00	$1.52	$19,100.00	$2.71	$6,187.50	$1.27	$4,200.00	$0.78
GRANVILLE	$25,623.00	$0.75	$45,950.98	$1.51	$24,002.64	$0.72	$28,544.02	$0.74	$26,714.94	$0.74
GREENE	$15,949.65	$0.32	$14,249.40	$0.94	$11,711.40	$0.57	$17,129.60	$0.69	$11,438.22	$0.80
GUILFORD	$313,825.19	$0.80	$273,294.95	No data	$359,011.36	$0.65	$366,384.45	$0.68	$407,831.66	$0.65
HALIFAX	$28,225.00	$1.52	$44,760.00	$0.93	$43,152.35	$3.50	$39,524.00	$1.25	$50,650.00	$2.01
HARNETT	$41,810.00	$4.40	$46,060.76	$0.92	$58,318.82	$0.69	$56,445.47	$0.69	$62,489.51	$0.69
HAYWOOD	$49,504.57	$1.24	$58,039.25	$1.23	$61,170.00	$1.25	$58,029.00	$1.28	$61,750.15	$1.32
HENDERSON	$51,363.29	$0.75	$70,109.37	$1.03	$87,220.00	$1.03	$86,854.00	$1.08	$101,484.23	$1.32
HERTFORD	$20,700.00	$1.32	$21,175.00	$1.25	$26,250.00	$1.55	$30,625.00	$1.65	$29,750.00	$1.53
HOKE	$13,635.04	$0.74	$0.00	No data	$11,637.00	$0.70	$0.00	$0.00	$19,552.00	$0.73
HYDE	$5,628.00	$1.73	$4,335.08	$1.45	$7,980.86	$0.95	$4,966.68	$0.98	$12,773.17	$0.97
IREDELL	$129,450.00	$1.46	$95,345.00	$0.77	$98,774.91	$0.71	$94,698.95	$0.71	$154,583.00	$0.97
JACKSON	$11,033.75	$1.51	$22,137.00	$1.33	$14,530.75	$1.31	$21,986.75	$1.12	$26,053.65	$1.35
JOHNSTON	$95,329.54	$0.76	$78,847.74	$0.75	$80,868.00	$0.68	$95,110.00	$0.82	No data	no data
JONES	$8,000.00	$0.98	$12,539.00	$0.57	$20,899.00	$0.63	$19,859.40	$0.66	$18,920.76	$0.66
LEE	$20,887.61	$3.72	$23,774.00	$0.94	$29,000.00	$0.55	$39,424.26	$0.94	$34,732.09	$0.74
LENOIR	$46,995.00	$0.62	$49,260.00	$0.59	$25,715.40	$0.60	$49,375.62	$0.60	$54,878.76	$0.68
LINCOLN	$57,000.00	$2.07	$60,000.00	$0.88	$55,000.00	$0.97	$55,000.00	$0.57	$57,965.15	$0.74
MACON	$24,318.00	$1.30	$36,409.00	$1.57	$39,539.00	$1.34	$36,275.00	$1.20	$39,900.00	$1.11

TABLE 2. EXPENSES INCURRED BY NORTH CAROLINA COUNTIES FOR TIRE DISPOSAL IN 1991 - 1997.

COUNTY	FY 1992-93 TOTAL COSTS	FY 1992-93 COST PER TIRE	FY 1993-94 TOTAL COSTS	FY 1993-94 COST PER TIRE	FY 1994-95 TOTAL COSTS	FY 1994-95 COST PER TIRE	FY 1995-96 TOTAL COSTS	FY 1995-96 COST PER TIRE	FY 1996-97 TOTAL COSTS	FY 1996-97 COST PER TIRE
MADISON	$26,739.17	$1.23	$22,849.72	$1.70	$24,556.70	$1.20	$24,400.00	$1.60	$23,615.85	$1.30
MARTIN	$26,478.00	$0.99	$18,656.14	$0.74	$26,952.00	$0.74	$46,328.25	$0.74	$20,101.00	$0.74
MCDOWELL	$23,478.00	$0.84	$23,511.14	$0.75	$36,574.00	$0.08	$37,851.50	$0.91	$42,064.88	$0.89
MECKLENBURG	$222,925.00	$0.69	$309,095.00	$0.72	$427,442.00	$0.78	$594,745.00	$0.80	$498,675.00	$0.64
MITCHELL	$14,003.00	$0.78	$17,550.00	$0.81	$19,595.11	$0.87	$22,023.75	$0.92	$23,190.00	$0.94
MONTGOMERY	$17,555.80	$0.63	$18,283.52	$0.64	$20,773.76	$0.64	$22,056.32	$0.64	$23,592.96	$0.60
MOORE	$46,130.00	$6.33	$32,608.58	$4.08	$24,366.23	$0.63	$46,045.47	$1.08	$60,321.58	$1.16
NASH	$45,868.88	$0.84	$52,857.00	$0.79	$66,236.25	$0.86	$87,750.00	$0.93	$85,109.50	$0.86
NEW HANOVER	$153,242.54	$0.82	$194,510.25	$0.83	$172,000.00	$0.82	$196,799.00	$0.83	$194,084.00	$0.80
NORTHAMPTON	$11,375.00	$0.93	$16,050.00	$1.57	$12,550.00	$1.37	$11,250.00	$0.94	$27,705.00	$0.92
ONSLOW	$65,592.64	$0.91	$114,504.00	$0.90	$97,040.66	$0.60	$111,523.62	$0.71	$109,807.48	$0.81
ORANGE	$43,100.00	$1.61	$69,815.00	$0.92	$117,183.00	$0.77	$106,166.00	$1.16	$91,918.00	$0.87
PAMLICO	$13,545.79	$18.51	$8,607.60	$1.44	$6,000.00	$0.74	$9,637.00	$1.18	No data	No data
PASQUOTANK	$48,097.80	$1.32	$52,515.00	$1.42	$37,342.50	$1.19	$47,571.10	$0.81	$62,304.66	$1.12
PENDER	$14,535.00	$0.86	$25,265.00	$1.15	$41,084.60	$1.12	$44,170.00	$1.36	$49,115.00	$1.32
PE/CH/GA*	$24,877.67	$2.44	$33,314.00	No data	$48,792.00	$3.35	$31,061.38	$0.79	$41,424.35	$1.73
PERSON	$23,551.16	$0.85	$21,805.00	$0.70	$26,743.88	$0.84	$24,149.00	$0.73	$27,902.00	$0.73
PITT	$70,000.00	$0.47	$70,000.00	$0.41	$136,901.00	$0.87	$113,662.68	$0.68	$113,887.00	$0.66
POLK	$8,732.90	$0.88	$9,804.38	$1.14	$0.00	$0.00	$17,258.00	$0.96	$0.00	$0.00
RANDOLPH	$76,703.96	$0.72	$79,327.12	No data	$100,755.22	$0.68	$102,351.17	$0.65	$98,262.91	$0.64
RICHMOND	$48,380.00	$1.25	$54,436.88	No data	$69,431.00	$0.76	$36,238.00	$2.85	$27,618.00	$0.44
ROCKINGHAM	$57,036.70	$2.18	$107,249.47	$0.89	$246,492.00	$0.97	$227,494.17	$2.62	$96,737.25	$0.90
ROBESON	$83,269.00	$1.33	$93,517.60	$2.12	$91,270.00	$1.17	$74,000.00	$0.41	$78,800.00	$1.11
ROWAN	$68,507.00	$1.18	$104,143.03	$0.82	$88,009.00	$0.85	$150,108.00	$1.21	$114,762.50	$1.16
RUTHERFORD	$45,768.38	$1.24	$51,151.00	$0.95	$45,568.00	$1.41	$65,586.28	$1.47	$83,684.54	$0.80
SAMPSON	$0.00	$0.00	$25,210.25	$0.99	$75,458.17	$0.97	$40,986.95	$0.42	$30,706.39	$0.86
SCOTLAND	$17,100.00	$0.95	$12,752.46	No data	$31,576.00	$0.54	$31,077.00	$0.63	$31,484.88	$0.64
STANLY	$30,151.00	$0.42	$41,037.90	$0.47	$41,640.00	$0.51	$62,382.50	$0.76	$77,947.22	$0.93
STOKES	$20,168.90	$0.64	$27,664.42	$0.67	$77,449.58	$2.04	$37,031.83	$0.71	$26,734.32	$0.71
SURRY	$31,610.80	$0.40	$31,328.80	$0.44	$38,798.55	$0.34	$72,684.00	$0.74	$39,552.30	$0.34
SWAIN	$8,835.50	$0.76	$13,345.00	$1.25	$18,000.00	$1.35	$17,226.00	$1.52	$15,000.00	$1.22
TRANSYLVANIA	$11,469.60	$0.90	$14,433.90	$0.62	$17,885.00	$0.86	$20,043.16	$0.78	$21,948.00	$0.79
TYRRELL	$2,264.60	$1.36	No data	$0.00	$2,254.50	$1.33	$5,317.60	$0.85	$4,538.85	$0.78
UNION	$50,102.00	$1.51	$60,903.99	$0.94	$97,761.40	$0.96	$105,213.60	$0.80	$96,611.20	$0.80
VANCE	$25,892.13	$1.12	No data	$0.00	$32,612.45	$0.76	$33,533.50	$0.65	$35,483.50	$0.83
WAKE	$207,572.00	$1.63	$370,619.00	$0.81	$497,874.00	$1.02	$478,320.00	$0.81	$530,833.54	$1.14
WARREN	$17,671.00	$3.42	No data	$0.00	$16,181.00	$0.94	$21,592.46	$0.74	$15,210.00	$0.96
WASHINGTON	$16,660.00	$1.66	$18,500.00	$0.90	$20,312.00	$0.51	No data	No data	$10,000.00	$0.43
WATAUGA	$22,815.35	$0.98	$34,691.11	$1.14	$31,723.49	$0.94	$19,930.20	$0.61	$34,441.24	$0.94
WAYNE	$106,088.25	$0.86	$83,592.00	$0.82	$88,752.00	$0.54	$87,750.00	$0.83	$98,250.00	$0.85
WILKES	$29,013.00	$1.77	$46,092.00	$1.36	$67,368.80	$1.26	$77,081.00	$0.83	$78,368.62	$0.94
WILSON	$38,272.50	$0.50	$44,101.80	$0.60	$73,106.60	$0.26	$97,533.00	$1.50	$89,457.00	$0.65
YADKIN	$22,321.77	$1.14	$19,179.91	$1.49	$31,925.20	$1.81	$20,677.46	$0.88	$26,747.54	$1.00
YANCEY	$16,009.55	$1.05	$18,256.25	$0.68	$10,503.84	$0.59	$20,866.95	$1.04	$27,327.22	$1.06
TOTALS	$4,746,711.80		$5,440,021.48		$6,667,905.83		$7,029,756.73		$7,198,865.92	
AVERAGES	$48,435.83	$0.89	$55,510.42	$0.78	$68,039.86	$0.72	$73,997.44	$0.81	$74,988.19	$0.90

