BACKGROUND DOCUMENT D

GREENHOUSE GAS EMISSIONS FROM MANAGEMENT OF SELECTED MATERIALS IN THE MUNICIPAL SOLID WASTESTREAM

COMMENT-RESPONSE DOCUMENT

Prepared for:

Office of Solid Waste
and
Office of Policy
U.S. Environmental Protection Agency

Prepared by:

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This document summarizes comments received on the Draft Report, *Greenhouse Gas Emissions from Municipal Waste Management* (EPA530-R-97-010), published in March 1997. A Federal Register notice published April 28, 1997 (62 FR 22942) announced the availability of this document and requested public comment on the methods and data in the report. Twenty-three individuals and organizations submitted comments, which ranged in specificity and scope from brief email notes to extensive, detailed comments.

This document first lists the commenters and describes how the comment summaries are organized. Then the comment summaries, along with EPA's responses, are presented.

Commenters

We received and summarized comments from the following:

- American Plastics Council, Washington, D.C.
- Steve Apotheker, Resource Recycling
- Morton Barlaz, North Carolina State University
- Art Dunn, Director, Minnesota Office of Environmental Assistance
- Scott Chubbs, American Iron and Steel Institute Representative, Viterra Inc.
- Gregory Crawford, Vice President, Operations, Steel Recycling Institute
- Martin Felker, Senior Environmental Engineer, Waste Management, Oak Brook, Illinois
- Karen Harrington, Principal Planner, Minnesota Office of Environmental Assistance
- Judy Hicks, American Forest and Paper Association, Washington, D.C. (Including comments from Ecobalance, Rockville, MD submitted on behalf of the American Forest and Paper Association)
- Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources
- Tom Kerr, EPA Office of Air and Radiation, Atmospheric Pollution Prevention Division
- Peder Larson, Commissioner, Minnesota Pollution Control Agency
- Paul McCarron, Chair, Minnesota Solid Waste Management Coordinating Board
- Gene Mossing, Solid Waste Director, Olmsted County, Minnesota, Public Works Department
- Steven Pomper, Alcan, Montreal
- Victoria Reinhardt, Chair, Ramsey/Washington County, Minnesota, Resource Recovery Project
- Trudy Richter, Executive Director, Minnesota Resource Recovery Association
- Clark Row, Row Associates
- John Ryan, Research Director, Northwest Environment Watch
- John Stutz, The Tellus Institute
- David Sussman, President, Poubelle Associates
- Michelle Swanson, Northern States Power Company
- Maria Zannes, President, Integrated Waste Services Association

Organization of the Comment Summaries

As shown in succeeding sections of this Comment-Response Document, many commenters provided thoughtful perspectives and useful information that substantially improved the utility and accuracy of the report. Largely as a result of the comments received on the draft report, the current version:

- adds two materials to the analysis—mixed paper and glass,
- revises system efficiencies for waste combustors, and provided a separate characterization of refuse-derived fuel (RDF) as a category of combustion,
- bases GHG reductions from displaced electricity on GHGs from fossil-fuel-fired generation, rather than from the national average mix of fuels, and
- adds a "post-consumer" perspective to the GHG analysis, where before only a "cradle-to-grave" perspective was provided.

In addition, the final report updates many of the inputs to the calculations (such as the global warming potential for various greenhouse gases), and uses more recent information on waste composition and recycling rates. Finally, in the final report, emphasis has been placed on providing guidance for the application of emissions factors in support of voluntary reporting of greenhouse gas emission reductions for all waste management practices discussed in this report.

We organized the comment summaries, along with our responses, according to the chapter of the MSW GHG report that the comment summaries address. Some of the comments pertain to the entire report, rather than a single chapter; we treat these as "general comments" and address them first. Throughout the remainder of the Comment-Response Document, we summarize the comments (generally using language directly from the comment, but sometimes paraphrasing), identify the commenter, and explain how the comment was addressed in the Final Report, *Greenhouse Gas Emissions From Management of Selected Materials in the Municipal Solid Wastestream.*

General Comments

- Discuss uncertainties in the assumptions, methodology, databases, and calculations. (American Plastics Council, Washington, D.C.) ***These are discussed, as limitations of the report, at the end of each chapter. The Final Report clarifies some limitations in the draft, and explains others more clearly; in many cases these revisions were suggested by specific comments.***

- Address the economic considerations of the report's recommendations. For example, what is the cost of recycling versus combustion? A number of studies have reached different conclusions yet the report holds out answers without addressing the economic consequences of the selection. (American Plastics Council, Washington, D.C.) ***Although a full cost and economic analysis of waste management options would be useful, it is beyond the scope of the report, which is intended to be a tool for estimating greenhouse gas emissions within the scope of a voluntary reporting process. EPA has developed other tools to facilitate cost and economic analysis of solid waste management options; some of these are listed on EPA's Solid Waste web site (http://www.epa.gov/epaoswer/osw/index.htm).***

- Estimate the costs per ton of carbon equivalents removed and/or not produced, as well as compare the municipal waste management options for each material, between materials, and between municipal waste management options and other GHG reduction approaches. (American Plastics Council, Washington, D.C.) ***However, this report is specifically intended to assist readers in quantifying GHG emissions associated with different waste management practices and to assist in estimating emissions reductions for GHG mitigation action plans.***

- Include the emission of biogenic-source carbon as a GHG. (American Plastics Council, Washington, D.C.) ***We followed the Intergovernmental Panel on Climate Change (IPCC) guidance on methods for accounting for GHG emissions. The IPCC convention is not to count biogenic emissions of*** CO_2 ***from sources that are harvested on a sustainable basis. In the US, the primary organic***

component of the wastestream is paper; because US forestry practices are deemed sustainable, CO_2 emissions associated with burning or decomposing paper are not counted towards greenhouse gas inventories. As noted in the draft report, this approach has important implications – for example, we do not count emissions of biomass fuels in paper production, nor do we count CO_2 emissions from combustors for materials other than plastics.

- Acknowledge that most GHG emissions in the future will be coming from developing countries and that it is not likely that any US action on MSW options would materially impact global GHG concentrations. The report should then place its recommendations in a larger context, including other environmental considerations, economic benefits, and practical solutions. (American Plastics Council, Washington, D.C.) ***MSW management can be a part of a broad portfolio of approaches to effectively reduce GHG emissions, both in the US and abroad. GHG emission reductions are only one factor among many that decision-makers may evaluate in developing waste management strategies. In the past, there was little or no information available on which to quantitatively evaluate GHG implications of these strategies. This report provides, for the first time, a set of material-specific emission factors to assist with voluntary reporting of greenhouse gas emission reductions from waste management practices. It does not address the full range of environmental, cost, and engineering issues associated with solid waste management, nor is it intended to provide a comparison with other GHG mitigation strategies in the US and elsewhere.***

- Include the consideration that global warming is not increasing as well as whether climate change is anthropogenic. (American Plastics Council, Washington, D.C.) ***To the extent that the report addresses the science of climate change, it does so by providing a brief summary reflecting the current international scientific consensus, as articulated by IPCC.***

- The report's focus on carbon dioxide emissions may lead to the general conclusion that certain end products should be made only of materials to facilitate recycling. The undesired result of this action may be, however, the manufacture of more resource-demanding products, with reduced energy efficiency and resulting greater carbon dioxide emissions. (American Plastics Council, Washington, D.C.) ***The emissions factors indicate that source reduction is generally the best waste management option from a GHG perspective, while recycling appears to be the next best management practice.***

- The report should make clear that environmental decisions cannot be driven by one factor alone (e.g., GHG/global warming), especially since global warming is acknowledged to be on a much slower developmental track than some other environmental concerns and permits a more considered response. Taking action based solely on the relative production of GHG from alternative materials and municipal waste management processes may negatively impact overall environmental objectives. (American Plastics Council, Washington, D.C.) ***In the first chapter of the report, we acknowledge that source reduction and recycling have environmental benefits in addition to GHG reductions; however, those benefits are outside the scope of the report. We also recognize that other factors such as cost and other environmental benefits play a dominant role in decision-making on MSW management issues.***

- The handling of data quality should be reviewed. Combining and averaging two sets of non-primary data from unrelated studies, with minimal consideration of the differences in age, geographic coverage, technology, and quality of the data, presents a very weak baseline. (American Plastics Council, Washington, D.C.) ***The data used in this report come from a number of sources, including sources within the industries that manufacture the materials analyzed. We recognize that additional data with consideration of age, geographic coverage, and technology would be very useful, and to that end the Federal Register notice announcing the availability of the Draft Report***

specifically requested commenters to provide such data. In particular, we acknowledge that some of the data sets on energy use and fuel mix from Franklin Associates Ltd. and the Tellus Institute were dissimilar (e.g., energy data for LDPE). However, because no new data sets were provided by industry during the public comment process, the data in the draft report represent the best data to which we have access and continue to be used in the final report. In light of the report's objective of providing a tool for estimating greenhouse gas emissions within a voluntary reporting program, we believe that averaging the two data sets—particularly for the materials where the two data sets had considerable overlap—is a reasonable methodological approach.

- The report leaves the impression that there are no technical and economic limitations to mechanical recycling. (American Plastics Council, Washington, D.C.) ***The report includes loss rates associated with mechanical recycling of plastics, and uses energy data that apply to mechanical recycling processes. In keeping within the scope limitations explained above, the report does not address issues of product quality or economics.***

- The summary tables presently describe GHG emissions per ton of material produced, without reference to the percentage composition of the material in MSW. While consideration of the amount of the component in municipal waste is part of the report's initial screen of materials to be studied, the study fails at the end of the analysis to relate the amount of a material with the impact on GHG emissions. In short, proper selection of certain MSW management options, based on GHG emissions, depends on the total amount of each material in MSW, not the emissions per ton of material. The different amounts of the materials in MSW directly influences what material contributes most to GHG for each MSW management option. (American Plastics Council, Washington, D.C.) ***The report is written to address management options for specific materials. However, the report also provides estimates for mixed paper and mixed MSW in order to address these concerns. The Final Report attempts to more clearly emphasize that evaluation of options should focus on tonnage of material managed, and that comparisons must be made with respect to a baseline management scenario.***

- The report often uses the term "material" and "product" interchangeably. A more precise word selection would be less confusing and more technically correct. More importantly, the "items" in municipal solid waste chosen for the study are a mix of products and materials. For example, an aluminum can is a product, HDPE plastic is a material. (American Plastics Council, Washington, D.C.) ***The materials and products addressed in the report are identifiable components of municipal solid waste. Some of the items (e.g., yard trimmings, food scraps) are clearly not products; others (e.g., aluminum cans) are. We retained the general terminology in the final report; however, in response to this commenter's specific suggestion regarding plastics, we revised our terms on plastic products (as discussed below).***

- Investigate the GHG emission implications of using alternatives to wood based materials that leave forest carbon sinks in place. (American Plastics Council, Washington, D.C.)***We included a discussion of material substitution in Chapter 4 of the report. Because any evaluation of material substitution must be based, in part, on the mass substitution rate (i.e., functional equivalents) of the products being compared, and this is a product-specific factor, we did not evaluate specific scenarios involving wood and other materials for specific applications.***

- Give consideration to options such as product substitution as a means to reduce GHGs instead of only addressing the potential to create GHGs. (American Plastics Council, Washington, D.C.) ***Material substitution does provide the possibility for GHG reductions. The final report does not evaluate specific substitution scenarios, but it does provide a general discussion of a method that could be used to evaluate material substitution in Chapter 4.***

It is not clear that a consistent baseline year was used in the report. We suggest using two baseline years, one being 1994 or 1995, to show the present situation, and the other being 2000 or 2010 to show possible future situations when waste-to-energy facilities are more efficient, recycling rates are higher or other improvements are present. (American Plastics Council, Washington, D.C.) We revised the baseline year in response to this point (which was also made by other commenters) and used the year 2000 as the baseline for combustion system efficiency, and landfill gas controls.

- Include the energy savings due to the use of post-industrial scrap. While this post-industrial scrap may not make the same contribution as post-consumer scrap in all areas of environmental benefits, it certainly does in the area of energy savings. This is particularly true for aluminum beverage cans. (Steve Apotheker, Resource Recycling) ***The energy intensity and fuel mix values used in the report account for the use of post-industrial scrap.***

- The report should provide a sensitivity analysis or an appendix that would give the reader some sense of what factors are more important than others. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance***) The final report provides additional sensitivity analysis, including the effects of assumptions on landfill gas recovery system efficiency, and methane oxidation rates. In addition, we have made the results more explicit for some of the key categories of technologies (e.g., we added refuse-derived fuel to the combustion analysis; and we displayed separate results for landfills without landfill gas (LFG) systems, with LFG and flaring, and with LFG and energy recovery).***

- Direct report more toward the local level. The current report does not provide assistance for local decision makers because it relies too much on national averages and does not provide a way to incorporate the strong influence of local conditions. We encourage EPA to develop software tools for use by local decision makers and businesses. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance; Paul McCarron, Minnesota Solid Waste Management Coordinating Board) ***As noted above, the final report provides more detail that de-emphasizes the national average values and illuminates variability at the local level. In response to the request for a software tool, EPA has been developing the WAste Reduction Model (WARM) to enable local decision-makers to incorporate local conditions in evaluating GHG emission reductions from waste management options.***

- Include glass in the analysis. Glass should be substituted for one of the three plastics itemized in the study in the list of the 10 materials given separate evaluations. Over the years we have gotten many questions regarding the environmental pros and cons of recycling glass, particularly in locations distant from a glass plant. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance) ***We have added glass to the analysis.***

- Need the source of data presented by Franklin Associates and the Tellus Institute. For better analysis of data quality, the ultimate source and date of information used is required. (Scott Chubbs, American Iron and Steel Institute) ***These data are available in the appendices to the report***.

- Standardize units. The report would be easier to evaluate if a consistent approach to units of measure were taken. (Scott Chubbs, American Iron and Steel Institute) ***The "mixed" units of metric tons of carbon equivalent per short ton of waste managed are a hybrid unit that may appear awkward. The reason we chose to present results in these units is because "MTCE" is standard in the climate change terminology and "short tons" is standard among US waste managers***.

- Clarify the tables. "The presentation of tables makes it very difficult to understand the information being presented. Clearer presentation of findings would make it easier to evaluate the report". (Scott Chubbs, American Iron and Steel Institute) ***We revised the tables throughout Chapters 4 through 8 to provide a more intuitive accounting approach, i.e., a post-consumer reference point for tallying emissions. We also emphasize the importance of comparing alternative scenarios to a baseline scenario. These changes in the final report are intended to make for a more user-friendly report.***

- There is no apparent analysis of the sensitivity of results to changes in the key variables. For example, how does the outcome change if the energy mix for manufacturing differs from the data given in the report? Sensitivity of key variables should by analyzed and included in the report. (Scott Chubbs, American Iron and Steel Institute) ***See above response to similar comment from Dunn, Larsen, and Harrington of MN OEA.***

- The Appendix should be mentioned in more than one place in the body of the report. (Ecobalance, on behalf of the American Forest and Paper Association) ***We have addressed this comment throughout the report.***

- The report should include the reliability of the data (pertains to how the data were obtained and verified) as well as the completeness of the data. (Ecobalance, on behalf of the American Forest and Paper Association) ***The data used in this report come from a number of sources, including sources within the industries that manufacture the materials analyzed. We did not have the resources to develop new data, so we had to rely on existing data. We hoped that publication of this report as a public document would result in additional data from the commenters; unfortunately, energy data were not forthcoming, so we were unable to update the information in the report. In light of the report's objective of providing a tool for estimating greenhouse gas emissions within a voluntary reporting program, we believe that averaging the two data sets—particularly for the materials where the two data sets had considerable overlap—is a reasonable methodological approach.***

- Final results should be presented in terms of ranges and ranges only. These ranges should be obtained by analyzing quantitatively the influence of various factors, including uncertain or variable data (such as combustion efficiencies of incinerators), and methodological choices (such as carbon dioxide sequestration credit attributed to recycling and source reduction of wood based materials). In terms of methodological choices, the quantitative results can dramatically differ for newspaper, depending upon inclusion of carbon dioxide sequestration considerations. For example, recycling option including carbon dioxide sequestration: -0.37 MTCE/ton (baseline result), or recycling option excluding carbon dioxide sequestration: +0.37 MTCE/ton. (Ecobalance, on behalf of the American Forest and Paper Association) ***Ideally, figures in this report would be presented as best estimates along with some statistical measures of variability, such as standard deviation or range. We did not have enough information on the underlying distributions to estimate standard deviation. In order for the range to provide an improvement over the "best estimate" measure of central tendency, one would need to know the minimum and maximum values for all of the input factors, whether they are independent, and how they are functionally related. Although the study evaluated the functional relationship among the factors, we were not able to collect information on the minimum and maximum values and the mutual dependence of the factors. In this situation, presenting ranges could be more misleading than helpful. For example, we collected energy intensity and fuel mix data from two sources – FAL and Tellus – and both of the sources were providing best estimates. Presumably, individual facilities in the US would have ranges of energy use well outside of the range of the two best estimates, so expressing the resulting GHG estimates as a range would not accurately reflect the true minimum and maximum values.***

As for providing results for possible combinations of what is included and excluded from the scope of the GHG emission calculations, the report provides sufficient information for readers to choose their own theoretical combinations and to make such calculations.

- A sensitivity analysis on the effects of greenhouse gases over time should be presented in the final results. (Ecobalance, on behalf of the American Forest and Paper Association) ***Several of the processes important to evaluating emissions or sinks change over time. For example, landfills emit methane in a cycle that starts a few months or years after initial waste placement and continues until putrescible waste or moisture is exhausted. In addition, several factors have characteristics that are likely to be affected by technologic or regulatory change (e.g. combustor system efficiency). Although we do not evaluate the time sensitivity of all of the factors affecting emissions and sinks, the final report does illustrate the effect of some of the most important, including the rate at which humus created in the composting process degrades (and its effect on incremental soil carbon storage); the effect of averaging period on values of forest carbon sequestration; and the effect of various assumptions on the proportion of landfills with landfill gas collection systems.***

- The assumptions and limitations should be provided in the summary tables, not somewhere else in the study. (Ecobalance, on behalf of the American Forest and Paper Association) ***The assumptions and limitations are included at the end of each chapter, where they are accompanied by discussions. We considered adding discussions to the summary tables, and concluded that it would make the report less user-friendly for most readers.***

- The report should be modified so that it does not lead the reader to believe that comparisons are being made between and among raw materials (i.e., paper vs. plastic vs. steel). (Judy Hicks, American Forest and Paper Association)***The report presents results for specific materials under various waste management options and allows for comparison between waste management options on the basis of GHG emissions. However, the report does not intend to highlight comparisons between materials.***

- Include a disclaimer in the preface of the report and on the final results table stating that the products must not be compared to one another. In other words, the tables are to be read horizontally, comparing options for each individual product or MSW mix, and not vertically (comparing products against each other), which some readers might be inclined to do. (Ecobalance, on behalf of the American Forest and Paper Association) (Judy ***The final report clarifies the basis for comparisons – i.e., one should compare a baseline and alternative scenario for a given product or material. The final version does include an explanation of how one could develop an analysis of material substitution, but it does not make comparisons of products.***

- All data sources should be listed in the report. (Ecobalance, on behalf of the American Forest and Paper Association) ***We believe the report and appendices correctly cite all the data sources used.***

- The study presents an extensive list of reviewers but the extent to which the life cycle methodology itself was reviewed is unclear. The ISO *Reporting* section requires the inclusion of "1) the name and affiliation of reviewers; 2) critical review reports; and 3) responses to recommendations." Not only are these items lacking, but there is no mention of the review process itself. Most of the reviewers were not LCA experts, and some of the reviewers only looked at portions of the report. The report should include remarks, criticisms, and recommendations of the review panel in the report (i.e., they should be made public). (Ecobalance, on behalf of the American Forest and Paper Association) ***The review process is described briefly in Chapter 1, Section 1.3 and in more detail in Appendix C. This***

comment-response document comprises thorough documentation of the most extensive review process to which the report has been subjected.

- The limitations of the data raises concerns that much of the analysis is based on assumptions made with limited data sources. (Gene Mossing, Solid Waste Director, Olmsted County Public Works Department) ***As part of an overall voluntary reporting process*, *this report may help states, municipalities, and other interested parties estimate the potential greenhouse gas impacts associated with voluntary actions to manage materials in the municipal solid waste stream. Although the analysis makes certain assumptions, we believe these are reasonable. By stating clearly our assumptions and limitations, we do not intend to undermine the results; rather, the intention is to provide readers with a basis for drawing their own conclusions and understanding the weaknesses in the data***

- The major shortcomings that should be corrected include problems of approach and coverage:

  1. Use a consistent stance that the emissions considered by a program are global, and not just those that might occur in the United States;
  2. Describe the existing programs in the action areas, their growth and accomplishments, and how they may be improved;
  3. Discuss the technical and economic feasibility of initiating action programs, or enhancements of existing ones,
  4. Describe potential policy instruments--voluntary programs, regulations, incentives, tax provisions--that might achieve program goals;
  5. Mention the additional benefits, particularly environmental, that would result if the goals were achieved. (Clark Row, Row Associates)

  The final report clarifies the geographic limitations of the forest carbon analysis, which is one of the areas where US actions have a global effects. The other suggestions are clearly worthwhile as components of a full policy analysis on GHG mitigation from waste management, but are beyond the scope of the report.

