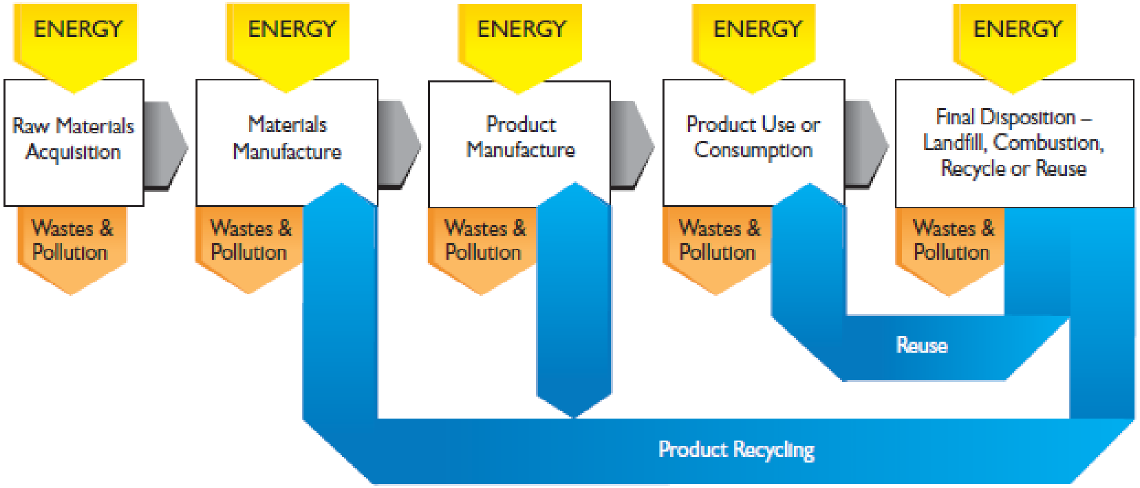
1. *Discussion of Life Cycle Assessment Used in MEBCalc™*

To assess the relative environmental impacts of diversion and disposal we utilize the Measuring Environmental Benefits Calculator (MEBCalc™) model, a life cycle assessment (LCA) tool developed by Sound Resource Management Group. The model employs a life-cycle approach to capture the input of energy and the output of wastes and pollution that occur over the three phases of a material's or product's life cycle:

- Upstream Phase – extracting raw material and energy resources from ecosystems, refining resources into industrial feedstocks, and manufacturing products and packaging materials from those feedstocks;
- Use Phase – using products and packaging in consumption activities; and
- Downstream or End-of-Life (EOL) Phase – managing product and packaging discards.

Figure 1, Product Life Cycle Phases, portrays the LCA approach employed in MEBCalc™. The figure indicates how reuse and recycling eliminate, i.e., avoid, some or all of the upstream phase, thereby conserving energy and reducing releases of wastes and pollution in the production of goods and services. Most of the environmental benefit of diversion comes from pollution reductions in the manufacture of new products made possible by the replacement of virgin raw materials with recycled materials and the replacement of synthetic petroleum-based fertilizers with compost. In addition, compost provides some product use phase benefits when reduced use of pesticides decreases human and animal exposure to toxics from pesticide applications, as well as when reduced use of synthetic fertilizers reduces eutrophication of waterways as a result of decreased runoff of water soluble nitrogen in synthetic fertilizer.

Figure 1: Product Life Cycle Phases



MEBCalc^{TM} is built on a "best-of" compendium of life cycle data from a number of environmental life cycle inventory and assessment models and studies, including:

- U.S. EPA's WARM calculator for GHG emissions from waste management systems and the associated reports (August 2010 version which is available at http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html).
- U.S. EPA's MSW Decision Support Tool (DST) and database which are available through Research Triangle Institute.[1]
- U.S. EPA's LandGEM model (EPA 2005).
- Carnegie Mellon University Green Design Institute's Economic Input-Output Life Cycle Assessment (EIO-LCA) model (available at www.eiolca.net).
- U.S. NIST BEES model (available at http://www.bfrl.nist.gov/oae/software/bees/model.html).
- U.S. EPA's TRACI 2.0 model (information about TRACI is available at http://www.epa.gov/nrmrl/std/sab/traci/).[2]
- U.S. EPA's AP-42 emissions data (available at http://www.epa.gov/ttn/chief/ap42/).
- A review of 82 very recent LCAs on organics end-of-life management methods conducted for the Alberta Ministry of the Environment (Morris, Matthews and Morawski 2011).
- Peer-reviewed journal articles including Morris (1996), Barlaz (1998), Morris (2005), Morris and Bagby (2008), Morris and Matthews (2010)[3], Morris (2010), Brown *et al* (2011), Muller *et al* (2011), and Morris *et al* (2012b).

In addition, the calculator relies on:

- A life cycle inventory for wood wastes developed recently for Seattle Public Utilities.[4]
- Franklin Associates report on environmental impacts of recycling glass into containers, fiberglass and aggregate.[5]
- R. W. Beck reports on conversion technologies and anaerobic digestion.[6]
- Anaerobic digestion life cycle profiles in an SRMG assisted RRS study for Eureka Recycling.[7]

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[1] See Research Triangle Institute (1999a and 1999b) and EPA et al (2003).
[2] Also see Bare (2002) and Bare *et al* (2003).
[3] The consumer environmental index (CEI) model developed for the Washington State Department of Ecology is also detailed in Morris *et al* (2007).
[4] Available in the monograph Morris (2012a).
[5] Available in the monograph Franklin (1998).
[6] Available in the Beck (2004) and Beck (2007) reports.
[7] See RRS (2012).

MEBCalc^{TM} estimates pollution reductions that are caused across all phases of product life cycles by diverting material discards to recycling (open- and/or closed-loop for some materials), composting, anaerobic digestion, or use as industrial fuels. The calculator accounts for the effects of recovery on waste management system pollution emissions from collection vehicles, recyclables processing facilities, composting facilities, disposal facilities, shipping of processed materials to end users, and production of recycled-content and virgin-content products by those end users.

MEBCalc^{TM} evaluates the potential effects of recovery for seven categories of impacts to public health, the environment and ecosystems[8]:

- Climate change – characterizes the potential increase in greenhouse effects due to anthropogenic emissions. Carbon dioxide (CO2) from burning fossil fuels is the most common source of greenhouse gases (GHGs). Methane from anaerobic decomposition of organic material is another large source of greenhouse gases.
- Human respiratory disease and death from particulates – characterizes potential human health impacts from anthropogenic releases of coarse particles known to aggravate respiratory conditions such as asthma, releases of fine particles that can lead to more serious respiratory symptoms and disease, and releases of particulate precursors such as nitrogen oxides and sulfur oxides.
- Human disease and death from toxics -- characterizes potential human health impacts from releases of chemicals that are toxic to humans. There are a large number of chemical and heavy metal pollutants that are toxic to humans, including 2,4-D, benzene, DDT, formaldehyde, permethrin, toluene, chromium, copper, lead, mercury, silver, and zinc.
- Human disease and death from carcinogens -- characterizes potential human health impacts from releases of chemicals that are carcinogenic to humans. There are a large number of chemical and heavy metal pollutants that are carcinogenic to humans, including 2,4-D, benzene, DDT, formaldehyde, kepone, permethrin, chromium, and lead.
- Eutrophication -- characterizes the potential environmental impacts from addition of mineral nutrients to the soil or water. In both media, the addition of mineral nutrients, such as nitrogen and phosphorous, can yield generally undesirable shifts in the number of species in ecosystems and a reduction in ecological diversity. In water, nutrient additions tend to increase algae growth, which can lead to reductions in oxygen and death of fish and other species.
- Acidification -- characterizes the potential environmental impacts from anthropogenic releases of acidifying compounds, principally from fossil fuel and

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[8] See Bare *et al* (2003) and Lippiatt (2007) for a detailed description and discussion of these environmental impact categories.

biomass combustion, which affect trees, soil, buildings, animals and humans. The main pollutants involved in acidification are sulfur, nitrogen and hydrogen compounds – e.g., sulfur oxides, sulfuric acid, nitrogen oxides, hydrochloric acid (HCL), and ammonia.