TABLE 3. PERCENTAGE OF COUNTY TIRE PROGRAM EXPENSES MET BY THE 2% STATE TIRE DISPOSAL TAX REVENUE RECEIVED JULY 1996 - JUNE 1997.

COUNTY	SHARE OF 2% TAX RECEIVED	COST OF THE PROGRAM	PERCENTAGE OF COSTS COVERED
ALAMANCE	$99,458.19	$117,946.09	84%
ALEXANDER	$26,024.19	$24,457.75	106%
ALLEGHANY	$8,296.86	$12,974.93	64%
ANSON	$20,555.05	$19,845.15	104%
ASHE	$19,833.83	$47,549.51	42%
AVERY	$13,100.09	$9,073.66	144%
BEAUFORT	$37,378.27	$51,207.31	73%
BERTIE	$17,803.16	$17,803.16	100%
BLADEN	$25,698.05	$21,862.80	118%
BRUNSWICK	$52,395.97	$86,663.80	60%
BUNCOMBE	$162,811.43	$127,200.16	128%
BURKE	$70,253.48	$78,096.16	90%
CABARRUS	$95,182.11	$46,357.59	205%
CALDWELL	$63,599.05	$62,208.50	102%
CAMDEN	$5,448.41	$38.50	100%
CARTERET	$49,698.50	$174,526.14	28%
CASWELL	$18,436.36	$18,392.20	100%
CATAWBA	$108,899.84	$150,519.74	72%
CHATHAM	$37,019.37	$30,972.00	120%
CHEROKEE	$18,826.28	$14,000.00	134%
CLAY	$6,669.94	$10,030.00	66%
CLEVELAND	$76,892.40	$128,940.94	60%
COLUMBUS	$44,225.89	$37,401.76	118%
CRAVEN	$74,028.37	$174,526.14	42%
CUMBERLAND	$253,625.11	$281,242.93	90%
CURRITUCK	$13,645.23	$17,311.00	79%
DARE	$22,219.94	$18,162.37	122%
DAVIDSON	$117,840.19	$98,278.21	120%
DAVIE	$25,650.64	$22,908.00	112%
DUPLIN	$36,896.87	$45,297.85	81%
DURHAM	$166,408.63	$157,870.70	105%
EDGECOMBE	$49,007.52	$68,459.85	72%
FORSYTH	$241,456.67	$352,917.47	68%
FRANKLIN	$35,928.16	$43,787.38	82%
GASTON	$153,931.37	$169,043.60	91%
GRAHAM	$6,440.44	$4,200.00	153%
GRANVILLE	$35,480.46	$26,714.94	133%
GREENE	$14,487.21	$11,438.22	127%
GUILFORD	$320,986.13	$407,831.66	79%
HALIFAX	$49,574.25	$50,650.00	98%
HARNETT	$66,388.86	$62,489.51	106%
HAYWOOD	$43,085.46	$61,750.15	70%
HENDERSON	$65,776.38	$101,484.23	65%
HERTFORD	$19,381.79	$29,750.00	65%
HOKE	$23,579.43	$19,552.00	121%
HYDE	$4,495.23	$12,773.17	35%
IREDELL	$89,250.56	$154,583.00	58%
JACKSON	$24,842.36	$26,053.65	95%

JOHNSTON	$82,307.17	$0.00	100%
JONES	$8,196.81	$18,920.76	43%
LEE	$39,693.55	$34,732.09	114%
LENOIR	$50,967.40	$54,878.76	93%
LINCOLN	$47,955.97	$57,965.15	83%
MACON	$22,673.66	$39,900.00	57%
MADISON	$15,336.00	$23,615.85	65%
MARTIN	$22,292.36	$20,101.00	111%
MCDOWELL	$32,128.21	$42,064.88	76%
MECKLENBU	$498,157.04	$498,675.00	100%
MITCHELL	$12,799.84	$23,190.00	55%
MONTGOMERY	$20,555.05	$23,592.96	87%
MOORE	$57,503.66	$60,321.58	95%
NASH	$72,432.48	$85,109.50	85%
NEW HANOVER	$120,404.84	$194,084.00	62%
NORTHAMPTON	$17,879.11	$27,705.00	65%
ONSLOW	$127,594.98	$109,807.48	116%
ORANGE	$91,285.51	$91,918.00	99%
PAMLICO	$10,238.67	$0.00	100%
PASQUOTANK	$28,717.30	$62,304.66	46%
PENDER	$29,908.61	$49,115.00	61%
PE/CH/GA*	$29,742.98	$41,424.35	72%
PERSON	$27,724.46	$27,902.00	99%
PITT	$101,291.28	$113,887.00	89%
POLK	$13,580.56	$0.00	100%
RANDOLPH	$99,676.46	$98,262.91	101%
RICHMOND	$39,167.34	$27,618.00	142%
ROCKINGHAM	$95,744.50	$96,737.25	99%
ROBESON	$76,200.55	$78,800.00	97%
ROWAN	$102,546.45	$114,762.50	89%
RUTHERFORD	$50,966.59	$83,684.54	61%
SAMPSON	$43,583.20	$30,706.39	142%
SCOTLAND	$29,949.19	$31,484.88	95%
STANLY	$46,396.26	$77,947.22	60%
STOKES	$35,429.51	$26,734.32	133%
SURRY	$56,137.21	$39,552.30	142%
SWAIN	$9,979.01	$15,000.00	67%
TRANSYLVA	$23,436.25	$21,948.00	107%
TYRRELL	$3,288.39	$4,538.85	72%
UNION	$84,704.44	$96,611.20	88%
VANCE	$34,540.98	$35,483.50	97%
WAKE	$447,081.87	$530,833.54	84%
WARREN	$15,645.75	$15,210.00	103%
WASHINGTON	$11,875.14	$10,000.00	119%
WATAUGA	$34,620.36	$34,441.24	101%
WAYNE	$95,768.71	$98,250.00	97%
WILKES	$53,532.04	$78,368.62	68%
WILSON	$58,520.71	$89,457.00	65%
YADKIN	$29,046.84	$26,747.54	109%
YANCEY	$13,925.63	$27,327.22	51%
TOTALS	$6,206,044.86	$7,198,865.92	
AVERAGES	$63,326.99	$73,457.82	91%

TABLE 4. GRANT REQUESTS AND AWARDS FROM THE SCRAP TIRE DISPOSAL ACCOUNT TO REIMBURSE COUNTIES FOR LOSSES INCURRED IN APRIL - SEPT 1996.