- Include discussions of existing programs in each action area. For example, recycling programs have been growing actively for 25 years which has led to major supplies of recyclable materials. Indeed the entire MSW system has been transformed in a generation. How was this done? What are the costs/benefits? What has been the effect on GHG emissions? What are the trends? Also include a characterization of the types of paper being recycled as well as the characteristics of recycling small town vs. big city. (Clark Row, Row Associates) ***Again, these areas of inquiry provide useful lessons that may be helpful to solid waste decisionmakers, but they are beyond the scope of the report.***

- The economic feasibility of the source reduction and recycling programs discussed should be addressed. (Clark Row, Row Associates) ***This report is specifically focused on GHG emissions. Other EPA projects and reports address the cost-effectiveness of these programs.***

- Some economists feel that increased progress will be slow if programs continue to rely primarily on voluntary programs, city/town MSW agencies, and private markets. What types of action--voluntary programs, regulations, incentives, tax provisions--might permit the programs to achieve the additional GHG reductions? What program improvements might accomplish reductions that the present programs have not achieved. (Clark Row, Row Associates) ***An investigation of these issues is beyond the scope of the report.***

- Acknowledge other environmental benefits. For example, source reduction and recycling would reduce the amount and cost of MSW to be disposed, use less landfill space, and reduce other environmental impacts. In other forestry-related programs, the non-GHG benefits, economic and environmental, equaled or exceeded a reasonable value of the emission reductions. Other environmental and economic impacts will play a very large role in the ultimate selection of programs and the willingness of the public to finance them. (Clark Row, Row Associates) ***In Chapter 1, we note that there are other environmental benefits, and define the scope of the report, viz. a streamlined life cycle analysis approach that focuses on GHG emissions.***

- The sources for carbon in US paper consumption are biogenic, just as the carbon sources for biofuels. If so, they should not be counted in the US carbon emission/sequestration accounting. (Clark Row, Row Associates) ***We believe that the accounting is correct for both biogenic fuels used in paper manufacture and forest carbon sequestration.***

- The most cost-effective sources of recoverable materials have been tapped. Where will the additional material come from? What are the costs and quality? (Clark Row, Row Associates) ***These questions will be addressed by municipalities and corporations nationwide as they make decisions on their waste management practices. Consideration of these issues, namely costs of new sources of recoverable materials, are beyond the scope of the report.***

- Include discussions of substitution among materials, producing pellet fuel from yard and landscape waste, and increased collection and burning of landfill methane. (Clark Row, Row Associates) ***We have addressed material substitution in Chapter 4 and included an analysis of Refuse-Derived Fuel (RDF) in Chapter 6 of the report. In addition, the report discusses trends in landfill gas collection.***

- Include "problem" types of MSW, such as magazines and mixed paper, for which the disposal costs are not obvious. (Clark Row, Row Associates) ***We have added mixed paper to the analysis.***

- Account for the fact that emissions upstream and downstream in a life cycle are not always emitted in the United States. Two examples of this are newsprint manufactured in Canada and waste paper which is exported. Thus using emission coefficients from US facilities from all newsprint production and disposal probably results in substantial error. (Clark Row, Row Associates)
The final report includes a new section in Chapter 3 that addresses geographic limitations in the analysis.

- Calculate the GHG emissions from food production. Yes, food is not "manufactured," but major amounts of fossil fuels are burned in modern agriculture (machinery, agricultural chemicals, irrigation pumping, transportation, etc.). This would be very useful data to have. My assistant is doing a literature search on the topic; I believe David Pimentel at Cornell University has compiled some data in this area. (John Ryan, Research Director, Northwest Environment Watch) ***In defining the boundaries on the life cycle, we had to make some analytic design decisions. We agree with the commenter that these data would be useful, but limits on project resources make it necessary to limit the scope of the report. We did not include food production GHG emissions in the final report.***

- The report does not address the study premise that MSW management and GHGs are related and that different management options may reduce or increase GHG emissions; this conclusion results from many assumptions that have error bands larger than the conclusions. MSW management is not a large environmental challenge and it is merely political. (David Sussman, Poubelle Associates) ***As part of an overall voluntary reporting process, this report may help states, municipalities, and other***

interested parties estimate the potential greenhouse gas impacts associated with managing materials in the municipal solid waste stream. Although the error bands are wide, limitations in the data and methods are clearly stated throughout the report so that the reader may draw his/her own conclusions on the reliability of the results. Our interpretation is that the results show quite clearly that MSW management and GHGs are indeed related. The report is intended to provide information that can be used by those interested in the environmental aspects of MSW management.

- Examine product substitution assumption. In the past 30 years waste reduction in the US has been accomplished in 3 ways: (1) product substitution (i.e., plastic for glass), (2) light-weighting, and (3) economic downturns. (David Sussman, Poubelle Associates) ***We addressed this comment by adding a discussion of material substitution in Chapter 4 of the report.***

- In order to provide meaningful results, the report should not use national averages where there are significant regional and facility differences. These differences could be significant enough to affect the conclusions of the study. (Michelle Swanson, Northern States Power Company) ***We addressed this comment throughout the text of the report; where relevant, we have noted that national and regional differences may exist. Moreover, we have created a spreadsheet model (WAste Reduction Model, WARM) to enable decision-makers at the local level to reflect these differences when considering GHG implications of waste management actions.***

- There are several calculations in the study which are based on point estimates only. It appears that in a number of instances that small differences in estimates can affect the conclusions of the study. It would be beneficial to incorporate ranges of estimates rather than point data. (Michelle Swanson, Northern States Power Company) ***See response to AF&PA comment, above, that is substantially similar (it starts, "Final results should be presented in terms of ranges and ranges only.").***

- This study was based on mass burn only. NSP combusts RDF, a derivative of MSW. MSW is sorted to remove metals, glass, problematic wastes, etc. and then is sized appropriately to be combusted. There may be significant differences in the waste stream between mass burn and RDF to affect the conclusions of the study. A similar analysis should be done for RDF. (Michelle Swanson, Northern States Power Company) ***We added an analysis of RDF to Chapter 6 of the report. The data we were able to obtain indicated that RDF facilities have a combustion efficiency similar to that of mass burn facilities (16.3 percent and 17.8 percent, respectively).***

- The report states that recycling facilities reject materials that are contaminated. These materials must be taken to a waste to energy facility or landfill. This may result in double transportation and additional GHG emissions. Please address this scenario. (Maria Zannes, President, Integrated Waste Services Association) ***Because transportation emissions are low compared to other emissions, and because we already account for loss rates, we believe that this issue has a negligible effect on our results.***

- Include N_2O emissions from utility boiler operation, vehicle operation, and fertilizer manufactured as an additive to aid composting. The impact may not be large but should still be considered. (Maria Zannes, President, Integrated Waste Services Association) ***Our original life cycle emissions data did not include N_2O; in a screening analysis we found that CO_2 emissions from utility boilers were 5 orders of magnitude greater than emissions of N_2O and thus these emissions have not been included under raw material acquisition and manufacturing. We performed a screening analysis on the ratio of CO_2 to N_2O emissions from transportation, and found that the GWP-weighted ratio was 116 to 1; thus, the contribution of N_2O is negligible. Finally, in order to discover whether the***

addition of nitrogen fertilizer was a common practice in composting, we contacted Cary Oshins of the Rodale Institute. He said that adding nitrogen fertilizer to compost was not a common practice because the nitrogen in fertilizer was too available and thus caused a burst of activity, which subsequently died off. Certain organic materials (e.g., wood chips) are used as additives or bulking agents, but we did not extend the life cycle upstream to evaluate GHG emissions from these additives.

- EPA has a stated goal of achieving 5.6 million MTCE by the year 2000, without addressing how this goal will be achieved. Some of the management alternatives address only a very small fraction of the waste stream. There is no data to support achievement of this goal. We are doubtful whether the reduction can be achieved. (Maria Zannes, President, Integrated Waste Services Association) ***These emissions are attainable through an increase in recycling and source reduction or recycling alone. These efforts would more than account for the 5.6 MTCE reduction mentioned here. In fact, an increase in the current national recycling rate from 27 percent to 35 percent is expected to yield 12 MTCE in emissions savings. However, the report is not intended to address the total emission reductions achievable by any policy option; rather it provides information that can be used to account for GHG emission reductions from waste management practices.***

- Include product substitution. Any and all conclusions may change drastically if the trend continues towards thinner and lighter packaging of goods. (Maria Zannes, President, Integrated Waste Services Association) ***We addressed this comment by adding a discussion of material substitution in Chapter 4 of the report. Moreover, because the report expresses emissions on a per ton basis, it allows analysts who wish to estimate effects of material substitution to first characterize functional equivalents of different materials, and then to calculate GHG effects of material substitution.***

- The report is not a reflection of greenhouse gas emission from the management options for municipal solid waste. The report is geared solely to review the possible greenhouse gas emissions that would result from differing management of very selected parts of the waste stream that traditionally are recycled. As such, the report's title is misleading. I would suggest another title, such as "Greenhouse Gas Emissions Resulting From the Management of Selected Materials in the Municipal Solid Waste Stream." (Maria Zannes, Integrated Waste Services Association) ***We have changed the title as suggested; it is indeed a more accurate description of the report's contents.***

- Include error range for numbers. (Art Dunn, Director, Peder Larson, Commissioner, Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance, and Maria Zannes, President, Integrated Waste Services Association) ***Ideally, figures in this report would be presented as best estimates along with some statistical measures of variability, such as standard deviation or range. We did not have enough information on the underlying distributions to estimate standard deviation. In order for the range to provide an improvement over the "best estimate" measure of central tendency, one would need to know the minimum and maximum values for all of the input factors, whether they are independent, and how they are functionally related. Although the study evaluated the functional relationship among the factors, we were not able to collect information on the minimum and maximum values and the mutual dependence of the factors. In this situation, presenting ranges could be more misleading than helpful. For example, we collected energy intensity and fuel mix data from two sources – FAL and Tellus – and both of the sources were providing best estimates. Presumably, individual facilities in the US would have ranges of energy use well outside of the range of the two best estimates, so expressing the resulting GHG estimates as a range would not accurately reflect the true minimum and maximum values.***

- Waste-to-energy facilities generated a significant amount of energy in 1995. (Maria Zannes, President, Integrated Waste Services Association) ***The report uses values of 5,000 BTUs per pound of mixed MSW, combustion system efficiencies of 550 kWh per ton for mass burn plants and 572 kWh per ton for RDF plants, and a transmission and distribution loss rate of 5 percent. These values were used to develop energy generation estimates of 523 kWh per ton and 544 kWh per ton for mass burn and RDF facilities, respectively. We do not address industry-wide energy generation in the report, but voluntary reports made by the industry as part of the Energy Policy Act 1605(b) GHG reporting system certainly support the commenter's statement.***

- Landfilling, recycling, and reduction estimates were projected outward to reflect a very optimistic next century with a recycling rate of 50 percent within 3 years and 100 percent of landfills complying with NSPS or EG rules for such sources. According to EPA's *Characterization of Municipal Solid Waste in the United States: 1996 Update*, the current national recycling rate is 27 percent, including composting, and not the 1994 rate of 35 percent. At the same time, EPA takes no account for the strict emissions limits placed on waste-to-energy plants in accordance with MACT regulations promulgated in 1995. (Maria Zannes, President, Integrated Waste Services Association) ***The 50 and 35 percent recycling rates mentioned here appear to mix two related, but discrete factors – recycling rates for paper (projected to reach 50 percent by 2000) and recycling rates for the entire wastestream (at 27 percent in 1996, including composting). Paper is the largest component of the wastestream and the most recycled material, on a weight basis. As for the MACT standards, while they do limit emissions of many pollutants, they do not set limits on GHG emissions***.

- The report assumes that CO_2 from biogenic processes is somehow different from other sources of CO_2. This is very misleading and favors nations that do not use as much fossil fuels and may encourage such actions as extensive forest cutting. (Maria Zannes, President, Integrated Waste Services Association) ***We followed the Intergovernmental Panel on Climate Change (IPCC) convention for emissions accounting. The IPCC convention is not to count carbon dioxide emissions from biomass grown on a sustainable basis. Under this accounting convention, a nation that uses more fossil fuels will have greater GHG emissions than a nation that uses less. Forest cutting that is not accompanied by replanting counts toward GHG emissions under the IPCC accounting method; deforestation is the primary source of GHG emissions in several developing countries, so it is not the case that the methods encourage extensive forest cutting.***

- The report normalizes the impacts based upon the particular material examined. For example, impacts for paper are presented per pound of paper. This method magnifies the role and impact on GHGs of lighter material such as plastics when they are combusted. The presentation is thus biased, and makes it appear as if waste-to-energy facilities generate large quantities of GHG emissions despite the reality that the facilities reduce such emissions. Data should be presented based on one ton of waste in all tables. (Maria Zannes, President, Integrated Waste Services Association) ***The report presents the estimated greenhouse gas impacts of each material on a per-ton basis. To facilitate comparison of managing mixed waste, we include estimates for mixed waste in the report as well, and these are either based on weighted averages for the components of mixed waste (e.g., for combustion) or based on attributes measured directly (e.g., methane generation in landfills). The final report indicates that combustion of mixed waste results in post-consumer emissions of –0.04 MTCE/ton, i.e., the credit for avoided utility fossil fuel CO_2 emissions outweighs the CO_2 emissions from the non-biogenic (plastic) component of the wastestream.***

Preface

- The document appears to have been prepared by the academia and EPA. It may have been appropriate for the applicable industries to have been more involved up to this date. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The review process is explained in more detail in the final report. The process was consistent with EPA's internal guidelines for review, which dictate that when a document is to be released beyond the internal review process that it be made widely available to all interested parties. As manifested by the comments summarized in this document, applicable industries have used the public comment period to become involved, and have made valuable contributions.***

Executive Summary

- APC believes that some of the more appropriate applications should be: (1) a departure point for broader public participation in the discussion and more research and programs designed to better understand climate change and GHG emissions; (2) encourage cooperative international responses; (3) consider a complete inventory of policy response options to GHG emissions (including adaptation, mitigation, and sequestration); and (4) clarify the economic and social impacts of specific policy choices. (American Plastics Council, Washington, D.C.) ***The report is intended to contribute to all of these applications, but to keep the scope tractable, it's objectives are more modest. As stated in the report, "The primary application of the GHG emission factors in this report is to support climate change mitigation accounting for waste management practices. Organizations interested in quantifying and voluntarily reporting GHG emission reductions associated with waste management practices may use these emission factors for that purpose. In conjunction with the Department of Energy, EPA has used these emission factors to develop guidance for voluntary reporting of GHG reductions, as authorized by Congress in Section 1605 (b) of the Energy Policy Act of 1992. EPA plans to use these emission factors to evaluate its progress in reducing US GHG emissions, by promoting source reduction and recycling through voluntary programs such as WasteWi$e and Pay-as-You-Throw (PAYT), as part of the US CCAP. The methodology presented in this report may also assist other countries involved in developing GHG emissions estimates for their solid waste streams."***

- Exhibit ES-1 is not clear with respect to plastics. For every category, except HDPE, LDPE, and PET, the percentages can be verified as product specific against the EPA MSW Characterization Report (1994 data). The percentages for HDPE, LDPE, and PET, however, are for all uses of these resins, including durable goods, non-durable goods and packaging. Not only is this point not clear, but the LCI data is based on blow-molded containers, that are not representative of the fabrication techniques used for various products. (American Plastics Council, Washington, D.C.) ***For HDPE, LDPE, and PET, Exhibit ES-1 was revised to reflect only the resins in blow molded containers.***

- Exhibit ES-4 is not clear. It shows no net source reduction emissions for aluminum, steel and plastics, so this must be the baseline of "no material produced." Yet the title of the exhibit states "Assuming Initial Product Using the Current Mix of Virgin and Recycled Inputs," indicating that something is being made. (American Plastics Council, Washington, D.C.) ***Exhibit ES-4, and the discussion concerning the reference point for tallying GHG emissions has been revised to provide a waste generation reference point as well as a cradle to grave reference point on counting emissions. These revisions attempt to clarify the issue raised by the commenter.***

- While it is difficult to determine from the report's table of percentage components of MSW (pg. 5) it appears that certain paper and paperboard materials, metals (other than aluminum), wood, some plastics, and miscellaneous materials were omitted (Characterization of Municipal Solid Waste in the United States: 1995 Update, EPA, March 1996). Failure to consider 50 percent by weight of MSW leaves a major gap in the report's overall analysis and tends to undermine the credibility of its recommendations. We believe that all components of MSW should be considered, to provide a full evaluation of the GHG implications of MSW options. (American Plastics Council, Washington, D.C.) ***The data set required to characterize all of the components of the MSW stream would be enormous, and early in the effort it became clear that we would need to limit the scope of the report to evaluate selected components of MSW. The set of components we evaluated addresses more than half of the materials in the wastestream, and as the report explains, it includes the materials where material-specific options (source reduction, recycling) are widely viewed as feasible from a technical and economic standpoint. We added glass and mixed paper to the analysis to increase***

coverage. And the report includes estimates for mixed waste, as disposed, for combustion and landfilling, the management techniques that deal with the full wastestream.

- Exhibit ES-3 shows no decrease in GHG emissions for source reduction, while Exhibit ES-5 shows a significant decrease. (American Plastics Council, Washington, D.C.) ***Exhibit ES-3 explains the components of net emissions; exhibit ES-5 (re-numbered ES-6 in the final report) shows source reduction relative to landfilling. The report clarifies the calculation of net emissions for specific options (as is done in Exhibit ES-3), and the method of comparing one option with another (baseline) option (as shown in Exhibit ES-6).***

- While Exhibit ES-2 gives a diagram of the scope, some issues remain unclear. The report should include a more extended explanation of the scope and boundaries of the life cycle inventory. In particular, the report could explain and justify the rationale for the streamlined life cycle inventory, and the report's sole focus on energy and 50 percent of the MSW stream. (American Plastics Council, Washington, D.C.) ***In Section ES.5, the report explains the focus on the percent of the MSW stream analyzed, the streamlined life cycle inventory approach, and the GHG sources and sinks considered (both energy-related and non-energy-related). The term "streamlined life cycle inventory" simply describes the type of analysis conducted; as stated above, the reasons for conducting this type of analysis are presented in Section ES.5.***

- Exhibit ES-5 shows source reduction results in significant GHG emissions, but it seems the baseline is landfilling, not "no material being manufactured." (American Plastics Council, Washington, D.C.) ***The emissions from source reduction were negative, not positive and the baseline was landfilling. The landfilling baseline is not to be confused with the accounting convention used to quantify emissions. Our initial presentation was apparently confusing, as shown by this and other comments, and we clarified the discussion in the report using a new accounting convention. Under the new accounting convention, most exhibits present a waste generation reference point (i.e., emissions after the material has already undergone the raw materials acquisition and manufacturing phase).***

- Plastic-related examples should be given along with paper-related examples to stress opportunities to provide environmental benefits. In the Executive Summary in the first paragraph on page 4, the second sentence could read: "Source reduction through the use of light weight plastics and recycling of paper and plastic products, for example, reduces energy consumption, decreases landfill methane emissions, and increases forest carbon sequestration." (American Plastics Council, Washington, D.C.) ***The section is introducing the relationship of MSW to GHG emissions; we use paper as an example because it illustrates the full range of possible GHG impacts (i.e., it includes landfill methane and forest carbon effects). While it is true that lightweighting plastics has GHG benefits (as made clear later in the report), these are concentrated in the raw material acquisition and manufacturing part of the life cycle, and we wanted to use a single example at this point in the Executive Summary that would cut across many points in a product life cycle.***

- The report's brief description of its uses does not help readers understand who the potential users of the report are and what they can do with the report's information and recommendations. (American Plastics Council, Washington, D.C.) ***We have augmented the discussion of uses, and added emphasis that the primary use is to support evaluation of voluntary actions.***

- The final application may unrealistically suggest that other nations, with waste composition and product life cycles relevant to their own countries, can adopt the report's assessment of MSW options applicable to the US (American Plastics Council, Washington, D.C.) ***We recognize that conditions***

may be quite different in other countries, and in Section ES-5, we added a footnote that clarifies this point.

- The first stated use of the report does not characterize how others might use the report and whether the conclusions are adequate for that purpose. (American Plastics Council, Washington, D.C.) ***The first stated use now appears in the second paragraph of the executive summary: "The report's findings may be used to support voluntary reporting of emission reductions from waste management practices." We believe the methods, data, and findings of the report are adequate for this purpose.***

- The second application of the report does not acknowledge that the report consists of a "streamlined" life cycle inventory of a partial selection of MSW components without a thorough quantitative analysis of uncertainties. (American Plastics Council, Washington, D.C.) ***Chapter 1 of the report discusses the streamlined life cycle approach used for this analysis.***

- The third proposed use seems premature without comparable analyses of economic and other environmental implications. (American Plastics Council, Washington, D.C.) ***It is beyond the scope of this report to evaluate economic and other environmental implications. The discussion of possible applications of the report, Section ES.4, emphasizes the use of emissions factors by voluntary programs. In these programs, participants make their own decisions with regard to economic and other environmental considerations.***

- On page 6, the GHGs associated with consumer use of products should be included. Omission of this life cycle stage neglects an advantage of life cycle analysis; its ability to determine trade-offs associated with alternatives. Knowledge of product use would provide valuable input for EPA to properly prioritize actions to reduce greenhouse gases. (Scott Chubbs, American Iron and Steel Institute**)** ***GHG emissions associated with consumer use of materials in MSW were excluded from the analysis because they are generally small. In addition, we expect no difference between recycled and virgin product use.***

- In Footnote 1 on page 9, include the referenced discussion. The footnote promises "a discussion of why recycling of aluminum...". This reviewer cannot find such discussion in Chapter 4. (Gregory Crawford, Steel Recycling Institute) ***A discussion of this issue is provided in Chapter 8, however the footnote has been removed. As an editorial matter, we had to choose the level of detail appropriate to include in the Executive Summary. Some of the finer points were deemed more appropriately handled in the body of the report.***

- This reviewer wonders whether the energy usage and GHG emissions impact of aluminum can collection and processing are taken into full account. The caveat "based upon the current mix of virgin and recycled inputs" is very important indeed since the amount of recycled inputs cannot be increased in the mix without significant energy considerations. This is due to the fact that the current mix accounts for the proportion of the two unique alloys used for aluminum cans, one for body stock and one for lid stock, respectively. Added recycling inputs would require that these two alloys be physically separated after recycling and collection by mechanical and thermal means before being smelted into recycled ingot. (Gregory Crawford, Steel Recycling Institute) ***While an upper limit on the recycling of cans back into cans exists, reports are mixed on the bounds of this limit; some manufacturers have higher limits than others. We believe the current recycling rates have not approached the limits. For example, recycling rates in Canada and Japan are higher than in the US, and apparently the limits have not been reached in these countries. In addition, past technological innovation has played a key role in the use of recycled aluminum cans. Steady***

increases in recovery will allow time for the development of technological improvements that may improve the technical feasibility of recycling aluminum cans.