- Ecosystems toxicity -- characterizes the relative potential for chemicals released into the environment to harm terrestrial and aquatic ecosystems, including wildlife. There are a large number of chemical and heavy metal pollutants that are toxic to ecosystems, including 2,4-D, benzene, DDT, ethyl benzene, formaldehyde, kepone, permethrin, toluene, chromium, copper, lead, silver, and zinc.

Life cycle analysis and environmental risk assessments provide the methodologies for connecting pollution of various kinds to these seven categories of environmental damage. For example, releases of various greenhouse gases (GHGs) -- carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), chlorofluorocarbons (CFCs) and others -- cause global warming which leads to climate change. In its periodic climate change assessments The United Nations Intergovernmental Panel on Climate Change (IPCC) thoroughly reviews available scientific data to determine the strength of each pollutant relative to carbon dioxide in causing global warming. For example, the most recent IPCC assessment estimates that over a hundred year time frame methane is 25 times and nitrous oxide 298 times more harmful than CO2. Based on these global warming potential factors the emissions of all greenhouse gas pollutants are aggregated into CO2 equivalents (eCO2). This eCO2 indicator serves as a measure for global warming potential from releases of all GHGs.

Similar scientific efforts enable the quantity of various pollutant releases to be expressed as single indicator quantities for the other six categories of environmental damage. This greatly simplifies reporting and analysis of different levels of pollution. By grouping pollution impacts into a handful of categories, environmental costs and benefits modeling is able to reduce the complexity of tracking hundreds of pollutants. This makes environmental impact data far more accessible to policy makers. For this pollutant aggregation process MEBCalc^{TM} currently relies on the methodologies used by the IPCC and U.S. EPA's TRACI (Tool for the Reduction and Assessment of Chemical and other environmental Impacts) 2.0 model.[9]

The IPCC and TRACI methodologies aggregate pollutants for each environmental impact category in terms of the following indicator pollutants:

- Climate change – carbon dioxide equivalents (eCO2),
- Human health-particulates – particulate matter less than 2.5 microns equivalents (ePM2.5),
- Human health-toxics – toluene equivalents (eToluene),

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[9] Bare (2002) and Bare *et al* (2003).

- Human health-carcinogens – benzene equivalents (eBenzene),
- Eutrophication – nitrogen equivalents (eN),
- Acidification – sulfur dioxide equivalents (eSO2), and
- Ecosystems toxicity – herbicide 2,4-D equivalents (e2,4-D).

2. Valuation of Life Cycle Environmental Impacts

The final step in estimating an environmental value for recovery is to determine a dollar value for the damage to public health and/or ecosystems caused by each of the indicator pollutants. Care needs to be taken in estimating damage costs so as to avoid double counting. An advantage of the TRACI methodology is that the TRACI score for a particular impact is expressed in terms of a reference chemical. That score refers only to a specific aspect of the reference substance's impact. For example, the TRACI score for human carcinogens is measured in benzene equivalents that are based only on benzene's carcinogenic effects. Thus, double counting in monetization is avoided as long as the monetization estimates for each environmental impact's reference substance are based on that impact for that substance.

Another important note regarding monetization is that human respiratory health impacts include the potential for particulates and particulate precursors to cause lung cancer. The substances that are scored by TRACI 2.0 for particulate respiratory health impacts include only filterable and condensable particulates, sulfur dioxide (SO_2), nitrogen oxides (NO_x), and total suspended particulates (TSP). These substances all have zero characterization factor scores for human health carcinogenic and toxicity impacts. What might seem like another possibility for double counting is thus avoided using the TRACI methodology.

The following list shows these estimated damage valuations. The remainder of this section discusses the sources and justifications for these valuations.