COUNTY	PERCENT OF REQUEST AWARDED	ACTUAL AWARD	REQUEST
ASHE	92%	$24,157.75	$26,380.00
BEAUFORT	46%	$5,474.01	$11,920.72
BUNCOMBE	90%	$7,284.58	$8,065.60
CASWELL	69%	$201.14	$292.91
CATAWBA	74%	$21,528.52	$29,166.71
CLEVELAND	53%	$14,238.32	$27,063.51
CURRITUCK	71%	$1,195.44	$1,694.56
DAVIDSON	44%	$1,088.17	$2,480.00
FORSYTH	37%	$36,681.37	$99,551.78
GUILFORD	50%	$25,713.31	$51,940.38
HAYWOOD	84%	$5,672.53	$6,715.47
HERTFORD	80%	$3,616.04	$4,495.51
JONES	49%	$3,139.48	$6,432.87
MADISON	90%	$2,376.90	$2,631.07
MCDOWELL	84%	$4,228.28	$5,009.72
MECKLENBURG	73%	$52,278.71	$71,387.93
MITCHELL	48%	$2,471.05	$5,154.28
ORANGE	76%	$13,818.94	$18,102.18
NASH	78%	$6,439.82	$8,307.43
NEW HANOVER	72%	$23,814.83	$33,217.42
PASQUOTANK	65%	$4,025.49	$6,208.44
PE/CH/GA	83%	$2,115.84	$2,554.02
ROCKINGHAM	69%	$20,054.60	$29,126.96
SAMPSON	31%	$495.29	$1,602.78
SWAIN	91%	$3,026.82	$3,321.98
UNION	73%	$10,622.75	$14,565.64
WARREN	87%	$408.55	$457.98
WILKES	69%	$8,536.42	$12,337.42
WILSON	50%	$9,934.11	$19,690.00
YADKIN	81%	$1,210.84	$1,493.80
TOTALS		**$314,640.07**	**$509,885.25**

*PE/CH/GA = Perquimans/Chowan/Gates regional facility

TABLE 5. GRANT REQUESTS AND AWARDS FROM THE SCRAP TIRE DISPOSAL ACCOUNT TO REIMBURSE COUNTIES FOR LOSSES INCURRED IN OCT 1996 - MARCH 1997.

COUNTY	PERCENT OF REQUEST AWARDED	ACTUAL AWARD	REQUEST
ALAMANCE	58%	$14,500.00	$24,793.90
ALLEGHANY	94%	$2,600.17	$2,757.17
ASHE	83%	$3,557.35	$4,311.17
BRUNSWICK	46%	$5,491.05	$11,912.28
CATAWBA	89%	$15,869.21	$17,869.21
CLEVELAND	81%	$20,131.16	$24,923.53
CURRITUCK	81%	$1,683.91	$2,076.13
DUPLIN	93%	$1,222.55	$1,318.26
FORSYTH	66%	$44,489.98	$67,037.48
GASTON	78%	$15,440.46	$19,763.42
GUILFORD	71%	$19,963.68	$28,312.15
HAYWOOD	91%	$4,486.01	$4,929.16
HERTFORD	86%	$3,683.33	$4,280.90
IREDELL	94%	$16,180.00	$17,180.00
JACKSON	98%	$2,491.54	$2,542.70
JONES	57%	$2,386.74	$4,172.61
MADISON	100%	$4,310.56	$4,310.56
MECKLENBURG	70%	$13,983.59	$19,963.03
MITCHELL	61%	$3,711.59	$6,133.46
NASH	75%	$4,747.87	$6,365.20
NEW HANOVER	71%	$30,976.28	$43,634.05
NORTHAMPTON	95%	$2,082.44	$2,198.25
ORANGE	88%	$1,029.23	$1,166.33
PE/CH/GA	84%*	$5,407.76	$6,449.58
PENDER	85%	$3,080.11	$3,616.10
PERSON	100%	$762.19	$762.19
PITT	48%	$7,408.94	$15,517.67
ROCKINGHAM	75%	$11,741.29	$15,714.19
RUTHERFORD	53%	$6,900.49	$13,117.03
SWAIN	100%	$2,651.45	$2,651.45
TYRRELL	73%	$1,162.17	$1,601.06
UNION	93%	$5,046.87	$5,441.40
WILKES	58%	$7,468.46	$12,947.85
WILSON	78%	$12,199.57	$15,617.88
YADKIN	94%	$80.71	$85.81
YANCEY	50%	$2,550.31	$5,143.18
TOTALS		**$301,479.02**	**$395,822.44**

*PE/CH/GA = Perquimans/Chowan/Gates regional facility

APPENDIX B

GENERAL ASSEMBLY OF NORTH CAROLINA
1997 SESSION

S.L. 1997-209
SENATE BILL 153

GENERAL ASSEMBLY OF NORTH CAROLINA
1997 SESSION

S.L. 1997-209
SENATE BILL 153

AN ACT TO EXTEND THE SCRAP TIRE DISPOSAL TAX AT ITS CURRENT RATE FOR FIVE MORE YEARS, TO AMEND THE SCRAP TIRE DISPOSAL ACT TO DISCOURAGE THE DISPOSAL OF SCRAP TIRES FROM OUTSIDE THE STATE, AND TO COMPLETE THE CLEANUP OF NUISANCE TIRE COLLECTION SITES, AS RECOMMENDED BY THE ENVIRONMENTAL REVIEW COMMISSION.

The General Assembly of North Carolina enacts:

Section 1. Section 9 of Chapter 548 of the 1993 Session Laws reads as rewritten:

"Sec. 9. Section 4 of this act becomes effective January 1, 1994. Section 8 of this act becomes effective June 30, 1997. All other sections of this act become effective October 1, 1993. ~~Sections~~ Section 1 ~~through 6~~ of this act ~~expire June 30, 1997.~~ expires June 30, 2002. Section 7 of this act expires June 30, 1995. ~~Any funds remaining in the Scrap Tire Disposal Account created by this act on June 30, 1997, shall be transferred to the Solid Waste Management Trust Fund.~~ The expiration of the additional tax imposed by Section 1 of this act does not affect the rights or liabilities of the State, a taxpayer, or another person that arise during the time the additional tax is in effect. The first quarterly report required by G.S. 130A-309.63(e), as enacted by this act, is due within 60 days after the quarter that ends on December 31, 1993."

Section 2. G.S. 130A-309.63 reads as rewritten:

"**§ 130A-309.63. Scrap Tire Disposal Account.**

(a) Creation. -- The Scrap Tire Disposal Account is established as a nonreverting account within the Department. The Account consists of revenue credited to the Account from the proceeds of the scrap tire disposal tax imposed by Article 5B of Chapter 105 of the General Statutes.

(b) Use. -- The Department may use revenue in the Account only as authorized by this section. The Department may use up to ~~twenty-five percent (25%)~~ fifty percent (50%) of the revenue in the Account to make grants to units of local government to assist them in disposing of scrap tires. To administer the grants, the Department shall establish procedures for applying for a grant and the criteria for selecting among grant applicants. The criteria shall include the financial ability of a unit of local government to provide for scrap tire disposal, the severity of a unit of local government's scrap tire disposal problem, the effort made by a unit of local government to ensure that only tires generated in the normal course of business in this State are provided free disposal, and the effort made by a unit of local government to provide for scrap tire disposal within the resources available to it. The Department may use up to forty percent (40%) of the revenue in the Account to make grants to encourage the use of processed scrap tire materials. These grants may be made to encourage the use of tire-derived fuel, crumb rubber, carbon black, or other components of tires for use in products such as fuel, tires, mats, auto parts, gaskets, flooring material, or other applications of processed tire materials. These grants shall be made in consultation with the Department of Commerce, the Division of Environmental Assistance and Pollution Prevention of the Department, and, where appropriate, the Department of Transportation. Grants to encourage the use of processed scrap tire materials shall not be used to process tires.

(c) Eligibility. -- A unit of local government is not eligible for a grant for scrap tire disposal unless its costs for disposing of scrap tires for the six-month period preceding the date the unit of local government files an application for a grant exceeded the amount the unit of local government received during that period from the proceeds of the scrap tire tax under G.S. 105-187.19. A grant to a unit of local government for scrap tire disposal may not exceed the unit of local government's unreimbursed cost for the six-month period.

