Economic Data and Indicators Scoping Analysis
U.S. Environmental Protection Agency
Office of Resource Conservation and Recovery
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Background

EPA's contractor was tasked to develop the following municipal solid waste (MSW) economic indicators:

1) MSW generation versus real Gross Domestic Product (GDP),

2) MSW disposal versus tipping fees, and

3) MSW product recycling rates versus commodity values.

This memo presents the final indicators and very brief observations about each indicator.

Indicators and Observations

Indicator 1: MSW Generation Versus Real GDP

MSW generation from 1960-2012, shown in Figure 1, is from EPA's report *Municipal Solid Waste in the United States: 2011 Facts and Figures* (U.S. EPA, 2013) and preliminary 2012 generation data compiled for the 2012 facts and figures, and is included to give perspective on what is included in MSW generation. Figures 2 and 3 show the indicators related to MSW generation and GDP, and have been included as each demonstrates different components of the MSW generation and GDP relationship.

Figure 2 additionally incorporates U.S. Census Bureau resident population data (U.S. Census Bureau, 2000, 2001, 2011, and 2013) and Bureau of Economic Analysis (BEA) real GDP data (BEA, 2013). All values are indexed to 1960 (i.e., a y-axis value of four means the value is four times that of 1960). This graph shows that while MSW generation has been increasing since 1960, the MSW generated per dollar of real GDP has steadily decreased, and over the past 20 years, the MSW generated per capita has slightly decreased as well. The contractor has since performed supplementary analysis, shown in Appendix A, showing the relationship between real PCE (the household spending component of GDP) and MSW generation.

Figure 3 explores the correlation between MSW generation and real GDP. The figure shows a rather strong relationship between how MSW generation per person increases with increasing real GDP per person. For every $5,000 increase in real GDP, the tons of MSW generated per person increases by approximately 0.065 tons per year (130 pounds). The contractor has since performed supplementary analysis, shown in Appendix A, showing the relationship between real PCE (the household spending component of GDP) and MSW generation.

**Figure 1: MSW Generated and Managed in the U.S. (1960-2012)**

No composting data are available prior to 1988.