- eCO2 -- $44 per tonne.
- ePM2.5 -- $11,023 per tonne. based on Eastern Research Group (2006).
- eToluene -- $130 per tonne.
- eBenzene -- $3,340 per tonne. based on Eastern Research Group (2006).
- eN -- $4 per tonne.
- eSO2 -- $452 per tonne.
- e2,4-D -- $3,616 per tonne.

The value of greenhouse gas (i.e., eCO2) emissions reductions

There is a very wide range in estimated costs for greenhouse gas emissions and valuations for the benefits of reductions in those emissions. The low end for valuations is the trading price for voluntary greenhouse gas emission reductions. Operating much as the markets in sulfur dioxide emissions permits do, several markets are available for trading voluntary greenhouse gas emissions reduction pledges. One of these, recently closed, was the Chicago Climate Exchange (CCX). Trading values on the CCX for CO2 reductions were between $1 and $4 per tonne of carbon dioxide over recent years prior to its closing. Values on European carbon markets have been ten times higher than trading prices on the CCX due to the mandatory CO2 emissions caps imposed on European greenhouse gas generators.

The recent review of the economics of climate change conducted by Nicholas Stern (2007) determined that a reasonable estimate for the cost of current greenhouse gas emissions was $85 per metric tonne, based on the risk of catastrophic environmental impacts in the future if substantial reductions in greenhouse gas emissions are not implemented today.

MEBCalc^{TM} uses $44 per tonne for the cost of greenhouse gas emissions. This is in the middle of the range between market values for voluntary emissions reductions and estimated costs of severe climate change impacts if today's emissions levels are not substantially reduced.

Other estimates appear in recently available literature, including $8 per tonne in a prestigious peer-reviewed economics journal (Muller, Mendelsohn and Nordhaus 2011). A recent working paper that has not yet been published in the peer-reviewed literature provides a very high estimate near $1,000 per tonne (Ackerman and Stanton 2011).

There are very high cost estimates for other environmental impacts as well, as indicated in the rest of this list of cost estimates. Using any one of these very high end estimates for just one particular impact in combination with the moderate cost estimates used for monetization in MEBCalc^{TM} for the other 6 environmental impacts will push overall monetization rankings for diversion versus disposal to mirror the ranking for that particular environmental impact.

The value of particulates (i.e., ePM2.5) emissions reductions

Eastern Research Group (2006) reports the following:

"Epidemiological studies have linked exposure to increased particulate matter (PM) levels to mortality and morbidity from chronic bronchitis and cardio-vascular disease. Time-series data from the 20 largest U.S. cities indicate a linear relationship between particulate air pollution and mortality.[10] The number of years of life lost from premature death, and wellbeing lost from illness, due to PM exposure depends on the age distribution and size of the exposed population. Many factors enter into the assessment of illness from PM exposure including weather, types of emissions, and health of the population. These analyses must be conducted at a local level in order to incorporate all of these factors."

"National estimates of the "per ton" benefits of reducing PM emissions are not often calculated. The importance of local factors in the effects of PM emissions makes such broad

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[10] M. J. Daniels, et al. 2000. Estimating particulate matter mortality dose-response curves and threshold levels: An analysis of daily time series for the 20 largest U. S. cities. *American Journal of Epidemiology*, 10:606-617.

estimates highly uncertain. In order to compare the benefits and costs of regulations that federal agencies had chosen not to monetize, the Office of Management and Budget (OMB) calculated a broad national value of the benefits of reducing PM emissions by one ton of $10,000 to $100,000 ($2001).[11] OMB based this estimate on the 1997 NAAQS benefit assessment, though their method is not described."

Based on this analysis by Eastern Research Group, MEBCalc^{TM} incorporates a cost valuation of $11,023 per tonne for emissions of PM2.5.