(d) Cleanup of Nuisance Tire Sites. -- The Department may use the remaining revenue in the Account only to clean up scrap tire collection sites that the Department has determined are a nuisance. The Department may use funds in the Account to clean up a nuisance tire collection site only if no other funds are available for that purpose.

(e) Reports. -- The Department shall report annually on the Scrap Tire Disposal Account to the Environmental Review Commission. The report shall be submitted by 1 October of each year for the fiscal year ending the preceding 30 June. The report shall show the beginning and ending balances in the Account for the reporting period, the amount credited to the Account during the reporting period, and the amount of revenue used for grants and to clean up nuisance tire collection sites."

Section 3. Section 8 of Chapter 548 of the 1993 Session Laws is repealed.

Section 4. This act is effective when it becomes law.

In the General Assembly read three times and ratified this the 10th day of June, 1997.

s/ Dennis A. Wicker
President of the Senate

s/ Harold J. Brubaker
Speaker of the House of Representatives

s/ James B. Hunt, Jr.
Governor

Approved 5:22 p.m. this 19th day of June, 1997

GS 130A-309.29. ADOPTION OF RULES.

The Commission may adopt rules to implement the provisions of this Part pursuant to Article 2 of Chapter 150B of the General Statutes.

NCGS 130A-309.30 through 130A-309.50: RESERVED FOR FUTURE CODIFICATION PURPOSES.

Part 2B. Scrap Tire Disposal Act

GS 130A-309.51. TITLE.

This Part may be cited as the "North Carolina Scrap Tire Disposal Act."

GS 130A-309.52. FINDINGS; PURPOSE.

(a) The General Assembly finds that:

(1) Scrap tire disposal poses a unique and troublesome solid waste management problem.

(2) Scrap tires are a usable resource that may be recycled for energy value.

(3) Uncontrolled disposal of scrap tires may create a public health and safety problem because tire piles act as breeding sites for mosquitoes and other disease-transmitting vectors, pose substantial fire hazards, and present a difficult disposal problem for landfills.

(4) A significant number of scrap tires are illegally dumped in North Carolina.

(5) It is in the State's best interest to encourage efforts to recycle or recover resources from scrap tires.

(6) It is desirable to allow units of local government to control tire disposal for themselves and to encourage multicounty, regional approaches to scrap tire disposal and collection.

(7) It is desirable to encourage reduction in the volume of scrap tires being disposed of at public sanitary landfills.

(b) The purpose of this Part is to provide statewide guidelines and structure for the environmentally safe disposal of scrap tires to be administered through units of local government.

GS 130A-309.53. DEFINITIONS.

Unless a different meaning is required by the context, the following definitions shall apply throughout this Part:

(1) "Collection site" means a site used for the storage of scrap tires.

(2) "Disposal fee" is any amount charged by a tire collector, tire processor, or unit of local government in exchange for accepting scrap tires.

(3) "In-county scrap tire" means any scrap tire brought for disposal from inside the

county in which the collection or processing site is located.

(4) "Out-of-county scrap tire" means any scrap tire brought for disposal from outside the county in which the collection or processing site is located.

(5) "Processing site" means a site actively used to produce or manufacture usable materials, including fuel, from scrap tires. Commercial enterprises processing scrap tires shall not be considered solid waste management facilities insofar as the provisions of G.S. 130A-294(a)(4) and G.S. 130A-294(b) are concerned.

(6) "Scrap tire" means a tire that is no longer suitable for its original, intended purpose because of wear, damage, or defect.

(7) "Tire" means a continuous solid or pneumatic rubber covering that encircles the wheel of a vehicle. Bicycle tires and other tires for vehicles propelled by human power are not subject to the provisions of this Part.

(8) "Tire collector" means a person who owns or operates a site used for the storage, collection, or deposit of more than 50 scrap tires.

(9) "Tire hauler" means a person engaged in the picking up or transporting of scrap tires for the purpose of storage, processing, or disposal.

(10) "Tire processor" means a person who engages in the processing of scrap tires or one who owns or operates a tire processing site.

(11) "Tire retailer" means a person who engages in the retail sale of a tire in any quantity for any use or purpose by the purchaser other than for resale.

Notice of Changes

The 1995 (Reg. Sess., 1996) amendment, effective October 1, 1996, in subdivision (7) deleted "and is subject to the tax imposed by Article 5B of Chapter 105" from the end of the first sentence and added the second sentence.

GS 130A-309.54. USE OF SCRAP TIRE TAX PROCEEDS.

Article 5B of Chapter 105 imposes a tax on new tires to provide funds for the disposal of scrap tires. A county may use proceeds of the tax distributed to it under that Article only for the disposal of scrap tires pursuant to the provisions of this Part or for the abatement of a nuisance pursuant to G.S. 130A-309.60.

NCGS 130A-309.55, 130A-309.56: REPEALED BY SESSION LAWS 1991, C. 221, S. 4, EFFECTIVE JULY 1, 1991.

Cross References. - As to privilege taxes imposed upon new tire sales, see GS 105-187.16. As to use of such tax proceeds, see GS 105-187.19.

GS 130A-309.57. SCRAP TIRE DISPOSAL PROGRAM.

(a) The owner or operator of any scrap tire collection site shall, within six months after October 1, 1989, provide the Department with information concerning the site's location, size, and the approximate number of scrap tires that are accumulated at the site and shall initiate steps to comply with subsection (b) of this section.

(b) On or after July 1, 1990:

(1) A person may not maintain a scrap tire collection site or a scrap tire disposal site unless the site is permitted.

(2) It is unlawful for any person to dispose of scrap tires in the State unless the scrap tires are disposed of at a scrap tire collection site or at a tire disposal site, or disposed of for processing at a scrap tire processing facility.

(c) By January 1, 1990, the Commission shall adopt rules to carry out the provisions of this section. Such rules shall:

(1) Provide for the administration of scrap tire collector and collection center permits and scrap tire disposal site permits, which may not exceed two hundred fifty dollars ($250.00) annually;

(2) Set standards for scrap tire processing facilities and associated scrap tire sites, scrap tire collection centers, and scrap tire collectors; and

(3) Authorize the final disposal of scrap tires at a permitted solid waste disposal facility provided the tires have been cut into sufficiently small parts to assure their proper disposal.

(d) A permit is not required for:

(1) A tire retreading business where fewer than 1,000 scrap tires are kept on the business premises;

(2) A business that, in the ordinary course of business, removes tires from motor vehicles if fewer than 1,000 of these tires are kept on the business premises; or

(3) A retail tire-selling business which is serving as a scrap tire collection center if fewer than 1,000 scrap tires are kept on the business premises.

(e) The Department shall encourage the voluntary establishment of scrap tire collection centers at retail tire-selling businesses, scrap tire processing facilities, and solid waste disposal facilities, to be open to the public for the deposit of used and scrap tires. The Department may establish an incentives program for individuals to encourage them to return their used or scrap tires to a scrap tire collection center.

GS 130A-309.58. DISPOSAL OF SCRAP TIRES.

(a) Each county is responsible for providing for the disposal of scrap tires located within its boundaries in accordance with the provisions of this Part and any rules issued pursuant to this Part. The following are permissible methods of scrap tire disposal:

(1) Incinerating;

(2) Retreading;

(3) Constructing crash barriers;

(4) Controlling soil erosion when whole tires are not used;

(5) Chopping or shredding;

(6) Grinding into crumbs for use in road asphalt, tire derived fuel, and as raw material for other products;

(7) Slicing vertically, resulting in each scrap tire being divided into at least two pieces;

(8) Sludge composting;

(9) Using for agriculture-related purposes;

(10) Chipping for use as an oyster cultch as approved by rules adopted by the Marine Fisheries Commission;

(11) Cutting, stamping, or dyeing tires;

(12) Pyrolizing and other physico-chemical processing;

(13) Hauling to out-of-State collection or processing sites; and

(14) Monofilling split, ground, chopped, sliced, or shredded scrap tires.

(b) The Commission may adopt rules approving other permissible methods of scrap tire disposal. Landfilling of whole scrap tires is prohibited. The prohibition against landfilling whole tires applies to all whole pneumatic rubber coverings, but does not apply to whole solid rubber coverings.

(c) Units of local government may enter into joint ventures or other cooperative efforts with other units of local government for the purpose of disposing of scrap tires. Units of local government may enter into leases or other contractual arrangements with units of local government or private entities in order to dispose of scrap tires.

