AN EXCERPT ON ENVIRONMENTAL SUITABILITY FROM THE REPORT:

DEVELOPMENT OF ENGINEERING CRITERIA FOR SHREDDED WASTE TIRES IN HIGHWAY APPLICATIONS

FINAL REPORT

by

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Research Report GT-92-9

September, 1992

This study was funded by
WISCONSIN DEPARTMENT OF TRANSPORTATION
Division of Highways
Bureau of Engineering, C.O. Materials
Applied Research
3502 Kinsman Blvd., Madison, WI 53704

and by

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
Waste Tire Management or Recovery Grant Program
Bureau of Solid and Hazardous Waste Management

Figure 9.6 Photograph of Sections 5 (foreground) and 3 & 4 (background) on June 1, 1992

10. Environmental Suitability

Waste tires are essentially a solid waste and recycling of tires will likely need an analysis and exemption from the Wisconsin Department of Natural Resources. An analysis is needed to support the department's ultimate decision. Furthermore, the information generated through waste characterization testing should also be of use in evaluating disposal and recycling proposals for abandoned tire piles.

In order to obtain an early evaluation of potential environmental problems, duplicate EP toxicity and AFS leaching tests were performed on tire chip samples by the State Laboratory of Hygiene (Edil, Bosscher, and Eldin, 1990). The duplicate results showed excellent correlation for all substances (see Appendix C). These test results indicate that the shredded automobile tire samples show no likelihood of being a hazardous waste. The shredded tires appear to release no base-neutral regulated organics. The tire samples showed detectable but very low release patterns for all substances tested and a declining concentration with continued leaching for most substances. Four metallic elements (Ba, Fe, Mn, and Zn) exhibited increasing concentrations with continued leaching. The highest concentrations for Fe and Mn were at or above their applicable drinking water standards, while those for Ba and Zn were well below their standards. Styrene-butadiene rubber is the most important synthetic rubber used by the tire industry. This material is known to absorb large amounts of hazardous organic chemicals from the surrounding environment (Park, Kim, and Edil, 1992). This can actually impart certain beneficial environmental attributes to shredded tires. In summary, shredded tires leach very small amounts of substances compared to other wastes. By comparison to other wastes for which leach test and environmental monitoring data are available, the tire leach data indicate little or no likelihood of shredded tires to have effects on ground water.

In a study conducted for the Minnesota Pollution Control Agency (1990), it was reported that metals are leached from tire materials in the highest concentrations under acid conditions. This study indicated that Ba, Cd, Cr, Pb, Se, and Zn concentrations in adjusted acid conditions (pH of 3.5 to 5) exceed the recommended allowable limits set by the Minnesota Department of Health for drinking water. However, the field ground water and soil samples near tire construction areas had a pH of 6.1 to 6.9 and did not exceed the recommended allowable limits. This study also found that polynuclear aromatic hydrocarbons and total petroleum hydrocarbons are leached from tire materials in the highest concentration under basic conditions (pH of 8.0). This study indicates potential problems under either acidic or basic conditions, i.e., if waste tires are utilized in locations where exposure to pH extremes is expected.

It is apparent that there is need for additional field studies. As part of this project, leachate samples were collected 10 times from the two lysimeters constructed under the test embankment since April 11, 1990. Both the quantity of the leachate generated and its quality are monitored. The chemical analysis of the leachate samples was performed by the State Hygiene Laboratory. The parameters tested include COD, BOD, Cl, SO_4, pH, alkalinity, hardness, TDS, Ba, Fe, Mn, Zn, Pb, Na.

The two lysimeters were sampled originally on a monthly basis and later at decreasing frequency for a period of more than two years. Prior to retrieving each sample the lysimeter collector was pumped out and the samples were taken from the next fresh inflow. The cumulative volume of water pumped out of the lysimeters is given in Figure 10.1. There is a drastic growth of water inflow into the West lysimeter after the initial 50 days period. This is a result of lateral surface water penetration into this portion of the test embankment where the West lysimeter is located. The base elevation of the embankment drops towards west and a swale cut on the north side of the embankment collects the surface water draining from the side slope of the landfill and conducts westward to a drain pipe under the west approach. This water invades the West lysimeter giving rise to collection of significant quantities of water in the collector. The east lysimeter being located at a higher elevation is not affected as much as the West lysimeter and is likely to collect more of the water percolating vertically down the tire chips embankment. However, this too would terminate after November 20, 1991 when the embankment was paved with asphalt.