- On page 5, clarify what components comprise "mixed MSW." (Martin Felker, Senior Environmental Engineer, Waste Management) ***In Section ES-5, we added a bullet to clarify this point. It reads "Mixed MSW is comprised of the waste material typically discarded by households and collected by curbside collection vehicles; it does not include white goods or industrial waste. This report analyzes mixed MSW on an "as disposed" (rather than "as generated") basis.***

- On page 10, the report says that combustion has lower GHG emissions than landfilling for several waste stream items. This assumes that the landfill gas is not combusted; whereas the emissions would likely be similar if the landfill gas is combusted. A significant factor that must be addressed is the time element: Combustion produces greenhouse gases immediately while landfilling produces them over a period of decades. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The final report provides separate results for landfills with and without landfill gas (LFG) recovery (although this is in Chapter 7, not in the Executive Summary), in addition to results for the "national average" landfill, so readers can see the range of difference in the with versus without LFG scenarios. As for the point on timing, from a GHG perspective, the difference between emissions that occur immediately versus emissions in ten years is small; global warming potentials are generally averaged over 100 years, and atmospheric lifetimes of some of the gases are in the range of several hundred years. In this context, we felt that the additional complexity involved in distinguishing between emissions on a short time scale was not warranted***

- On page 2 the report should examine information that there is no greenhouse effect. While the author of these comments does not have the reference at hand, the authors of the report should be aware that there may be documented literature that suggests that there has not been a temperature rise and/or that the rise that has occurred could be part of a normal cycle that the earth's climate goes through. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The report focuses on GHG mitigation (i.e., emission reduction and sink enhancement) and does not attempt to report the full range of positions taken on climate science. We believe that it accurately reports the current scientific consensus.***

- On page 6, include the metabolic CO_2 given off by human and animal populations. (Martin Felker, Senior Environmental Engineer, Waste Management) ***We followed the convention of the Intergovernmental Panel on Climate Change (IPCC). The IPCC convention is not to count these biogenic emissions.***

- On page 11, include a time factor in the limitations section. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The 100-year time horizon is used in the US GHG inventory, and we believe it is appropriate for use in this report as well. We believe the time factor does not appear to be as significant a concern as other limitations.***

- On page 8, include reuse in the hierarchy of greatest to least environmental benefits. Reuse should also be considered as one of the end-of-life alternatives. It seems peculiar that source reduction, obviously and unarguably the lowest contributor to GHG emissions, is presented as one of the options considered for this study, and reuse is not considered at all. (Ecobalance, on behalf of the American Forest and Paper Association) ***We consider reuse to be a form of source reduction.***

- On page 10, include a footnote explaining why newspapers result in carbon sequestration while office paper and corrugated cardboard create methane. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***As an editorial matter, we had to choose the level of detail appropriate to include in the Executive Summary. Some of these finer points were deemed appropriate for the body of the report. Please refer to the appropriate chapter in the body of the report.***

- In Exhibit ES-4, some emissions should be attributed to composting. Many backyard composters do a lot of anaerobic work that creates methane. A bit more explanation is warranted in the footnote as well as an additional explanation of their assumptions and bounding analysis is appropriate. The footnote should also refer to the discussion of "limitations" given on pg. 80, where a more explicit statement should be made due to the high probability that some amount of anaerobic decomposition will take place in composting systems. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***Again , we had to choose the level of detail appropriate to include in the Executive Summary. Some of these finer points were deemed more appropriate for the body of the report than for the executive summary.***

- In Exhibit ES-3, "Change in Soil Carbon Storage" is used as a column heading. This consideration of soil carbon seems to reflect only the application of composted materials to land. A footnote is needed to refer the reader back to the discussion on page 57 regarding the use of the FORCARB model. The footnote, or the discussion on page 57, should clearly state that the FORCARB model understates the accumulation of soil carbon in the forest ecosystem. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***We combined soil and forest carbon in the revised version of this exhibit. Although we did not add a footnote in the exact place suggested, we did add a note to the limitations section a few pages later, stating that our estimate of forest carbon sequestration did not include soil carbon storage changes.***

- On page 3 it states that the "CCAP outlines over 50 initiatives to reduce GHG emissions in the US". It may be a good idea to mention EPA's Landfill Methane Outreach Program (LMOP), which focuses specifically on reducing methane emissions from existing landfills, as the readers of this document may also be interested in some of the information that the LMOP has to offer. (Tom Kerr, OAR/OAP/APPD) ***In Section ES-2 we added the suggested text and a footnote to incorporate this information into the report.***

- On page 5, Exhibit ES-1, if the percent weight contribution of the aluminum can in the waste stream is multiplied by the total weight of the waste stream (i.e., 209 million tons from page 1), it suggests that there are 103 billion cans going to landfills. Since there are only 100 billion produced per year, and 63.5 percent are recycled, the figure should be reduced to 0.3%. (Steven Pomper, Alcan) ***The exhibit in question addresses the percentage of each material in municipal waste as <u>generated</u>, not the percentage of waste that is <u>landfilled</u>.***

- On page 11, second bullet, the assumption that land use changes will not be changed by source reduction or recycling is not valid, because lower prices for pulpwood will reduce incentives to invest in planting marginal land to forest plantations. A small point, if idea that roundwood supplies are biogenic is accepted. (Clark Row, Row Associates) ***This is a modeling assumption that was incorporated in the USFS model systems, and it is addressed as a limitation.***

- On page 2, paragraph 2, in the list of environmental changes, add ecosystem changes, agricultural shifts, and losses in biological diversity. (Clark Row, Row Associates) ***In Section ES-1, we addressed this comment.***

- Should Exhibit ES-3 have a column for landfills? (Clark Row, Row Associates) ***This exhibit includes a row for landfills.***

- Exhibit ES-4. In Exhibit ES-4 over what period of time are the landfill emissions? (Clark Row, Row Associates) ***The time period for landfill emissions is about 30 to 40 years, i.e., the time period over which all methane emissions occur, and at the end of which degradation of organic materials is complete.***

- On page 11, ES-7 highlights some of the limitations of the study. It points out among other things, that it uses point estimates. This study should attempt to provide a range of estimates for all data included. (Michelle Swanson, Northern States Power Company) ***To the extent feasible, we have provided sensitivity analyses, based on ranges for certain estimates.***

- On page 2, the discussion of the findings of the IPCC are taken slightly out of context. For example, in the statement ". . . the buildup of carbon dioxide and other GHGs in the atmosphere will lead to major. . .", will should be changed to may. Scientists have not yet concluded that these environmental changes will occur. (Michelle Swanson, Northern States Power Company) ***The first part of the sentence reads "There is growing scientific consensus that the buildup . . .". We believe the statement is accurate, although it is certainly the case that there is not unanimity among scientists.***

- The statement, "The best current predictions suggest that the rate of climate change attributable to GHGs will far exceed any natural climate changes that have occurred during the last 10,000 years" also appears to be out of context. Page six of the 1995 Second Assessment Report (SAR), Working Group I, states that the average rate of warming would probably be greater than any seen in the last 10,000 years. On page 30 of the same SAR report, it states that "it is likely that much of the rise in seal level" is related to a rise in global temperature. (Michelle Swanson, Northern States Power Company) ***We have addressed this comment in the report and used the language from page six of the IPCC's 1995 Second Assessment Report.***

- In regard to extreme rainfall events, though there have been extreme rainfall events documented in the US, it does not mean it is the result of climate change. Page 30 states, "there are inadequate data to determine whether consistent global changes in climate variability or extremes have occurred over the 20th century." Sea level rise and extreme rainfall events may have been documented, but they cannot and should not be used as evidence that global climate change is already occurring. The 1995 SAR does not support this link. (Michelle Swanson, Northern States Power Company) ***The paragraph at issue starts, "Many of these changes appear to be occurring already." We believe that the language in the report is accurate as it stands, and that it reflects the growing international scientific consensus.***

- On page 5, Exhibit ES-1 gives a characterization of municipal solid waste on a national basis. Based on a Minnesota composition study done in 1991-1992, the breakdown of wastes is significantly different. In particular, there are large differences in the volume of food scraps, yard trimmings and corrugated cardboard on a Minnesota basis. This could have a significant impact on the conclusions of this study. It is important for this study to acknowledge and to incorporate in its methodology, the ability to use and apply more facility specific or regional data, rather than national data. (Michelle Swanson, Northern States Power Company) ***In Section ES-5, we have addressed this comment by emphasizing that local conditions differ from the national average. As noted elsewhere, we have also developed WARM to assist solid waste decisionmakers in evaluating GHG implications of their management decisions, and accounting for local variability.***

- On page 7, Exhibit ES-2, under the combustion heading, CH_4 emissions should be listed. According to the DOE report *Sector-Specific Issues and Reporting Methodologies Supporting the General Guidelines for the Voluntary Reporting of Greenhouse Gases under Section 1605 (b) of the Energy Policy Act of 1992, Volume 1*, page C.6, there are CH_4 emissions associated with the combustion of MSW. The emission rate is very small, and it may have been that you chose not to incorporate it for this reason. If that is the case, it should be stated in the report that there are CH_4 emissions associated with combustion, but because of their size, they will not be addressed. (Michelle Swanson, Northern States Power Company) ***We reviewed the DOE guidelines and estimate the CH_4 emissions from the combustion of MSW to be negligible (approximately $2.85x10^{-5}$ MTCE per ton of mixed MSW).***

- On page 8, Exhibit ES-3, CH_4 should be listed under combustion. (Michelle Swanson, Northern States Power Company) ***See previous response.***

- On page one, the second paragraph mentions CO_2 and CH_4 as greenhouse gases which could be affected by different MSW management options. Because later in the report you discuss N_2O emissions associated with various MSW options, it is important to note N_2O in the introductory section. (Michelle Swanson, Northern States Power Company) ***The passage now reads, "Among the efforts to slow climate change are measures to reduce emissions of carbon dioxide from energy use, reduce methane emissions, and change forestry practices to promote long-term storage of carbon in trees." In addition to N_2O, the report also addresses PFCs, but the contribution of these to the overall GHG effect is minor. Thus, for the introduction, we covered only the major gases.***

- Exhibit ES-2 should indicate the energy-related emissions associated with recycling, utility boiler operation, and vehicle operation. (Maria Zannes, President, Integrated Waste Services Association) ***The emissions are described in slightly more detail in Exhibit ES-3, and are further elaborated in Chapters 2 and 4***.

1. Methodology

- All municipal solid waste should be analyzed. Its omission leaves a major gap and may undermine the report's credibility. (American Plastics Council, Washington, D.C.) ***The report includes mixed MSW in the analysis, however, we did not have the resources to look at every individual material in MSW. In order to utilize resources most efficiently, we focussed on materials that appeared to represent the most potential for GHG emission reductions.***

- On page 16, the report assumes that harvesting trees results in no diminution of the forest carbon stock and no additional carbon dioxide in the atmosphere. On understanding that forests provide a net reduction in GHG, it would seem that harvesting trees, with the attendant energy consumption from cutting and transportation, would both add carbon dioxide and remove carbon stock. (American Plastics Council, Washington, D.C.) ***On page 16 the report states "...the baseline is based on the assumption that the forest will be harvested on a sustainable basis…". In fact, sustainable forestry is the norm in the US and we believe that this will continue to prevail. At the forest level, carbon storage is equal to growth minus removals minus degradation. Energy consumption from harvesting trees for paper is counted in the analysis.***

- The gross quantity of greenhouse gas emissions, in the absence of forest carbon sequestration "credits" should be included in the report. We note that most MSW options and components are about equal in greenhouse gas emissions when carbon sequestration credits are removed and uncertainty factors are considered. (American Plastics Council, Washington, D.C.) ***We believe it is most appropriate to include forest carbon; the models to estimate this factor are the best available. The structure of the tables in the Summary Chapter allows the reader to include or exclude any component, however.***

- The report's screen for selecting the 10 materials analyzed eliminated almost 50 percent of MSW, including materials that may be high GHG emitters, but are not currently recycled or source-reduced. The justification for this approach and its possible impact on the report's conclusions needs further development. (American Plastics Council, Washington, D.C.) ***We did not have the resources to look at all of the items in MSW, so we evaluated those that appeared to represent the best opportunities for GHG emission reductions. In an effort to cover the total municipal solid wastestream, we also developed an emission factor for mixed MSW.***

- The report should include glass in the analysis. It is not sufficient to simply state that it is not included because of, "the relatively small difference between the amount of energy used in manufacturing glass from virgin versus recycled inputs" (Footnote 19, pg. 14). This observation is true for some of the selected materials as well. (American Plastics Council, Washington, D.C.) ***EPA plans to include glass containers, pending review by the glass industry. The glass industry was given the opportunity to comment on our data sources for glass.***

- Because the report's conclusions are similar within classes of materials, and the database and analysis are subject to so much variation, the report should be modified so that it deals with classes of materials, such as "all paper" or "all plastics" rather than specific types of paper or plastic. The report's segmentation of materials accompanied by tables of data relating to each, suggest a level of accuracy that may be misleading to readers without a full understanding of the assumptions and data underlying the report. (American Plastics Council, Washington, D.C.) ***We believe the estimates for the individual materials included in the analysis reflect important differences in energy use, methane generation, and other attributes, and that it is more useful to make the distinctions than to***

blur them. For the purpose of voluntary reporting of source reduction and recycling activities, segmenting the materials will be more applicable.

- On page 16, the study assumes that forests will be harvested on a sustainable basis (i.e., trees will be grown at the same rate of harvesting for paper). While questionable on its face, the assumption is supported with the overly optimistic assertion that future US timber harvesting practices will be "sustainable" because the US is currently experiencing net reforestation (footnote 21). (American Plastics Council, Washington, D.C.) ***We believe assumptions used in the report regarding sustainable forestry practices into the future are reasonable, based on projections from the Forest Service, American Forests, and other forestry experts, all of which predict continued investment in replanting and reforestation.***

- It is difficult to understand the explanations for some of the methodology and the source of figures. The baseline of "no material being manufactured," is a non-intuitive assumption and difficult to understand from the report's explanation and results. (American Plastics Council, Washington, D.C.) ***The confusion exhibited in this and other comments is exactly the reason we revised discussion in the report using a new accounting convention. Under the new accounting convention, only emissions from a waste generation reference point (once the material has already undergone the raw materials acquisition and manufacturing phase) are quantified. In other words, the baseline assumes initial manufacture of the material. Emissions reductions are then applied to the baseline. For example, source reduction reduces emissions below the baseline because less of the material is made.***

- The report should discuss the selection of the functional units. The report should explain how the selection of weight places a burden on lighter weight materials. For example, a steel can weighs more than an HDPE bottle and, based on similar capacity, many more HDPE bottles can be produced from 1,000 pounds resin than steel cans from 1,000 pounds of steel. (American Plastics Council, Washington, D.C.) ***We addressed this comment in a footnote to Section 1.4, which says "note that the comparative analysis among materials may vary for different units of measure. For example, a comparison between two packaging materials based on the GHG impacts per thousand packages will differ from a comparison based on the GHG impacts per ton of packaging material; the former comparison will account for the different weights of different types of packages. However, we chose to develop emission factors on a per-ton basis because this report's analysis focuses on greenhouse gas impacts from waste management, and waste is typically measured in tons."***

- The study should review GHG in terms of GHG per functional equivalent, rather than GHG-per-ton of material. (American Plastics Council, Washington, D.C.) ***See previous response.***

- Materials cannot be substituted on a pound for pound basis, nor is their life cycle impact comparable on a weight basis. (American Plastics Council, Washington, D.C.) ***See previous response.***

- On page 16, the study fails to recognize that the total concentrations of GHG, not annual emissions, are key to limiting the risk of significant climate change. Essentially, the study fails to consider the impact of other carbon sinks (e.g. the ocean, oil and coal reserves, and landfills). (American Plastics Council, Washington, D.C.) ***In Kyoto, the Annex I countries set goals in terms of emissions, not atmospheric concentrations. This report provides a means of evaluating GHG effects in terms of emissions, not atmospheric concentrations. If we were to wait to publish results until we could consider the impact of other carbon sinks like the ocean, we may not be able to provide useful results for years.***

- On page 18, the study improperly assumes that, when paper products are source reduced, the additional carbon is sequestered in forests. The wood could and probably would be used for other uses. (American Plastics Council, Washington, D.C.) ***The report assumes that source reduction or avoided production of paper will effectively result in increased carbon sequestration. This assumption is based on the premise that the demand for paper products influences the amount of wood harvested.***

- On page 22, it appears that the CO_2 from decomposition of paper products is not counted in the balance since it is CO_2 from the carbon in plants that came from the air in the first place. However, CO_2 generated from petroleum products is counted, yet it also originated from the carbon in plant life, which originated from CO_2 in the atmosphere. The environment has sequestered significant amounts of C in the form of petroleum products. Therefore it would seem appropriate to treat it equally with other forms of carbon that have been sequestered, particularly since it is from the same source, CO_2 from the atmosphere which is returning to the atmosphere. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The report follows the convention of the Intergovernmental Panel on Climate Change (IPCC). The IPCC convention is to count CO_2 from fossil fuel combustion. Although this carbon was initially removed from the atmosphere by photosynthesis, it would be unavailable for cycling throughout the biosphere if it remained underground, so it is the process of fossil fuel combustion that re-introduces it to the active carbon cycle.***

- On page 17, it is unclear how landfill methane emissions reductions would be counted twice. In addition, by using the year 2000 as a baseline, methane emissions reductions from landfills that occur prior to that year are not considered. (Martin Felker, Senior Environmental Engineer, Waste Management) ***We addressed this comment in Section 1.4 of the report (under "Baseline Year"). In essence, if we were to count emission reductions from landfill gas collection as well as from diverting organics, there would be double-counting.***

- List the 37 most common materials and products found in MSW that were used in the screening analysis. (Martin Felker, Senior Environmental Engineer, Waste Management) ***We added a footnote in Section 1.3 that addresses this comment.***

- On page 15, referring to the statement that "methane from landfills is the largest source of methane in the US," it is important to realize that methane generation does not equate to methane emissions. Existing worldwide landfill methane emissions estimates vary over a wide range, suggesting considerable uncertainty with respect to this particular source (Bogner, J., Meadows, M., and Czepial, P., 1997A, Bidirectional Fluxes of Methane between Landfills and the Atmosphere: Landfills as Sources and Sinks, Soil Use and Management, accepted.--and sources listed within). Moreover it has been shown at a northeastern Illinois landfill site that landfill cover soils with high capacities for methanotrophic methane oxidation can function as sinks for atmospheric methane rather than sources (Bogner et. al. 1995, Landfills as Atmospheric Methane Sources and Sinks, Chemosphere 31(9): 4119-4130. and Bogner et al. 1997b, Kinetics and CH_4 Oxidation in a Landfill Cover Soil: Results of a Whole-Landfill Oxidation Experiment, and Modeling of Net CH_4 emissions, Environmental Science and Technology, accepted.). (Martin Felker, Senior Environmental Engineer, Waste Management) ***The report is correct in stating that methane emissions from landfills are the largest anthropogenic source of methane in the US. However, we agree that there is considerable uncertainty concerning methane from landfills. In addition, we agree that oxidation is an important factor for consideration of landfills as methane sources. We obtained the sources cited above and conclude that the report accounts for methane oxidation in an appropriate way in Chapter 7. Most recently, research findings presented in the Journal of Geophysical Research (April 20, 1998), support the 10% oxidation rate presented in the report.***

- On page 24, it is emphasized in the sixth paragraph that methane from landfills is a potent GHG, 24 more times potent than CO_2. However in the fifth paragraph, no mention is made of the GHG potency of N_2O from combustion of waste, which is 11 times more potent as a greenhouse gas than methane, and 270 times more potent than CO_2. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The GWPs are revised to reflect the most recent IPCC values. The word "potent" was deleted in our description of methane.***

- The Life Cycle framework for the analysis has not conformed to the approach articulated in International Organization for Standardization and Society of Environmental Toxicology and Chemistry documents regarding principles of Life Cycle Assessments. The study should have conformed to the standards established for the LCA technique in order to make any comparative assertions among the various management systems. Without meeting those standards, there can be no assurances that the LCA was conducted to address all known biases, uncertainties, and data gaps in a manner consistent with the advice provided by the international experts in the field of LCA. The full disclosure issue is critical to this LCA report. Sensitivity and data quality analyses are necessary first steps. EPA must then undertake a critical review of the results, as outlined in ISO 14040, for comparative assertions. (Judy Hicks, American Forest and Paper Association) ***ISO 14040 is a set of life cycle assessment documents developed to give businesses a tool to measure the environmental impacts of their products from cradle to grave (from gathering raw materials, through manufacturing, and finally to disposal). It is not the intent of this report to compare products in terms of all potential environmental impacts. Instead, the report focuses on greenhouse gas emissions for selected materials resulting from specific municipal solid waste management decisions. For the purposes of this analysis, we attempted to use the most current data available, actively pursued new data, and where necessary, were forced to average data sets to generate the best available estimates. All limitations concerning data quality, uncertainties and biases are outlined in the limitations sections of each chapter throughout the report.***

- The study implies that there is a linear correlation between increased recycling and energy requirements of the life cycle system. This is inconsistent with findings of previous studies on recycling (see AFPA comments for specific examples). With the use of data derived from current recycling schemes, and the assumption that all impacts including transportation are linear (i.e., on a per-ton basis), there is an implicit justification to promote an increase in recycling. However it is not clear where on the curve the current recycling scheme may lie. If today's situation is at the most efficient point (i.e., minimum) on the curve, an increasing recycling rate will not yield the expected benefits that the study expects because recycling energy per ton will increase. (Ecobalance, on behalf of the American Forest and Paper Association) ***One of the limitations noted in the report is the assumption that changes in energy and fuel mix are linear between scenarios that correspond to manufacture with (a) 100% virgin inputs and (b) 100% recycled inputs. We interpolated between these points to estimate energy use (and GHG emissions) for the current mix, and used these points to estimate the effect of replacing virgin inputs with recycled inputs. In some cases, the relationship between energy and inputs may actually be a step function (e.g., where increased recycling drives investment in a new plant with new technology, and there is a dramatic shift in energy intensity) and in others, the relationship may be simple and linear. We had hoped to receive industry data on energy use and fuel mix as part of the public comments on the draft report; however, no industries provided data on general energy use in manufacturing processes, much less on the shape of the curve for energy use as a function of the mix of virgin versus recycled inputs. As new data becomes available, modifications can be made to the emissions factors and the correlation between increased recycling and energy requirements will become more***

clear. In the absence of better data, in our judgment the assumption that the relationship is linear is most appropriate.