- ■ Recovery for composting
- ■ Recovery for recycling
- ■ Combustion without energy recovery
- ■ Combustion with energy recovery
- □ Landfill
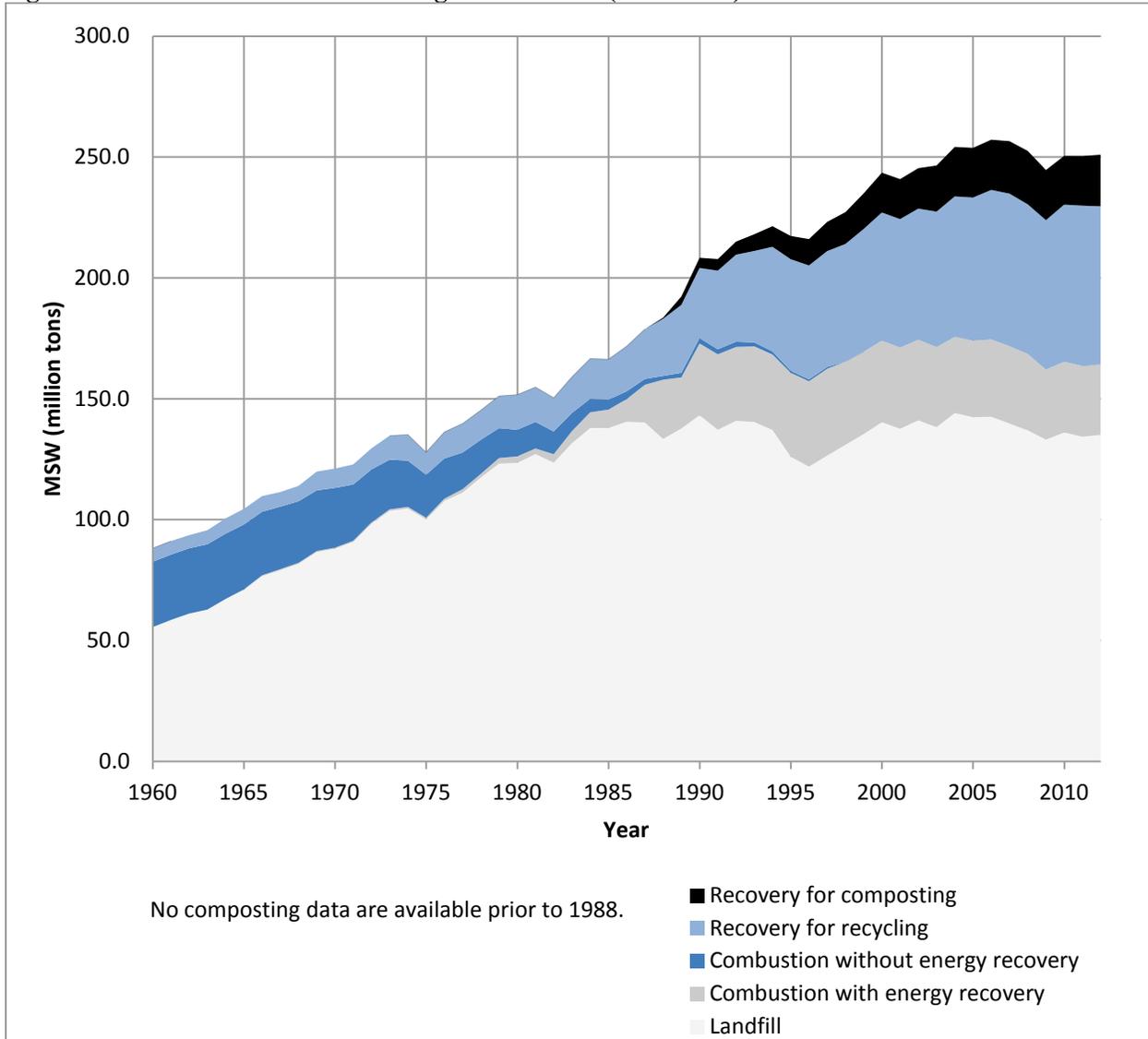
**Figure 2: U.S. Municipal Solid Waste