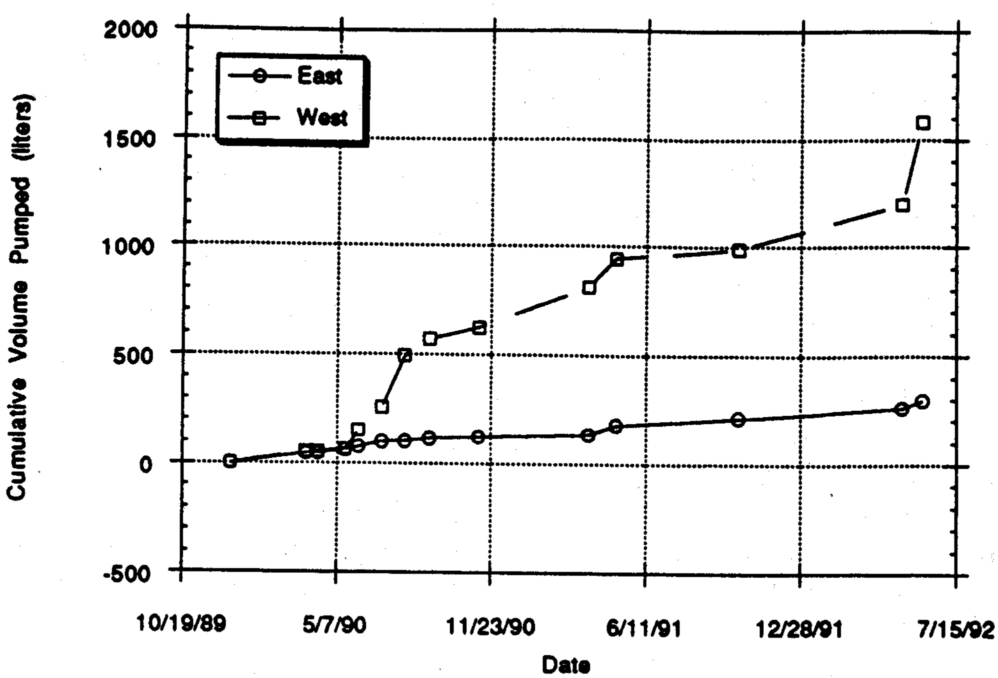

Figure 10.1 Cumulative Volume of Water Pumped from Lysimeters

The results of water quality analyses performed at the State Hygiene Laboratory are summarized in Tables 10.1 and 10.2 along with the limits given for the parameters considered in the primary and secondary drinking water standards.

Based on a review of the data, the following summary observations are made:

1. The lysimeter data show little or no likelihood of significant leaching of tire chips for substances that are specific public health concern, such as lead and barium. The leachate pH indicates slightly alkaline conditions (7.3 to 7.9).

2. Tire chips may have some leaching potential for two other metallic elements, manganese and zinc. Leaching of these elements also occurs from soil. Iron concentrations in the leachate were quite low, comparable to concentrations detected in undisturbed soils by monitoring wells.

3. The lysimeter samples contained high concentrations of cationic compound parameters, such as conductivity, hardness, calcium, and magnesium. It is very difficult to separate the source of these as soils or tire chips based upon the lysimeter data. These parameters also show increases after the fall of 1990 which may have been due to the roadway dust treatment on the embankment by application of calcium chloride in early October, 1990 (see Figure 10.2). The leach test data indicate that tire chips are very unlikely to release these constituents in the concentrations observed in the lysimeters.

