ENVIRONMENTAL BENEFITS OF RECYCLING STUDY

For the
ST. LOUIS-JEFFERSON SOLID WASTE MANAGEMENT DISTRICT
City of St. Louis, Jefferson County, St. Louis County and St. Charles County

Prepared by

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I. INTRODUCTION

Recycling by definition is to use discarded and unwanted products to create new products. Recycling has the dual benefit of saving scarce landfill space and limited natural resources. Recycling means saving the environment.

Recycling can be considered to be any action which collects, separates or processes solid waste or materials that would otherwise become solid waste; and processes or returns them to use either as raw materials or products. Through recycling, natural resources and energy can be saved and pollution reduced.

- Recycling aluminum saves 95 percent of the energy used to manufacture virgin aluminum
- Recycling 1 ton of newspapers saves enough energy to heat a home for 6 weeks
- Recycling 1 ton of plastics saves the equivalent of 3.85 barrels of oil
- Recycling 1 glass bottle can save enough energy to light a 100-watt bulb for 4 hours

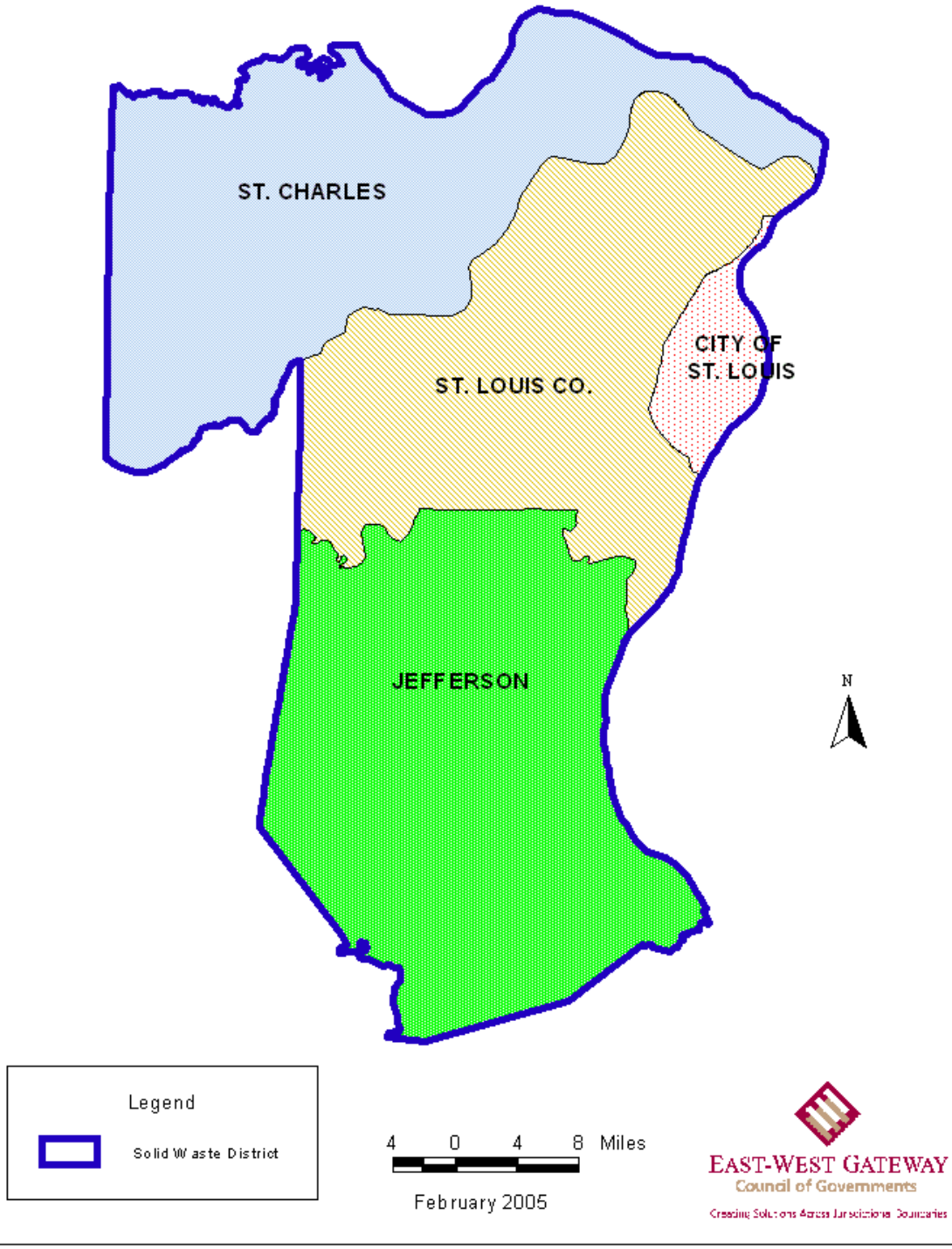
Background

In 1989 Missouri established an integrated solid waste management hierarchy with waste reduction, recycling, reuse and composting having the highest priority. The Missouri Solid Waste Management Act was amended in 1990 by Senate Bill 590 (SB590) in order to implement this policy. This legislation set a goal of reducing the amount of solid waste disposed of in landfills in Missouri by 40 percent by 1998. SB590 also allowed counties to form regional solid waste management districts to promote waste reduction and recycling.

The St. Louis-Jefferson Solid Waste Management District was formed in 1991. The District was created to assist the public, private and not-for-profit sectors in establishing and expanding waste reduction, recycling and composting efforts by encouraging cooperation and fostering innovation. District grants and extensive networking encourage cooperative, innovative waste reduction activity, with economically sustainable results. The District was originally composed of Jefferson County, St. Louis County and the City of St. Louis. St. Charles County joined the District in 2002. (see Figure 1) The District contains over 120 municipalities as well as rural and suburban unincorporated areas. The 2004 population of the District was estimated to be 1,888,700 with approximately 70 percent of the population residing in urbanized areas. The 2000 Census showed that there were 724,500 households in the District.

The 2001 Missouri Solid Waste Diversion and Recycling Status Report, prepared by the Missouri Department of Natural Resources (MoDNR), documented the progress made from 1990 to 2001 in diverting municipal solid waste from disposal in Missouri landfills. This study showed that since 1989 the number communities recycling has increased from 51 to 403 in 2001, an increase of over 600 percent. In 2001 , the per capita disposal rate was approximately 1.11 tons per year. MoDNR has estimated that about 9,020,234 tons of municipal waste has been recycled in Missouri from 1998 to 2001. More recently, MoDNR has calculated that in 2003, 45 percent of the municipal solid waste generated in the state was diverted from disposal in landfills.