- Include what other products were considered besides the glass and other waste stream components. (Ecobalance, on behalf of the American Forest and Paper Association) ***We added a footnote in Section 1.3 that addresses this comment. The footnote states, "materials and products in the screening analysis included, in addition to the materials and products covered in this report, the following: other paper materials (bags and sacks, other paper packaging, books, other paperboard packaging, wrapping papers, paper plates and cups, folding cartons, other nonpackaging paper, and tissue paper and towels), other plastic materials (plastic wraps, plastic bags and sacks, other plastic containers, and other plastic packing), other metal materials (aluminum foil/closures, other steel packaging), and other miscellaneous materials (miscellaneous durable goods, wood packaging, furniture and furnishings, carpet and rugs, and other miscellaneous packaging)."***

- Include glass in the study. The fact that there is little difference in energy between manufacturing from virgin vs. recycled glass should not exclude glass from the study. In fact, based on assumptions made in the study, the small difference in energy between manufacturing virgin and recycled glass may show that recycling glass does not offset the GHG impact as much as the other materials studied. Purposefully omitting an important component of the MSW stream, such as glass, from the study indirectly favors recycling since the glass product might have shown recycling was not the best end-of-life option for all products. (Ecobalance, on behalf of the American Forest and Paper Association) ***The report now includes glass containers. The glass industry was given the opportunity to provide comment prior to publication of the final report.***

- Include the latest IPCC global warming potentials in the calculations. Using different GWPs could significantly affect the results (e.g., GWP of 21, not 24.5, for methane, much larger differences for perfluorocarbons). (Tom Kerr, EPA) ***The report reflects the latest IPCC global warming potentials.***

- On page 16, footnote 21, the major cause in recent decades is growth of biomass in forests. Land reversion is no longer as significant and is being offset by conversion of forest to urban, transportation and other uses. (Clark Row, Row Associates) ***We addressed this comment in the footnote cited, based on the trends presented in the US GHG Inventory. The footnote states, "assuming a sustainable harvest in the US is reasonable because from 1952 to 1992 US forest carbon stocks steadily increased. In the early part of this period, the increases were mostly due to reversion of agricultural land to forest land. More recently, improved forest management practices and the regeneration of previously cleared forest areas have resulted in a net annual uptake (sequestration) of carbon. The steady increase in forest carbon stocks implies sustainable harvests, and it is reasonable to assume that the trend of sustainable harvests will continue."***

- On page 17, the second full paragraph, the idea that most biofuels in paper or forest products industries are converted to electricity is wrong. Most biofuels are burned to provide process energy, which is a far more efficient use. Otherwise most biofuels are used to provide residential or other building heat; little is used to generate electricity. (Clark Row, Row Associates) ***The paragraph in question is intended to discuss the use of waste to displace electric utility GHG emissions. This paragraph is written generally to address all types of waste that could be used to generate electricity, either through combustion or methane recovery from a landfill. This paragraph is not intended to imply that the majority of biofuels in paper and/or forest products are converted to electricity.***

- On page 18, fourth full paragraph, as noted, making paper from recycled fiber requires more energy than making it from roundwood, exactly the reverse of what is stated. (Clark Row, Row Associates) ***The paragraph in question is talking in general terms about the relationship of energy required using virgin versus recycled inputs. This generalization is correct as it stands. However, Chapter 4 presents more detailed information on the variation in energy requirement for different types of recycled materials.***

- On page 23, "Recycling" open loop processes are more complex in most paper grades than described. Most tissue paper is neither landfilled or recycled. (Clark Row, Row Associates) ***The final report states more clearly that other materials are recycled in open loop processes, but due to limited resources, these processes were not analyzed.***

- On page 24, last paragraph, landfill gas is about ½ CO_2, ½ methane. It takes considerable energy to scrub landfill gas so it can be used. I hope this was considered. (Clark Row, Row Associates) ***The report considers this point.***

- Include the latest IPCC global warming potentials in the calculations. Using different GWPs could significantly affect the results (e.g., GWP of 21, not 24.5, for methane, much larger differences for perfluorocarbons). (John Ryan, Research Director, Northwest Environment Watch) ***The report reflects the latest IPCC global warming potentials.***

- On page 22, provide this data. "For the amounts of fuel used, we used data on the average fuel consumption per ton-mile for each mode of transportation." (John Ryan, Research Director, Northwest Environment Watch) ***We added a footnote in Section 1.6 (under "Transportation Energy Greenhouse Gas Emissions") stating these data can be found in the Appendices.***

- On page 14, provide the GHG emissions from manufacturing data for the 37 materials. "We performed a screening analysis of 37 of the most common materials and products found in..." (John Ryan, Research Director, Northwest Environment Watch) ***We believe it would be ill-advised to include the preliminary estimates of GHG emissions from manufacturing for the other materials. The estimates have not been subject to the same level of review as the other estimates in the report, and they use obsolete values for GWPs.***

- The report assumes steel cans are recycled into more steel cans. In fact, most ferrous materials recovered from MSW are not steel cans but mixed iron items that are discarded; from auto parts to propane tanks etc. It may not change the numbers but it should be noted. (David Sussman, Poubelle Associates) ***Under the subtitle "GHG Emissions and Carbon Sinks Associated with Waste Management" of Section 1.7, we addressed this point by adding a footnote to the "recycling" discussion. The footnote states, "…not all steel cans are recycled into more steel cans; not all aluminum cans are recycled into more aluminum cans."***

- Make the baseline year consistent across all options. The year 2000 is used, after which theoretically, all landfills will be in compliance with the new rules and most landfills will be recovering GHG emissions extremely efficiently, yet you use an early 1990's report for the combustion option. Municipal waste combustors (MWC) have regulatory requirements that will be fully implemented, by law, in the year 2000. (David Sussman, Poubelle Associates) ***For the combustion system efficiency for WTE, we now use the year 2000 as the baseline.***

- On pages 19, 20, and 24, CH_4 emissions should be listed under combustion. (Michelle Swanson, Northern States Power Company) ***We reviewed the DOE guidelines and estimate the CH_4 emissions from the combustion of MSW to be negligible (approximately 2.85×10^{-5} MTCE per ton of MSW).***

- The eight items in the municipal waste stream that were evaluated barely account for half the assumed waste generation and less than half of all combustibles, which comprise 70 percent to 75 percent of the waste stream. The report also neglects the contribution of wood, which ranges from 4 percent to 6 percent, as well as textiles. Ignoring large portions of the waste stream biases the report against waste-to-energy. Combustion and landfills are assumed to take the entire waste stream, leading to misconceptions of GHG emissions potential. (Maria Zannes, President, Integrated Waste Services Association) ***Both the combustion analysis and the landfilling analysis considered combustion of mixed MSW***.

- The current baseline is inconsistent and misleading. The report assumes all landfills will be in compliance by the year 2000 (baseline year). According to EPA at least 25 percent of landfill capacity will not be in compliance. Waste to energy technology, on the other hand, is provided a baseline year of 1990 even though significant retrofits and emissions reduction have already taken place in the past seven years, and even greater reductions will be accomplished, according to EPA's own estimates. (Maria Zannes, President, Integrated Waste Services Association) ***For the system efficiency of WTE, we now use the year 2000 as the baseline.***

- Conduct a full life cycle assessment. Because this was not done, energy and materials consumption that results in GHG emissions and is an indirect result of waste management options is not included despite the potential for significant GHG impact on the environment. (Maria Zannes, President, Integrated Waste Services Association) ***A full life cycle assessment is beyond the scope of this report.***

- Include fugitive emissions in the analysis. Exhibit 1-2 presents carbon coefficients for selected fuels. Fuels with a high volatile fraction such as gasoline have a higher tendency to cause fugitive emissions. (Maria Zannes, President, Integrated Waste Services Association) ***The report does account for fugitive methane emissions associated with production and distribution of coal, natural gas, and oil. The amounts of fugitive emissions for gasoline are small, and no global warming potential values have been developed for the nonmethane volatile organic compounds in fugitive emissions.***

2. Raw Materials Acquisition and Manufacturing

- In Exhibit 2-2, the recycled input percentages for HDPE, LDPE, and PET cannot be verified from the Franklin reports or APC data on recovery. It appears that the recycling rates for HDPE, LDPE, and PET should be corrected to be 9 percent, 1.4 percent, and 31 percent respectively. (American Plastics Council, Washington, D.C.) ***The recycling rates for HDPE, LDPE, and PET have been revised per this comment, however, the new rates correspond to resins for blow-molded containers only, rather than to all HDPE, LDPE, and PET resins in MSW (as the recycling rates quoted by this commenter do). The rates used in the report are based on data in Characterization of Municipal Solid Waste in the United States: 1997 Update, by Franklin Associates, Ltd. and are 26 percent, 0 percent, and 30 percent, respectively.***

- In Exhibit 2-2, column d, recycling rate assumptions are too low because of the classification of all HDPE, LDPE, and PET resin in MSW, as opposed to the use of special applications for paper, aluminum, and steel, e.g., newspaper, aluminum cans, and steel cans. Even with the existing categories, the recycling rates for HDPE and PET should be changed to 9 and 31 percent respectively, to be consistent with the use of other Franklin-derived (1994 EPA report) recycling rates. MSW management decision makers would be interested in the GHG impact of MSW management options for resin applications, such as HDPE bottles, not all of one particular resin. (American Plastics Council, Washington, D.C.) ***The recycling rates for HDPE, LDPE, and PET have been revised, as noted above, to be specific to blow-molded containers.***

- We have found that recycled materials are often used in open loop applications, e.g., glass used as roadbed aggregate, plastic used in lumber, and paper in insulation and roofing. In fact, plastic should be *credited* for carbon sequestration when recycled plastic materials are used to replace wood or paper products or packaging. Assuming closed loop, instead of open loop recycling, has obvious impacts on subsequent calculations that are not adequately assessed. (American Plastics Council, Washington, D.C.) ***Analyzing the GHG impacts of all types of open-loop recycling was beyond the scope of this report. However, we have added a discussion of material substitution in section 4.3.***

- Exhibit 2-2 shows data from Franklin and Tellus, with an average percent difference between the two data sets of about 15 percent. However, there are significant differences for some materials, especially plastics, where there is nearly a factor of two. Simply averaging the two data sets and using a single number is not justified. (American Plastics Council, Washington, D.C.) ***Franklin Associates Ltd., and the Tellus Institute obtained the data used in this report. The data come from several sources, including sources within the industries that manufacture the materials analyzed. While we acknowledge that some of the data represent practices as much as 20 years old, we do not have better data. We did not receive any newer data during the public comment period, despite a specific request to that effect. Under the circumstances, the data we are using are the best available. Given that the report is intended as a tool for estimating greenhouse gas emissions within a voluntary reporting program, we believe that averaging the two data sets is a reasonable approach. Unfortunately, we were not provided with any superior data as a result of the public comment process, therefore, we used the data from the draft report.***

- In Exhibit 2-2, column d, recycling inputs for aluminum cans are listed at 53% (Tellus) and 54% (FAL). The aluminum industry generally lists post-consumer recycled content (PCRC) for aluminum cans in that range. For 1996, the PCRC was 51.6 percent. However, it is also documented that a substantial quantity of post-industrial can scrap, called class scrap, is reused in the manufacture of cans. This post-industrial scrap accounts for 25 percent of a new can's raw material. Thus, virgin aluminum, with its high energy consumption, only accounts for 25 percent of a new can's feedstock.

If correct, directly query all trade associations for the targeted materials to determine whether their recycling figures incorporate any post-industrial scrap, or only focus on post-consumer scrap. It would be helpful to put post-consumer and post-industrial numbers in separate lines in Exhibit 2-2 before arriving at a total recycled input. (Steve Apotheker, Resource Recycling) ***Industrial scrap is included in the calculations. The methodology used by FAL in their energy life cycle estimates has been peer reviewed and insures a careful and accurate inclusion of all of the energy and emissions, including any savings from the use of scrap.***

- In Exhibits 2-3 and 2-4, the process energy for steel cans is given as 31.58 million BTUs per ton of product (Ex. 2-3) and the transportation figure is 4.60 million BTUs per ton of product (Ex. 2-4). These figures equate to 36.73 MJ/kg and 5.35 MJ/kg respectively. In contrast, the preliminary results of a global life cycle inventory project for tinplated steel gives a value of 34.32 MJ/kg, including transportation. This value is for "cradle to gate," that is to the point of manufacture at a steel plant, and does not include steel can manufacturing or transportation to the can manufacturer. The data for steel can manufacturing and transportation is not revealed in the report and the difference between 42.08 MJ/kg (36.73 + 5.35) and 34.32 MJ/kg can not be explained. The report authors should consider this discrepancy as the energy use is significant in determining greenhouse gas emissions. (Scott Chubbs, American Iron and Steel Institute) ***The reviewer quotes energy values for steel from a preliminary version of a steel industry study; this study has not been made available to us so we were not able to evaluate the differences. At issue is the methodology and inclusiveness of this study. LCA studies conducted by different study groups cannot be directly compared until a careful comparison of study methods and procedures is completed, including a clear delineation of scope and boundaries, data sources, data quality, and other factors.***

- Assigning "virgin production" to the Basic Oxygen Furnace (BOF) and " recycled production" to the Electric Arc Furnace is not accurate. The BOF uses about 28% recycled material as explained in the attached fact sheet "The Inherent Recycled Content of Today's Steel." Thus, about 3/4 of the inputs are virgin but the balance is recycled content. The EAF, on the other hand, is using increasing amounts of scrap substitutes or virgin inputs in the form of direct reduced iron, hot briquetted iron and iron carbides. Thus, the inputs are mainly but not necessarily wholly recycled production. (Gregory Crawford, Steel Recycling Institute) ***We addressed this comment in a footnote added to Section 2.1 (under "Methodology") which says, "note that the basic oxygen furnace process can utilize approximately 25 percent recycled inputs."***

- I would have thought that the PFC effect would have been greater given the published numbers which are around 1.0 to 1.5 kilograms/tonne. The figure in the report seems to be half that. (Steven Pomper, Alcan, Montreal) ***The PFC emissions we used reflect some recent changes in the US aluminum industry. Several of the largest aluminum manufacturers are participating in the Voluntary Aluminum Industrial Partnership, which is reducing emissions of PFCs by reducing the frequency of upset conditions that generate them. The value we used is consistent with the emission factor in the recent US Inventory of GHG Emissions (USEPA, Draft, April 1998).***

- On page 28, footnote 35, one cannot extrapolate to 100 percent virgin inputs as it relates to steel can production. The system is optimized at roughly 15 percent post consumer scrap. Therefore there is no zero percent recycling and there is no 100 percent recycling of steel cans since the figures that are quoted in Exhibit 2-5 are for non-steel can applications that is through electric arc technology. Actual can manufacturing is therefore not included in the process energy consumption. (Steven Pomper, Alcan, Montreal) ***We recognize that the use of recycled inputs is customary in the manufacture of steel cans. The 100 percent virgin and 100 percent recycled values for steel are not representative of production at actual facilities; these values have been extrapolated from mixes of virgin and***

recycled inputs. Because we model recycling as displacing 100 percent virgin inputs, this extrapolation is used for modeling purposes to calculate the effect of shifting the mix to use higher proportions of recycled inputs.

- On page 28, note 33, of the paper grades considered, biofuels are least important for newsprint, then corrugated containers, and most important for bleached grades. (Clark Row, Row Associates) ***We have revised the footnote accordingly.***

- On page 31, last paragraph, in paper manufacture, energy improvements in use of roundwood fiber are likely to be greater than that for recycled fiber. Recovery of biomass energy can be greatly improved as well as the usual process energy. In addition, the technical improvements in digestion seem to be progressing faster than in other processes. (Clark Row, Row Associates) ***This comment provides more detail on the point made in the referenced paragraph and supports the conclusion that reductions in energy inputs could occur; it is consistent with the point made in the report.***

- Update the analysis of the energy consumed in paper production in the US. The energy used in paper production is far more complex than can be drawn from summary industry and DOE documents. It is not well described in the draft report.

  There are at least four major stages in making paper from roundwood (i.e., virgin fiber), and three for making paper from recovered paper:
  Breakdown (chipping roundwood, repulping recovered paper)
  Digestion of chips (only roundwood)
  Bleaching (& deinking recovered paper), screening fiber
  Paper formation.

  Some paper grades are not bleached, of course. The big energy using steps are digestion, and paper formation (all the water must be removed).

  Most of the biofuel energy comes from burning the black liquor that results from digestion, which contains roughly half the carbon in the raw wood. Less energy comes from bark, and fines from chipping and fiber screening. The biofuels from roundwood paper production theoretically provide sufficient energy for the entire pulp/paper production. Few mills are yet this efficient, for a variety of reasons, including the value of marginal energy recovery compared with the current low price of natural gas and other fossil fuels. But some mills, particularly those that are being built or enlarged to provide additional output, are coming close. In addition, paper mills that use roundwood have the potential of bringing in additional forest waste from harvesting or from timber improvement treatments. By year 2020, almost all of corrugated container production and most printing and writing papers may have no net use of fossil energy.

  Manufacture of paper from recovered paper, however, generates little biofuel. The same enormous energy is necessary for paper formation, as well as for deinking and bleaching. Thus use of recovered paper results in substantial emissions of carbon. Technological improvements may reduce this large energy use, but not eliminate it.

  Paper industry sources are better sources for exact, up-to-date energy use and biofuel energy recovery. But even they can only provide average energy use, not the more efficient marginal use in the new and rebuilt plants that would be most affected by programs to reduce sources and recycle additional paper. But to a non-industry observer, it appears that paper is a more emissions-efficient material that is portrayed in the draft report. (Clark Row, Row Associates) ***Our analysis includes all***

the major manufacturing stages mentioned by this commenter. The fuel mix in the paper industry is extremely complicated, as Dr. Row points out. We did not have adequate resources to pursue a full-scale data collection and analysis effort for the paper industry, and had hypothesized that the public comment process would yield new data. However, no data on marginal (or even average) fuel use were provided by public comments, and so the final report uses the average data for paper manufacturing that appeared in the draft report. We address the use of biofuel energy in a footnote within Section 2.1, which says, "note that when paper is made from virgin inputs, a substantial amount of biomass fuel (e.g., black liquor from the digestion process and tree bark) is used. However, when paper is made from recycled inputs, no biomass fuel is used."