(d) Each county is responsible for developing a description of scrap tire disposal procedures. These procedures shall be included in any solid waste management plan required by the Department under this Article. Further, any revisions to the initial description of the scrap tire disposal procedures shall be forwarded to the Department.

(e) **(Effective until June 30, 2002)** A county shall provide, directly or by contract with another unit of local government or private entity, at least one site for scrap tire disposal for that county. The unit of local government or contracting party may not charge a disposal fee for the disposal of scrap tires except as provided in this subsection. A unit of local government or contracting party may charge a disposal fee that does not exceed the cost of disposing of the scrap tires only if:

(1) The scrap tires are new tires that are being disposed of by their manufacturer because they do not meet the manufacturer's standards for salable tires; or

(2) The scrap tires are delivered to a local government scrap tire disposal site without an accompanying certificate required by G.S. 130A-309.58(f) that indicates that the tires originated in a county within North Carolina.

~~[illegible] of local government or private entity, at least one site for scrap tire disposal for that county. The unit of local government or contracting party may charge a disposal fee for the disposal of scrap tires only to the extent that the cost per tire of disposal exceeds the amount received by the county under G.S. 105-187.19 during the preceding 12-month period, divided by the number of tires disposed of within the county according to the tire disposal procedures during that period. The unit of local government or contracting party may charge a disposal fee for the disposal of scrap tires regardless of whether a tax ha[illegible].~~

(f) Every tire retailer or other person disposing of scrap tires shall complete and sign a certification form prescribed by the Department and distributed to each county, certifying that the tires were collected in the normal course of business for disposal, the county in which the tires were collected, and the number of tires to be disposed of. This form also shall be completed and signed by the tire hauler, certifying that the load contains the same tires that were received from the tire retailer or other person disposing of scrap tires. The tire hauler shall present this certification form to the tire processor or tire collector at the time of delivery of the scrap tires for disposal, collection, or processing. Copies of these certification forms shall be retained for a minimum of three years after the date of delivery of the scrap tires.

(g) The provisions of subsection (f) of this section do not apply to tires that are brought for disposal in quantities of five or less by someone other than a tire collector, tire processor, or tire hauler.

Notice of Changes

Subsection (e) Set Out Twice. - The first version of subsection (e) set out above is effective until June 30, 1997. The second version of subsection (e) set out above is effective June 30, 1997.

The 1995 (Reg. Sess., 1996) amendment, effective October 1, 1996, added the last sentence of subsection (b).

GS 130A-309.59. REGISTRATION OF TIRE HAULERS.

(a) Before engaging in the hauling of scrap tires in this State, any tire hauler must register with the Department whereupon the Department shall issue to the tire hauler a scrap tire hauling identification number. A tire retailer licensed under G.S. 105-164.29 and solely engaged in the hauling of scrap tires received by it in connection with the retail sale of replacement tires is not required to register under this section.

(b) Each tire hauler shall furnish its hauling identification number on all certification forms required under G.S. 130A-309.58(f). Any tire retailer engaged in the hauling of scrap tires and not required by subsection (a) of this section to be registered shall supply its merchant identification number on all certification forms required by G.S. 130A-309.58(f).

GS 130A-309.60. NUISANCE TIRE COLLECTION SITES.

(a) On or after July 1, 1990, if the Department determines that a tire collection site is a nuisance, it shall notify the person responsible for the nuisance and request that the tires be processed or removed within 90 days. If the person fails to take the requested action within 90 days, the Department shall order the person to abate the nuisance within 90 days. If the person responsible for the nuisance is not the owner of the property on which the tire collection site is located, the Department may order the property owner to permit abatement of the nuisance. If the person responsible for the nuisance fails to comply with the order, the Department shall take any action necessary to abate the nuisance, including entering the property where the tire collection site is located and confiscating the scrap tires, or arranging to have the scrap tires processed or removed.

(b) When the Department abates the nuisance pursuant to subsection (a) of this section, the person responsible for the nuisance shall be liable for the actual costs incurred by the Department for its nuisance abatement activities and its administrative and legal expenses related to the abatement. The Department may ask the Attorney General to initiate a civil action to recover these costs from the person responsible for the nuisance. Nonpayment of the actual costs incurred by the Department shall result in the imposition of a lien on the owner's real property on which the tire collection site is located.

(c) This section does not apply to any of the following:

(1) A retail business premises where tires are sold if no more than 500 scrap tires are kept on the premises at one time;

(2) The premises of a tire retreading business if no more than 3,000 scrap tires are kept on the premises at one time;

(3) A premises where tires are removed from motor vehicles in the ordinary course of business if no more than 500 scrap tires are kept on the premises at one time;

(4) A solid waste disposal facility where no more than 60,000 scrap tires are stored above ground at one time if all tires received for storage are processed, buried, or removed from the facility within one year after receipt;

(5) A site where no more than 250 scrap tires are stored for agricultural uses; and
(6) A construction site where scrap tires are stored for use or used in road surfacing and construction of embankments.

(d) The descending order of priority for the Department's abatement activities under subsection (a) of this section is as follows:

(1) Tire collection sites determined by the Department to contain more than 1,000,000 tires;
(2) Tire collection sites which constitute a fire hazard or threat to public health;
(3) Tire collection sites in densely populated areas; and
(4) Any other tire collection sites that are determined to be a nuisance.

(e) This section does not change the existing authority of the Department to enforce any existing laws or of any person to abate a nuisance.

(f) As used in this section, "nuisance" means an unreasonable danger to public health, safety, or welfare or to the environment.

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GS 130A-309.61. (Effective until June 30, [redacted]) EFFECT ON LOCAL ORDINANCES.

This Part preempts any local ordinance regarding the disposal of scrap tires to the extent the local ordinance is inconsistent with this Part or the rules adopted pursuant to this Part.

Notice of Changes

Section set out twice. - The section above is effective until June 30, 1997. For the section as amended effective June 30, 1997, see the following section, also numbered GS 130A-309.61.

Session Laws 1993, c. 548, s. 9 provides that s. 5 of c. 548, which amended this section, will expire June 30, 1997.

[redacted]

~~This Part preempts any local ordinance regarding the disposal of scrap [illegible] that any local ordinance is inconsistent with this Part or rules [illegible] pursuant to this Part. A [illegible] of local government may not charge any fees for the disposal of scrap tires except as authorized by this Part.~~

~~Notice of Change~~

~~Section set out twice. - The section above is effective June 30, 1997. For the section as in effect until June 30, 1997, see the preceding section, also numbered GS 130A-309.61.~~

GS 130A-309.62. FINES AND PENALTIES.

Any person who knowingly hauls or disposes of a tire in violation of this Part or the rules adopted pursuant to this Part shall be assessed a civil penalty of fifty dollars ($50.00) per violation. Each tire hauled or disposed of in violation of this Part or rules adopted pursuant to this Part constitutes a separate violation.

GS 130A-309.63. (Expires June 30, 1997) SCRAP TIRE DISPOSAL ACCOUNT.

(a) Creation. - The Scrap Tire Disposal Account is established as a nonreverting account within the Department. The Account consists of revenue credited to the Account from the proceeds of the scrap tire disposal tax imposed by Article 5B of Chapter 105 of the General Statutes.

(b) Use. - The Department may use revenue in the Account only as authorized by this section. The Department may use up to twenty-five percent (25%) of the revenue in the Account to make grants to units of local government to assist them in disposing of scrap tires. To administer the grants, the Department shall establish procedures for applying for a grant and the criteria for selecting among grant applicants. The criteria shall include the financial ability of a unit of local government to provide for scrap tire disposal, the severity of a unit of local government's scrap tire disposal problem, and the effort made by a unit of local government to provide for scrap tire disposal within the resources available to it.

(c) Eligibility. - A unit of local government is not eligible for a grant unless its costs for disposing of scrap tires for the six-month period preceding the date the unit of local government files an application for a grant exceeded the amount the unit of local government received during that period from the proceeds of the scrap tire tax under G.S. 105-187.19. A grant to a unit of local government may not exceed the unit of local government's unreimbursed cost for the six-month period.

(d) Cleanup of Nuisance Tire Sites. - The Department may use the remaining revenue in the Account only to clean up scrap tire collection sites that the Department has determined are a nuisance. The Department may use funds in the Account to clean up a nuisance tire collection site only if no other funds are available for that purpose.

(e) Reports. - The Department shall report annually on the Scrap Tire Disposal Account to the Environmental Review Commission. The report shall be submitted by 1 October of each year for the fiscal year ending the preceding 30 June. The report shall show the beginning and ending balances in the Account for the reporting period, the amount credited to the Account during the reporting period, and the amount of revenue used for grants and to clean up nuisance tire collection sites.