Figure 1 - St. Louis-Jefferson Solid Waste Management District



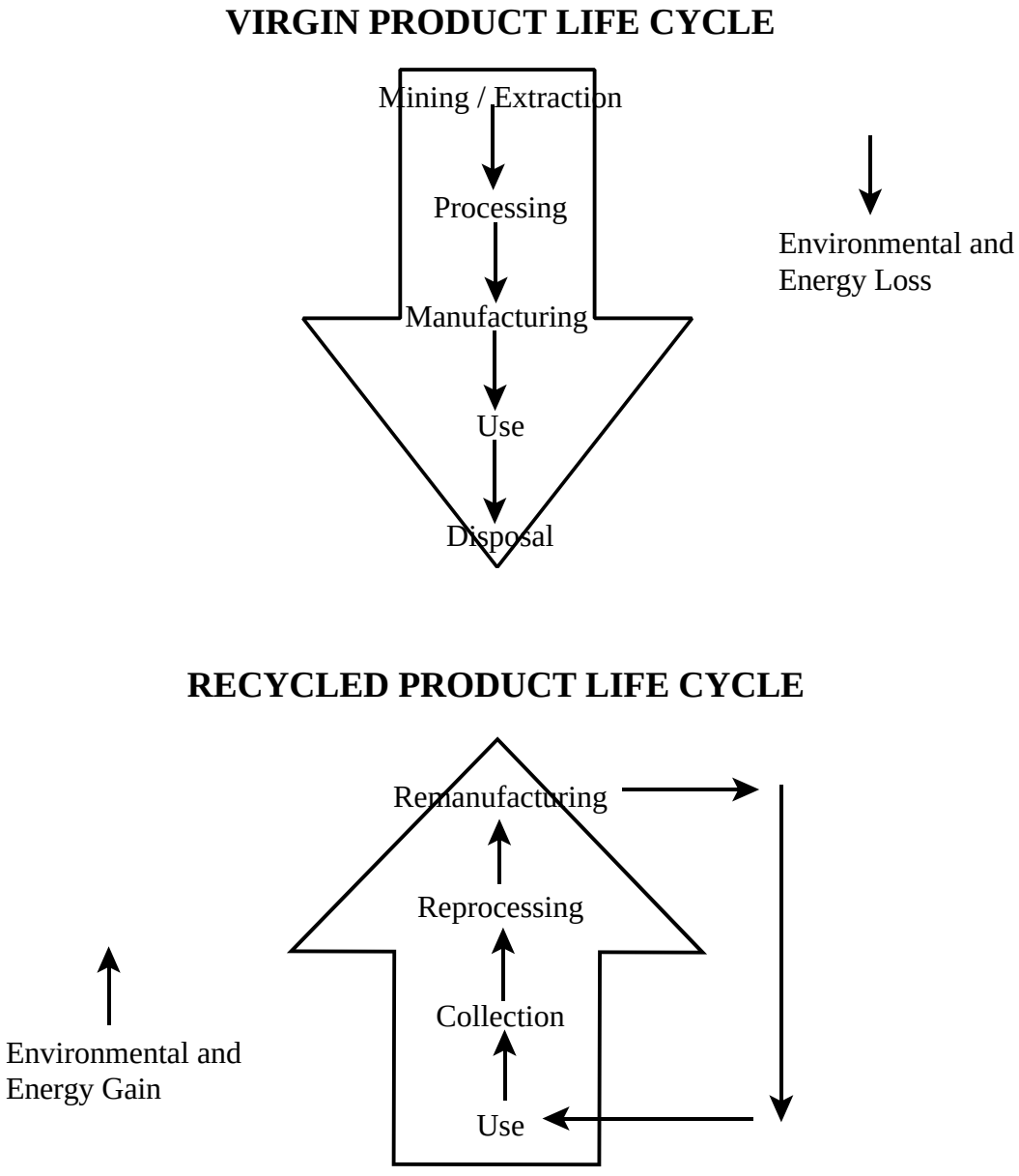
Purpose of Study

When individuals, institutions and businesses recycle, less trash is disposed of in landfills. Waste reduction and recycling activities help to extend the lifespan of landfills. More importantly, recycling also helps to save energy and natural resources which would otherwise be needed to create new products out of virgin materials. There are energy, pollution reduction and natural resource benefits associated with recycling which are evident in all of the stages of consumer product development. The energy and environmental benefits and losses associated with a virgin product life cycle and the life cycle of a recycled product are shown in Figure 2. Although the economic benefits of recycling and reuse activities have been well documented, the environmental benefits derived from these recycling activities are of equal, if not greater, value.

Therefore, the purpose of the Environmental Benefits of Recycling Study was to measure and document the positive effects on the environment gained from recycling, reuse and waste reduction performed by the residents and businesses in the District. Environmental effects to be considered included: conservation of energy; air quality; water quality; and conservation of natural resources. The findings of this study will be incorporated into the District's ongoing public information and education efforts to encourage and sustain support for and participation in recycling programs throughout the District. In addition, the study results can be used to enhance understanding about the synergistic environmental effects of recycling and reuse programs currently in operation.

The report has been organized into the following sections: a discussion about municipal solid waste generated and recycled in the District; an examination of environmental benefits calculators; and an analysis of environmental benefits from recycling in the District.

Figure 2 - Virgin and Recycled Products Life Cycles



Source: U.S. Environmental Protection Agency

II. DISTRICT MUNICIPAL SOLID WASTE INFORMATION

The municipal solid waste stream is made up of waste generated by households, institutions such as schools, office buildings and governmental facilities, etc. and businesses such as restaurants and retail stores. District specific municipal solid waste generation and recycling data was developed using information from the District, the Missouri Waste Composition Study by the Midwest Assistance Program, MoDNR and USEPA.

The Missouri Solid Waste Diversion and Recycling Status Report for Calendar Year 2001 stated that the statewide municipal solid waste generation rate was 6.15 pounds per capita per day. This rate was assumed to be the generation rate for the District. The per capita rate of 2,245 pounds per year was then multiplied by the 2004 District population estimate. This estimate was developed by the East-West Gateway Council of Governments. From this calculation, it was estimated that approximately 2,119,830 tons of municipal solid waste was generated in the St. Louis-Jefferson Solid Waste Management District.

For 2003, MoDNR has determined that 45 percent of the municipal solid waste generated in Missouri was diverted from disposal in a landfill in 2003. The District was assumed to have the same diversion, or recycling, rate. Therefore, approximately 953,924 tons of the municipal solid waste generated in the District was recycled.

In order to estimate the amount of materials in the District's municipal solid waste, information was gathered on the types of materials found in municipal solid waste and their percentage share. The 1999 Missouri Waste Composition Study, prepared by the Midwest Assistance Program, identified the following categories: paper; glass; metals; plastics; organics and inorganics. However, data was missing in reference to the proportional share that items banned from disposal in Missouri landfills (yard waste, rubber/tires, lead acid batteries or white goods/appliances) had in the municipal solid waste stream. To determine the percentage share that these banned items had in municipal solid waste stream nationally, the 2003 Municipal Solid Waste in the United States: 2001 Facts and Figures report prepared by Franklin Associates for USEPA was examined. It was assumed that items banned from landfills made up 20 percent of the municipal solid waste stream in the District. The 2003 USEPA report was also used to determine what were the percentage shares of specific subcategories of paper, metals and yard waste.

To estimate the amount that each waste material category and subcategory was recycled, District specific and national information from the 2003 USEPA report were used. From these amounts, the tons of materials recycled by general category and subcategory in the District were estimated. The information on the amount and composition of municipal solid waste generated in the District, amount and types of materials recycled can be found in Appendix A. This information was entered into the selected environmental benefits calculator.

III. ENVIRONMENTAL BENEFITS CALCULATORS

An environmental benefits calculator is a tool used to measure and document the impact that recycling has on the such elements as greenhouse gas emissions, air and water pollution, energy usage and natural resources. These benefits can be evaluated in a quantitative manner. An environmental benefits calculator requires area-specific information on amounts and types of materials recycled and disposed. The three most widely used calculators are discussed below.

WAste Reduction Model

The WAste Reduction Model (WARM) was developed by USEPA. It calculates greenhouse gas emissions for baseline and alternative waste management practices. These practices include source reduction, recycling, combustion, composting and landfilling. The model calculates emissions in metric tons of carbon equivalent and metric tons of carbon dioxide equivalent across a wide range of material types commonly found in municipal solid waste. In addition, the model calculates energy use for each of the waste management options.

Environmental Benefits Calculator of the Northeast Recycling Council

The Northeast Recycling Council (NERC) is a ten state organization based in Brattleboro, Vermont. It is a non-profit organization which promotes the environmental and economic benefits of recycling and source reduction. For a specific area, the NERC Environmental Benefits Calculator takes the amount of solid waste by category which are recycled, landfilled or incinerated and generates estimates of the environmental benefits. The calculator incorporates per ton figures of the estimated energy use and emissions from several lifecycle analysis studies. It also contains the most recent USEPA calculator and information. The estimates are average figures based on "typical" facilities and operating characteristics existing in the United States. Landfill gas recovery and generation of electricity are not part of this calculator. The calculator can be used by areas and states outside of the Northeast. The NERC has also developed a template for a report describing the results from the calculator. This calculator was prepared with the support of funds from USEPA Region 2.

The NERC Environmental Benefits Calculator yields the following detailed tables with descriptive charts:

- Materials Management Overview
- Reductions in Greenhouse Gas Emissions as a Result of Recycling
- Greenhouse Gas Savings Comparisons
- Energy Savings as a Result of Recycling
- Energy Savings Comparisons
- Life-Cycle Stage Comparisons
- Air Emission and Waterborne Waste as a Result of Recycling
- Emissions Savings Comparisons
- Selected Natural Resource Savings
- Energy Savings from Computer Recycling
- Energy Savings from Computer Reuse

Environmental Benefits Calculator of the National Recycling Coalition

The National Recycling Coalition (NRC) is a non-profit organization which represents all those committed to the common goal of maximizing recycling. The NRC Environmental Benefits Calculator is based on the calculator model originally developed for the NERC. The NRC has modified the NERC calculator model to enable usage by broader audiences and to streamline the data entry process and identification of information sources. Sections have been added on trees saved as a result of recycling and the amount of virgin materials conserved due to recycling steel. Lastly, in coordination with the USEPA Office of Solid Waste, the calculator was recently revised to ensure consistency with their WARM calculator. The NRC Environmental Benefits Calculator estimates the environmental benefits of recycling, based on the number of tons of specified materials which are recycled or disposed for a particular area. The NRC Environmental Benefits Calculator yields detailed tables and accompanying graphs for each of the following:

- Waste Management Overview
- Reductions in Greenhouse Gas Emissions through Recycling
- Energy Savings from Recycling
- Life Cycle Stage Comparisons
- Air Emissions and Waterborne Wastes
- Select Natural Resource Savings
- Number of Trees Saved

The calculator is based on per ton calculations for energy use and emissions estimated in several recent life cycle analysis studies. The estimates are average figures based on "typical" facilities and operating characteristics. The calculator assumes a baseline of 100 percent landfilling i.e., a ton of material recycled is assumed to have otherwise been destined for a landfill. This baseline can be customized by entering data on tons landfilled and incinerated in a particular area. The NRC has also developed a report template to present the findings of the calculator.