- "To count 'pre-combustion' energy, we scaled up the amount of each fuel combusted during manufacture by the amount of energy needed to produce that fuel." Can you tell me what these amounts were for the various fuels examined? Did your calculation include processing energy (e.g., gasoline refining) as well as extraction energy? (John Ryan, Research Director, Northwest Environment Watch) ***The "pre-combustion" amount for each fuel was estimated as a percentage of the combustion energy. The proportion varies among fuels, with the following values attributable to precombustion energy for each source category: 18.5 percent of the combustion energy for diesel, 20.5 percent for gasoline, 17.2 percent for residual fuel oil 18.5 percent for distillate fuel oil, 12.1 percent for natural gas, and 2.4 to 2.7 percent for coal. This information was added as a footnote to section 2.1 (under "Methodology").***

- In Exhibit 2-1, the units are "kg CO_2-C". You mean "kg C" right? If not, what is a "kg CO_2-C?" (John Ryan, Research Director, Northwest Environment Watch) ***We revised Exhibit 2-1 and clarified the units. Our original use of "kg CO_2-C was intended to denote carbon in the form of CO_2 (as opposed to carbon in the form of CH_4 or other compounds).***

- The CO_2 emissions from the transport of MSW from collection to the landfill or municipal waste combustor are equal. This is illogical as most MWC's are located close to the point of waste generation and most if not all of landfills are located a distance away. Haul distances of 200 to 500 miles are common for waste transport to large regional landfills. The difference in transport for these two options should be about an order of magnitude and not the same. (David Sussman, Poubelle Associates) ***We asked Franklin Associates, Ltd. to investigate this issue further. After their investigation, we believe that definitive data on the average distance to a local or remote landfill is not available. Thus, given the small role of transportation to a landfill (or to a WTE facility), we believe the transportation value is within reason—particularly until more definitive data are developed.***

- On page 26, when estimating the GHG emissions when electricity is used, a national average mix of fuels was used. What was the mix, and were nuclear and renewables such as hydropower and wind incorporated? Where is the mix documented in the draft? When electricity is used (and not generated on-site by a manufacturer), it can be generated by many non-carbon emitting sources. It is not apparent that non-carbon emitting sources have been accounted for. (Michelle Swanson, Northern States Power Company) ***New Exhibits 6-3 and 6-4, which were added to Chapter 6, we present the mix of fuels. As shown in Exhibit 6-4, the mix includes about 33 percent generation from non-carbon emitting sources, including nuclear, hydropower, and renewables.***

3. Forest Carbon Sequestration

- The report's consideration of carbon sequestration confuses the analysis of what municipal waste management options are preferable. By application of the sequestration "credit" the report suggests that carbon dioxide emissions from plastics combustion are a GHG concern, but not the emissions from paper and other biogenic substances, yet combustion of all such materials emit carbon dioxide. (American Plastics Council, Washington, D.C.) ***The IPCC convention is not to count biogenic emissions, as explained earlier. The commenter's interpretation is correct — CO_2 from combustion of plastics is counted, CO_2 from combustion of paper is not.***

- Address the relationship of forest carbon sequestration to other manufactured products in MSW as well as discussing the relationship of other, even larger carbon sinks, to MSW management and global climate change. (American Plastics Council, Washington, D.C.) ***The report addresses forest carbon sequestration as it applies to paper; it is only relevant to other manufactured products in the context of material substitution (which is addressed briefly in section 4.3). We believe the report covers all major sinks that are related to MSW and are affected by human activities.***

- Given that the carbon sequestered in soils in forest ecosystems is estimated to be larger than the carbon sequestered in marketable wood, it may be more significant to model the effect of future practices on the carbon sequestration in soils (it appears this was modeled as a net carbon storage value, but no detailed backup was provided). (American Plastics Council, Washington, D.C.) ***Soil carbon accumulates slowly in forest soils until there is an equilibrium between deposition and metabolism. Although the rate of this accumulation is slow compared to the more dramatic changes associated with land use change, many scientists assert that this is a significant process in the carbon cycle. Because there is very large uncertainty in the rates of accumulation, however, and the modelers were not confident that the magnitude of soil carbon changes was correct, we omitted this element in our overall estimate of forest carbon sequestration.***

- On page 43, the report assumes that when paper products are source reduced or recycled, the trees that otherwise would have been cut are left standing. It is more likely that the wood would be used for different purposes or trees would never have been planted in the first place. (American Plastics Council, Washington, D.C.) ***The models account for non-paper uses, as explained in a footnote to the introductory section of the chapter. The footnote states, "Note that . . . the trees that would otherwise have been harvested to make new paper do not all remain unharvested. Instead, as the demand for trees falls with increased source reduction and recycling, the price of trees also falls, and consequently some additional trees are harvested for non-paper purposes . . .". As for the comment that the trees would never have been planted in the first place, the models do not assume that forest owners have perfect foresight of future timber markets when they plant trees.***

- On page 55, the study focuses on US commercial forest production and fails to consider non-commercial forest growth/loss and foreign stocks. (American Plastics Council, Washington, D.C.) ***Non-commercial forest growth and loss is incorporated in the study as part of the TAMM/ATLAS system. Foreign forest stocks (other than Canada's) are not. We added a section to Chapter 3 that more clearly explains the geographic limitations of the analysis.***

- On page 43, footnote 18, the study assumes that no forested lands will be converted to non-forest uses as a result of paper recycling. It would seem more likely that increased recycling would lower the value of forests, causing such land to be converted to more profitable uses (e.g., agriculture, development, etc.). Peculiarly, the report acknowledges, but does not apply this understanding. (American Plastics Council, Washington, D.C.) ***This limitation is clearly stated, and is explained in the limitations section at the end of Chapter 3. In essence, we simulated paper recycling as affecting forest composition and age, rather than forest acreage.***

- The forest carbon sequestration analysis needs further explanation, documentation, and justification, particularly the assumption regarding forest sustainability and the application of forest sequestration to other carbon sources, sinks, and non-biogenic materials. (American Plastics Council, Washington, D.C.) ***We have added some additional documentation targeted at specific comments. Forest carbon sequestration does not apply to other carbon sources, sinks, and non-biogenic materials, however, and thus we did not address this comment specifically.***

- Provide factual perspective on the subject of sustainable forestry. In addition read excerpt APC prepared that they feel shows that the US is not experiencing sustainable forestry. (American Plastics Council, Washington, D.C.) ***USFS experts and other forestry experts note that in recent decades US forest harvests have not exceeded reforestation—in fact US forests represent a net sink of over 100 MMTCE per year. Thus carbon is accumulating in forests, and the forests are being harvested on a sustainable basis. This comment has been addressed in the introductory section of Chapter 3 (in the body of text preceding Section 3.1) and in an accompanying footnote.***

- Why does the report consider a period from 2000 to 2040 in discussing forest carbon sequestration, but then make projections for 2010, rather than use an average for the entire period? (American Plastics Council, Washington, D.C.) ***The reasons for making this choice are explained in detail in Section 3.6 of the report. This section basically explains that the timeframe chosen for the forest carbon sequestration analysis is in line with the targets set forth in the Kyoto protocol. The Kyoto protocol establishes a US target of reducing GHG emissions to a level 7 percent below 1990 emissions over a 5 year period from 2008 through 2012. If the US ratifies the Kyoto protocol, these emissions factors may be used to help the US evaluate progress in meeting the emission reductions set forth in the protocol. In developing these estimates, we chose the forest carbon sequestration factor for the period ending in 2010 as the best approximation of the forest carbon benefits from increasing source reduction and recycling by the year 2000 because we believe that the value for the year 2010 strikes the best balance in capturing the relatively higher short-term benefits of forest carbon sequestration (attributable to increased source reduction and recycling prior to 2000), and recognizing that these benefits decline over time. Given the uncertainty of the analysis, the timeframes chosen for developing emission factors are appropriate for the evaluation of voluntary programs. The sensitivity of the results to various end years for the simulation period is shown in Exhibit 3-8.***

- While the set of US Forest Service models may be relatively accurate, the differences predicted by the models under both the baseline and high recovery cases are relatively small. Because of the small differences being modeled, it is doubtful whether the models used are sufficiently accurate to predict changes in the forest carbon inventories in the US that are less than 0.5 percent of the total estimated forest carbon inventory in trees and understory, even if the uncertainty associated with most of the assumptions can be discounted, as the results of the analysis are relative, not absolute values. (American Plastics Council, Washington, D.C.) ***Carbon flows out of forests are indeed small when compared to carbon stocks; the difference in carbon flows in the two paper recycling scenarios (baseline recycling, enhanced recycling) is even smaller. Although the increments in carbon storage are small, the USDA-FS model results are probably reasonable. This is because much of the uncertainty in the model results is due to assumptions that apply to both the baseline and policy scenarios - assumptions about population growth, economic growth, tree growth, and land use changes. Any error in these assumptions would tend to bias the results in the baseline and policy scenarios in the same direction. Thus, when the outcomes of the baseline and policy scenarios are compared, errors in the assumptions tend to cancel each other out. The USFS models are the most accurate system available to simulate forest carbon inventories. The models are used to guide***

resource planning decisions for publicly owned forests, and thus have profound business implications for the forest products industry, so we believe their results are suitable for estimating the GHG benefits of various waste management practices.

- AF&PA believes that the additional carbon sequestration calculated based upon an increase in the recycling rate is statistically insignificant. The calculated differences are well within any margin of error and uncertainty associated with the scientific and technical methodology for estimating carbon sequestration and sinks. As an example, the increase of 24 MMTC for the high recycling scenario in the year 2000 represents an increase in carbon sequestration of approximately .03%, well within statistical "noise." (Judy Hicks, American Forest and Paper Association) ***The increment in storage is indeed a small fraction of total carbon stored in forests, and is probably less than the likely statistical error in measuring the inventories. Although the estimated effect is a small proportion of the total inventory, the relationship between recycling and stocks is clear, and the magnitude of the effect is plausible and is significant on a per-ton basis. It is also totally consistent with a physical (mass balance) model.***

- Given the lack of time and significant resources needed to conduct an exhaustive assessment of the TAMM, ATLAS, and NAPAP modeling assumption, AF&PA urges EPA to consult with the USFS to review the contents of the report. Because one of the main missions of the USFS is to develop timber supply and demand projections, they should be consulted for their expertise in this area. (Judy Hicks, American Forest and Paper Association) ***For the final report, this chapter has been reviewed and edited by a forestry consultant who was involved in the development and application of these models. USDA-FS also reviewed this chapter prior to publication of the draft report and more recently we discussed the methods and results with them in light of comments received on the draft report. During this discussion, consensus was reached that a modeled estimate for forest carbon sequestration is acceptable for use in voluntary reporting of greenhouse gas emission reductions.***

- AF&PA does not believe that a 55% recovery rate is realistic. AF&PA has set a voluntary goal to achieve a 50% paper recovery rate in the year 2000. Our goal was partially based on the Japanese experience where, despite a significantly greater population density, a relatively homogenous population, and a lack of forest resources, they have been unable to sustain a paper recovery rate higher than 50% for the past several years. (Judy Hicks, American Forest and Paper Association) ***The report does not attribute the 55 percent scenario to the AF&PA. The 55 percent scenario was developed for modeling purposes only, to allow us to estimate the forest carbon impacts of increased paper recycling.***

- The assertions regarding the relationship between carbon sequestration and recycling rates are inaccurate. AF&PA can find no correlation between carbon sequestration (as defined by growing additional trees) and recycling rates, given the unsurpassed success the US has had in both planting trees and in implementing paper recovery and recycling activities. Trees are now being planted at the same rate they have been planted during the period in which paper recovery rates have dramatically increased. The report should acknowledge the continued high demand for all products from forests, not just paper products. The paper should also address the necessity of virgin fiber infusion into the recycled paper stream to maintain the quality of recycled-content papers so they may compete in the world market. In addition, the paper should address the industry's contribution to increasing carbon sequestration through increasing productivity per acre of trees grown. As a result of these inappropriate assertions, the paper assumes that higher fiber recovery rates will reduce greenhouse gases. (Judy Hicks, American Forest and Paper Association) ***As this commenter has noted, our projections of the incremental storage due to recycling represents a very small fraction of total forest carbon storage; unless one were to design a very careful and thorough empirical study to***

detect the influence of recycling on forest carbon storage, it is unlikely that the correlation would be detectable. As for tree planting rates, the scenarios used in this report are based on USDA-FS projections of forest product demand; these projections foresee continued high demand for all types of forest products as noted in the final report. Overall, we conclude that there is a relationship between carbon sequestration and recycling rates, and that this effect is quantifiable through the use of existing USDA-FS models. Provided that forest owners continue to invest in reforestation at rates corresponding to increased demand for forest products in general, this relationship will hold.

- Paper use and demand should be treated as constant because this study focuses on end-of-life options, and not the growing or decreasing functions of paper use and demand. With a constant demand, it is uncertain what happens to the amount of trees planted when recycling increases. A farming logic (which applies to today's industry practices) implies that no unnecessary trees will be planted. However, if trees are still planted but for non-paper uses (i.e., lumber), the carbon dioxide sequestered cannot be counted as credit toward recycling from paper, but should be allocated to the non-paper uses. (Ecobalance, on behalf of the American Forest and Paper Association) ***It would be unrealistic to assume that paper use and demand will be constant; both recent history and industry projections point to continued growth in output and demand. Moreover, one of the benefits of using the USDA-FS models is that they incorporate econometric relationships in the supply-demand functions and their forecasting capabilities make them useful as resource planning tools. We do not subscribe to the view that all landowners engage in planting behavior with perfect foresight in regard to paper markets. The modeling framework accounts for "leakage" in the form of increased wood use for non-paper applications; we believe that our approach appropriately controls for other variables and allocates forest carbon benefits to paper recovery in a logical way.***

- Because of the considerable uncertainty and lack of scientific validity surrounding this specific carbon sequestration issue, the following alternatives should be considered (in order of preference): 1) Dropping the analysis on carbon sequestration and the associated credit when paper is recycled (or source reduced), or 2) In the event that carbon sequestration remains in the analysis, two sets of final results should be presented: a table of the study results using a range of the carbon sequestration estimate (based on assumptions and limitations on carbon sequestration), and another table presenting results without any carbon sequestration factored in. (Ecobalance, on behalf of the American Forest and Paper Association) ***Although there is considerable uncertainty surrounding carbon sequestration, we retained the analysis in the final report. The structure of the tables in the summary chapter allows the reader to include or exclude any component of the analysis. We believe that emissions factors containing modeled estimates for the forest carbon sequestration benefits of source reduction and recycling are acceptable for voluntary reporting of greenhouse gas emission reductions.***

- In the references cited on pg. 55 as having used the HARVCARB concept, it was my research on post-harvest carbon flows that was used. (Clark Row, Row Associates) ***We have cited Dr. Row's seminal work in developing HARVCARB. HARVCARB was first described by C. Row, and R.B. Phelps , 1990, "Tracing the flow of carbon through the U.S. forest products sector", Presentation at the 19th World Congress, International Union of Forestry Organizations, 5-11 August 1190, Montreal, Quebec., and described more fully in Row and Phelps, 1996 "Wood Carbon Flows and Storage after Timber Harvest", in Forests and Global Change. Vol 2, R. Neil Sampson and Dwight Hair, eds. American Forests, Washington, DC, p 27-58.***

- Use more realistic assumptions in the forest sector analysis, particularly in regard to use of residuals for fiber and biofuels, and relative to imports and exports. (Clark Row, Row Associates) ***We believe the input assumptions to be generally realistic, and they have been deemed adequate for resource planning activities. The imports and exports picture is complicated; the revised version of this chapter elaborates on the effect of import and export assumptions.***

- Reconsider the use of the TAMM/ATLAS/NAPAP model as a means of analyzing emissions from recycling and source reduction. Two assumptions that are particularly questionable are: 1) Imports and exports are fixed, at least for paper products. Many manufactured bulk products and quite a few recovered MSW materials trade actively in international markets. Not recognizing international markets fully does not seem consistent with this Administration's policies. 2) The assumption in the allocation model that the oldest and presumably most financially mature forest stands are cut first, for both large sawtimber and pulpwood. For pulpwood this is quite unrealistic, and is one of the reasons the models have tracked inventories and growth of smaller trees relatively poorly. (Clark Row, Row Associates) ***See previous response.***

- On page 43, note 20, the issue of combustion of paper products reducing GHG emissions should not have been ignored. It hurts the credibility and unbiasedness of the analysis. (Clark Row, Row Associates) ***This comment has been addressed in footnote 20 in Chapter 3, which says, "some analysts have suggested that more efficient municipal waste combustors and increased paper combustion rates, combined with more intensive tree planting, could result in reduced GHG emissions [Electric Power Research Institute, "Paper Recycling: Impact on Electricity-Use, Electro-Technology Opportunities," Report RP-3228-06 (1993), cited in Gaines, Linda L. and Frank Stodolsky, "Energy Implications of Recycling Packaging Materials" (Argonne, IL: Argonne National Laboratory) 1994]. However, a comprehensive examination of the interplay between combustion and forest dynamics was beyond the scope of this report…"***

- On page 44, sidebar, aside from the first sentence, the note is nonsense. What really hurts the use of the Forest Service models, is that most of the "what if" questions they have been used for involve aspects and assumptions of the model for which they were not designed. (Clark Row, Row Associates) ***Although the models were originally designed to address issues in the context of the Resource Planning Act, they are the best available tools to evaluate forest carbon sequestration associated with paper recycling. Like most other models, as additional questions have been raised, they have been adapted to answer them.***

- On page 62, fifth paragraph, this doesn't seem logical. In most forest management, carbon in soil doesn't change much unless the land is converted from crops or pasture to forest (soil carbon increases), or from forest to agricultural use (carbon decreases). This also applies to last bullet on page 65. (Clark Row, Row Associates) ***Soil carbon accumulates slowly in forest soils until there is an equilibrium between deposition and metabolism. Although the rate of this accumulation is slow compared to the more dramatic changes associated with land use change, many scientists assert that this is a significant process in the carbon cycle. Because there is very large uncertainty in the rates of accumulation, however, and the modelers were not confident that the magnitude was correct, we omitted this element in our overall estimate of forest carbon sequestration.***

- On page 64, note 44, the decision to use the same ratio appears wrong. If source reduction takes place, the steep elasticity of supply of recycled fiber will cause the price of recovered paper to drop steeply (as it does periodically), and more than pulpwood would. It thus would pay paper manufacturers to use as much as possible. Since MSW systems must get rid of recovered paper, is has sometimes been given away. In more understandable terms, waste paper cannot be stored as easily as trees in the forest (which also grow). (Clark Row, Row Associates) ***The report acknowledges that this approach yields an approximation. We were unable to develop another approach that would be more defensible.***

- On page 62, first paragraph, since the carbon emissions involved in manufacturing paper from roundwood are quite different from those from recovered paper, isn't this procedure wrong? (Clark Row, Row Associates) ***The paragraph addresses forest carbon sequestration, not greenhouse gas emissions from manufacturing.***

- In scanning the materials and footnotes, I did not find references to some sources on information I would think essential to your study (Clark Row, Row Associates):

  Sandra Brown: Of the EPA Corvallis lab on her critique of the original Birdsey methods of computing carbon in forests. She, Birdsey, and others have collaborated on recent papers correcting some of the biases in the methodology,
  Susan Thorneloe: Of the EPA Research Triangle laboratory, on her, colleagues, and contractors work in documenting carbon emissions from landfills. I have been using her recent work in updating HARVCARB's section on landfills.
  Ken Skog: Of the Forest Service's Forest Products Laboratory, on the work that he and a least one FPL pathologist on the anaerobic decomposition on wood materials in landfills. Their estimates of carbon emissions are much lower than any used previously.
  The AFPA, especially Pat Layton: The AFPA's work on fuel use in paper production is much more detailed that that of DOE, and gives some indication of future trends in purchased fuel use vs. use of biofuels for energy in paper production.
  NCASI, or the National Council for Air and Stream Improvement, which I believe is the best source of information on sources on other pollutants produced by forest product manufacture.
  American Forests: Their volumes I and II of "Forest and Global Change" probably represents the best overall assessment of the role of forests in climate change, and particularly the prospects of forest- related programs to mitigate climate change. That work should at least be referenced.
  We have consulted the majority of these sources in the development of this analysis. Dr.s Brown and Skog participated in conference calls reviewing the modeling system, and comments received in the public comment period. Dr. Thorneloe has sponsored the work on methane emissions and landfill carbon sequestration performed by Dr. Mort Barlaz, which forms the basis for much of the work reported in Chapter 7. AF&PA provided detailed comments on the draft report, summarized elsewhere in this comment-response document. The other sources are not specifically referenced in the report because we did not use any specific information from them.

- On page 43, note 18, the note implies that timber for solid wood products (sawtimber) is perfectly substitutable for that for paper (paper). While the larger sawtimber can be used for pulpwood, that use is limited because of cost. The other way, only the larger pulpwood can be made into solid wood products (except flakeboard, etc.), so the technical substitution is limited. The last sentence is incorrect. The uses of almost all solid wood products sequester more carbon than the equivalent wood in paper products. There is no reduction in carbon from pulping, use lives are longer, and they do not decompose as fast. (Clark Row, Row Associates) ***We have revised the footnote accordingly.***

- The Forest Service models suggest that for each ton of paper not used or recycled, roughly ½ ton of carbon is retained sequestered in forests. At the additional recycling rates, this means that inventories gain about 3 billion cubic feet of wood a year. However, this means that US forest inventories would increase by a maximum of ½ of one percent, from a base of 540 billion feet, in 2030 (exhibit 3-4). This small increase is much smaller that the error in measuring the inventory and could easily be offset by a number of additional factors. However, in the context of the draft report, the sequestration affects the analysis of the disposal alternatives for the types of paper analyzed. (Clark Row, Row Associates) ***Carbon flows out of forests are indeed small when compared to carbon stocks; the difference in carbon flows in the two paper recycling scenarios (baseline recycling, enhanced recycling) is even smaller. The USFS models are the most accurate system available to simulate forest carbon inventories. The models are used to guide resource planning decisions for publicly owned forests, and thus have profound business implications for the forest products industry, so we believe their results are suitable for providing an estimate of the GHG benefits of voluntary programs for recycling and source reduction.***

- I do not believe that is appropriate or good science to assume that the carbon in waste that came from biomass items is sequestered when those items are placed in a disposal unit. Carbon that is not converted to CO_2 or CH_4 should be out of the loop and no credit should be given to disposal options for sequestration of carbon. For example, trees grown and cut for wood that are then made into a product with a finite lifetime. When disposed, some wood may be converted into CO_2 and some may not, that which is not if given credit for carbon sequestration is double counted. (David Sussman, Poubelle Associates) ***There is no double-counting. FORCARB evaluates carbon stocks in forests. HARVCARB models carbon flows in the wood product pool. The report includes HARVCARB estimates only for the change in the product pool; changes in landfill storage are computed as described in Chapter 7. The approach used in the report is consistent with that used in the US GHG inventory.***

4. Source Reduction and Recycling

- The definition of source reduction should include product substitution. Comparisons based on a "per-ton" basis rather than by "functional equivalent" may be misleading. (American Plastics Council, Washington, D.C.) ***We have added a discussion of material substitution in Section 4.3, and noted that functional equivalent (or mass substitution rate) is a key factor.***

- Basing Exhibit 4-2 results on tons of material recovered, rather than actually recycled, results in an overstatement of the GHG emission impacts per ton. (American Plastics Council, Washington, D.C.) ***The loss rates, presented in the exhibit now numbered Exhibit 4-3, make the necessary adjustment to account for the difference in tonnage collected versus tonnage remanufactured.***

- "As presented, there appears to be a net reduction in GHG for paper. The stated rationale is 'carbon sequestration,' in which source reduction presumably causes less paper to be used, fewer trees harvested and, accordingly, more carbon sequestration. But this paradigm is not the only way and not necessarily the best way to view the GHG reductions of source reduction. Just as not producing an amount of a material can result in no production of GHG, as concluded in the report, not producing an amount of material can also result in less total production of the material and fewer GHG emissions." (American Plastics Council, Washington, D.C.) ***The confusion exhibited in this and other comments is exactly the reason we revised discussion in the report using a new accounting convention. Under the new accounting convention, only emissions from a waste generation reference point (once the material has already undergone the raw materials acquisition and manufacturing phase) are quantified. In other words, the baseline assumes initial manufacture of the material. Emissions reductions are then applied to the baseline. For example, source reduction reduces emissions below the baseline because less of the material is made.***

- The technical database provided is inadequate to allow organizations to quantify GHG emission reductions due to source reduction or recycling. For example, a product manufacturer will want to consider both use of alternative packaging materials and the potential light-weighting of a given material, as either optional or complementary routes to source reduce its packaging. The information provided is insufficient for this purpose. (American Plastics Council, Washington, D.C.) ***Product manufacturers will have site-specific energy data available that will provide a superior basis for evaluating emission reductions. Using the site-specific data in the framework provided by the report will provide a dependable estimate of the GHG effects of light-weighting or material substitution. We did add a brief discussion of material substitution in Chapter 4, Section 4.3.***