Notice of Changes

Session Laws 1993, c. 548 provides that s. 6, which added this section, will expire June 30, 1997.

Session Laws 1993, c. 548, s. 9 provides in part: "Any funds remaining in the Scrap Tire Disposal Account created by this act on June 30, 1977, shall be transferred to the Solid Waste Management Fund . . . . The first quarterly report acquired by B. S. 130A-309.63(e), as enacted by this act, is due within 60 days after the quarter that ends December 31, 1993.

The 1995 (Reg. Sess., 1996) amendment, effective October 1, 1996, in subsection (e) substituted "report annually" for "make quarterly reports", added the second sentence, substituted "reporting period" for "quarter" in the third sentence, and deleted the last sentence, which read "A quarterly report shall be filed within 60 days after the end of a calendar quarter."

NCGS 130A-309.64 through 130A-309.69: RESERVED FOR FUTURE CODIFICATION PURPOSES.

SECTION .1100 - SCRAP TIRE MANAGEMENT

.1101 DEFINITIONS

The definitions in G.S. 130A-309.53 and the following definitions shall apply throughout this Section:

(1) "Disposal site" means any place at which scrap tires are disposed of by sanitary landfill, incineration, or other method as may be approved by the Division.
(2) "Processing" means chopping, chipping, shredding, slicing, cutting, stamping, dyeing, pyrolizing or other physicochemical processing of scrap tires either for disposal or production of useable materials.
(3) "Scrap tire monofill" means a sanitary landfill, or portion thereof, permitted exclusively for scrap tire disposal.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1102 APPLICATION FEE AND ANNUAL PERMIT FEE

(a) A permit application for a scrap tire collection site or scrap tire disposal site shall be accompanied by a non-refundable twenty-five dollar ($25.00) application fee. The application fee shall be credited toward the permit fee which shall be paid before a permit is issued.
(b) An annual permit fee shall be paid to the Division on or before July 1, as follows:
(1) A scrap tire collection site: two hundred and fifty dollars ($250.00); and
(2) A scrap tire disposal site: two hundred and fifty dollars ($250.00).

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1103 GENERATOR OF SCRAP TIRES

No person shall discard, deposit or dispose of a scrap tire except at a site or facility permitted to receive scrap tires under these Rules, or at a legitimate business exempt from a permit under G.S. 130A-309.57(d).

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1104 GENERAL CONDITIONS

(a) Landfilling of whole scrap tires is prohibited.
(b) Demonstrated methods of scrap tire disposal, in addition to the disposal methods in G.S. 130A-309.58, may be approved by the Division.
(c) The tire collector shall notify the Division by submitting a form giving complete information regarding the location, size, period of operation, ownership and operation of the site, and the number of scrap tires accumulated at the site.
(d) Scrap tire certification forms, in accordance with G.S. 130A-309.58(f) shall be obtained from units of local government.

History Note: Statutory Authority G.S. 130A-309.58; Eff. October 1, 1990.

.1105 PERMIT REQUIRED

(a) No person, other than a person exempted by G.S. 130A-309.57(d), shall establish, operate or maintain, or allow to be established, operated or maintained upon his land, a scrap tire collection site or scrap tire disposal site unless a permit for the site has been obtained from the Division.

(b) Application for permits required by this Rule shall be forwarded to the Solid Waste Section, Solid Waste Management Division, P.O. Box 27687, Raleigh, North Carolina 27611.

(c) A permit is issued to the permit applicant for a particular site and is non-transferrable.

(d) Scrap tire collection sites exempt from permitting under G.S. 130A-309.57(d) and Rule .1105 (i) of this Section are not subject to the storage requirements of Rule .1107 of this Section with the exception of Rule .1107(1) and (2)(c).

(e) Trailers and roll-off containers used as scrap tire collection facilities are exempt from the requirements of Rule .1106 (c) of this Section with the exception of 3, 4, 8 and 10.

(f) A permitted sanitary landfill, other than a demolition landfill, is deemed permitted as a scrap tire disposal site. Records shall be maintained in accordance with Rule .1108(c) of this Section.

(g) A permitted sanitary landfill operated by a unit of local government is deemed permitted as a scrap tire collection site and may store up to 25,000 scrap tires for the purpose of comprising a marketable commodity.

(h) Units of local government are not required to provide proof of financial responsibility.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1106 SCRAP TIRE COLLECTION SITE PERMIT REQUIREMENTS

(a) A scrap tire collection site permit shall be issued for a period of not longer than three years. Permit renewal applications shall be submitted to the Department not less than 60 days prior to the expiration date of the permit.

(b) A permit shall limit the number of tires stored at a scrap tire collection site to the stated number of tires shipped off-site and/or disposed of on-site per month, unless otherwise specified by the Division. At no time shall more than 60,000 scrap tires be stored at a scrap tire collection site. Storage limits for collection sites permitted in association with processing facilities shall be determined as in Rule .1110(a).

(c) Scrap tire collection sites shall meet the following siting and design requirements in order for a permit to be issued:

- (1) A site shall not be located within either the 100-year floodplain or 100 feet of any surface water. A site shall not be located within any wetland as defined in the Clean Water Act, section 404(b)(1).
- (2) A site shall maintain a minimum of a 50-foot buffer between all property lines and scrap tire storage areas.
- (3) The site and proposed plan shall comply with all requirements of the local zoning ordinance.
- (4) The site shall be served by an access road which shall be kept passable for any motor vehicle, including fire trucks, at all times.
- (5) Drainage shall be effective to prevent standing water on-site and shall not cause off-site drainage problems.
- (6) A site shall meet the requirements of the Sedimentation Pollution Control Law (15A

NCAC 4).

(7) A site shall meet the screening requirements of N.C.G.S. 136-144, if applicable.

(8) Access to the site shall be controlled through the use of fences, gates, berms, natural barriers or other means.

(9) The site shall be bermed or given other protection, if necessary to keep liquid runoff from a potential tire fire from entering any surface water.

(10) The provider of fire protection services for the site shall be identified in the permit application.

(d) In addition to the form prescribed and provided by the Division, three copies of the following information shall be submitted in an application for a scrap tire collection site permit:

(1) Name and location of proposed facility, including street address or state road number, city, county, and zip code.

(2) Name, address, telephone number and signature of site operator.

(3) Name, address, telephone number and signature of property owner.

(4) A map or aerial photograph accurately showing the area within one-fourth mile of the site, and identifying the following:

(A) Entire property owned or leased for use as a scrap tire collection site by the applicant;

(B) Location of all homes, buildings, public or private utilities, roads, wells, water courses, floodplains and other applicable details regarding the topography.

(5) A description of the general operation of the facility.

(6) Sources and quantity of tires expected, expressed in tons (assume 100 tires per ton or ten tires per cubic yard) to be received per month; quantity of tires to be stored on-site and quantity of tires to be shipped off-site per month.

(7) Plans for disposition of all tires collected at the site, including the names, addresses and permit information, if applicable, of all facilities where the tires will be recycled, processed or disposed.

(8) Projected date of commencing operation.

(9) A description of how any waste resulting from the operation of the tire site will be disposed.

(10) A description of how the scrap tire collection site will meet the siting and design requirements of Rule .1106(c).

(11) A letter stating that this use complies with local zoning from the unit of local government having zoning authority over the site. If no zoning is applicable, the unit of local government shall provide documentation to that effect.

(12) A letter from the local fire protection authority accepting the responsibility for fire protection services for the site.

(13) A description of how the scrap tire collection site will meet the operational requirements of Rule .1107 of this Section.

(14) Documentation of the operator's ability to meet the financial responsibility requirements of Rule .1111 of this Section.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1107 SCRAP TIRE COLLECTION SITE OPERATIONAL REQUIREMENTS

Scrap tire collection sites shall meet the following operational requirements:

(1) Scrap tires stored indoors shall be stored under conditions that meet those in "The Standard for Storage of Rubber Tires", NFPA 231D-1986 edition, published by the National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts, which has been adopted in accordance with G.S. 150B-14(c). Copies of this document are available for inspection at the Department.

(2) All scrap tire collection, processing or disposal sites which store scrap tires or processed tires outdoors must comply with the following technical and operational standards:

(a) Whole scrap tires shall be placed in an outdoor scrap tire pile(s) having dimensions no greater than 200 feet in length, 50 feet in width and 15 feet in height.

(b) A 50-foot wide fire lane shall be placed around the perimeter of each scrap tire pile. Access to the fire lane for emergency vehicles shall be unobstructed and passable at all times.