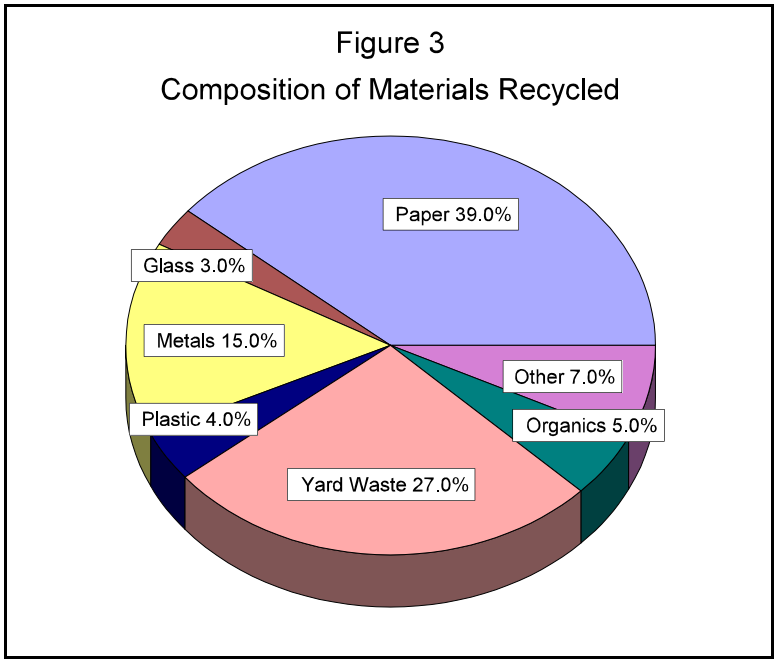
Selected Study Calculator

A sensitivity analysis was performed to choose the appropriate calculator for the study area. The selection was based on the expected results and data available for and from the District. The scope of the study required a calculator to produce comprehensive analysis for the entire waste stream. For example, the calculator was expected to produce results such as greenhouse gas emissions, air and water quality benefits; and natural resources and energy savings. The NRC Environmental Benefits Calculator was chosen because in addition to the results that the WARM and the NERC calculators produced, the use of the NRC calculator would aid in understanding the number of trees that were saved as a result of recycling paper and conserving natural resources. An overview of the selected NRC calculator can be found in Appendix B.

IV. ANALYSIS OF CALCULATOR RESULTS

Information on the amount of municipal solid waste generated in the District and materials recycled by category type were processed through the NRC Environmental Benefits Calculator. Output from the Calculator can be found in Appendix B.

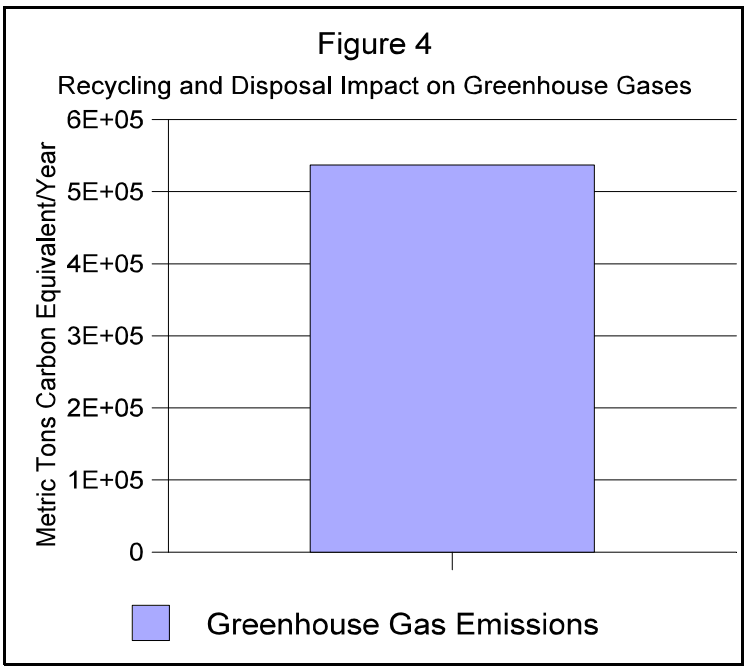
Out of the total 2,119,830 tons of municipal solid waste generated in the District, it is estimated that approximately 953,924 tons is recycled. This represents 45 percent of municipal solid waste stream. The remainder of the solid waste is disposed of in landfills located within and outside of the District. Figure 3 shows the composition of the recycled materials in the District. The majority compositions of the recycled materials are paper at 39 percent and yard waste at 27 percent. Ferrous and non-ferrous metals account for 15 percent of the materials found in solid waste stream which are recycled.



Greenhouse Gas Emissions

Recycling offers an important environmental benefit in that these actions help to reduce the emission of greenhouse gases that may contribute to global climate change. Greenhouse gases, such as carbon dioxide, methane, nitrous oxide and chlorofluorocarbons, trap heat in the lower atmosphere that would otherwise escape to the stratosphere. Both the manufacture and distribution of products and the disposal of associated solid waste in landfills can contribute to the emission of greenhouse gases. Recycling and composting help to reduce greenhouse gas emissions by: decreasing the energy needed to make products from raw material; reducing emissions from incinerators and landfills, which are major sources of methane gas emissions in the U.S.; and slowing the harvest of trees, thereby maintaining their carbon dioxide storage benefit.

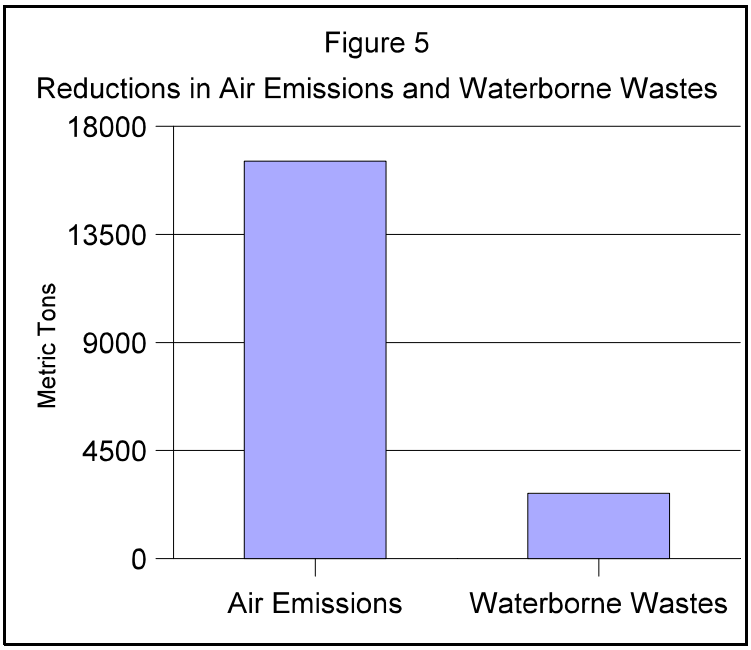
Figure 4 shows the impact that the recycling of municipal solid waste and solid waste disposal has on greenhouse gas emissions. Based on the recycling activities in the District, it is estimated that there would be a reduction of 536,912 metric tons of carbon equivalent per year. This amount is comparable to the carbon emissions from 405,000 cars or about 20 percent of the vehicles in the eight county St. Louis (Missouri-Illinois) metropolitan area.



Air and Water Pollution Emission Reduction

By decreasing the need to mine and process virgin materials from the earth, recycling can eliminate the pollution associated with material extraction and material processing which are the first two stages of a product's development. Mineral mining and processing pollute the air, land and water with toxic materials, such as ammonia, carbon dioxide, carbon monoxide, methane and sulfur dioxide. Recycling reduces, and in many cases eliminates, these pollutants. In addition, recycling keeps materials out of landfills where they can produce methane gas and can introduce leachate into groundwater and surface waters.

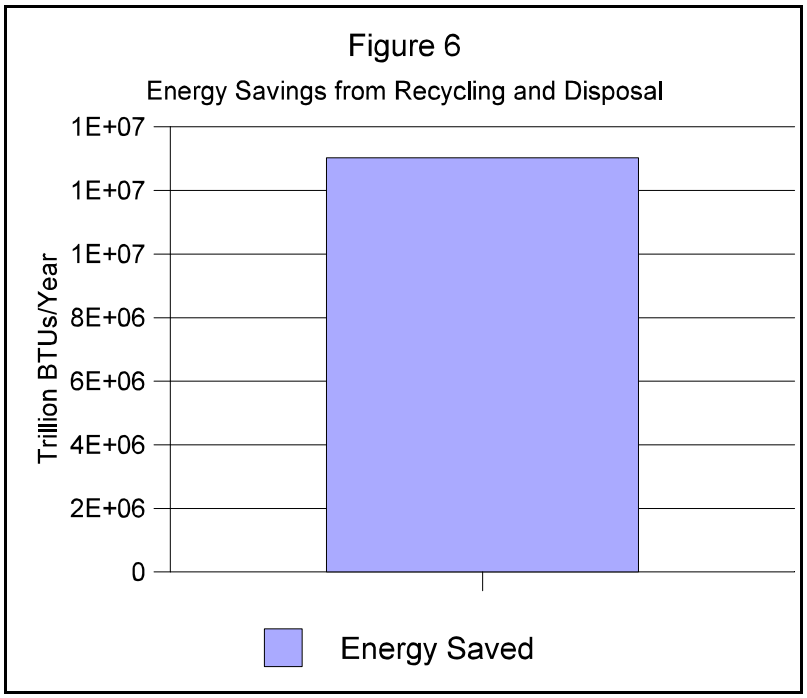
Figure 5 shows that the estimated reduction in air emissions other than greenhouse gases (i.e., carbon dioxide and methane) due to recycling and manufacturing using recycled materials was 16,550 tons. These emissions include such gases as sulfur oxides, nitrous oxide, hydrocarbons, carbon monoxide and fine particulate matter. Making up the 2,710 tons of waterborne waste that is reduced or eliminated are suspended particles, fluorides, iron, oil, dissolved solids and other materials.