- Include a discussion of material reuse. The study fails to account for products that may have higher comparative GHG emissions, but can be used many times, compared to products that have lower GHG emissions that are not durable and need to be replaced. For example, because they are durable, plastics can be used over and over, while paper cannot. Reuse allows more product benefits for the same or less material, resulting in less potential environmental impact, including GHG. (American Plastics Council, Washington, D.C.) ***We regard reuse as a source reduction technique as is stated in the first sentence of Section 4.3, which reads, "…our analysis of source reduction is based on an assumption that source reduction is achieved by practices such as lightweighting, double-sided copying, and material reuse." Benefits of reuse can be calculated directly based on functional equivalents.***

- The report suggests that it is preferable not to source-reduce most materials. The report seems to assert that only paper products reduce GHG, while source reduction for other materials has no beneficial impact on GHG emissions (Exhibit 8-1). The report does not adequately demonstrate that source reduction for all materials, especially when there is positive substitution by other products, is a net environmental gain. (American Plastics Council, Washington, D.C.) ***Chapter 4 of the report clearly states that from a GHG perspective it is preferable to source reduce most materials. The first sentence of Section 4.1 states, "when a material is source reduced (i.e., less of the material is made), the greenhouse gas emissions associated with making the material and managing the post-consumer waste are avoided." Only after this statement are the ancillary benefits of source reducing paper introduced to the chapter.***

- Include product substitution in the definition of source reduction. (American Plastics Council, Washington, D.C.) ***The report now addresses material substitution in Chapter 4, Section 4.3.***

- The report's "zero impact" baseline (i.e., a material is not made in the first place, so there are no GHG emissions) leads to the conclusion that there can be no benefit for source reduction for nonbiogenic materials. Non-production of plastics, for example, yields no GHG benefit, but non-production of paper yields a net GHG reduction. This peculiar result comes from the carbon sequestration credit that gives a net GHG benefit when there is non-production of biogenic materials. A more realistic and accurate analysis would be to evaluate GHG emissions based on production reductions from actual baseline levels. (American Plastics Council, Washington, D.C.) ***The confusion exhibited in this and other comments is exactly the reason we revised discussion in the report using a new accounting convention. Under the new accounting convention, only emissions from a waste generation reference point (once the material has already undergone the raw materials acquisition and manufacturing phase) are quantified. In other words, the baseline assumes initial manufacture of the material. Emissions reductions are then applied to the baseline. For example, source reduction reduces emissions below the baseline because less of the material is made.***

- In Section 4-2 the report states, "When a material is recycled, it is used in place of virgin inputs in the manufacturing process...". We have found that recycled materials are often used in open loop applications, e.g. glass used as roadbed aggregate, plastic used in lumber, and paper in insulation and roofing. While acknowledging the prevalence of open loop recycling in footnote 47, we question the rationale for ignoring it in footnote 48. In fact, plastic should be credited for carbon sequestration when recycled plastic materials are used to replace wood or paper products or packaging. Assuming closed loop instead of open loop recycling has obvious impacts on subsequent calculations that are not adequately assessed. (American Plastics Council, Washington, D.C.) ***We acknowledge the prevalence of open loop recycling, although an analysis of all open loop recycling is beyond the scope of this report. The statement made above by the commenter regarding carbon sequestration credit for plastic appears to speak to material substitution rather than to open loop recycling. Section 4.3 provides a brief discussion on materials substitution, but does not specifically address the type of substitution suggested by this commenter.***

- Account for the GHG emissions associated with disposal of recovered product lost in the recycling process. (American Plastics Council, Washington, D.C.) ***We have addressed this issue in the limitations section of Chapter 4.***

- Modify the report so that the GHG emissions due to avoided acquisition and manufacturing credits are more evident. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance) ***We have modified the exhibits in the report to address this comment.***

- The information presented in Figure 4-2 is incorrect. Information from the peer reviewed AAR study indicates that there is a 6.45 percent loss within the shredding and decoating process. This 6.45

percent loss includes contamination (e.g. tramp metals, stones, etc.), moisture content, and the lacquers and coatings. When the hot chips from decoating are put in the melters there is a further 3.79 percent loss. This represents the average performance of AAR facilities, some processes are more efficient than those represented by the average and some improvements should have occurred since the AAR study. (Steven Pomper, Alcan, Montreal) ***We requested the industry report cited by the commenter. However, because we have not been able to review the report to evaluate the extent to which the figures cited are based on the same approach for calculating loss rates as used in our model, we have not changed the values in the draft report.***

- Technical improvements have allowed publishers to use printing papers, including newsprint, that are thinner and stronger. Any source reduction must be based on additional technical advances. What are the prospects? (Clark Row, Row Associates) ***The report describes "lightweighting" as an example of source reduction. Investigating all technological advancements within each industry is beyond the scope of this report.***

- An assessment of recycling should include some allowance for methane generation from paper sludge. (Maria Zannes, President, Integrated Waste Services Association) ***The report addresses this comment in the limitations section of Chapter 4, which reads: "We did perform a screening analysis for paper sludge, however, based on (1) data on sludge generation rates and sludge composition (i.e., percentage of cellulose, hemicellulose, lignin, etc. in sludge), and (2) professional judgment on the methane generation rates for cellulose, etc. The screening analysis indicated that net GHG emissions (methane emissions minus carbon sequestration) from paper sludge are probably on the order of 0.00 MTCE per ton of paper made from virgin inputs to 0.01 MTCE per ton for recycled inputs. Our worst case bounding assumptions indicated maximum possible net GHG emissions ranging from 0.03 to 0.11 MTCE per ton of paper (depending on the type of paper and whether virgin or recycled inputs are used)." Because the screening analysis yielded very low values for this factor, we omitted it from the calculation of net GHG emissions.***

5. Composting

- Develop the absolute yields of carbon dioxide generated by aerobic decomposition, including composting, in much more detail. This analysis needs to be done prior to giving any GHG emission "credits." The fact that there are wide variations in the amount of carbon trapped in humus reflects the type of material being subjected to composting (e.g. food wastes compared to yard wastes) produces additional uncertainties that need to be addressed. (American Plastics Council, Washington, D.C.) ***Because the IPCC convention is that biogenic carbon is not counted, we have not developed the absolute yields requested. The limitations section clearly acknowledges the significant uncertainties in our analysis of composting, and this remains an area where additional research is needed.***

- The carbon has already been sequestered in yard waste, for example, and in the absence of release as carbon dioxide cannot be counted as sequestered a second time. (American Plastics Council, Washington, D.C.) ***The baseline assumption is that yard waste will soon decompose in the yard if it is not managed in some other way.***

- In the future include the full range of GHG emissions (particularly NO_x) from solid waste composting. We understand that the global warming potentials for some of these compounds have not yet been developed, however, which prevents their consideration at this time. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance) ***We are not aware of any GHG emissions from composting of gases for which global warming potential values have been developed. We are aware of only CO_2 and CH_4 emissions from composting; if NO_x is also emitted, we would not include it because, as the commenter notes, no global warming potential has yet been developed for NO_x.***

- It would seem that the application of compost, due to its more bulky and voluminous nature would require more mechanical energy than applying fertilizers or pesticides. This energy should be considered. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The GHG emissions associated with a consumer's use of a product is outside the scope of the analysis, however, we consider it likely that incorporation of this factor would be unlikely to change the result.***

- Composting results in an overabundance of compost in some areas that needs to be transported elsewhere. Emissions from transportation should be addressed, as well as the costs, because the report gives credit to composting as a replacement fertilizer. (Maria Zannes, President, Integrated Waste Services Association) ***The report's convention (as explained in the report) is not to count GHGs from transportation of finished products. In addition, the report does not give credit to composting as a replacement fertilizer. The report estimates GHG emissions associated with composting several materials.***

- Include methane emissions from composting. (Maria Zannes, President, Integrated Waste Services Association) ***Methane emissions from composting were considered in this analysis, however, the emissions were determined to be negligible. Based on these findings, we decided not to include methane emissions from composting in the report.***

- Decomposing material from biogenic sources has a very short half-life. There should not be a credit given for carbon sequestration from compost heaps. (Maria Zannes, President, Integrated Waste Services Association) ***The report considered only incremental long-term carbon sequestration.***

6. Combustion

- Use a 2000 to 2010 time frame to model the consequences of improving the efficiency of waste-to-energy plants themselves. The value of 471 kWh/ton of MSW used to analyze the net electricity yield from a WTE plant is out-dated. The value quoted in the latest Governmental Advisory Associates' report is 512 kWh/ton and, as more inefficient plants are taken out of service and newer plants are built the value will increase. Wheelabrator has reported achieving as high as 700 kWh/ton in their most recently constructed plants. The GHG emission offset credits should be recalculated using these higher electricity generating efficiencies. A sensitivity analysis should be completed, as was done for landfill gas (LFG) collection efficiencies (see Exhibit 7-6). The report should use values between 512 kWh/ton and 700 kWh/ton in its baseline, and future scenario calculations for municipal solid waste combustion, and not 471 kWh/ton. (American Plastics Council, Washington, D.C.) ***We addressed this comment in Chapter 6, Section 6.1, under the subheading "Estimating Utility CO_2 Emissions Avoided." Based on data provided by several sources, the report now uses a value of 550 kWh/ton for mass burn facilities and a value of 655 kWh/ton for RDF facilities.***

- APC estimates that municipal solid waste combustion in 1995 contributed about 36 million tons of carbon dioxide emissions (0.6 percent) out of a total US production of about 5,900 million tons per year from the burning of fuels. If all of the MSW produced each year in the US were recovered in waste-to-energy plants, municipal waste combustion would still account for only about 4 percent of total carbon dioxide emissions. The report should note that WTE is not now and will not become a major source of either carbon dioxide or greenhouse gas emissions. (American Plastics Council, Washington, D.C.) ***While we recognize that GHG emissions from MSW are a small component of total GHG emissions, it is beyond the scope of the report to compare waste management disposal options to other sources of greenhouse gas emissions. However, as we have said in responses to similar comments, EPA believes that any/all cost effective GHG emission reduction activities should be undertaken.***

- Show the absolute amount of carbon dioxide produced by each material and product for each of the waste management options. (American Plastics Council, Washington, D.C.) ***We believe the report addresses this comment; the unit chosen for the report is metric tons of carbon equivalent.***

- The report notes that carbon sequestration can be either a man-made or natural process. It is probable that over the time scale used for some of the analysis in the report, i.e., through 2040, technology to sequester carbon dioxide from the combustion of fossil fuels will have been developed. In fact, the technology may come into existence much sooner. (American Plastics Council, Washington, D.C.) ***We are aware that the International Energy Agency and other organizations are investigating carbon sequestration technologies such as deep ocean injection of CO_2. We are not aware of any such technologies that bear on waste management and are likely to come on-line in the near future.***

- The report states that the combustion of plastics results in substantial net GHG emissions per ton, compared to other materials, because of the high content of non-biomass carbon in plastics. This statement is not a complete picture in the context of the report. The reason for the high comparative GHG results is that the report does not give sequestration credits to non-biomass carbon. This should be noted in the data presentation. (American Plastics Council, Washington, D.C.) ***The report follows the Intergovernmental Panel on Climate Change convention which is to count GHG emissions from fossil fuels but not from biogenic sources. In the GHG accounting framework, petroleum extracted from the earth and converted to plastic is not considered an emission of carbon (it is as if the carbon were left in the oil-bearing stratum underground). By this logic, it would not be correct***

to regard landfilling of plastic as creating a carbon sink. If the IPCC accounting convention were to count all plastics as if they were an emission at the point of manufacture, then in that situation it would be logical to credit landfilling for sequestration (and to not count emissions from burning plastic).

- It is not clear whether the computations in Exhibit 6-1 for steel and aluminum take into account the carbon dioxide emission generated in the MSW combustion process. It appears that steel and aluminum are given credit for emissions avoided by recycling, that would only occur because of MSW combustion. It would appear that steel and aluminum should be held accountable for emissions from MSW combustion, especially if those emissions are counted against other materials. If steel and aluminum get the "benefit" of MSW combustion, they should also absorb the cost. (American Plastics Council, Washington, D.C.) ***Like the other materials, steel and aluminum are allocated emissions associated with transportation and N_2O emissions. They are also treated as taking a "penalty" in terms of avoided utility emissions. Because these materials absorb heat, they reduce overall system efficiency. Each of these three effects happens to have a net emission of 0.01 MTCE/ton. Steel gets credit for recycling in our calculus; aluminum does not, because it is still not a widespread practice at combustors. Exhibit 6-6 in the final report tabulates each component of net GHG emissions for each material.***

- Consider nitrogen oxide, nitrogen dioxide, and sulfur dioxide; because these are not included, the report favors materials that emit these gases. (American Plastics Council, Washington, D.C.) ***These gases are not included because global warming potentials have not been established for them.***

- On page 92, first and fourth bullet, the report fails to mention the beneficially high Btu content of plastics in several examples in its analysis. (American Plastics Council, Washington, D.C.) ***The energy content of plastics (BTUs per pound) is presented in Exhibit 6-2. Because of their high BTU values, they get the highest credit for avoided utility emissions, ranging from 0.29 to 0.56 MTCE/ton for mass burn facilities and 0.26 to 0.51 MTCE/ton for RDF facilities (see Exhibits 6-2 and 6-6 in the final report).***

- The report fails to note that waste-to-energy plants produce insignificant emissions of methane. This amount contrasts with landfills that produce a gas consisting of about 50 to 55 percent methane, which, as the report notes, is about 25 times more potent a GHG than carbon dioxide and amenable to only partial collection at landfills. (American Plastics Council, Washington, D.C.) ***The report shows how one can compare an alternate scenario with a baseline scenario. If one compares combustion as an alternative to landfilling (especially at a landfill without gas collection), combustion reduces GHG emissions, largely because of the avoided emissions of methane.***

- Put combustion and landfilling on an equivalent basis when extrapolating to future scenarios. (American Plastics Council, Washington, D.C.) ***We incorporated year-2000 baselines for WTE combustion system efficiency. Because we were unable to obtain a reliable estimate of increased ferrous recovery over the next few years, we were unable to project the amount of ferrous recovery in the year 2000, but in most respects we believe that our analysis places landfilling and combustion on an equal footing.***

- WTE should also get full credit for any pre-combustion carbon dioxide saved due to the replacement of coal with MSW. This is a more reasonable approach for analyzing the GHG impact of WTE than the more "conservative" assumptions used in the study. The end result would be to increase the "Avoided Utility Carbon Dioxide Per Ton Combusted (MTCE/ton)" results in column (c) and reduce the "Net GHG Emissions from Combustion (MTCE/ton)" results in column (e) for each material in

Exhibit 6-4. It is predicted that a careful recalculation of the data would lead to the conclusion that WTE is a zero contributor to GHG emissions. (American Plastics Council, Washington, D.C.) ***We addressed this comment in the report. Although we do not treat the avoided utility emissions as coming completely from coal, we have changed the mix of generation to be for fossil fuels only (rather than the national average mix, as it was in the draft report). This change, and the increase in overall system efficiency, has resulted in a change in the overall estimate for combustion of mixed waste, as predicted by the commenter; net emissions are now estimated at –0.04 MTCE/ton, while they were slightly positive in the draft report.***

- In Exhibit 6-2, the emission factor for utility-generated electricity is given as 0.051 MTCE/million Btu's of electricity delivered. This statement assumes the current mix of electricity generation. The report states that assuming electricity was generated solely by coal would increase this value to 0.076 MTCE/million Btu delivered. Which value to use depends on the baseline year. It may be correct to use the average mix of fuels for plants currently in operation, but for any future scenario it is probably correct to say electricity from waste-to-energy replaces coal alone. (American Plastics Council, Washington, D.C.) ***Although we did not use the assumption that WTE electricity displaces coal-fired generation, we did assume that it displaces the average fossil-fuel-fired mix. We then recalculated the figure in question to derive an estimate of 0.083 MTCE/million BTUs delivered, as shown in Exhibit 6-2 of the final report. In addition, we added Exhibits 6-3 and 6-4; these exhibits present the data and methods used to recalculate the emission factor for utility-generated electricity.***

- The report's application of an electricity distribution loss factor (9%), to analyze the net GHG emission from WTE plants, is not the appropriate methodology to use. The end-result of following more reasonable and appropriate guidelines is to increase the carbon offset for waste-to-energy by about 40 percent. This number should be further increased by selecting coal-fired utility plants (relatively low efficiency, relatively high carbon dioxide per million Btu) as the most likely offset, instead of using a national average fuel mix. This will clearly be the case for any new plants built. (American Plastics Council, Washington, D.C.) ***The report now uses a 5 percent line loss rate, based on data provided by IWSA and Mr. Greg Gesell at American Ref-Fuel. The above responses address the point on coal as the marginal fuel at utilities.***

- Include the opportunity to reduce GHG emissions through the use of process engineered fuel (PEF) derived from source separated paper and plastic feedstocks as a replacement for coal in industrial, utility, and institutional boilers. This emerging technology has the potential to recover the energy value of post-use plastics and paper with 30 to 50 percent higher efficiencies than achieved by waste-to-energy. In addressing a time frame out to 2040, PEF's potential impact on GHG emissions should be noted. (American Plastics Council, Washington, D.C.) ***Although we did not have sufficient data to evaluate PEF, we did add RDF to the analysis.***

- The report unrealistically and unfairly assumes a worst case scenario in combustion of textiles and rubber. (American Plastics Council, Washington, D.C.) ***As a footnote to Section 6.1 explains, the difference between a worst case and best case assumption for textiles is an effect of about 0.01 MTCE per ton for mixed waste; the effect for rubber is similar. These differences are very small with respect to the uncertainty in the results.***

- The report incorrectly attributes nitrogen emissions to the combustion of plastics. Few plastics contain nitrogen. In general, NOx emissions derive from both fuel bound nitrogen and combustion air derived nitrogen. Although the mechanisms related to NOx formation are reasonably well understood, the conditions under which nitrous oxide would also be formed need to be determined.

(American Plastics Council, Washington, D.C.) ***We allocated N_2O emissions equally to all of the combustible materials; this allocation approach is appropriate for a situation where the nitrogen is derived from fuel and combustion air.***

- In Minnesota the dominant MSW processing method is RDF, rather than mass-burn. We would like to see a discussion of RDF included in the report. We believe that it is possible that the results for RDF may be different than those for mass burn, due to differences in system efficiencies and the composition and disposition of incoming waste materials. To the extent that it may be of use to you in expanding the processing discussion, we are willing to provide you with any of our available data. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner -- Minnesota Office of Environmental Assistance; Paul McCarron, Minnesota Solid Waste Management Coordinating Board) ***We added RDF throughout Chapter 6 of the report, and relied on data provided by some of the sources identified by these commenters.***

- The figure of 532,000 tons per year of ferrous metals recovered from MSW in WTE plants is believed to be too conservative. Review of information from the Integrated Waste Services Association and the US EPA Characterization of MSW over time suggest that the tonnage would be closer to 1.1 million tons. (Gregory Crawford, Steel Recycling Institute) ***We addressed this comment in Chapter 6, Section 6.1, under the subheading "Approach to Estimating Utility CO_2 Emissions Avoided Due to Increased Steel Recovery." The report now uses a figure of 775,000 tons per year of ferrous materials recovered, based on the 1997-1998 IWSA Waste-To-Energy Directory Of United States Facilities.***

- The combustion efficiency stated in the study of 13.6 percent is too low for a typical waste-to-energy facility. An average combustion efficiency for a WTE facility is about 20 percent. (Ecobalance, on behalf of the American Forest and Paper Association) (***We re-evaluated combustion efficiency and expressed separate values for mass burn and refuse-derived fuel combustion systems. Based on data provided by a few sources (for example, The 1997-1998 IWSA Waste-To-Energy Directory Of United States Facilities, experts for the WTE industry, DOE-EIA, etc.) we updated Exhibit 6-2 to reflect a system efficiency of 17.8% for mass burn and 16.3% for RDF (the value for RFD reflects the energy cost of the processing step). In addition, we added Exhibits 6-3 and 6-4; these exhibits present the data and methods used to recalculate the emission factor for utility-generated electricity.***

- Exhibit 6-2 *Avoided Utility GHG Emissions from MSW Combustion* presents the emission factor for utility-generated electricity at 0.05 MTCE per million British thermal units (Btu's). This emission factor corresponds to carbon dioxide emissions due to electricity delivered in the electricity grid as approximately 177 grams carbon dioxide per MJ delivered electricity. This figure is 9 percent lower than the Franklin Associate's estimate of about 193 grams carbon dioxide per MJ in its recycling study prepared for Keep America Beautiful, and 31 percent lower than the 232 carbon dioxide grams per MJ in Ecobalance's electricity model, containing the full life cycle of electricity delivered to the electricity grid using a 1994 mix of fuels. Transparency of the data, including the electricity fuel mix assumed and the inclusion/exclusion of upstream burdens, is vital to assess how the estimate of 177 grams carbon dioxide per MJ was achieved. Either the electricity production data used to obtain the value of MTCE should be updated, or a sensitivity analysis should be performed for the range of values, and should be presented in the final results. A higher electricity production could change the results for waste management options, such as combustion. (Ecobalance, on behalf of the American Forest and Paper Association) ***We calculated a value for carbon emissions from the national fuel mix for electricity, using data from Franklin Associates, Ltd. (FAL) and the US DOE Energy Information Administration. We calculated values both for all fuels and for fossil fuels only; our***

findings are presented a transparent way in Exhibits 6-3 and 6-4. The final report assumes that electricity generated at combustors (and landfills with gas collection and energy recovery) displaces the average fossil fuel mix at utilities; this substantially increases the credit for avoided GHG emissions.