The value of human toxics (i.e., eToulene) emissions reductions

As with the valuation of the costs of greenhouse gas emissions, there is a wide range in the estimated costs for emissions of pollutants that are toxic to humans. Eastern Research Group (2006) found estimates ranging up to $3,000 per tonne of eToluene for the human health costs of toxic air pollutant emissions. MEBCalc^{TM}'s conservative estimate of monetary costs for toxic air emissions is closer to the estimates based on a peer-reviewed study on the health effects of atmospheric emissions of mercury. That study was sponsored by the Northeast States for Coordinated Air Use Management (NESCAUM) and conducted by scientists at the Harvard Center for Risk Analysis (Rice and Hammitt 2005). The study evaluated neurological and possible cardiovascular health impacts from exposure to methyl mercury through fish consumption, where atmospheric releases of mercury result in depositions of mercury in water bodies within and bordering the U.S. These depositions lead to increases in methyl mercury concentrations in fish.

The NESCAUM study evaluated three main health effects from methyl mercury exposure – neurological decrements associated with intrauterine exposure, myocardial effects associated with adult exposure, and elevated childhood blood pressure and cardiac rhythm effects associated with *In Utero* exposure. The NESCAUM study's health cost estimate from these three health effects for exposure to methyl mercury as a result of mercury air pollution is US$188.3 million in year 2000 dollars per ton of mercury emitted to the atmosphere. Inflating that estimate to current dollars and converting the cost to toluene emissions, the indicator substance for human toxicity, yields $33 per tonne of eToluene for the cost of pollutant emissions that are toxic to human health.

The value of human carcinogens (i.e., eBenzene) reductions

Eastern Research Group (2006) reports research suggesting that the cost to human health from benzene exposure could be 950 times greater than toluene. Given a valuation of $130 per tonne for toluene, this ratio implies that benzene's valuation should be nearly $125,000 per tonne. This cost valuation is extremely high. Instead MEBCalc^{TM} uses $3,340 per tonne, which is about 10% above the midpoint of the range $0.06 to $6.00 per kilogram for expected health risks from Benzene releases that is also discussed in the Eastern Research Group study.

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[11] Office of Management and Budget, Office of Information and Regulatory Affairs. 2005. *Validating Regulatory Analysis: 2005 report to Congress on the costs and benefits of federal regulations and unfunded mandates on state, local, and tribal entities*.

The value of reductions in eutrophying emissions (i.e., eN)

In soil or waterways, the addition of large quantities of mineral nutrients, such as nitrogen and phosphorous, results in generally undesirable shifts in the number of species in ecosystems and a reduction in ecological diversity. In water, it tends to increase algae growth, which can lead to lack of oxygen and therefore death of species such as fish. MEBCalc^{TM}'s estimate of the cost of releases of nutrifying compounds is based on EPA's cost-effectiveness analysis for the NPDES regulation on effluent discharges from concentrated animal feeding operations. That analysis estimated that costs up to $4.41 per metric tonne of nitrogen removed from wastewater effluents were economically advantageous (US EPA 2002, p. E-9).

The value of reductions in acidifying emissions (i.e., eSO2)

We estimate the value of acidification reductions at $320 per tonne. This is the average of 2005 ($690), 2006 ($860), 2007 ($433), 2008 ($380), 2009 ($62), 2010 ($36), 2011 ($2), and 2012 ($1) market clearing spot prices per short ton in EPA's annual acid rain sulfur dioxide emissions permit allowances auction under the Clean Air Act.

The value of ecosystem toxics (i.e., e2,4-D) reductions

A study estimated the toxicity cost to plants and wildlife from application of a kilogram of 2,4-D herbicide at $3.616. This is an updated estimate from Joe Kovach, Integrated Pest Management Program at Ohio State University, based on his research originally reported in Kovach *et al* (1992) on putting an environmental price to pesticide use.[12] The estimate includes costs for impacts on fish, birds, bees and beneficial arthropods, but not the estimated costs developed by Kovach for impacts on human health as a result of groundwater contamination. That human health cost is captured in the human toxicity potential impact category.

3. Key Assumptions Used in MEBCalc^{TM}

There are two sets of important assumptions that are hard wired into MEBCalc^{TM}. This section discusses the reasons for their use.