Energy Savings

The manufacturing of products with recovered or recycled materials as feedstock instead of virgin materials uses significantly less energy. Energy is saved by reducing the need to extract and process raw materials so that new products can be manufactured. For example, by recycling one ton of plastics, the equivalent of 3.85 barrels of oil is saved. Less energy used means less burning of fossil fuels such as coal, oil and natural gas. Most of the energy used in industrial processes and in related transportation involves burning fossil fuels. When these fuels are burned, pollutants such as sulfur dioxide, nitrogen oxide and carbon monoxide are released into the air.

The energy savings due to recycling is shown in Figure 6. The 953,900 tons of paper, glass, metals, plastics and other materials recycled in 2003 in the District saved about 13 trillion BTUs of energy, enough to power nearly 124,000 homes for one year. This number is equivalent to 16 percent of the housing units found within the District.



Natural Resource Savings

By using recycled materials instead of trees, metal ores, minerals, oil and other raw materials taken or harvested from the earth, recycling-based manufacturing helps to conserve limited natural resources. Sound conservation practices help to reduce the need to expand logging and mining operations. Furthermore, it also can help to reduce the disturbance of areas which are home to a variety of endangered flora and fauna.

The total natural resources saved due to recycling ferrous steel are shown in Table 1. By recycling 85,000 tons of steel in 2003, District residents saved 106,000 tons of iron ore, 59,000 tons of coal and 5,000 tons of limestone. Ferrous steel includes white goods or appliances. These figures are based on the assumption that recycling one ton of steel saves 2,500 pounds of iron ore, 1,400 pounds of coal and 120 pounds of limestone.

Table 1
Natural Resources Saved

Material Saved	**Tons**
Iron ore	105,991
Coal	59,355
Limestone	5,088
Total	170,434

By recycling over 116,000 tons of paper in the District last year, over 1.8 million trees did not need to be harvested. The number of trees saved, based on the type of paper recycled is shown in Table 2.

Table 2
Total Trees Saved

Paper Recycled	**Trees Saved**
Ground wood paper - 82,826 tons	993,912
Free sheet paper - 33,883 tons	813,192
Total Number of Trees Saved	1,801,104

V. CONCLUSIONS

Waste reduction, composting and recycling efforts continue to expand throughout the District. Approximately 45 percent of what was once considered waste is now being diverted from disposal in landfills. These results have been accomplished through the collaborative efforts of the public, private and not-for-profit communities. Because of these efforts, less waste is going to our landfills. But in addition, significant amounts of energy and natural resources are conserved. Recycling also reduces, and in many cases eliminates, the pollution associated with virgin material extraction and processing. Another important environmental benefit of recycling programs, which is often overlooked, is the significant reductions in greenhouse gases. These greenhouse gas reductions result because recycling decrease the energy needs of product development, reduces emissions from incinerators and landfills and lastly, recycling programs save trees which act as a carbon sink for carbon dioxide in the lower atmosphere. Therefore, continuing growth of waste reduction and recycling activities will, also, increase the environmental benefits in the future.

APPENDIX A

St. Louis-Jefferson Solid Waste Management District
Municipal Solid Waste Generated and Recycled

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Table A - 1
Estimated 2003 Municipal Solid Waste Generation
St. Louis-Jefferson Solid Waste Management District

Per Capita Daily Waste Generation Rate*	6.15 pounds
Annual Per Capita Waste Generation	2245 pounds or 1.12 tons
2004 District Population Estimate**	1,888,700
Municipal Solid Waste Generated	2,119,820 tons

*Missouri statewide generation rate from the Missouri Solid Waste Diversion and Recycling Status Report for Calendar Year 2001, Missouri Department of Natural Resources.
**From East-West Gateway Council of Governments

Table A - 2
Estimated 2003 Municipal Solid Waste Management
St. Louis-Jefferson Solid Waste Management District

Municipal Solid Waste Generated	2,119,830 tons
Municipal Solid Waste Landfilled	1,165,906 tons
Municipal Solid Waste Recycled*	953,924 tons

*Assumed 2003 Missouri statewide recycling percentage of 45 percent. Taken from Missouri Solid Waste Diversion and Recycling Status Report for Calendar Year 2003, Missouri Department of Natural Resources.

Table A - 3
Estimated 2003 Municipal Solid Waste Stream Composition
St. Louis-Jefferson Solid Waste Management District

Category	Percent Share of Waste Stream	Tons
Paper	30	627,470
Glass	5	101,752
Metals	6	118,711
Plastics	11	237,421
Organics		
Food Waste	15	322,214
Wood Waste	1	16,959
Textiles	3	67,834
Disposable Diapers	3	67,834
Other Organics	2	50,876
Inorganics		
Fines	2	50,876
Other Inorganics	2	33,917
Lead Acid Batteries	1	21,198
Yard Trimmings	12	254,380
Rubber/Tires	3	63,595
Ferrous/White Goods	4	84,793
Total	100	2,119,830

Categories and percentage share of waste stream originally from the Missouri Waste Composition Study, Midwest Assistance Program, 1999 and was adjusted to include the percentage share for lead-acid batteries, yard trimmings, rubber/tires and ferrous/white goods taken from Municipal Solid Waste in the United States: 2001 Facts and Figures, 2003, prepared by Franklin Associates for U.S. Environmental Protection Agency.

Table A - 4
Estimated Municipal Solid Waste Recycled
St. Louis-Jefferson Solid Waste Management District

Category	Recovery/Recycled as Percent of Generation	Tons
Paper	60	376,482
Glass	25	25,438
Metals	35	41,549
Plastics	15	35,613
Organics		
Food Waste	3	9,666
Wood Waste	10	1,696
Textiles	15	10,175
Disposable Diapers and Other Organics	21	24,929
Inorganics		
Fines	Negligible	Negligible
Other Inorganics	Negligible	Negligible
Lead Acid Batteries	100	21,198
Yard Trimmings	100	254,380
Rubber/Tires	100	63,595
Ferrous/White Goods	100	84,793
Total		949,514

Recovery/recycled percentages derived from assumptions for the District and from Municipal Solid Waste in the United States: 2001 Facts and Figures, 2003, prepared by Franklin Associates for U. S. Environmental Protection Agency. As lead acid batteries, yard waste, tires and white goods are banned from disposal in Missouri landfills, their recycling rate was assumed to be 100 percent.

Table A - 5
Estimated 2003 Municipal Solid Waste Recycled Allocation
St. Louis-Jefferson Solid Waste Management District

Municipal Solid Waste Recycled	953,924 tons
Municipal Solid Waste Recycled by Category	949,514 tons
Difference Assigned to Mixed Recyclables Category	4,110 tons

Table A - 6
Breakdown of Selected Recycling Categories
St. Louis-Jefferson Solid Waste Management District
For Use in NRC Environmental Benefits Calculator

Paper Sub-Categories	**Percentage Share of Paper Category**	**Tons Recovered/Recycled**
Corrugated Cardboard	36	135,534
Magazines & Standard Mail	9	33,883
Office Paper	9	33,883
Phone books	1	3,765
Textbooks (Books)	1	3,765
Mixed Paper (Other Commercial Printing)	8	30,119
Newspaper	14	52,707
Other Uncategorized Paper	22	82,826
Total	100	376,482

Percentage shares derived from U.S. Environmental Protection Agency, Municipal Solid Waste in the United States: 2001 Facts and Figures, 2003, prepared by Franklin Associates.

Table A - 6 Continued
Breakdown of Selected Recycling Categories
St. Louis-Jefferson Solid Waste Management District
For Use in NRC Environmental Benefits Calculator

Metals Sub-Categories	**Percentage Share of Metals Category**	**Tons Recovered/Recycled**
Aluminum Cans	25	10,387
Steel Cans	38	15,789
Mixed Metals (aluminum scrap, other nonferrous, aluminum, other steel packaging, aluminum foil and closures)	37	15,373
Total	100	41,549

Percentage shares derived from Franklin Associates for U.S. Environmental Protection Agency, Municipal Solid Waste in the United States: 2001 Facts and Figures, 2003, prepared by Franklin Associates.