Generation and GDP (1960-2012)**
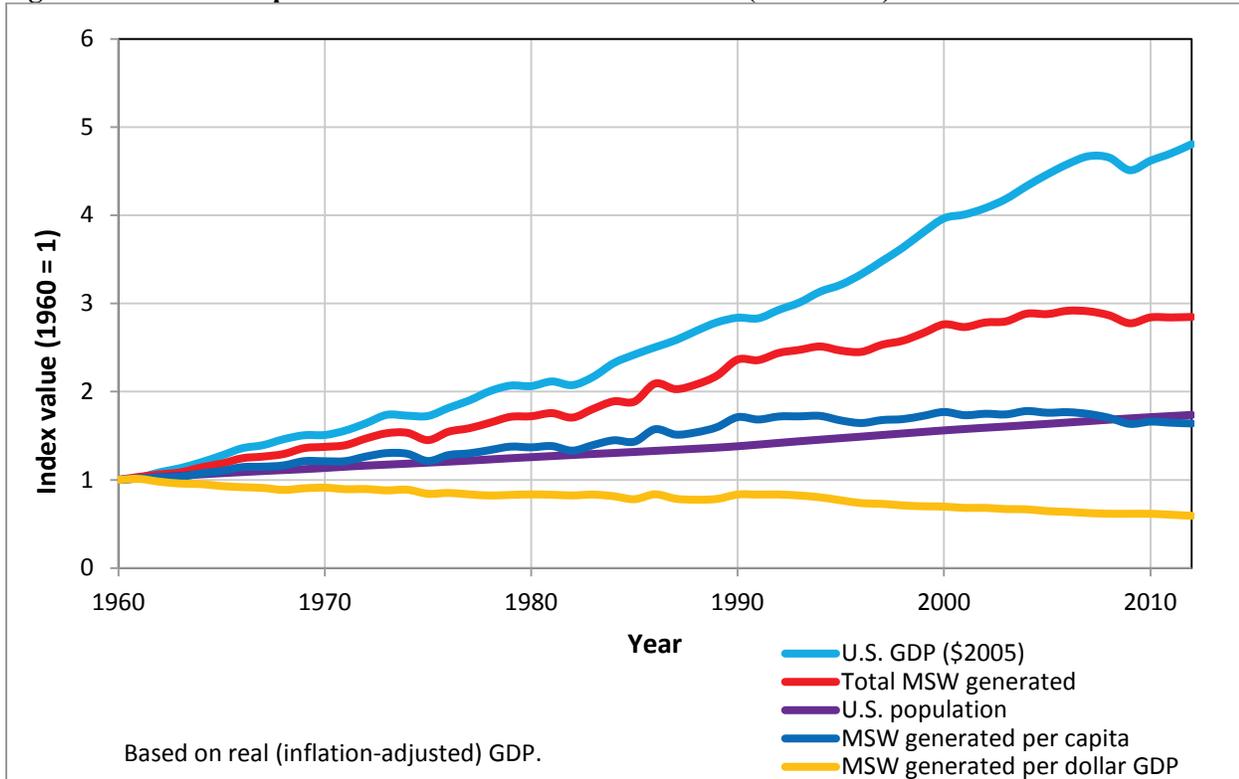
Figure 3: MSW Generation Versus Real GDP (1960-2012)
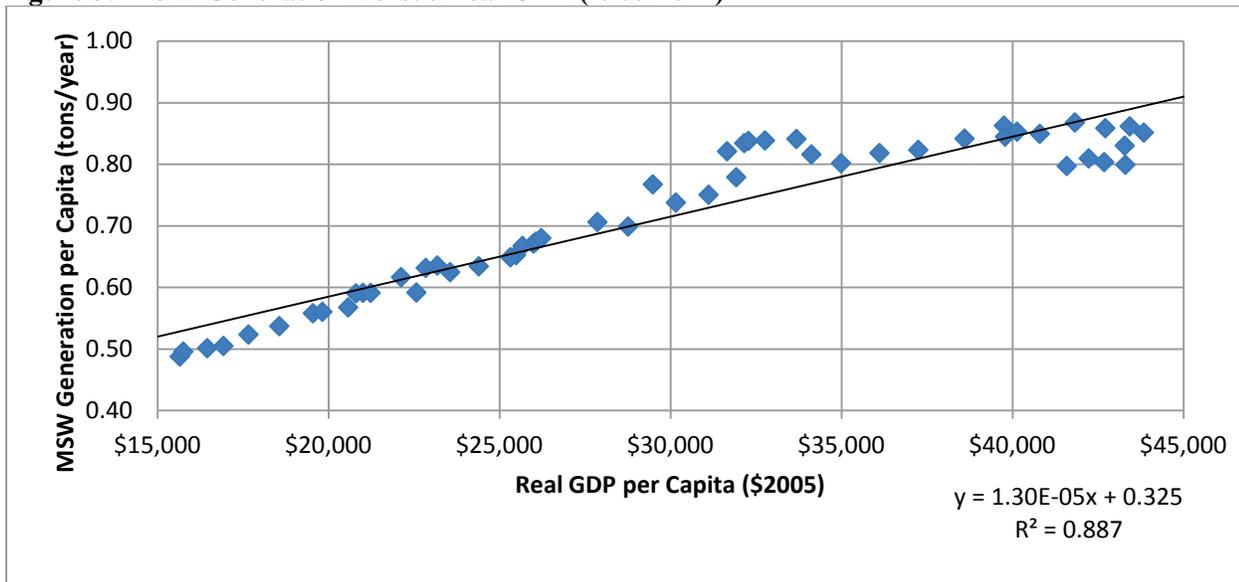
Indicator 2: MSW Disposed Versus Landfill Tip Fees