(c) The owner or operator of any scrap tire collection site shall control mosquitoes and rodents so as to protect the public health and welfare. Whole and sliced scrap tires, and other scrap tires capable of holding water shall be covered upon receipt with a water shedding material or disposed of, processed or removed from the site within ten days of receipt. Sliced scrap tires stacked concave-side down are not required to be covered.

(d) If the scrap tire collection site receives tires from persons other than the operator of the site, a sign shall be posted at the entrance of the site and the sign shall state the operating hours. An attendant shall be present when the site is open for receipt of tires.

(e) No operations involving the use of open flames, blow torches or highly flammable substances shall be conducted within 50 feet of a scrap tire pile.

(f) A fire safety survey shall be conducted annually by local fire protection authorities or other persons as approved by the Division.

(g) Communication equipment shall be maintained at the scrap tire collection site to assure that the site operator can contact local fire protection authorities in case of a fire.

(h) The scrap tire storage area(s) within the scrap tire collection site shall be kept free of grass, underbrush, and other potentially flammable vegetation at all times.

(i) The operator of the scrap tire collection site shall prepare and keep an emergency preparedness manual at the site. The manual shall be updated at least once a year, upon changes in operations at the site, or as required by the Department. The manual shall contain the following elements:

(i) A list of names and numbers of persons to be contacted in the event of a fire, flood or other emergency;

(ii) A list of the emergency response equipment at the scrap tire collection site, its location, and how it should be used in the event of a fire or other emergency;

(iii) A description of the procedures that should be followed in the event of a fire, including procedures to contain and dispose of the oily material generated by the combustion of large numbers of tires; and

(iv) A listing of all hazardous materials stored on-site, their locations and information regarding precautions which should be taken with these materials.

(j) The operator of the scrap tire collection site shall immediately notify the Division in the event of a fire or other emergency if that emergency has potential off-site effects. Within two weeks of any emergency involving potential off-site impact, the operator of the site shall submit to the Division a written report describing the cause(s) of the emergency, actions taken to deal with the emergency, results of the actions taken, and an analysis of the success or failure of these actions.

(k) The operator of the scrap tire collection site shall maintain at his in-state place of principal business a copy of the permit with required attachments, records of the quantity of scrap tires and processed tires received at the site, stored at the site and shipped from the site, including destination (name and address of facility) and all certification forms applicable to any tires received, stored or shipped from the site.

(l) The number of scrap tires stored at a scrap tire collection site shall not exceed the stated number of scrap tires shipped off-site per month plus the stated number of scrap tires disposed of on-site per month, unless otherwise specified by the Division. At no time shall more than 60,000 scrap tires be stored at a scrap tire collection site. Storage limits for collection sites permitted in association with processing facilities shall be determined as in Rule .1110(a) of this Section.

(3) Processed tires shall be stored in accordance with the requirements of indoor or outdoor storage in this Rule, and in accordance with the following:

(a) The temperature of any above-ground piles of compacted, processed tires over 1,000 cubic yards in size shall be monitored and may not exceed 300 degrees Fahrenheit. Temperature control measures shall be instituted so that pile temperatures do not exceed 300 degrees Fahrenheit. Temperature monitoring and controls are not required for processed tires disposed of in permitted landfills.

(b) Any residuals from a scrap tire collection site shall be managed so as to be contained on-site, and shall be controlled and disposed of in a permitted solid waste management facility or properly recycled.

(4) The Division may approve exceptions to the preceding technical and operational standards for a person collecting scrap tires if:

(a) At least once during each 30-day period all scrap tires, including processed tires, are removed from the site for processing or disposal; and

(b) The Division and the local fire authority are satisfied that the site owner or operator has sufficient fire suppression equipment or materials on-site to extinguish any potential tire fire within an acceptable length of time.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1108 SCRAP TIRE DISPOSAL SITE PERMIT AND OPERATIONAL REQ.

(a) Scrap tire disposal site shall be permitted and operated in accordance with the provisions of Rules .0503, .0504, and .0505 of this Subchapter. Permits shall be recorded in accordance with Rule .0204 of this Subchapter. A proposal to establish a scrap tire monofill at a permitted sanitary landfill may be submitted as an application for modification of the construction plan. A scrap tire monofill may not be located in any required buffer zone.

(b) Scrap tires may not be burned in a permitted solid waste incinerator without a permit modification from the Division.

(c) The operator of a permitted scrap tire disposal site shall maintain at his in-state place of principal business, a copy of the permit with required attachments. Records of the quantity of scrap tires and processed tires received and disposed of at the site, and all certification forms applicable to any tires received and disposed at the site shall be maintained for a period of three years.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1109 CLOSURE OF NON-CONFORMING SITES

(a) Any scrap tire collection or disposal site which does not meet the requirements of this Section shall be closed.

(b) In closing any scrap tire site the owner or operator shall:

(1) Prevent public access to the site;
(2) Post a notice indicating the site is closed and the nearest permitted site where scrap tires can be deposited;
(3) Notify the Division of the closing and obtain Departmental approval of the plan to remove tires prior to tire removal;
(4) Remove all scrap tires, processed tires and residuals to a waste tire processing facility, solid waste management facility permitted to accept scrap tires or processed tires, a legitimate user of processed tires, or other facility approved by the Division;
(5) Remove any solid waste to a permitted solid waste management facility;
(6) Provide documentation that tires were received by approved facility; and
(7) Notify the Department when closure is complete.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1110 SCRAP TIRE PROCESSING FACILITIES

(a) Scrap tire collection sites to be permitted in association with scrap tire processing facilities shall be permitted and operated in accordance with the provisions of Rules .1106 and .1107 of this Section, except that the storage limit shall be determined by multiplying the daily through-put of the processing equipment used by 30. A scrap tire processing facility shall not accept any scrap tires for processing above the number which can be processed daily if it has reached its storage limit. At least 75 percent of both the scrap tires and processed tires that are delivered to or maintained on the site of the scrap tire processing facility site shall be processed and removed for recycling or disposal at a permitted solid waste management facility within one year of their receipt. Processed tires stored for recycling or disposal are subject to the storage requirements specified in Rule .1107 of this Section unless otherwise authorized by the Division.

(b) Wastes resulting from the operation of the scrap tire processing facility shall be evaluated in accordance with 15A NCAC 13B .0103(e) prior to disposal.

(c) The owner or operator of a scrap tire processing facility shall record and maintain for three years the following information, and these records shall be available for inspection by Division personnel during normal business hours:

(1) For all scrap tires and processed tires shipped from the facility: the name of the hauler, the hauler or merchant identification number of the tire hauler who accepted the scrap or processed tires for transport, the quantity of scrap or processed tires shipped with that hauler, designation of scrap or processed tires (name and address of facility), and documentation of receipt of tires by the receiving facility;

(2) For all scrap tires and processed tires received at the facility: the name of the hauler, the hauler or merchant identification number of the scrap tire hauler who delivered the scrap or processed tires to the facility, the quantity of scrap or processed tires received from that hauler and where the tires originated (name and address of facility);

(3) For tires received, stored, shipped or processed, completed certification forms as required by G.S. 130A-309.58(f) except for quantities of five tires or less brought for processing by someone other than a tire collector, tire processor or tire hauler.

(d) Owners and operators of scrap tire processing facilities shall submit to the Division an annual report, by March 1 of each year, that summarizes the information collected under Paragraph (c) of this Rule for the previous calendar year. The report shall be submitted on a form prescribed and provided by the Division. The following information shall be included, at a minimum:

(1) The facility name, address, and permit number, if any;

(2) The year covered by the report;

(3) The total quantity and type of scrap tires or processed tires received at the facility during the year covered by the report;

(4) The total quantity and type of scrap tires or processed tires shipped from the facility during the year covered by the report;

(5) The quantity of scrap tires or processed tires shipped to each receiving facility identified by name and address;

(6) The total quantity and type of scrap tires or processed tires located at the facility on the first day of the calendar year.

History Note: Statutory Authority G.S. 130A-309.57; Eff. October 1, 1990.

.1111 FINANCIAL RESPONSIBILITY REQUIREMENTS

(a) Owners and operators of scrap tire disposal sites shall provide proof of financial responsibility in accordance with the financial responsibility rules for landfills adopted pursuant to G.S. 130A-294(b) and 130A-309.27.