Table A - 6 Continued
Breakdown of Selected Recycling Categories
St. Louis-Jefferson Solid Waste Management District
For Use in NRC Environmental Benefits Calculator

Yard Trimmings Sub-Categories	**Percentage Share of Yard Trimmings Category**	**Tons Recovered/Recycled**
Grass	50	127,190
Brush	25	63,595
Leaves	25	63,595
Total	100	254,380

Percentage shares derived from Franklin Associates for U.S. Environmental Protection Agency, Municipal Solid Waste in the United States: 2001 Facts and Figures, 2003, prepared by Franklin Associates.

Table A - 7
Estimated Materials Recycled by Category
St. Louis-Jefferson Solid Waste Management District
For Use in NRC Environmental Benefits Calculator

Material Type	Tons
Aluminum Cans	10,387
Steel Cans	15,789
Mixed Metals, including Lead Acid Batteries	36,571
Ferrous Scrap Metal/White Goods	84,793
Glass	25,438
Mixed Plastics (HDPE, LDPE, PET)	35,613
Corrugated Cardboard	135,534
Magazines and Standard Mail	33,883
Newspapers	52,707
Office Paper	33,883
Phone Books	3,765
Text Books/Books	3,765
Mixed Paper/Other Commercial Printing	30,119
Other Uncategorized Paper	82,826
Dimensional Lumber/Wood Waste and MDF	1,696
Food Scraps	9,666
Grass	127,190
Leaves	63,595
Branches	63,595
Mixed Organics/Textiles	10,175
Unclassified Organics/Disposable Diapers, Other Organics	24,929
Other Recyclables/Tires	63,595
Mixed Recyclables/Unassigned Diverted Materials	4,110
Total Recycled/Diverted	953,924

APPENDIX B

Environmental Benefits Calculator Overview and Output

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This Appendix contains an overview of the Environmental Benefits Calculator of the National Recycling Coalition (NRC). It also has tables and graphs summarizing estimated environmental benefits of recycling in the St. Louis-Jefferson Solid Waste Management District. This information was developed using the NRC Environmental Benefits Calculator.

Estimates of the Environmental Impacts of Recycling in
St. Louis-Jefferson Solid Waste Management District
December 2004

National Recycling Coalition
Environmental Benefits Calculator

What the Calculator Does

This Environmental Benefits Calculator generates estimates of environmental benefits, based on the number of tons of specified materials recycled, landfilled and incinerated in a particular geographic region. The calculator yields detailed tables and accompanying graphs for each of the following:

1. Waste Management Overview
2. Reductions in Greenhouse Gas Emissions through Recycling
3. Energy Savings from Recycling
4. Life-Cycle Stage Comparisons
5. Air Emissions and Waterborne Wastes
6. Select Natural Resource Savings
7. Number of Trees Saved

How the Calculator Works

The calculator is based on per-ton figures for energy use and emissions estimated in several recent lifecycle analysis studies. The estimates are average figures based on "typical" facilities and operating characteristics. The model tailors results to a particular region based on the amount of materials recycled in that region. The model assumes a baseline of 100 percent landfilling – i.e., a ton of material recycled is assumed to have otherwise been destined for a landfill. Users can adjust this baseline by entering data on tons landfilled and incinerated in their region.

How to Use the Calculator

Step 1. Click on the "Data Input Sheet" tab at the bottom of the spreadsheet. For your jurisdiction, enter information in each green colored data box as prompted. To run the calculator, data for a minimum of one category of recycled materials is required.

Step 2. Click on the results sheet tabs at the bottom of the spreadsheet. The sheets include automatically generated tables for each of the environmental benefits identified about, along with descriptive graphs accompanying each table. Print each sheet for a summary of environmental benefits associated with the recycling and disposal figures input in Step One. See below for a detailed explanation of each of the summary tables.

Explanation of the Calculator Results

There are many details involved in deriving environmental benefits estimates. The calculator uses statistics from several different sources, and involves important assumptions and caveats. Following is an explanation of each of the nine summary tables.

Table 1. Waste Management Overview is a restatement of the waste management data input by the model user.

Table 2. Reductions in Greenhouse Gas Emissions through Recycling is based on the data and methodology developed by the U.S. Environmental Protection Agency.[i] EPA based most of its calculations on data from Franklin Associates, [ii] Research Triangle Institute, [iii] and research on methane emissions by N.C. State University. The calculator estimates reductions in emissions from recycling by calculating the difference between the net emissions if the materials were disposed and net emissions if they were recycled. Emissions estimates are derived from estimated climate change impacts of both energy use and non-energy process activities. Recycling process activities include collection, transportation, processing, generating electricity, and recovery of scrap steel. Landfill activities include collection, transportation and landfill operation. Landfills are assumed to have the national average distribution of no recovery of landfill methane (51 percent), recovery and flaring (25 percent), and recovery and electricity generation (24 percent). Emissions calculations for this latter category include an emissions "credit" for avoided utility emissions. Column three presents the net greenhouse gas reduction, based on the quantities recycled and the assumed baseline. EPA was used as a source since it is fast becoming a standardized source for greenhouse gas estimates, used by states and other entities throughout the nation, and because it represented a recent effort based on a broad review of sources. However, it should be noted that other sources are independently investigating greenhouse gas implications of recycling; most notably the Tellus Institute,[iv] the Environmental Defense Fund (EDF),[v] and EPA's Office of Research and Development.

Table 3. Energy Savings from Recycling is based on the energy use estimates cited by EPA in deriving greenhouse gas estimates.[vi] Average energy use figures for each life-cycle state were taken from Franklin and RTI studies, [vii] as cited by EPA.

Table 4. Life-Cycle Stage Comparisons presents the net energy used in each waste management activity (recycling, landfill and incineration), as well as the net energy credit allocated to recycling

and incineration. Unlike the previous tables, it is based on average figures for a "typical" ton of recyclables, using an average of figures from Franklin Associates and the Tellus Institute, as cited by Richard Denison of the EDF.[viii] Tonnage from Table 1 included as "recyclable commodities" is used as the basis for the estimates.

Table 5. Air Emissions and Waterborne Wastes presents estimates of air and water emissions resulting from recycling (including collection, processing, transportation and substitution for virgin materials in manufacturing) and resulting from the current mix of incineration and landfilling (including collection, processing, landfill operations and/or incineration electricity generation). Like Table 6, it is based on average per ton figures for a "typical" ton of recyclables, and was derived using average statistics from Franklin Associates and Tellus, as cited by EDF.[ix] The "recyclable commodities" from Table 1 was used as a basis in the calculations.

Table 6. Select Natural Resource Savings presents estimates of resource savings associated with ferrous steel recycling (including iron ore, coal and lime stone). Unfortunately, precise estimates for natural resource savings associated with other recycled materials are not available. Forest resource savings associated with paper recycling have been most comprehensively analyzed in the literature, but because of complex market dynamics and widely varying environments in which wood pulp is harvested, it is difficult to make meaningful estimates for trees saved or forest lands conserved. The most comprehensive review of paper recycling impacts is series of reports put out by the Environmental Defense Fund's Paper Task Force.

Table 7. Number of Trees Saved from Recycling presents estimates of the number of trees saved from recycling various grades of papers. These calculations represent "ballpark" estimates, and are based on revised estimates from Conservatree on the number of trees it takes to make paper from both the "groundwood" process and the "free sheet process".

Who Developed the Calculator

The model on which the calculator is based was originally developed by Ed Boisson and Associated for the Northeast Recycling Council, with funding provided by U.S. EPA, Region II. To create this calculator, the National Recycling Coalition (NRC) has modified the original model to enable usage by broader audiences, and to streamline the process for data enetry and identification of information sources. In addition, the NRC has added an additional section on the number of trees saved by recycling paper. Lastly, on behalf of EPA's Office of Solid Waste, ICF Consulting recently revised the calculator to ensure consistency with EPA's WAste Reduction Model (WARM). The WARM model is available on EPA's website at http://www.epa.gov/globalwarming/actions/waste/warm.html. Background on the WARM emission factors are presented in *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* (EPA 530-R-02-066), available online at http://www.epa.gov/mswclimate/greengas.pdf . For additional information on the calculator, please contact Michael Alexander of the NRC at (802) 254-3338 or at michaela@nrc-recycle.org .

End Notes

[i] See U.S. EPA. *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* (EPA 530-R-02-006), available online at http://www.epa.gov/mswclimate/greengas.pdf . See also U.S. EPA, revised "WARM" model, May 2002, available online at http://www.epa.gov/globalwarming/actions/waste/warm.html .

[ii] Franklin data is from: "The Role of Recycling in Integrated Solid Waste Management to the Year 2000," for Keep America Beautiful, 1994, and individual reports.

[iii] Research Triangle Institute developed life-cycle data sets to create a municipal solid waste Decision Support Tool (DST) on behalf of EPA's Office of Research and Development. For further information, refer to the project web site at http://www.rti.org/units/ese/p2/lca.cfm#life .

[iv] Tellus is currently engaged in greenhouse gas (GHG) related studies involving lifecycle analysis of recycling in the states of Minnesota and Iowa.