Landfill Carbon Storage

MEBCalc^{TM} uses US EPA's latest estimates in WARM for carbon storage rates. The main purpose of life cycle analysis and assessment of waste management systems is to provide a holistic picture of the environmental impacts of waste management choices. Burial of certain materials such as wood and paper in anaerobic landfills preserves a substantial portion of the carbon stored in those materials when trees were harvested and used to manufacture these products. Not all the carbon that a tree sequesters is released when it is harvested. The

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[12] Pesticide wash-off may be higher in a hilly urban environment than in a flat agricultural field. To the extent that Kovach relied on agricultural crop studies, his estimate of the cost to non-target plants and wildlife may underestimate the cost of pesticide applications in an urban environment.

portion that is formed into products continues to be stored throughout a product's useful life. Some of this carbon will continue to be stored when the product is landfilled. This stored carbon will not be released to cause climate change and, thus, should not be counted among the GHG releases avoided when a material is recycled rather than landfilled.

Compost Substitutions for Synthetic Fertilizers & Pesticides

MEBCalc™ bases its upstream benefits of composting on the following data and assumptions regarding reductions in synthetic fertilizer and pesticide usage as a result of using compost.

Fertilizers

1. The average yard and garden size in Seattle is about 1/10th acre or 4356 square feet.
2. The rate of fertilization recommended by Washington State University (WSU) Extension Service is 4 pounds nitrogen (N) per 1000 square feet of lawn. MEBCalc™ assumes the same fertilization rate for garden. This means a household requires between 17 and 17.5 pounds N each year.
3. The average amount of yard debris and food scraps sent for recycling by a household in Seattle and King County is about 1/3 tonne. 1/3 tonne of organics produces somewhat less than 1/6 tonnes of finished compost.
4. At that rate of production of compost by a household and 2% N for compost from household yard debris and food scraps, the household can supply 6.7 pounds N from its own yard debris and food scraps, or about 40% of the recommended N needs.
5. Nitrogen in organic fertilizers and compost is less than 10% water soluble, versus "quick release" synthetic fertilizers which are over 75% water soluble. Thus more of the N in compost actually stays around to benefit lawn and garden growth.
6. Based on the lower water solubility of N in compost, it is assumed that the compost user needs to apply 25% less N. As a result, compost use reduces synthetic fertilizer use by 50%.

Pesticides

1. Based on sales data gathered by the Washington Toxics Coalition for King County, each year the average household purchases pesticides and fertilizers containing about 3.5 pounds of active ingredients.
2. Due to healthier plants resulting from use of compost and resulting reduction of 50% in use of synthetic fertilizers, it is assumed that pesticide usage (directly or indirectly in fertilizers) drops at least 25%.

These assumptions were used in the analysis discussed in Morris and Bagby (2008), and were not disputed by the peer reviewers of that article.

4. References

Anderson, Peter N. (2007), Comments to the California Air Resources Board on Landfills' Responsibility for Anthropogenic Greenhouse Gases and the Appropriate Response to Those Facts. Center for a Competitive Waste Industry, St. Paul, MN.

Bare, Jane C. (2002), *Developing a Consistent Decision-Making Framework by Using the U.S. EPA's TRACI,* U.S. Environmental Protection Agency, Cincinnati, OH.

Bare, Jane C., Gregory A. Norris, David W. Pennington and Thomas McKone (2003), TRACI: The Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts. *Journal of Industrial Ecology* 6(3-4): 49-78.

Barlaz M et al (2003a): Comparing Recycling, Composting and Landfills. *BioCycle* 44, 9, 60-66.

Barlaz M et al (2003b): Evaluating Environmental Impacts of Solid Waste Management Alternatives. *BioCycle* 44, 10, 52-56.

Cicas, Gyorgyi, H.S. Matthews, and C. Hendrickson (2006), *The 1997 Benchmark Version of the Economic Input-Output Life Cycle Assessment (EIO-LCA) Model*, Green Design Institute, Carnegie Mellon University, Pittsburgh, PA.