Table 10.1 Water Quality Data from West Lysimeter

SAMPLE	Unit	Limits for Primary and Secondary Drinking Water Standards	4/11/90	5/9/90	6/6/90	7/5/90	8/3/90	9/4/90	12/14/90	3/28/91	10/10/91	6/1/92
pH	su		7.6	7.5	7.6	7.9	7.3	7.5	7.8	7.2	7.1	7.8
Alkalinity	mg/L		381	557	656	722	710	726	760	729	766	910
Barium	µg/L	1000 (P)	240	240	230	210	360	470	690	430	430	160
B O D	mg/L		41	15	<6	5.2	17	40	LA	4.1	<3	—
Calcium	mg/L		190	180	160	140	120	110	160	240	200	300
Chloride	mg/L	250 (S)	770	570	300	230	120	150	480	760	580	810
C O D	mg/L		200	110	84	120	140	230	290	140	71	240
Conduc-tivity	µmhos/cm		3880						2660	3100	2960	3840
Iron	mg/L	0.3 (S)	0.05	<0.05	0.24	0.57	0.26	4	0.25	0.96	0.13	0.56
Lead	µg/L	50 (P)	<3	<3	<3	<3	<3	<3	<3	5	<3	<3
Magnesium	mg/L		190	160	150	130	120	130	180	220	240	320
Manganese	µg/L	50 (S)	170	200	220	350	2500	2100	1900	1200	45	2600
Sodium	mg/L		330	290	220	130	86	89	140	87	58	230
Sulfate	mg/L	250 (S)	130	97	130	150	140	110	117.5	140	95	42
Total solids	mg/L	500 (S)	3010	2150	1400	1330	1180	1290	1850	2610	1770	2240
Zinc	µg/L	5000 (S)	19	12	17	ND	16	44	19	30	13	750
Hardness	mg/L		1300	1100	1000	900	780	830	1100	1500	1500	2100

Table 10.2 Water Quality Data from East Lysimeter

SAMPLE	Unit	Limits for Primary and Secondary Drinking Water Standards	4/11/90	5/9/90	6/6/90	7/5/90	8/3/90	9/4/90	12/14/90	3/28/91	10/10/91	6/1/92
pH	su			7.7	7.4	7.8	7.5	7.3		7.7	7.3	7.4
Alkalinity	mg/L			533	567	625	671	705		792	616	657
Barium	µg/L	1000 (P)	220	210	240	190	270	310		350	190	570
B O D	mg/L			14	10	39	75	57		70	5.7	—
Calcium	mg/L		200	170	180	110	130	140		340	290	180
Chloride	mg/L	250 (S)		460	340	130	170	200		1400	900	1200
C O D	mg/L		280	170	220	320	290	390		560	200	78
Conduc-tivity	µmhos/cm									5150	3880	4820
Iron	mg/L	0.3 (S)	1.3	<0.05	0.12	0.54	5.3	0.36		0.7	0.15	1.6
Lead	µg/L	50 (P)	9	<3	5	4	15	6		22	<3	<3
Magnesium	mg/L		200	150	150	96	110	120		390	240	270
Manganese	µg/L	50 (S)	230	270	300	1200	1700	2300		3200	3200	1300
Sodium	mg/L		280	220	260	98	120	140		200	210	210
Sulfate	mg/L	250 (S)		140	140	92	150	180		450	290	260
Total solids	mg/L	500 (S)		2000	1480	1110	1290	1510		4630	2460	3080
Zinc	µg/L	5000 (S)	84	46	44	540	560	120		560	84	33
Hardness	mg/L		1300	1100	1100	660	780	860		2500	1700	1500