[v] Perhaps the most detailed commodity specific life cycle analysis to date is EDF's Paper Task Force, "Recommendations for Purchasing and using Environmentally Preferable Paper," 1995. Several White Papers investigate the environmental impacts of paper manufacture, recycling and disposal in detail.

[vi] See note 1.

[vii] See notes 2 and 3.

[viii] Denison, Richard. "Environmental Life-Cycle Comparisons of Recycling, Ladfilling and Incineration: A Review of Recent Studies." Annual Review of Energy and the Environment. 1996. 21:191-237.

[ix] Ibid.

[x] Ibid., page 223.

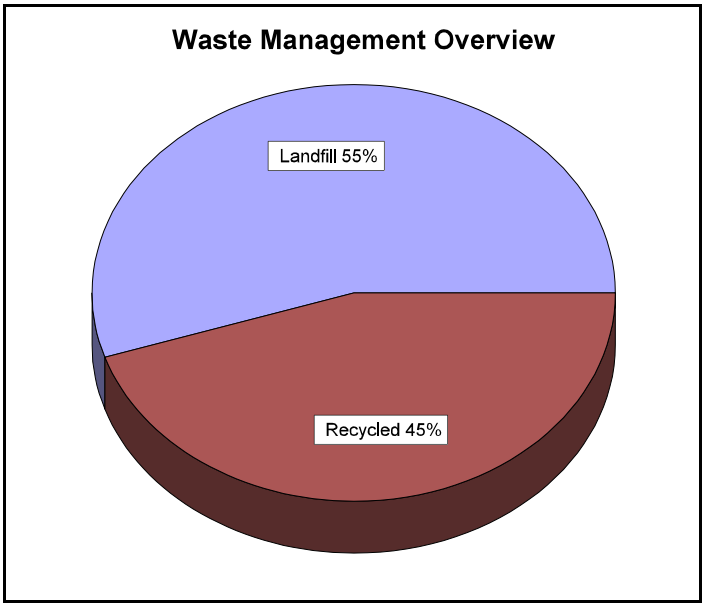
Table B-1. Waste Management Overview

	Tons Recycled
RECYCLABLE COMMODITIES	
Aluminum Cans	10,387
Steel Cans	15,789
Mixed Metals	36,571
Ferrous Scrap Metal	84,793
Glass	25,438
HDPE	0
LDPE	0
PET	0
Mixed Plastics	35,613
Unclassified Plastics	0
Corrugated Cardboard	135,534
Magazines/Third-class Mail	33,833
Newspaper	52,707
Office Paper	33,883
Phonebooks	3,765
Textbooks	3,765
Mixed Paper	30,199
Other Uncategorized Paper	82,826
Dimensional Lumber	1,696
Medium-Density Fiberboard	0
TOTAL - COMMODITIES	**586,769**
OTHER MATERIALS	
Food Scraps	9,666
Yard Trimmings	0
Grass	127,190
Leaves	63,595
Branches	63,595
Mixed Organics	10,175
Unclassified Organics	24,929
Construction	0
Mixed Recyclables	4,410
Other Recyclables	63,595
TOTAL - OTHER MATERIALS	**367,155**
TOTAL - ALL MATERIALS	**953,924**

Table B-1- Continued

Tons Landfilled	**1,165,906**
Tons Incinerated	0
Tons Generated	**2,119,830**
Recycling Rate (% of generation)	**45.0%**
Incineration Rate (% of generation)	**0.0%**
Landfill Rate (% of generation)	**55.0%**
Incineration Rate (% of disposal)	**0.0%**
Landfill Rate (% of disposal)	**100.0%**

Graph B-1



Graph B-2

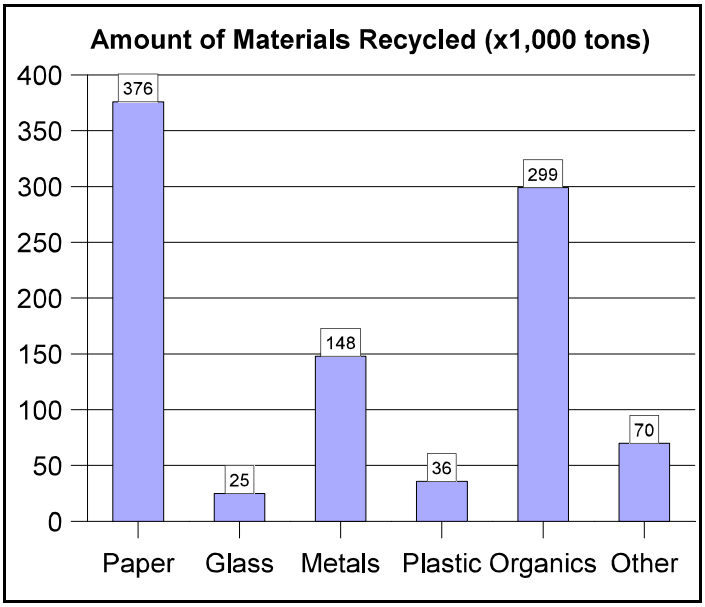

Amount of Materials Recycled (x1,000 tons)
400
350
300
250
200
150
100
50
0
376
25
148
36
299
70
Paper
Glass
Metals
Plastic
Organics
Other

Table B-2. Reductions in Greenhouse Gas Emissions through Recycling

	Tons Recycled	Greenhouse Gas Emissions Associated with Recycling (MTCE)	Greenhouse Gas Emissions if all Disposed (MTCE)	Net Greenhouse Gas Emissions from Recycling Compared to Disposal (MTCE)	Greenhouse Gas Reductions in Passenger Cars Equivalent (# of cars off the road per year)
RECYCLABLE COMMODITIES					
Aluminum Cans	10,387	-41,632	109	-41,741	-31,496
Steel Cans	15,789	-7,726	165	-7,891	-5,954
Mixed Metals	36,571	-63,539	383	-63,923	-48,234
Ferrous Scrap Metal	84,793	-41,489	889	-42,378	-31,977
Glass	25,438	-1,938	267	-2,204	-1,663
HDPE	0	0	0	0	0
LDPE	0	0	0	0	0
PET	0	0	0	0	0
Mixed Plastics (HDPE, LDPE, and PET)	35,613	-14,708	373	-15,081	-11,380
Unclassified Plastics	0	0	0	0	0
Corrugated Cardboard	135,534	-96,010	10,483	-106,492	-80,355
Magazines/Third-class Mail	33,883	-24,989	-4,075	-20,913	-15,780
Newspaper	52,707	-50,030	-10,960	-39,069	-29,480
Office Paper	33,883	-22,947	21,103	-44,050	-33,239
Phonebooks	3,765	-3,426	-783	-2,643	-1,994
Textbooks	3,765	-2,816	2,345	-5,161	-3,894
Mixed Paper	30,119	-25,088	4,625	-29,713	-22,421
Other Uncategorized Paper	82,826	-55,760	8,461	-64,221	-48,459
Dimensional Lumber	1,696	-1,135	-177	-958	-723