- On page 88, the US average of 9% transmission and distribution loss is used. Often WTE plants are located very near their users to limit transportation costs of the waste. Identify to what extent 9% can be reduced given a short transmission distance. At a minimum a footnote should be added to indicate that if the energy produced is used on-site, this 9% figure should be considered as a higher level of loss than actual. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***The report now uses a line loss rate of 5 percent, based upon data provided by IWSA and Greg Gesell of American Ref-Fuel. The final report acknowledges that there are differences in loss rates based upon the location of the plant relative to its users and that future technology improvements may decrease line loss rates.***

- On pages 86-89, include the efficiency of co-generation WTE facilities. Exhibit 6-2 (pg. 87) could be presented in landscape, versus portrait, with additional "Combustion System Efficiency (percent)" and "Avoided Utility CO_2 Per Ton Combusted (MTCE)" columns reflecting co-generation efficiencies added to the existing data. This will allow potential developers of WTE plants to weigh benefits of co-generation. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***Because our data sources indicated that only a small percentage of waste combustion involves cogeneration, we did not conduct a separate investigation of cogeneration in the analysis.***

- Include RDF processing. Special attention should be given to the impact of RDF processing on greenhouse gases. (Victoria Reinhardt, Chair, Ramsey/Washington County Resource Recovery Project) ***As noted above, we have addressed RDF throughout Chapter 6 of the report.***

- The makeup of a given community's MSW does vary nationally. (Trudy J. Richter, Executive Director, Minnesota Resource Recovery Association) ***The report prominently acknowledges this point in the Executive Summary and Chapters 1 and 8 of the report, and as noted previously, we are developing WARM to assist decisionmakers at the community level to reflect locally varying factors when evaluating actions to reduce GHG emissions.***

- Change the MWC system efficiency number. The report uses a figure of 471 kWh of electricity from one ton of 5,358 Btu/pound waste. The result is a heat rate of 25,000 Btu/kWh or 13.6 system efficiency, which is incorrect. Modern MWCs, especially those in operation in the base year 2000, generate 570 kWh per ton of 5,000 Btu/pound waste. (David Sussman, Poubelle Associates) ***We addressed this comment in Chapter 6, Section 6.1, under the subheading "Estimating Utility CO_2 Emissions Avoided." Based on data provided by several sources, the report now uses a value of 550 kWh/ton for mass burn facilities and a value of 655 kWh/ton for RDF facilities.***

- The report deducts a 9% transmission loss from the energy produced from a MWC but there does not appear to be a similar loss in the landfill section. Neither option should have a transmission deduction. One kWh of waste generated electricity replaces one kWh of fossil electricity. All generators should have the same average line loss and therefore no one generator should be changed for all. (David Sussman, Poubelle Associates) ***We accounted for this loss, for both MWCs and landfills; the loss for landfills is shown in row 6 of the exhibit now numbered Exhibit 7-4.***

- Trace levels of N_2O emissions have been measured in MWC emissions and should be counted. The same emissions are present in landfill gas emissions, both fugitive and from control devices. They, likewise, should be counted. (David Sussman, Poubelle Associates) ***These emissions are counted for MSW combustion. We checked several sources — including the California Air Resources Board Landfill Gas Assessment (as suggested by the commenter), ICF experts on landfill gas, Susan Thorneloe at EPA's Office of Research and Development (who is conducting a multi-pollutant LCA of waste management), the EPA Emissions Guidelines for Existing Sources/New Source Performance Standards for Municipal Waste Combustors, and the air pollution emission factor standard reference (AP-42) — none had data on N_2O emissions from landfill gas.***

- It is obvious that this chapter and the landfill chapter were written by two different researchers and that assumptions were not coordinated. This chapter uses the most pessimistic assumptions while the landfill chapter uses the most optimistic. (David Sussman, Poubelle Associates) ***The chapters were actually drafted by the same authors, in continuous coordination. The assumptions are generally consistent (e.g., incinerators without energy recovery, which make up part of the current population of combustors, were excluded from the analysis to reflect the fact that they are being phased out). Chapter 6 now reflects estimates for system efficiency in the year 2000.***

- The report states 532,000 tons of ferrous was recovered from 32 million tons of waste. This recovery rate is incorrect. For 1996, 754,000 tons of iron was recovered from 32 million tons of waste. I'm sure the MWC industry could estimate the year 2000 ferrous recovery rate for a more correct report. (David Sussman, Poubelle Associates) ***We have addressed this comment in Section 6.1 (under the subsection "Approach to Estimating CO_2 Emissions Avoided Due to Increased Steel Recovery"), and used the IWSA estimate of 754,000 tons of ferrous recovered in 1996. We were unable to obtain a solid estimate for future ferrous recovery rates, and therefore used the 1996 rate in the report as the projected rate for 2000.***

- On page 88, the combustion system efficiency rate appears to be significantly lower than actual NSP plant data. Small changes in the combustion system efficiency rate can significantly affect the conclusions of this study. Use of a range rather than point estimates would be beneficial. (Michelle Swanson, Northern States Power Company) ***We recalculated the efficiency based on data provided by several sources (for example, The 1997-1998 IWSA Waste-To-Energy Directory Of United States Facilities, experts for the WTE industry, DOE-EIA, etc.) and updated Exhibit 6-2. In addition, we added Exhibits 6-3 and 6-4; these exhibits present the data and methods used to recalculate the emission factor for utility-generated electricity.***

- Chapter 6 should include CH_4 emissions associated with combustion of MSW. (Michelle Swanson, Northern States Power Company) ***We reviewed DOE data and estimate the CH_4 emissions from the combustion of MSW to be negligible (approximately $2.85x10^{-5}$ MTCE per ton of MSW).***

- Regarding the appropriate estimate of energy released per ton of waste combusted, mass burn waste-to-energy facilities average on a net basis 550 kilowatt hours per ton of waste combusted. Approximately 70 percent of the waste managed at waste-to-energy facilities is handled at mass burn facilities. This national factor takes into account the increased efficiency at newer facilities as well as older, less efficient plants. The figure of 550 kWh per ton may be used as a system average for mass burn facilities. We would estimate that RDF facilities average 800 kWh per ton of RDF (waste) combusted. (Maria Zannes, Integrated Waste Services Association) ***We used the suggested value as the system average for mass burn facilities. Based on input from other experts in the WTE industry, we used an estimated value of 655 kWh/ton for RDF facilities.***

- The recovery of ferrous metals at waste-to-energy facilities is on the rise. Approximately 775,000 tons of ferrous metals were recovered in 1996, up from 740,000 in 1995. On-site recycling of non-ferrous materials, including other metals, accounted for about 135,000 tons in 1996, an increase from 117,000 tons in 1995. Our industry has taken an aggressive stance on metals recovery. We would estimate that of the 135,000 tons of non-ferrous materials recycled, about 25 percent, or nearly 34,000 tons, would be non-ferrous metals such as copper, brass, and aluminum. Several large vendors are installing non-ferrous metal recovery systems. Once operating, we will see a significant increase in recovery of metals at waste-to-energy plants. I would estimate that the non-ferrous metal recovery would more than double by the year 2000. More facilities are installing ferrous recovery, and we therefore expect the ferrous recycling figures to increase over time at about 5 percent a year. (Maria Zannes, Integrated Waste Services Association) ***We addressed this comment in Chapter 6, Section 6.1, under the subheading "Approach to Estimating Utility CO_2 Emissions Avoided Due to Increased Ferrous Recovery." Assuming a 5 percent increase in the rate of ferrous recovery through 2000 would result in a recovery rate exceeding 100 percent. We subsequently discussed this problem with the commenter; at that point, we determined that it would be most defensible to continue to use the 1996 percentage through 2000.***

- Our Directory reports that about 10 percent of the waste managed by waste-to-energy facilities is used in co-generation. Therefore, of the nearly 32 million tons managed by waste-to-energy plants, approximately 3.2 million tons is used at co-generation waste-to-energy facilities, and the remaining 90 percent, or 28.8 million tons is used to generate electricity. (Maria Zannes, Integrated Waste Services Association)***. We obtained expert opinions from facility engineers in the WTE sector on whether sufficient data would be available to include co-generation. Based on the complexity of analyzing energy flows, the relatively small number of facilities, and the lack of readily available data, we did not include co-generation in the scope of the final report.***

- Waste-to-energy facilities do not have differential line loss. Several people suggested that the model used in the report must include a line loss figure. We recommend five percent, which is very conservative. Our facilities are located within a city and therefore very near our energy customers. I would urge you to calculate a line loss for all other sources of power, including all utility sources and landfills. Other sources of power, such as coal-fired generation, nuclear power plants, hydroelectric power are often many hundreds of miles from their customers. For example, landfills that are large enough to produce any appreciable power would be located far from cities. The line loss for other power sources should reflect the distance from customers. (Maria Zannes, Integrated Waste Services Association) ***The report now uses a line loss rate of 5 percent, based upon conversations with IWSA and Greg Gesell of American Ref-Fuel. The report acknowledges that there are differences in loss rates based upon the location of the plant relative to its users and that future technology improvements may decrease line loss rates.***

- The combustion of MSW avoids the release of both CO_2 and CH_4 from landfills. For example, approximately 33.3 million tons of trash was combusted in 1995, resulting in the avoidance of about 9 million tons of CO_2 over the life of the landfill. Landfill methane will be reduced by about 4 million tons over the same time frame. Because of CH_4's higher global warming potential, the avoidance of 4 million tons of methane is equivalent to a CO_2 emissions reduction of 98 million tons. (Maria Zannes, President, Integrated Waste Services Association) ***The analysis accounts for CO_2 from MWCs and CH_4 from landfills. The report provides a framework for comparing management options, and landfill methane is a key component of landfill emissions.***

- Operators of the MRF facilities at several waste-to-energy plants report that materials are seldom rejected due to contamination, and cannot recommend that more time be spent on this issue. In discussions with the operators of MRF's, however, they suggested that operators at paper mills that accept large quantities of homogenous recyclable material may face much more difficulty in accepting all loads, and rejection of even one load may be sizable. You may wish to raise this issue with the representatives of the paper industry, if time permits. (Maria Zannes, Integrated Waste Services Association) ***The report accounts for loss rates of the various materials. We did not receive information from the paper industry regarding loss rates.***

- Since the directives issued by EPA in 1995, we have seen a steady, but slow increase in the use of ash as landfill cover and road aggregate. The National Renewable Energy Laboratory of the Department of Energy estimates that approximately 6.4 percent of ash is beneficially used, or approximately 500,000 tons of ash out of the eight million tons of ash produced. Less than one percent of ash was beneficially used prior to 1995. Respondents to the IWSA survey report that nearly all facilities are investigating beneficial use of ash. I would estimate that about one million tons, or 12 percent of ash will be put to beneficial use by the turn of the century. About eighty five percent of ash reuse is as cover and road bed in landfills. About 15 percent, or approximately 75,000 tons, is used as road aggregate or building material. (Maria Zannes, Integrated Waste Services Association) ***Other than tallying the emissions from energy used to transport ash to a landfill, we did not include ash in the emissions or sinks calculation. To the extent that some of the ash is biogenic in origin, landfilling it could represent a sink. As noted in two footnotes to the report, ash absorbs CO_2 as it ages, and organics in ash could decompose to CH_4 in landfills. In both cases, the effect is a very small one.***

- The report assumes that power from a utility plant that is displaced by a waste-to-energy facility will be generated by the utility's most efficient plant. The report uses an average utility value which includes hydroelectric, nuclear, and the most efficient fossil fuel. However the most likely replacement of power is an older cycling coal-fired plant or other unit. Nuclear and hydroelectric power account for approximately 30 to 35 percent of electric generation. The carbon coefficient should be raised by about 33 percent, please change figure 6.2. (Maria Zannes, President, Integrated Waste Services Association) ***We recalculated the figure in question. As noted above, the final report assumes that electricity generated at combustors (and landfills with gas collection and energy recovery) displaces the average fossil fuel mix at utilities; this substantially increases the credit for avoided GHG emissions, and changes the value in Exhibit 6-2 to 0.083 MTCE per million BTUs. The basis for this calculation is shown in Exhibits 6-3 and 6-4; these exhibits present the data and methods used to recalculate the emission factor for utility-generated electricity.***

- Regarding the displacement of other electricity power sources by power generated at waste-to-energy facilities, we noted in our comments that the most likely and most often replacement of power is not the utility average, which includes nuclear, hydroelectric, and efficient fossil fuel generated power, but rather the older, less efficient cycling coal-fired plants or similar units. Utilities are a business, and as such look to generate power at the lowest cost. When buying power from an independent power producer, something utilities must do in accordance with the Public Utility Regulatory Policy Act (PURPA), a utility will "switch off" the most inefficient (i.e., costly) power in its grid. For example, hydroelectric power would be the last source to be replaced because there is little or no cost to produce electricity from hydroelectric generation after the initial investment. You noted that nuclear power may be shut down for long periods of time, but his large energy source is replaced by another large energy source, coal-fired generation, because that fossil fuel source can replace both the size and reliability offered by the nuclear plant and essential to utilities that must guarantee universal service. Therefore, when the nuclear power source is off-line, waste-to-energy power offsets even more coal-fired generation. (Maria Zannes, Integrated Waste Services Association) ***See previous response.***

- Recovery of aluminum and other non-ferrous metals is part of the waste-to-energy process at some facilities. More than 117,000 tons of on-site non-ferrous materials recovery, a portion of which is metals, took place at our facilities in 1996. Recovery of such non-ferrous metals will increase and should be included. (Maria Zannes, President, Integrated Waste Services Association) ***We investigated the potential for performing a quantitative analysis on non-ferrous recovery, but because we only had an emission factor for aluminum, and aluminum appears to be a minor component of the non-ferrous materials recovered, we did not include this in the final report. We did recognize this issue in a footnote to the introduction of Chapter 6.***

- Exhibit 6-2 presents energy content data. The mixed waste stream does not indicate if it excludes the fractions of newspapers, office paper and other materials listed above or if it represents the entire waste stream. Whether included or not, the estimate of 5358 Btu/lb. is too high. The report should use an estimate of 5000 Btu/lb. (Maria Zannes, President, Integrated Waste Services Association) ***The report clarifies that the mixed waste stream represents the entire waste stream as disposed. For the energy content of MSW, the report now uses a value of 5000 Btu/lb, as suggested by the commenter.***

- Our industry has long used the factor of 5000 BTU per pound in engineering design and operation. A simple phone survey of waste-to-energy facilities in New Jersey resulted in an average 5200 BTU/lb.; and therefore the 5000 BTU/lb. would be conservative, but nonetheless appropriate. Not surprisingly, RDF waste combusted at RDF facilities averages 6000 BTU/lb. (Maria Zannes, Integrated Waste Services Association) ***See previous response.***

- The assumed efficiency of 13 percent is incorrect. The percentage varies with the fuel. Mixed MSW would provide a typical value of 20 percent. Implementation of the MACT standards will result in less efficient units being closed, thus increasing the overall average efficiency. In addition, some facilities generate steam for process use that is even more efficient than electricity production. (Maria Zannes, President, Integrated Waste Services Association) ***We recalculated the efficiency based on data provided by a few sources (for example, The 1997-1998 IWSA Waste-To-Energy Directory Of United States Facilities, experts for the WTE industry, DOE-EIA, etc.) and updated Exhibit 6-2. In addition, we added Exhibits 6-3 and 6-4. The recalculated efficiency values are 17.8 % for mass burn and 16.3% for RDF facilities.***

- We have not been successful in obtaining N_2O emissions from other industries, but again suggest that such emissions are a logical consequence of composting, boiler operation, and vehicle operation. As we discussed at our meeting, we have little confidence in the N_2O emissions factor used in your report. Several facilities have attempted to quantify N_2O emissions, but there is little confidence in the test method and results. Our facilities emit trace amounts, if any. (Maria Zannes, Integrated Waste Services Association) ***We have kept nitrous oxide from combustion in the analysis based on the fact that IPCC's guidelines on developing national inventories of GHGs provide an emission factor for this gas from MWCs.***

- The 1997-98 Waste-to-Energy Directory that will contain detailed information about facilities in the United States is currently being completed. Plant managers at all 112 facilities either have mailed written surveys or responded in phone interviews. The Directory is a good source of information about the industry. (Maria Zannes, Integrated Waste Services Association) ***We obtained a copy of this report and incorporated some of the data into the analysis, such as the amount of ferrous material recovered, the number of RDF facilities, and other information used in Chapter 6.***

- Regarding the amount of waste that may be managed by incineration facilities without energy recovery, there has been a steady decline of incineration and this trend is expected to continue. Less than one half of one percent (0.4 percent) of the waste stream, or 0.9 million tons, was incinerated in 1995 at one of the 21 small facilities. We found only 18 facilities open in 1997, managing about 0.7 million tons. I would estimate that by the year 2000, well less than one-half million tons of waste will be incinerated without energy recovery. In fact, we expect that promulgation of new Clean Air Act rules for small combustion units, expected within the next two years, will force closing of these older incinerators. (Maria Zannes, Integrated Waste Services Association) ***We agree with the commenter, and for the reasons cited did not include incinerators without energy recovery in the analysis.***

7. Landfilling

- Discuss implications of regional differences in light of the fact that bacterial degradation is highly moisture dependent. (American Plastics Council, Washington, D.C.) ***The regional differences are discussed in a footnote to the introductory section of Chapter 7 (the text preceding Section 7.1).***

- The report concludes that municipalities should landfill plastics, rather than use them as alternative fuels, when many experts and observers are coming to understand the benefits of using unrecycled plastics for their energy value. Plastics constitute about 9.5 percent of MSW by weight, but provide about 30 percent of the energy content when MSW is burned to produce electricity. (*Energy Recovery Option in Plastics Resource Management*, Michael M. Fisher, November 1996). (American Plastics Council, Washington, D.C.) ***The report does not specifically recommend landfilling plastics rather than combusting them. It does, however, indicate that, according to IPCC GHG accounting principles, plastics combustion does not displace enough utility fossil fuel GHGs to result in negative net emissions.***

- The report should show absolute values for carbon dioxide emissions. This information may include the gross carbon dioxide derived from aerobic degradation and the combustion of LFG under various LFG scenarios. (American Plastics Council, Washington, D.C.) ***The IPCC convention is not to count these biogenic emissions.***

- The assumption that it is appropriate to discount certain landfilled carbon as sequestered needs further analysis. APC is not aware of any internationally accepted guidelines in this area. Since carbon from the atmosphere has already been counted as sequestered in a tree, the acts of harvesting the tree for pulpwood, converting the cellulose and lignin into paper products, and then landfilling the paper products cannot involve sequestration of the same carbon when degradation of the paper products, releasing carbon back into the atmosphere, has occurred. To do so would mean counting the carbon twice during the same "life-cycle." (American Plastics Council, Washington, D.C.) ***We believe the report's approach is correct. When a tree is harvested, its carbon is no longer counted as sequestered in the forest. Landfilling material is a waste management option that has greenhouse gas impacts for certain materials, whether those impacts are methane emissions or carbon sequestration. The carbon sequestration attributed to organic matter placed in the landfill is carbon that would have otherwise decomposed to carbon dioxide had it been left to decompose on the ground. Thus, the chosen waste management option (landfilling) has different greenhouse gas impacts than the option of leaving the material to decompose on the ground. In the case of landfilling, there is a carbon sequestration component attributable to the waste management option. This does not apply to plastic. Whether plastic is landfilled or left on the ground, the greenhouse gas impacts are essentially the same. Moreover, in the national inventory of emissions, the carbon contained in petroleum used to make plastics is not counted as an emission; in essence, it remains in storage.***

- The failure to count the carbon in fossil fuel derived plastics as sequestered in landfills is a question of methodology only. Historically, the petroleum light fractions used to produce plastics were burned. (American Plastics Council, Washington, D.C.) ***See previous response; also note that if petroleum fractions are burned, then the CO_2 emissions would be counted.***

- Create a new column for Exhibit 7-5 which would show values that would not include any carbon sequestration credit for the carbon already sequestered in the cellulose and lignin. (American Plastics Council, Washington, D.C.) ***We do not believe that this is an appropriate way to account for net***

emissions from landfills. By presenting a separate value for landfill carbon sequestration in the chapter, we enable readers who wish to evaluate the sensitivity of the result to carbon sequestration to do so.

- Since plastics are essentially inert in sanitary landfills over very long periods of time, we question why carbon in landfilled plastics is not considered sequestered. The report recognizes that biogenic materials (e.g. food) do not completely decompose in landfills and, accordingly some of the carbon is sequestered. It would seem by the same token that plastics, which are even less subject to decomposition, should be sequestered. (American Plastics Council, Washington, D.C.) ***In the GHG accounting framework, petroleum extracted from the earth and converted to plastic is not considered an emission of carbon (it is as if the carbon were left in the oil-bearing stratum underground). By this logic, it would not be correct to regard landfilling of plastic as creating a carbon sink. If the IPCC accounting convention were to count all plastics as if they were an emission at the point of manufacture, then in that situation it would be logical to credit landfilling for sequestration (and to not count emissions from burning plastic).***

- The report should address landfilling on a global basis. (American Plastics Council, Washington, D.C.) ***Although we have provided caveats on recycling paper due to the global nature of the marketplace, the primary focus of this chapter of the report is on US landfilling practices. Therefore, the analysis is limited to carbon sinks and GHG emissions from US landfills.***

- Plastics should receive a GHG reduction credit for replacing wood-based products that would otherwise be landfilled at the end of their useful life. Plastics, therefore, reduce the generation of both carbon dioxide and methane compared to the landfilling of alternative wood-based products. (American Plastics Council, Washington, D.C.) ***The report does not make comparisons among materials because it is impossible to generalize for the functional equivalents across a broad range of applications. We do include a description of a framework that can be used to evaluate material substitution in Chapter 4, section 4.3.***

- The use of laboratory data for methane production from landfilling could result in significant errors, compounded by the fact that methane is such a potent GHG, therefore the data reported should show ranges. (American Plastics Council, Washington, D.C.) ***The final report provides additional sensitivity and bounding analyses. In addition, we have tried to make our calculations more transparent so that readers can conduct their own sensitivity analyses. The report clearly acknowledges the limitation that the methane generation data come from a single source, and the landfilling results are very sensitive to methane generation rates.***

- No attempt was made in the report to assess realistic landfill conditions. In the experiments described in the report, organic waste was "seeded" with bacteria and allowed to decompose under artificial conditions of moisture and temperature. The assumption that these two-liter plastic containers can represent landfill conditions is highly questionable. The fact that no uncertainties are given provides the impression of highly accurate data. This is not the case. (American Plastics Council, Washington, D.C.) ***Although the experimental set-up was designed to optimize methane production, Dr. Barlaz's value for methane generation from mixed MSW is actually lower than the values estimated by several other models, including that used by EPA's Landfill Methane Outreach Program (LMOP) to estimate methane potential for candidate landfills. Thus, we do not believe the Barlaz data overstate methane potential, and we regard his results as providing a reasonable approximation of landfill conditions. As a practical matter, there are no landfills where only a single MSW material has been disposed so that one could measure methane, for specific materials, under actual field conditions. Dr. Barlaz's data is the best information available, and no***

commenters stepped forward with alternative data, so we continue to rely on his information in the final report.