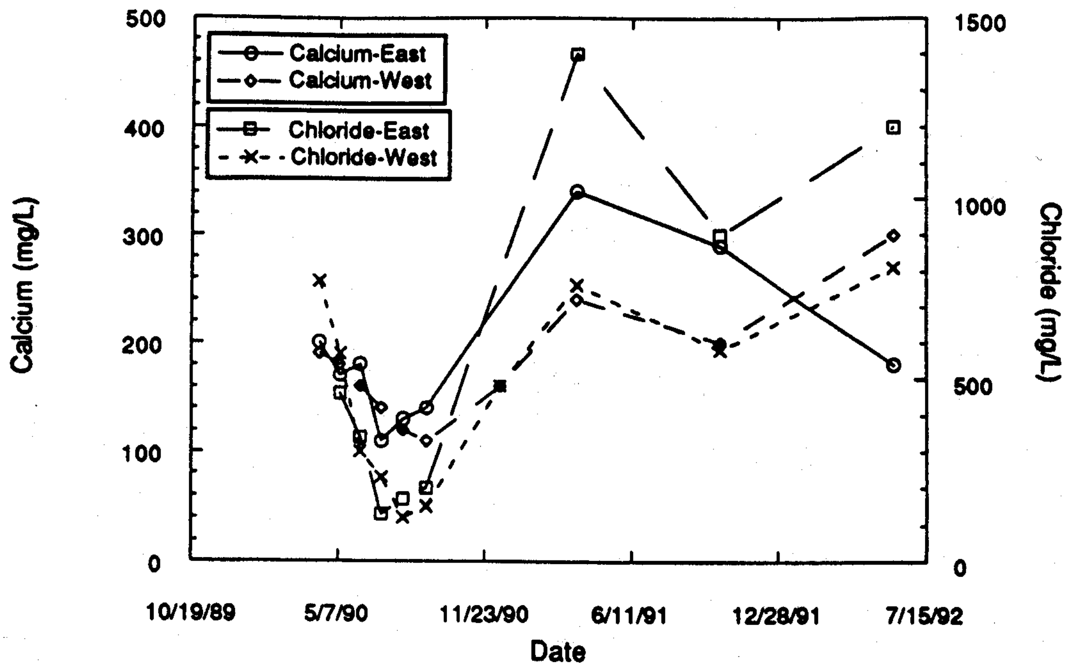

Figure 10.2 Calcium and Chloride Concentrations vs. Time

4. The lysimeter samples contained very high concentrations of anionic compounds, alkalinity, chloride, and sulfate. Chloride concentrations increased dramatically in the samples retrieved subsequent to October 1990 dust treatment on the embankment (see Figure 10.2). The leach test data for tire chips were extremely low in these parameters indicating that tire chips are very unlikely to release these constituents in any significant concentration. The high concentrations seen in the lysimeter samples for these substances are most likely due to another source.

5. The lysimeter samples contained elevated and relatively constant concentrations of organic compounds represented by COD and BOD, with no particular pattern over time. The leach tests indicated that the tire chips release these parameters but the concentrations decline rapidly. Tire chips may have contributed organic substances to the lysimeter fluids but are not likely to be responsible for the continuous presence of these compounds over the monitoring period.

Lysimeter samples showed concentrations of most parameters that were much higher than those seen in most groundwater monitoring wells near the embankment. The data indicate that effects of leaching of tire chips can be heavily masked or overwhelmed by leaching of soil materials used in the embankment. The data appear to be strongly influenced by other sources and factors as well. Some of the sources and factors that may have affected the measured concentrations include the following:

1. There was a salt (calcium chloride) treatment of the embankment surface course in October 1990 to control dust and air quality.

2. Asphalt pavement of the surface in November 1991 would inhibit downward percolation of water along the longest path through the tire chips after this date (only would impact the tenth sample).

3. While it was intended to drain the lysimeter collectors prior to sampling and then to collect a sample from the subsequent fresh inflow, there is doubt that this was followed strictly after the first few samples. So some samples may reflect the cumulative effects of collection over a period of time.

4. The type of flooding of the West lysimeter in particular, as described above, would allow intrusion of large quantities of surface water laterally traversing only a small amount of tire chips into the lysimeters. The quality of this water would overshadow the contribution of the tire chips to the measured parameters.

5. There is a possibility that the base course material used may have some salt to keep it from freezing.

6. The slopes of the adjacent landfill upstream from the lysimeters and the slopes of the embankment itself were treated with fertilizers to support vegetation.