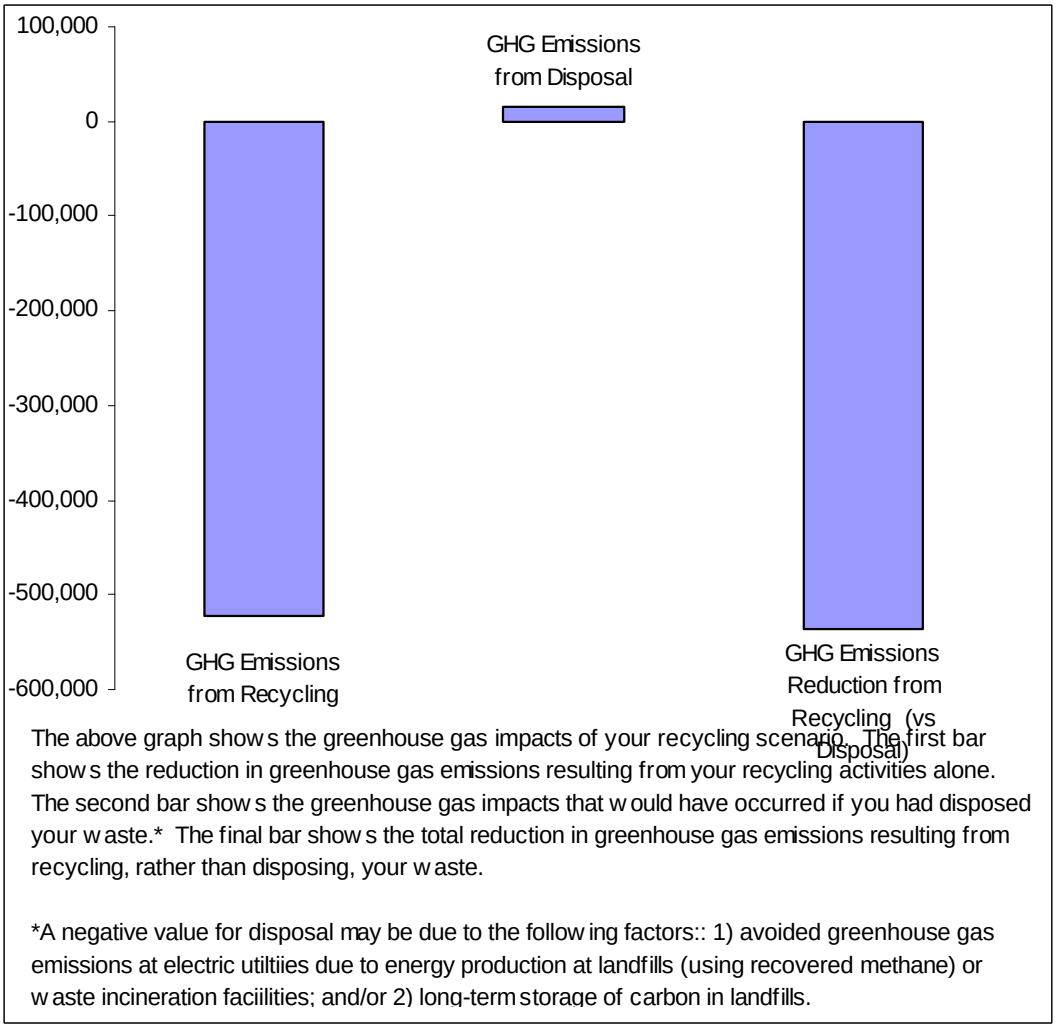
Table B-2 Continued

Medium-density Fiberboard	0	0	0	0	0
TOTAL - COMMODITIES	**586,769**	**-453,233**	**33,207**	**-486,439**	**-367,048**
OTHER MATERIALS					
Food Scraps	9,666	-522	1,647	-2,169	-1,637
Yard Trimmings	0	0	0	0	0
Grass	127,190	-6,872	1,319	-8,191	-6,180
Leaves	63,595	-3,436	-18,571	15,135	11,420
Branches	63,595	-3,436	-6,651	3,215	2,426
Mixed Organics	10,175	-550	343	-892	-673
Unclassified Organics	24,929	-1,347	840	-2,187	-1,650
Construction	0	NA	NA	NA	NA
Mixed Recyclables	4,410	-3,363	229	-3,592	-2,710
Other Recyclables	63,595	-48,490	3,303	-51,793	-39,081
TOTAL - OTHER MATERIALS	**367,155**	**-68,015**	**-17,542**	**-50,472**	**-38,084**
TOTAL - ALL MATERIALS	**953,924**	**-521,247**	**15,664**	**-536,912**	**-405,132**

Sources: U.S. EPA, Revised "WARM" model. July, 2003. Available online at http://yosemite.epa.gov/oar/globalwarming.nsf/WARM.

For information on sources of GHG emissions to compare to the reductions resulting from recycling in your state, see http://yosemite.epa.gov/globalwarming/ghg.nsf/emissions/state

Graph B-3
GHG Impacts of Recycling and Disposal (MTCE/yr.)



The above graph shows the greenhouse gas impacts of your recycling scenario. The first bar shows the reduction in greenhouse gas emissions resulting from your recycling activities alone. The second bar shows the greenhouse gas impacts that would have occurred if you had disposed your waste.* The final bar shows the total reduction in greenhouse gas emissions resulting from recycling, rather than disposing, your waste.

*A negative value for disposal may be due to the following factors:: 1) avoided greenhouse gas emissions at electric utiltiies due to energy production at landfills (using recovered methane) or waste incineration faciilities; and/or 2) long-term storage of carbon in landfills.

MTCE - Metric Ton of Carbon Equivalent

Table B-3. Energy Savings from Recycling

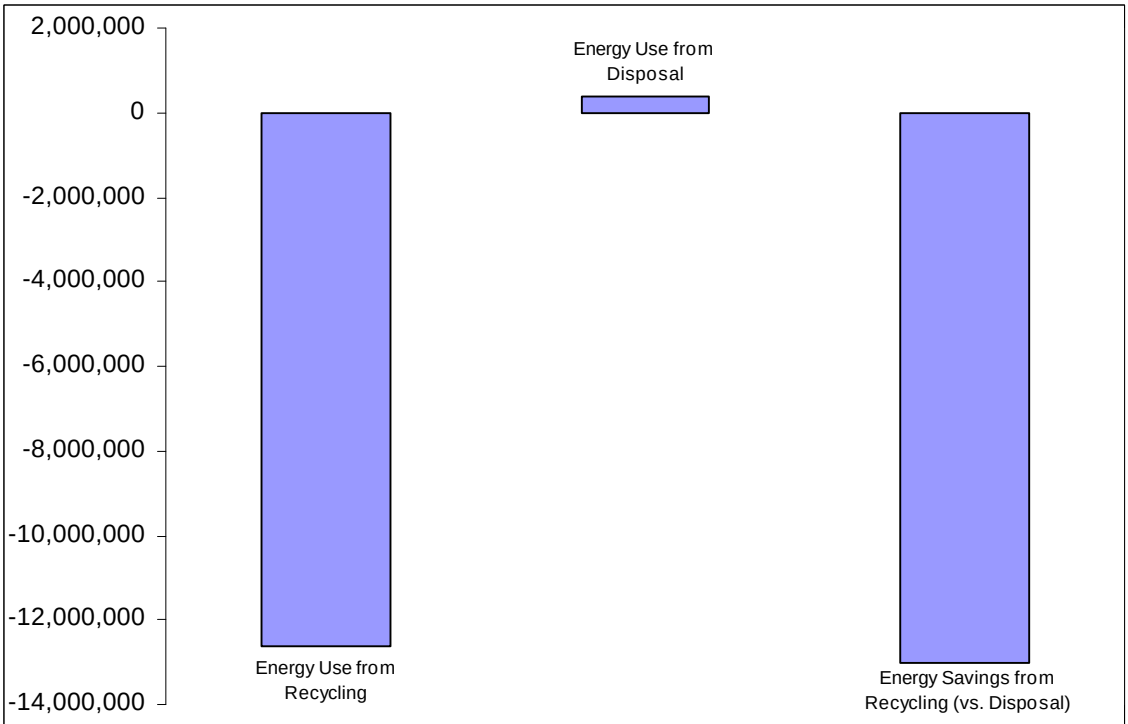
	Tons Recycled	Energy Use if All Recycled (million BTU)	Energy Use if All Disposed (million BTU)	Net Energy from Recycling Compared to Disposal (million BTU)	Energy Savings in Per Household Equivalent (# of houses/year)
RECYCLABLE COMMODITIES					
Aluminum Cans	10,387	-1,968,639	5,478	-1,974,117	-18,765
Steel Cans	15,789	-315,246	8,327	-323,573	-3,076
Mixed Metals	36,571	-2,929,714	19,288	-2,949,001	-28,032
Ferrous Scrap Metal	84,793	-1,692,994	44,720	-1,737,714	-16,518
Glass	25,438	-54,066	13,416	-67,482	-641
HDPE	0	0	0	0	0
LDPE	0	0	0	0	0
PET	0	0	0	0	0
Mixed Plastics (HDPE, LDPE, and PET)	35,613	-752,838	18,782	-771,620	-7,335
Unclassified Plastics	0	0	0	0	0
Corrugated Cardboard	135,534	-1,762,156	47,264	-1,809,420	-17,200
Magazines/Third-class Mail	33,883	-23,232	14,550	-37,782	-359
Newspaper	52,707	-868,925	23,258	-892,183	-8,481
Office Paper	33,883	-341,576	4,261	-345,837	-3,287
Phonebooks	3,765	-44,920	1,661	-46,582	-443
Textbooks	3,765	-3,867	473	-4,341	-41
Mixed Paper	30,119	-420,201	9,412	-429,612	-4,084
Other Uncategorized Paper	82,826	-551,029	27,564	-578,593	-5,500
Dimensional Lumber	1,696	997	799	199	2
Medium-density Fiberboard	0	0	0	0	0
TOTAL - COMMODITIES	**586,769**	**-11,728,405**	**239,254**	**-11,967,659**	**-113,761**

Table B-3 Continued

OTHER MATERIALS					
Food Scraps	9,666	5,645	4,021	1,624	15
Yard Trimmings	0	0	0	0	0
Grass	127,190	74,279	58,014	16,265	155
Leaves	63,595	37,139	30,022	7,118	68
Branches	63,595	37,139	29,945	7,195	68
Mixed Organics	10,175	5,942	4,484	1,458	14
Unclassified Organics	24,929	14,559	10,987	3,572	34
Construction	0	NA	NA	NA	
Mixed Recyclables	4,410	-69,437	1,659	-71,096	-676
Other Recyclables	63,595	-1,001,332	23,920	-1,025,252	-9,746
TOTAL - OTHER MATERIALS	**367,155**	**-896,066**	**163,051**	**-1,059,117**	**-10,068**
TOTAL - ALL MATERIALS	**953,924**	**-12,624,470**	**402,305**	**-13,026,776**	**-123,829**

Sources: U.S. EPA, Revised "WARM" model. July, 2003. Available online at http://yosemite.epa.gov/oar/globalwarming.nsf/WARM.