(b) Owners and operators of scrap tire collection sites permitted under these Rules shall provide proof of financial responsibility to ensure closure of the site in accordance with these Rules and to cover property damage or bodily injury to third parties which may result from fire or other public health hazard occurring at the site. Financial responsibility may be demonstrated through surety bonds, insurance, letters of credit, a funded trust, or other documents which show that the owner or operator has sufficient resources to meet the requirements of this Rule, including the guarantee of a corporate parent with sufficient resources to meet the requirements of this Rule. Documentation of financial responsibility shall be kept current, and updated as required by changes in these Rules, changes in operation of the site, and inflation.

(c) Owners and operators of scrap tire collection sites shall demonstrate the following minimum amounts of financial responsibility:

(1) For site closure: one dollar and fifty cents ($1.50) per tire for the maximum number of tires permitted to be stored on the site at any one time.

(2) For property damage and bodily injury to third parties and public property: two thousand five hundred dollars ($2,500) worth of coverage per occurrence for each 1,000 tires permitted to be stored on-site, with an annual aggregate of five thousand

dollars ($5,000) worth of coverage for each 1,000 tires permitted to be stored on-site. Maintenance of financial responsibility in the required amounts in Paragraphs (c)(1) and (2) does not in any way limit the responsibility of owners and operators for the full costs of site closure and clean-up, the expenses of any on-site or off-site environmental restoration necessitated by activities at the site, and liability for all damages to third parties or private or public properties caused by the establishment and operation of the site.

History Note: Statutory Authority G.S. 130A-294(b); 130A-309.27; Eff. October 1, 1990.

.1112 SCRAP TIRE HAULER REQUIREMENTS

The requirements of G.S. 130A-309.59 and the requirements of this Section apply to persons engaged in transporting scrap and/or processed tires for the purpose of storage, processing or disposal of scrap tires and processed tires.

(1) All persons hauling tires shall carry a copy of the document assigning the scrap tire registration number or merchant identification number at all times while engaged in hauling scrap tires.

(2) To obtain or renew a scrap tire hauling registration number and approval to transport scrap tires, a tire hauler shall submit an application on a form prescribed and provided by the Division. A tire hauler must renew its identification number annually. For a scrap tire hauler, the application shall be submitted at least 30 days before the hauler intends to begin transporting scrap tires. Renewal applications shall be submitted at least 30 days before the expiration date of the existing hauling identification number. The application shall contain at least the following information:

(a) A description, license number, Vehicle Identification Number and name of the registered vehicle owner for each vehicle used for transporting scrap tires, and if the vehicle is owned by a business entity, the names and addresses of the officers or owners of that entity;

(b) The geographical area that will be served;

(c) Where the scrap tires will be collected and where they will be delivered or deposited.

(3) A corporation, partnership or local government may submit one application for registration for its entire fleet of vehicles.

History Note: Statutory Authority G.S. 130A-309.59; Eff. October 1, 1990.

SECTION .1200 - MEDICAL WASTE MANAGEMENT

.1201 DEFINITIONS

For the purpose of the Section, the following definitions apply:

(1) "Blood and body fluids" means liquid blood, serum, plasma, other blood products, emulsified human tissue, spinal fluids, and pleural and peritoneal fluids. Dialysates are not blood or body fluids under this definition.

(2) "Generating facility" means any facility where medical waste first becomes a waste, including but not limited to any medical or dental facility, funeral home, laboratory, veterinary hospital and blood bank.

(3) "Integrated medical facility" means one or more health service facilities as defined in

APPENDIX C

STANDARDS/REGULATIONS OF SELECTED STATES FOR THE USE OF TIRE CHIPS IN SEPTIC SYSTEMS

IOWA

The Iowa Administrative Code considers the use of processed waste tire (i.e., a tire that can no longer be used for its original intended purpose) in septic systems as beneficial use. The code allows the use of shredded tires in on-site wastewater treatment and disposal systems (i.e., septic systems), including the use of tire chips in the trenches and as fill material to cover distribution pipe, under the following conditions.

1. The on-site wastewater treatment and disposal system must be constructed and permitted according to the prevailing requirements.

2. The minimum width of tire chips for use in septic systems shall be one inch and the maximum length of the chips shall be three inches (i.e., the dimensions for width and length shall be between one and three inches).

3. An administrative authority responsible for issuing septic system permits must authorize the beneficial use of tire chips in the trenches of the respective system. This individual shall have the sole discretion to deny the use of shredded tires in the construction of any septic system based on any engineering or design principles.

SOUTH CAROLINA:

In September of 1991, the South Carolina Division of Onsite Wastewater Management, Bureau of Environmental Health, Department of Health and Environmental Control, approved the use of tire chips as a substitute for gravel aggregate in the trenches of septic systems on a one-for-one volumetric basis. In December 1995, The Division of Onsite Wastewater Management revised the original standards for using tire chips in the trenches of septic systems. Under the revised standards, tire chips must be between 1/2 and 4 inches in size with steel wires not protruding more than 1/2-inch from the sides of the chips. For use in septic systems, at least 90% of the tire chips must meet the above standards. Under these standards, tire chips must be free from fine sized particles, defined as particles or substances which can settle to the bottom of the trenches of septic systems and reduce infiltration capacity of the soil. A synthetic geotextile fabric must be placed above the tire chips in the trenches of the septic system under consideration prior to backfilling the trenches. The septic tank installer using tire chips can submit tire chip samples to the Division. However, the final approval of tire chips for use in septic systems occurs at each septic system job site.

TEXAS

The Texas Natural Resource Conservation Commission rules allow septic system installers to use tire shreds (chips) as the porous media (i.e., gravel aggregate) in the construction of the lateral lines of septic systems, where appropriate. Under these rules, a tire shredding industry standard chip size called “2-inch minus”, in which tire chips, including the protruding wires, are not larger than 2 inches on any side (tire chips that can pass through a 2-inch sieve) are approved for on-site sewage facilities.

Local wastewater authorities, however, may approve the use of larger sizes of tire chips on a case-by-case basis. When tire chips are used in place of gravel in the septic system drainlines, care must be taken to prevent the protruding wires from puncturing the geotextile fabric that is required for covering the tire chips in the trenches. Contractors can use a heavier textile or other means to protect the fabric. In order to use tire chips in place of gravel in the septic system trenches, the tire shred user must complete a one-time-only application and document the use of tire shred by signing a tire shred manifest. The waste tire processor (supplier of tire chips) provides the necessary forms, which are required for tracking purposes, and attach no additional liability to the homeowner. The local wastewater authorities should be consulted to confirm that local codes allow the use of shredded tires in place of gravel in septic systems.

VIRGINIA

Under a request form the Virginia Department of Environmental Quality (DEQ), the Division of Onsite Sewage and Water Services of the Virginia Department of Health (VDH) issued a policy (GMP #91) in August, 1997, authorizing the use of tire chips as an alternative replacement for gravel aggregate in the trenches of septic systems subject to a set of conditions. Under this policy, no permit changes are required, and the septic system installers, under their discretion, can substitute tire chips for gravel aggregate when meeting a set of specified standards in any conventional and low pressure pipe distribution systems. The contractor and the homeowner of any system in which tire chips are used must complete and sign the appropriate DEQ-VDH form entitled “Certification of Use of Tire Chips in a Residential Septic Drainfield”. The environmental health specialist (EHS) inspecting the completed system must then sign and note the permit number and date of inspection on the completed form. Copies of the signed form must be retained on file. The standards developed under GMP #91 are:

1. Tire chips are approved by VDH and DEQ as a substitute for stone aggregate in non-proprietary subsurface absorption fields (e.g., conventional septic systems) on a one-for-one volumetric basis.

2. When using tire chips, trench design, installation, and location are to remain the same as the original plan for using stone aggregate. Building paper or geotextile fabric must be used on top of the tire chips in the trenches to prevent translocation of fine particles into the aggregate volume.

3. Each installation must have a valid VDH permit, and the use of tire chips in place of gravel aggregate must be authorized by the property owner, and be certified by VDH and the contractor using the 4-part Certification of Use of Tire Chips in a Residential Septic Tank Drainfield system form.

4. Proprietary systems (e.g., aerobic treatment systems), and systems designed by a professional engineer are not automatically authorized to replace gravel aggregate with tire chips. Replacement of gravel with tire chips must be approved in writing by either the manufacturer or the professional engineer designing the system prior to approval.

5. Tire chips must meet the following standards:

   a. The nominal size for the tire chips is 2 inches, and the tire pieces may range from 1/2-inch to 4-inch in any one dimension.

   b. Steel wires cannot protrude more than one-half inch from the tire chips.

   c. At least 95% of the tire chips must meet the above specifications.

   d. Tire chips must be free from fine particles, defined as materials less than 2-mm in size.