Eastern Research Group (2006), Draft Report: Cost Benefit Analysis for Six "Pure" Methods for Managing Leftover Latex Paint - Data, Assumptions and Methods. Prepared for the Paint Product Stewardship Initiative.

EPA, North Carolina State University, and Research Triangle Institute (2003). Municipal Solid Waste Life-Cycle Database for the Decision Support Tool on Municipal Solid Waste Management. Research Triangle Park, NC.

EPA (2006), *Solid Waste Management and Greenhouse Gases – A Life-Cycle Assessment of Emissions and Sinks*, 3rd edition, Environmental Protection Agency, Washington, D.C.

Franklin Associates (1998). Environmental and Economic Analysis of Glass Container Recycling from Portland's Curbside Collection Program, Final Report. Prepared for City of Portland, July 1998.

Kovach J, Petzoldt C, Degni J, Tette J (1992): A Method to Measure the Environmental Impact of Pesticides. Integrated Pest Management Program Cornell University, New York State Agricultural Experimentation Station, Geneva, NY (Available through Online Publications of the New York State IPM Program at http://www.nysipm.cornell.edu/publications).

Morawski, Clarissa (2008a). The New “Eco-Currency”: New model monetizes environmental benefits and reveals new cost savings in waste diversion, *Solid Waste & Recycling*, December/January 2008.

Morawski, Clarissa (2008b). Composting – Best Bang for MSW Management Buck, *Biocycle*, October 2008.

Morris, Jeffrey (1996), Recycling versus incineration: an energy conservation analysis. *Journal of Hazardous Materials* 47 277-293.

Morris, Jeffrey (2005), Comparative LCAs for Curbside Recycling Versus Either Landfilling or Incineration with Energy Recovery. *International Journal of Life Cycle Assessment* 10(4) 273-284.

Morris, Jeffrey, H. Scott Matthews, Frank Ackerman, Michelle Morris and Rock Hlavka (2007), The Washington State Consumer Environmental Index (CEI) – A Summary of the Development of a Tool to Understand and Support Consumer Choices That Have Preferable Environmental Outcomes. Prepared for the Washington State Department of Ecology, July 31, 2007.

Morris, Jeffrey, and Jennifer Bagby (2008). Measuring Environmental Value for Natural Lawn and Garden Care Practices. *International Journal of Life Cycle Assessment*, 13(3) 226-234.

Morris, Jeffrey (2012a). Environmental Impacts for Clean Wood Waste Management Methods: Final Updated Life Cycle Assessment, prepared for Seattle Public Utilities, August 2012.

Research Triangle Institute (1999a), A Decision Support Tool for Assessing the Cost and Environmental Performance of Integrated Municipal Solid Waste Management Strategies: Users Manual, Draft EPA/xxx-R-99-xxx.

Research Triangle Institute (1999b), Application of Life-Cycle Management to Evaluate Integrated Municipal Solid Waste Management Strategies, Draft EPA/xxx-R-99-xxx.

Rice, Glenn, and James K. Hammitt (2005): Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants. Prepared for Northeast States Coordinated Air Use Management (NESCAUM) by the Harvard Center for Risk Analysis, Boston, MA

R W Beck (2004), Anaerobic Digestion Feasibility Study, Final Report. Prepared for Bluestem Solid Waste Agency and Iowa Department of Natural Resources. April 2004.

RW Beck (2007), Comparative Evaluation of Waste Export and Conversion Technologies Disposal Options – Internal Draft. Prepared for King County department of Natural resources and Parks Solid Waste Division, May 2007.

Stern, Nicholas (2007). *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, England and New York, NY.

US Environmental Protection Agency, Office of Research and Development (2002): Economic Analysis of the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations. EPA-812-R-03-002, December 2002, Washington, DC.

Weber, Christopher L., and H. Scott Matthews (2007). Embodied environmental emissions in U.S. international trade. *Environmental Science and Technology*, 41(14), 4875-4881.