These considerations help understand some of the concentrations above normal groundwater concentrations measured in the lysimeter samples. It is not a pristine water but not much of the observed concentrations are attributable to tire chips. Highway construction results in disturbance of soils and allows stripping of certain elements. The gravel used in constructing the base course may contain dolomite or limestone; if so, this would be a major source of constituents such as hardness, alkalinity, calcium, magnesium and sulfate. The leaching effects of tire chips could be more easily evaluated if the tire chips had some unique tracer constituent. The leach tests did not reveal one and what is known of tire composition does not suggest one.

APPENDIX C - Review of the Waste Characterization of Shredded Tires

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

FILE REF: 4410-1

DATE: October 19, 1989

To: Paul Koziar - SW/3

FROM: Robert Grefe - SW/3

SUBJECT: Review of the Waste Characterization of Shredded Tires

This memo is in followup to my memo dated January 31, 1989 and the waste characterization information provided by the State Laboratory of Hygiene (LOH) to the Department under contract. The information consists of various leaching test data transmitted to you in July of this year. I provided a verbal analysis to you on the data in early August. This memo formally documents my review of the leaching test data.

The LOH suggested some changes to the proposed leach test protocol in a meeting in June. They explained that they could not do an oil & grease analysis under the circumstances of the leaching tests. They did not report total dissolved solids or conductivity. Given the low level of organics and other dissolved substances in the data, these variances are not serious. In all other respects, they appear to have followed the recommendations in my memo, including the use of the AFS test leach test method with three elutions.

The leaching tests were performed in duplicate, with the duplicate results showing excellent correlation for all substances. The duplicates appear to have been performed for all leach tests, although the supplementary test results provided on August 1, 1989 did not include the initial leach test results for Cd.

To summarize, the leach tests indicate that the shredded automobile tire samples show no likelihood of being a hazardous waste. The shredded tires appear to release no base-neutral regulated organics, including the PAH compounds that I suggested would be the most likely substances to be extracted from tires. The tire samples showed detectable but very low release patterns for all substances tested and a declining concentration with continued leaching for most substances. I suspect that several of the substances were released from surface coatings rather than leached from the tire material. Four metallic elements (Ba, Fe, Mn, and Zn) exhibited increasing concentrations with continued leaching. The highest concentrations for Fe and Mn were at or above their applicable drinking water standards, while those for Ba and Zn were well below their standards.

My summary judgement is that the test results indicate that shredded automobile tires leach very small amounts of substances compared to other wastes. The leaching behavior does not indicate that use of tires in earthen embankments or other earthwork structures would constitute a threat to groundwater or surface water. The minor amount of leaching of indicators and some metals suggests that tires are best used in buried locations above the water table, rather than in surface applications or in contact with open water bodies. Use of shredded tires need not be restricted in ways different from those placed on whole tires.

This opinion does not mean that use of tires should be deregulated. Waste tires are still a public health and nuisance threat. They present problems with both aesthetics and combustion effects. Their use in earthwork structures should continue to be reviewed on a case-by-case basis. There is flexibility within the low-hazard waste exemption (s. 144.44(7)(g), Stats.) to review and approve use of waste tires either in an individual project or in a category of projects controlled by a single sponsor.

Blanks

Blank water samples were run for all of the EP Toxicity, Base-Neutral, and AFS test results. The three sequential blank samples for each test all showed suitably low detectable or nondetectable concentrations for the substances tested for in each test. There was no significant variation between samples.

EP Toxicity Test Results

The EP toxicity test was run for the elements Ba, Cd, Cr, Pb, and Hg, but not for As, Se, or Ag. Relatively high detection levels were used for Cr and Pb. Neither duplicate had concentrations above the detection levels used in the test. The AFS test results also indicate that there is little likelihood that this test protocol will produce high concentrations of any regulated metal. The test results indicate that waste automobile tires are extremely unlikely to be classified as a hazardous waste.

Base-Neutral Organics Test Results

Both duplicates exhibited identical results. No compounds were detected at detection limits of 2 to 40 micrograms per liter for the listed 45 compounds. The analytical equipment used was GC-MS. There were no changes in the particular detection limits for each compound between either duplicate, the sequential elutions, or between blanks and samples. This information, plus the low organic content indicated in the AFS test results, indicates that there were no interference effects present which might distort sample results.