Graph B-4
Energy Impacts of Recycling and Disposal (million BTU/yr)



The above graph shows the energy impacts of your recycling scenario. The first bar shows the reduction in energy use resulting from your recycling activities alone. The second bar shows the energy use that would have occurred if you had disposed your waste.* The final bar shows the total reduction in energy use resulting from recycling, rather than disposing, your waste.

*A negative value for disposal is due to avoided energy use for electricity generation resulting from energy production at landfills (using recovered methane) and/or waste incineration facilities.

Table B-4. Life Cycle Stage Comparisons

Note: These figures are based on an average ton of recycled commodities.

	Energy Used During Recycling Collection & Processing	Energy Used During MSW Collection and Landfill	Energy Used During MSW Collection, Processing & Incineration	Energy Used for the State's Average Mix of Landfill and Incineration
Energy Used during Each Stage of the Materials Life Cycle (mil. Btu/ton)	**0.838**	**0.312**	**1.088**	**0.312**
Total Energy Used Based on # of tons of Recycled paper, metals, glass and plastics (mil. Btu)	**491,712**	**183,072**	**638,405**	**183,072**

Sources:

District and USEPA

Denison, Richard A., "Environmental Life-Cycle Comparisons of Recycling, Landfilling and Incineration: A Review of Recent Studies, Annual Review of Energy and the Environment. 1996.21:191-237.

Franklin Associates, "The Role of Recycling in Integrated Waste Management to the Year 2000." For Keep America Beautiful. 1994.

Tellus Institute. "The Role of Recycling in Integrated Waste Management to the Year 2000." For Keep America Beautiful. 1994.

Graph B-5

Comparison of Energy Used During Each Life Cycle Stage - based on tons of recycled paper, plastic, metals and glass (trillion BTU)

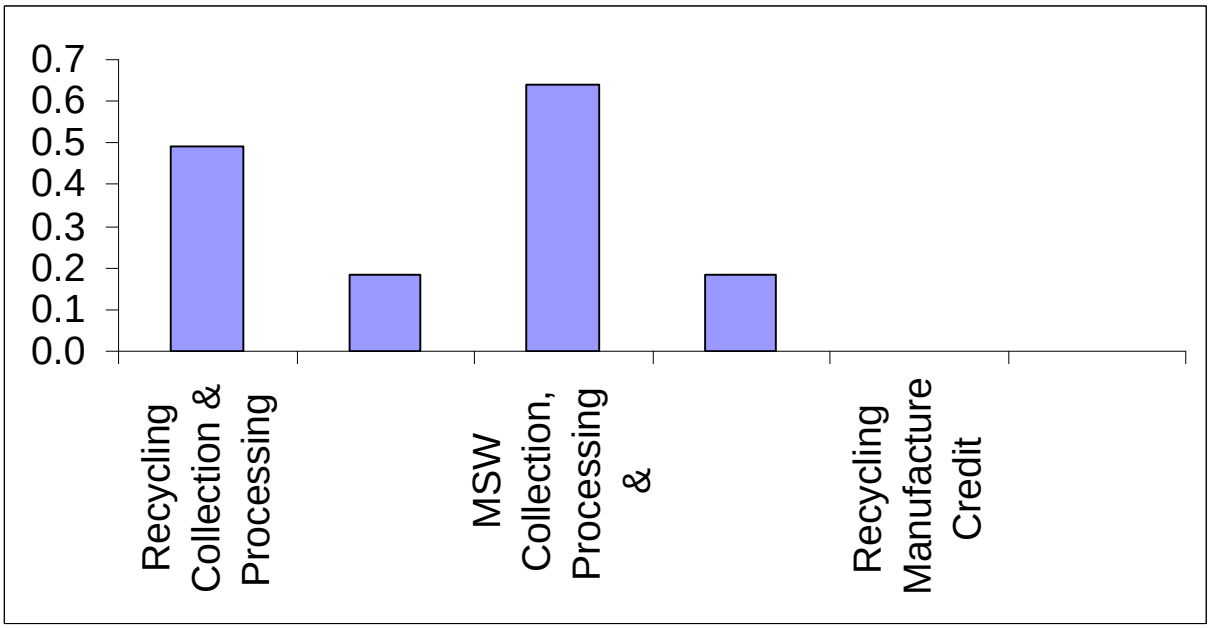


Table B-5. Reduced Air Emissions and Waterborne Wastes

Note: These figures are based on an average ton of recycled commodities – statewide totals for recycled paper, plastic, glass and metals are used to generate the estimates. Air and water emissions vary considerable in their level of toxicity and other environmental impacts.

Air Emissions	Reduced Emissions Due to Recycling (tons)
aldehydes	129.1
ammonia	1.9
carbon dioxide	681,670.4
carbon monoxide	6,343.6
chlorine	11.0
hydrogen flouride	42.8
lead	1.5
hydrogen chloride	0.0
metals	93.9
hydrocarbons	1,688.0
methane	29,825.9
nitrogen oxides	2,536.2
other organics	235.0
particulates	2,795.4
sulfur oxides	2,671.5
Total	728,046.0
Total (Excluding CO_2 and Methane)	**16,549.8**

Waterborne Wastes	Reduced Emissions Due to Recycling (tons)
acid	107.1
ammonia	22.9
BOD	130.4
COD	360.6
cyanide	0.9
dissolved solids	1,375.1
flourides	25.2
iron	19.6
metal ion	49.9
oil	11.5
phenol	0.6
sulfuric acid	0.6
suspended solids	606.0
Total	**2,710.5**

Sources:

Denison, Richard A., "Environmental Life-Cycle Comparisons of Recycling, Landfilling and Incineration: A Review of Recent Annual Review of Energy and the Environment." 1996.21:191-237. Page 227.

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For information on sources of acid rain emissions to compare to the reductions resulting from recycling in your state, see http://yosemite.epa.gov/globalwarming/ghg.nsf/emissions/EmissionsFromElectricUtilities?Open .

Graph B-6

Reductions in Air Emissions and Waterborne Wastes due to Recycling and Recycling Manufacture (metric tons)

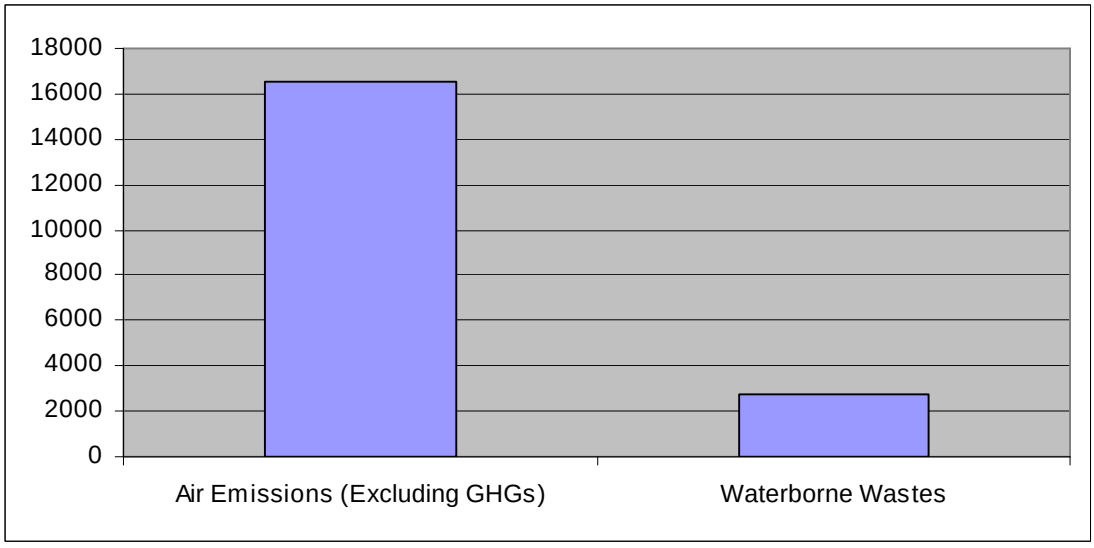

Table B-6. Select Natural Resource Savings

Source: http://www.recycle-steel.org/index2.html

Tons of Ferrous Steel Recycled	84,793
Pounds of iron ore saved per ton steel recycled	2,500
Pounds of coal saved per ton steel recycled	1,400
Pounds of limestone saved per ton steel recycled	120
Tons iron ore saved	105,991
Tons coal saved	59,355
Tons lime stone saved	5,088
Total Tons Resources Saved	**170,434**

Table B-7. Number of Trees Saved From Paper Recycling

Source: http://www.conservatree.org/learn/Enviro_Issues/TreeStats.shtml

Tons of groundwood paper recycled	82,826	Includes newsprint and mixed paper
Number of Trees Saved	993,912	
Tons of freesheet paper recycled	33,883	Includes office paper
Number of Trees Saved	813,192	
Total Number of Trees Saved	**1,807,104**	

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