- The landfill development trend is toward mega-landfill sites large distances from metropolitan areas. The GHG emission factors used for transportation should be significantly higher than those used for WTE plants that are located much closer to the population. (American Plastics Council, Washington, D.C.) ***We investigated this issue and have determined that definitive data on the average distance to a local or remote landfill is not available. Given the small effect of transportation on net emissions for landfills (and waste-to-energy facilities), we believe the transportation value is reasonable until more definitive data are developed.***

- On page 94, the experiments did not simulate a typical landfill as stated at the beginning of Section 7.1. Experiments were designed to measure ultimate methane production from a landfill in which decomposition was optimized. This is explained properly in paragraphs below the first paragraph in Section 7.1, but the statement could be taken out of context. Also at the bottom of pg. 96 it says, "Because the conditions in the reactor simulated landfill conditions...." (Morton Barlaz, North Carolina State University) ***We clarified this point in Section 7.1 of Chapter 7.***

- The EPA final report on Barlaz's work is now out and could be referenced: Barlaz, M.A., "Biodegradative Analysis of Municipal Solid Waste in Laboratory-Scale Landfills," EPA 600/R-97-071, 1997. (Morton Barlaz, North Carolina State University) ***In Section 7.1, we now cite this report.***

- See the Barlaz manuscript on carbon sequestration. It may improve calculations a small amount. (Morton Barlaz, North Carolina State University) ***We have updated the values, and revised the report accordingly.***

- Focus more attention on how much methane real landfills actually generate over time, based on studies beyond the Barlaz work. [The comment refers to another document for more information.] (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance; Paul McCarron, Minnesota Solid Waste Management Coordinating Board) ***Our report's focus is on methane per ton of MSW generated, not total landfill methane emissions from historical wastes in place (addressed by the referenced document).***

- Is the 85% capture efficiency for methane recovery at landfills supportable in the general literature? We feel a more realistic efficiency under actual conditions is in the range of 60 to 85%. Given the sensitivity of the results to changes in capture efficiency, it would be useful to include a table that reports a range of GHG values on different assumptions about capture efficiency. (Art Dunn, Director, Peder Larson, Commissioner, and Karen Harrington, Principal Planner-Minnesota Office of Environmental Assistance) ***The report now uses an estimated landfill gas recovery efficiency of 75 percent. In addition, new Exhibit 7-8 provides a sensitivity analysis for varying landfill gas capture efficiencies.***

- In Footnote 84 on page 93, applicability of the New Source Performance Standards (NSPS) for landfills should be 2.5 million metric tons and (no "or" as it presently reads) 2.5 million cubic meters. The comparison to the 50 metric ton threshold is based on very conservative calculation methods that over-estimate non-methane organic compounds emissions. The second half of the sentence should be revised by inserting the words "are calculated to" before the word emit. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The commenter is correct on the issue of calculated emissions, but incorrect on the issue of "and" versus "or." The footnote has been revised accordingly.***

- On page 100, the 91 percent assumption in the following statement appears aggressively unrealistic: "Of the 58 percent of all methane generated at landfills with LFG recovery, 91 percent (or 53 percent of all methane) is expected to be generated at landfills that use LFG to generate electricity,…". (Martin Felker, Senior Environmental Engineer, Waste Management) ***In Section 7.2, a footnote was added that addresses this issue. It reads, "The assumption that 91 percent of landfills recovering methane will use it to generate electricity is subject to change over time based upon changes in the cost of recovery, and the potential payback. Additionally, new technologies may arise that use recovered methane for purposes other than generating electricity."***

- Dr. Barlaz's average measured methane yield for mixed MSW of 92 ml per dry gram is only 74% of the 125 ml per gram methane yield given in AP-42. If the Barlaz number was a wet weight basis number, the methane yield would be even lower relative to AP-42. Landfills routinely use AP-42 for calculating landfill emissions. It is unclear why such an important document which may have significant impacts on the solid waste management industry is based on assumptions that are inconsistent with information published by EPA (AP-42) regarding this industry. The value used in this study should be acceptable by EPA for use by industry in other calculations. (Martin Felker, Senior Environmental Engineer, Waste Management) ***We recognize that substantial uncertainty remains regarding the methane emissions from landfills. For the purposes of this report, we needed to use material-specific methane yields for the organic materials analyzed. Only one researcher (Dr. Barlaz) has estimated material-specific values, and we obtained these values from him. For the sake of consistency, we also used Dr. Barlaz's value for mixed MSW. We do not suggest that this value is more reliable than the value reported in AP-42.***

- On page 100, an 85% landfill gas recovery efficiency is inconsistent with the industry standard of 75% which is used in AP-42. (Martin Felker, Senior Environmental Engineer, Waste Management) ***The report now uses an estimated landfill gas recovery efficiency of 75 percent.***

- On page 106, account for the timing of methane generation in landfills. The methane (and CO_2) generation from landfills occurs over a period of decades. The CO_2 from combustion occurs immediately. This will have a significant impact on the rate at which these GHG's are emitted. (Martin Felker, Senior Environmental Engineer, Waste Management) ***We addressed this commenter's point in the limitations section, which now includes the following passage related to timing: "First, landfill methane emissions prior to 2000 will not be recovered at the year 2000 levels, thus, keeping organic materials out of landfills prior to the year 2000 will have GHG benefits in excess of those estimated here. Second, because landfill methane generation occurs over time and has significant timing delays (i.e., methane generation may not begin until a few years after the waste is deposited in the landfill and can continue for many years after the landfill is closed), the values listed in this chapter represent total methane generated, over time, per ton of waste landfilled. To the extent that LFG recovery rates shift dramatically over time, these shifts are not reflected in the analysis. Third, landfills with LFG recovery will be permitted, under EPA regulations, to remove the LFG recovery equipment when three conditions are met: (1) the landfill is permanently closed, (2) LFG has been collected continuously for at least 15 years, and (3) the landfill emits less than 50 metric tons of nonmethane organic compounds per year. Although the removal of LFG recovery equipment will permit methane from closed landfills to escape into the atmosphere, the amounts of methane emitted should be relatively small, because of the relatively long time period required for LFG collection before LFG recovery equipment is removed.***

- Methane's global warming potential over time should be taken into account. Over time, the impact potential of methane decreases from a carbon dioxide equivalency factor of 62 in 20 years to 7.5 in

500 years. Although this study takes into account only the 100-year equivalency factor of 24, all of these numbers are provided by the Intergovernmental Panel on Climate Change (IPCC) and the numbers for their respective years are considered equally valid. To account for the scientific uncertainty in the global warming phenomenon and differing time frames which could be considered, this range should be part of the sensitivity analysis. (Ecobalance, on behalf of the American Forest and Paper Association) ***The 100-year time horizon is used in the US GHG inventory, and we believe it is appropriate for use in this report as well. The final report uses a (100-year) GWP of 21 for methane, to be consistent with the most current guidance from the Intergovernmental Panel on Climate Change.***

- Perform a sensitivity analysis on the percentage of all landfill methane generated and the recovery efficiency. Regarding landfill gas recovery in the year 2000, the study states, "58 percent of all landfill methane will be generated at landfills with recovery systems, and 42 percent will be generated at landfills without LFG recovery". Because of the new emissions standards for new MSW landfills, this 58 percent figure seems low, given the implication that 42 percent of all methane from landfills will be released to the atmosphere. Also, 58 percent seems low because as energy costs rise, there will be a motivation for landfills to build recovery systems and collect the gas for its energy use. Because this figure drives the results for the landfilling option, a sensitivity analysis needs to be performed. (Ecobalance, on behalf of the American Forest and Paper Association) ***In the final report, we did adjust the best estimate for national methane recovery, but we adjusted it downward to 54 percent. This reflects a more recent projection made by EPA's Office of Air and Radiation. Although the factors cited by the commenter would indeed motivate more landfill owners to install gas collection, two factors counterbalance them: (1) many landfills have been able to "test out" of the landfill gas rule's requirements (e.g., they are able to demonstrate that their non-methane organic compound emissions are below the rule's threshold), and (2) some of the tax incentives that had previously favored recovery systems are likely to expire.***
  Exhibit 7-7 provides the sensitivity analysis suggested by the commenter. The exhibit shows net GHG emissions at the 1995 recovery rate of 17 percent, as well as net GHG emissions at increasing LFG recovery rates, up to a 60 percent recovery rate (exceeding 54 percent, the rate projected for 2000). As the exhibit shows, the net post-consumer GHG emissions for landfilling mixed MSW are positive at lower rates of recovery, and turn negative only when the LFG recovery rate exceeds 40 percent. At the local level, the GHG emissions from landfilling MSW are quite different depending on whether the local landfill has LFG recovery; the final report also provides separate results for landfills with and without LFG recovery and relies less on the "national average" in its discussion of results for landfills.

- Address GHG emissions resulting from both handling of waste at the landfill by heavy duty diesel equipment and sludge treatment. (Ecobalance, on behalf of the American Forest and Paper Association) ***The GHG emissions data already incorporate the use of landfilling equipment. Sludge treatment is beyond the scope of the report.***

- On pages 97 and 98, Barlaz's estimates of CH_4 emissions from office paper and newsprint indicated much higher methanogenic decomposition of office paper than newsprint. The reason for this result is that newsprint contains higher lignin than office paper, but this explanation is not intuitive and should be stated in the report. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***In the explanatory note for Exhibit 7-1, we added text that clarifies this point.***

- Missouri data on the current rates of landfill gas collection differ from the projected year 2000 rates used in the report. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of

Natural Resources) ***There will be many instances where state-level data differ from the national average data used in the report. We added text throughout the report emphasizes that local conditions often do not reflect national conditions.***

- Regarding the estimate that 90 percent of methane is released from a landfill: measurements of methane releases in Tier 2 reports indicate that the amount of release of methane is less than EPA estimates. Landfill gas is not easily detected an inch above the surface of the landfill, and was found to be only 2000 ppm under a two-foot square plastic sheet. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***We believe the estimated conversion rate of ten percent is within reason. This estimate may be revised in the future if continued research provides data that supports a higher conversion rate.***

- Citing information that 0-47% of carbon in landfills is converted to landfill gas, one commenter concluded that 53-100% of carbon in landfills is sequestered, which is much higher than the 20% shown in Exhibit 7-2. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***This exhibit (new Exhibit 7-3) does not show the percentage of carbon sequestered. Rather, it shows the ratio of carbon sequestered to the dry weight. If one adjusts for carbon content and wet weight, the numbers are more similar.***

- Reconsider the assumption that 91% of landfills required to recover methane will capture it for energy. Decisions will be based on incremental cost of capturing methane for energy (vs. flaring it) to the expected stream of discounted revenue from energy capture. The potential payback for energy capture may in some cases be limited by location (must be a local market for methane). Some landfill operators may be very risk-averse. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***In terms of the number of landfills converting gas to electricity, we use the forecasted value, which is consistent with projections made by EPA on the effectiveness of landfill gas controls and the extent of voluntary participation in landfill gas control as a result of the Landfill Methane Outreach Program (LMOP).***

- Exhibit 7-3 assumes that as of the year 2000, 91% of landfills required to recover methane by the new source performance standard will capture the methane to generate electricity and 10 percent will flare it. There is a missing category in Ex 7-3, methane capture for use other than electric generation. For example in MO one landfill captures gas for its electricity. No independent power producers sell power to the grid in MO. Restructuring could open up or close new opportunities. Landfill methane capture is likely to take a wide variety of forms besides electric generation. Other forms do not have the same stringent engineering requirements as electric generation which requires a constant flow of methane. This change would affect the calculation of potential reductions in GHG. In MO where coal combustion dominates utility generation, displacement of natural gas implies lower GHG savings than displacement of utility generated electricity. (Jim Hull, Chief, Engineering and Planning Section, Missouri Department of Natural Resources) ***As the commenter notes, it is difficult to predict how a given landfill that recovers gas will use the recovered gas, and there are uses other than electricity generation. Still, energy recovery is the dominant use of landfill methane, and we believe that, as a first approximation, our nationwide projections remain valid. We addressed this commenter's points in a footnote to Section 7.2.***

- More is needed on estimating the actual GHG emissions from depositing MSW in a landfill. As you noted in the report, the analysis presented in the Landfilling Chapter relies only on the laboratory results of Dr. Morton Barlaz. While this data is a good start, we strongly recommend that OSW work closely with operating landfills to conduct more research that determines the level of GHG emissions at various sites. This field data will help to balance the laboratory data of one researcher. (Tom Kerr, OAR/OAP/APPD) ***We appreciate this recommendation and noted this as an area for further research in the report.***

- On page 93, footnote 84, there is one other criteria to help determine if a particular landfill is affected by the landfill gas rule: it must receive waste on or after Nov. 11, 1987. If it does not, the site is not affected by the NSPS/EG. (Tom Kerr, OAR/OAP/APPD) ***We added this information to the report.***

- A sensitivity analysis is needed that would measure what would happen if the estimates for MSW landfill methane recovery systems are inaccurate. There is no explanation as to why 58% was selected to represent the number of methane recovery systems in landfills by the year 2000 when only 17% have such systems in 1995. It is not enough to merely note in the report that "small changes in the LFG recovery rate...could have a large effect on the net GHG impacts of landfilling and....on the ranking of landfilling relative to other MSW management options". Further sensitivity analyses should be conducted. (Trudy J. Richter, Executive Director, Minnesota Resource Recovery Association) ***Exhibit 7-7 provides the sensitivity analysis suggested by the commenter. In addition, the final report presents separate results for landfills with and without gas collection, rather than only showing a national average value (as did the draft report). This portrays the sensitivity of the results to assumptions related to recovery systems much more vividly.***

- The total number of landfills compared to waste combustors should be included in the calculation. When taken as a whole, the CO_2 per ton of MSW, as published in *Solid Waste Technologies,* indicates more than double CO_2 equivalents for landfills than waste combustors. Combine that with non-methane organic carbons and other toxic emissions from landfills, particularly those that combustion eliminates completely, and the overall impact of landfilling MSW in terms of air emissions is significant. (Trudy J. Richter, Executive Director, Minnesota Resource Recovery Association) ***We did not evaluate emissions other than GHGs in the report, nor was it within our scope to compare emissions from various waste management methods on a national level.***

- Try to get around the lack of research on in-place degradation of materials in landfills. (Clark Row, Row Associates) ***We sought additional information on in-place degradation, but did not identify other sources that provided information on specific components of the MSW wastestream.***

- The information presented in the report on rates and completeness of material degradation in landfills comes entirely from Barlaz research which seemed to represent the maximum rates and completion for the various organic materials tested. Within landfills, according to research from EPA Research Triangle Lab and others, conditions are often less than optimum for degradation. The Barlaz rates would be corrected or discounted to represent average in-place conditions. (Clark Row, Row Associates) ***Although the experimental set-up was designed to optimize methane production, Dr. Barlaz's value for methane generation from mixed MSW is lower than the values estimated by several empirical estimates. Thus, we believe the Barlaz data are within reason and do not need to be adjusted.***

- Modify the treatment of disposal. As an example, consider landfilling. Presumably, if an additional ton is landfilled, the supply of recycled aluminum that would have come from that ton is lost; the report does not account for this effect. To do so, I assumed that 52.5 percent of the extra ton would have been recycled (52.5 percent is the average of the aluminum recycling rates shown in Exhibit 2.2). This leads to an impact at the remanufacturing stage of the life-cycle analysis: the need for virgin production to offset the lost recycling creates incremental GHG impacts equal to 52.5 percent of the GHG credit for recycling a full ton. (John Stutz, Tellus) ***The report's analysis uses a consistent baseline for each waste management option, so that any comparison correctly accounts***

for GHG impacts. We do not believe that this approach uses the same baseline for comparing recycling to landfilling.

- The report assumes that landfills with gas recovery will recover 85% of what is generated, 50% to 70% is a more likely range. Secondly, the number of landfills converting the gas to electricity is very high. Should Congress end or not renew the landfill gas subsidy for the year 2000, a drastic drop in recovery will be experienced. The assumptions in this section need to be reassessed and the GHG emissions should be recalculated. (David Sussman, Poubelle Associates) ***The report now uses an estimated landfill gas recovery efficiency of 75 percent. In terms of the number of landfills converting gas to electricity, we use the forecasted value, which is consistent with projections made by EPA on the effectiveness of landfill gas controls and the extent of voluntary participation in landfill gas control as a result of the Landfill Methane Outreach Program (LMOP).***

- The report assumes between 60 percent and 85 percent of landfill methane will be recovered by the year 2000, as well as 91 percent of recovered methane used to generate electricity. This does not seem correct, given no more than 75 percent of all landfill capacity is expected to meet the NSPS and EG standards, according to EPA. (Maria Zannes, President, Integrated Waste Services Association) ***The report now uses an estimated landfill gas recovery efficiency of 75 percent.***

- The total gas stream is 50/50 CO_2 and CH_4 on a dry basis with trace quantities of other gases. It is also very wet. Thus, the heat content of landfill gas would not be 1,000 Btu/CF unless it is cleaned and dried and the CO_2 is removed. This process would require energy to complete and therefore would reduce the overall efficiency of a landfill gas-fired unit when compared to a natural gas-fired unit. Another option is to burn the gas as it vents from the landfill, resulting in significantly lower efficiencies. Due to these conditions, the assumption for kWh/Btu should be half the value assumed (.00004 instead of .00008 kWh/Btu). (Maria Zannes, President, Integrated Waste Services Association) ***The exhibit in question states that the Btu value of landfill methane (not landfill gas) is 1,000 Btu per cubic foot. The value of 0.00008 kWh/Btu is a calculated ratio (1/13,000) for internal combustion engines—where the value of 13,000 Btu per kWh reflects the efficiency of converting landfill gas (including CO_2 and moisture) to electricity.***

- Transportation costs are assumed to be identical for landfilling and combustion. However, the vast majority of waste-to-energy facilities are in major cities with nearby collection. Landfills, on the other hand are usually located farther away, often up to 500 miles from the collection area. (Maria Zannes, President, Integrated Waste Services Association) ***We investigated this issue and have determined that definitive data on the average distance to a local or a remote landfill are not available. Given the small contribution of transportation to total emissions from a landfill (or WTE facility), we believe the transportation value is within reason—particularly until more definitive data are developed.***

- Some landfills collect and combust a portion of emitted methane while a limited number of others use methane for the generation of electricity. New regulations (NSPS and EG) require collection and destruction of landfill gases at those facilities with a design capacity of 2.5 million metric tons and with annual non-methane organic compound emissions of at least 50 megagrams/year. Once fully implemented those affected landfills will consist of approximately two-thirds of the nation's total landfill capacity. Most facilities are expected to install a flare system to burn off the collected methane. The methane combusted by flaring will result in CO_2 emissions increase of 24.1 million tons. See table 2 for summary of GHG benefits. (Maria Zannes, President, Integrated Waste Services Association) ***The report follows the IPCC guidelines concerning biogenic CO_2. The IPCC***

convention is not to count biogenic CO_2 emissions from sustainable sources , therefore, these emissions have not been included in the report.

8. Comparison of Options

- The report should provide a table of gross carbon dioxide, methane, and nitrous oxide emissions by material and, in the absence of any "credits" for each recovery and/or disposal option. The report can then go on to develop tables of gross, net, and comparative GHG emissions that require specific assumptions and modeling. The absolute carbon dioxide, methane, and nitrous oxide yields are necessary in order to make the report a living document that can be revisited as new technologies develop and/or assumptions and modeling methodologies change. The report loses technical integrity with only the "modeled" GHG emissions presented. (American Plastics Council, Washington, D.C.) ***EPA has prepared tables showing emissions, by gas (without weighting for GWP), to be published in DOE's report, Form EIA 1605, Voluntary Reporting of Greenhouse Gases, Instructions. We have included this information in the revised Chapter 8. The values shown are for management options compared to landfilling.***

- Exhibit 8-2 representing the net GHG emissions (by material type) associated with recycling instead of landfilling, is unclear. It appears inconsistent that the net carbon values for recycling, rather than landfilling plastic and steel are positive. Recycling steel cans and plastic containers consumes less energy than landfilling and therefore should reduce GHG emissions. If the Exhibit is correct then it needs more clarification and interpretation. (American Plastics Council, Washington, D.C.) ***The new Exhibit 8-2 (and as noted elsewhere, the entire final report) reflects a different measurement reference point than the draft report, one in which the GHG emissions are tallied with respect to the point of discard. Note that neither the old or new Exhibit 8-2 shows recycling GHG emissions relative to landfilling.***

- Explain more fully why, for aluminum, recycling is the preferred option over source reduction. This fuller discussion would also help explain and motivate the results in the report showing source reduction of average and virgin tons (see Exhibit 8-1). Perhaps this could be done by means of a simplified example like the one which follows. If one manufactured aluminum cans from a 50/50 mix of virgin and recycled inputs, with virgin producing 6 MTCE and recycled 1 MTCE per ton (the approximate values in Exhibit 2-2), then reducing demand by one ton would save 3.5 MTCE, while recycling one ton would save 5 MTCE. However, if the virgin and recycled GHG impacts are a bit closer together, say 5 and 2 rather than 6 and 1, the situation would shift. Source reduction would still avoid 3.5 MTCE, but recycling would only save 3 MTCE. This is because the benefit of recycling depends on the difference between virgin and recycled GHG impacts, which has dropped from 5 to 3. (John Stutz, Tellus) ***The approach suggested by the commenter represents a significant improvement to the explanation in the draft report. We adopted it directly and it appears in a footnote to Chapter 8.***