AFS Test Results

The LOH followed the AFS test procedure for evaluating the leaching behavior of metals, anions and organic and inorganic indicator parameters. The shredded tire samples were leached in three sequential elutions with distilled water at a liquid to solid mass ratio of 5:1. Detection limits for metals were in the single micrograms per liter (ug/l) range, while the indicators and anions had detection limits in the milligram per liter (mg/l) range. In contrast to the results of the tests discussed above, several substances were detected in one or more of the elutions. The results allow discussion of the trends in leaching behavior of groups of substances.

pH The samples indicate that the shredded tires cause the leaching medium to be slightly alkaline (7.13 to 7.43), with no apparent trend over the three elutions.

Alkalinity and Hardness

In both samples, alkalinity showed a constant concentration (17-19 mg/l) over the 3 elutions, while hardness showed a slight decrease (19 to 13 mg/l). The hardness appears to consist entirely of Ca, as elemental analyses revealed no Mg over a detection limit of 1 mg/l.

Anions and Organic Indicators

Cl decreased from 3.9 to less than 0.3 mg/l.

SO_4 decreased from 6.5 to 1 mg/l.

BOD decreased from 22 to 6.5 mg/l. In both duplicates, no results were obtained from the second elution, apparently due to some toxicity effects on the organisms. COD decreased from 68-72 to 24-27 mg/l. The BOD/COD ratio declined from .33 to .25 over the three elutions.

NO_2-NO_3 concentrations were an order of magnitude below those for TKN and decreased from .37 to .02 mg/l. TKN decreased from 3 to 1.2 mg/l.

Most of these parameters exhibited the greatest decline in concentrations between the first and second elutions. Concentrations are low compared to leachate or other contaminated liquids. The organic fraction appears to be moderately biodegradable. The rapid decrease between the first and second elutions indicates that the majority of the mass for these substances may come from surface coatings rather than the structure of the tire compounds.

Metallic Elements

Below Detection limits

The following elements were not detected at the indicated detection limits in any elution:

As	10 ug/l
Cd	0.2 ug/l
Cr	3 ug/l
Cu	20 ug/l
Se	5 ug/l
Ti	ND=3 ug/l

Decreasing Concentrations

Pb decreased from 15 to less than 3 ug/l.

Na decreased from 4 to 1 mg/l.

The greatest decreases occurred between the first and second elutions. The concentrations involved are very low compared to other waste leaching results and many natural groundwater results. As with the substances in the previous section, it may be that the majority of the leached mass originates in surface coatings on the tires. Pb is a common road surface contaminant due to the use of lead compounds in gasoline.

Increasing Concentrations

Ba exhibited a constant or slightly increasing concentration of approximately 110 ug/l.

Fe concentrations increased at the third elution from below the detection limit of 50 ug/l to 150-230 ug/l.

Mn concentrations increased between the second and third elutions, from 80-85 to 250-300 ug/l.

Zn concentrations also increased between the second and third elutions, from 38-40 to 360-630 ug/l.

The patterns in the increasing trends indicate that these substances are being extracted from the mass of the shredded tires rather than from a surface coating. The delay in release until the third elution may be due to oxidation of the wire bead or tire compounds. If so, leaching under anaerobic conditions may be less than the leach tests indicate.

The Mn concentration at the third elution exceeded the drinking water standard (50 ug/l), and that for Fe was close to its standard (300 ug/l). The concentrations for Ba and Zn were an order of magnitude below their respective standards.

Neither groundwater standards nor leach test results can be used to predict the actual effects of shredded tires on groundwater in a disposal or reuse project. However, by comparison to other projects where leach test and environmental monitoring data are available, the tire data indicate little or no likelihood of shredded tires to have effects on groundwater even in restricted groundwater flow regimes. Confirmation of this can be obtained from the monitoring of pilot or full scale projects. I recommend the use of collection basin lysimeters rather than groundwater monitoring wells for this purpose.

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cc. Gene Mitchell - SW/3
Lakshmi Sridharan - SW/3