Figures 4 and 5 show the indicators related to MSW disposed through landfilling and landfill tip fees. The landfill component of the MSW generation and management data in Figure 1 was used for this analysis. National Solid

Wastes Management Association (NSWMA) average U.S. landfill tip fee data for intermittent years between 1985 and 2011 were used (NSWMA, 2012). This analysis excludes illegal dumping, litter, and marine debris. Tip fees were normalized to constant $2005 using the consumer price index (CPI) from the Bureau of Labor Statistics (BLS, 2013). Figure 4 shows a rapid increase in tip fees from 1985 to 1995 followed by a relatively stable period through 2011 while MSW disposed per capita has fallen rather steadily through this entire (1985-2011) period.

Figure 4: Indexed Tip Fees and MSW Disposed

Based on real (consumer price index-adjusted) tip fees.
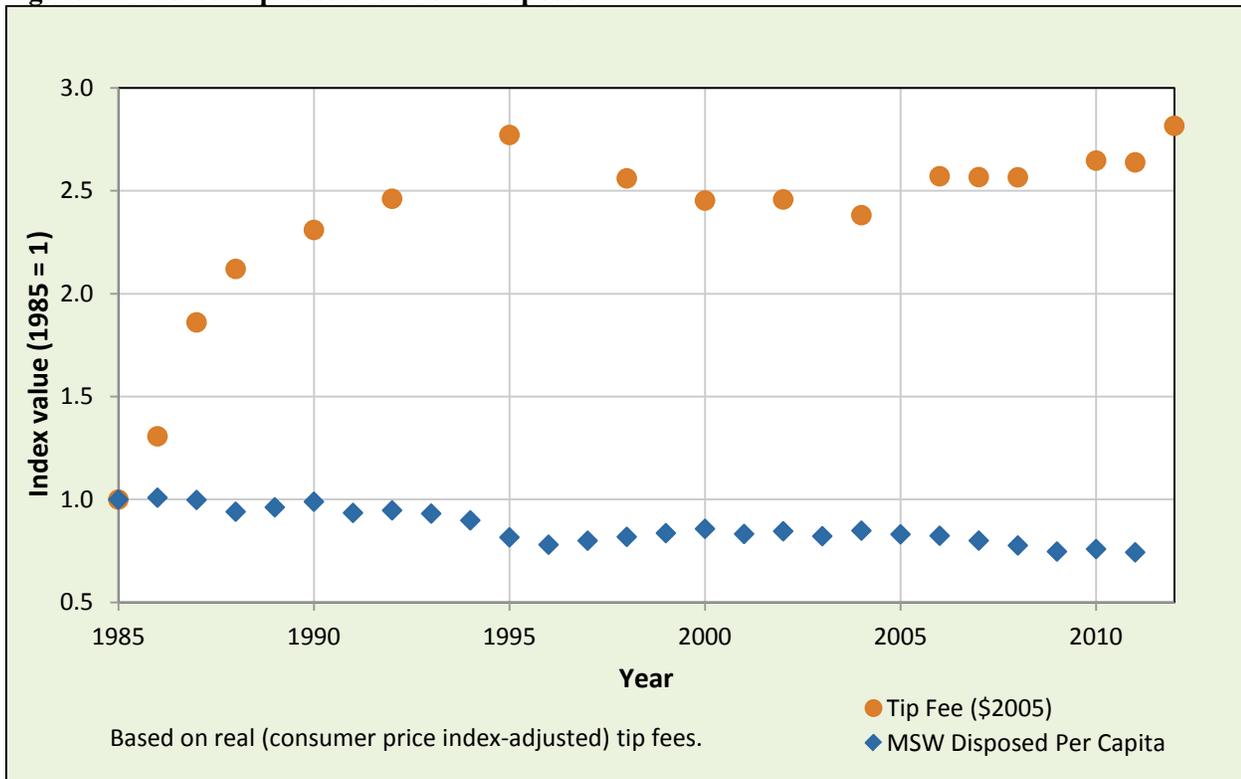
Figure 5a shows the correlation between MSW disposed by landfilling and tip fees from 1985 to 2011. As expected, as tip fees increase in real dollars, MSW disposal also decreases; however, there may be some other forces affecting the amount of MSW disposed. MSW disposed has a relatively weak correlation to the disposal tip fee.

Figure 5b (1998-2011) was developed to explore the same relationship between MSW disposed by landfilling and tip fees after 1995 to help isolate this indicator from any potentially related effects of a rapidly changing landfill market from the mid 1980s to mid 1990s due to increased regulatory costs. The regression in Figure 5b shows a correlation coefficient of 0.78 while a weaker correlation (0.62) is shown in the Figure 5a regression that includes data during the period of increasing regulations from 1985 to 1995. This increased correlation when isolating the later years could be coincidence, could be the result of isolating the data from the potentially related effects of rapidly changing landfill market, in 1985-1995, or could be the result of isolating the data from other major drivers in MSW disposal that occurred in the early 1990s.

Figure 5a: MSW Disposed Versus Landfill Tip Fees (1985-2011)

y = -11.40x + 1,401.23
R² = 0.62

Based on real (consumer price index-adjusted) tip fees.

Figure 5b: MSW Disposed Versus Landfill Tip Fees (1998-2011)

y = -31.72x + 2,135.30
R² = 0.78

Based on real (consumer price index-adjusted) tip fees.

Indicator 3: Recycling Rates Versus Commodity Values

Figures 6-14 (found at the end of this document) show the indicators related to recycling rates and commodity values. The contractor used in-house commodity value data from 1990-1996 for PET plastic, HDPE plastic, aluminum used beverage containers (UBC), steel cans, and old newspaper grade 6 (ONP) and commodity value data from 1990-2003 for old corrugated containers grade 11 (OCC). To supplement these data, the contractor purchased data from Secondary Materials Pricing and Secondary Fiber Pricing (SFP and SMP, 2013) to attain commodity value data from 2005-2011 for aluminum UBC, steel cans, PET plastic, and HDPE plastic and from 2003-2011 for ONP and OCC. The contractor used recycling data (tons and percent recycled) from EPA's *Municipal Solid Waste in the United States: 2011 Facts and Figures* (U.S. EPA, 2013) for each of these categories. Commodity values were normalized to $2005 using the CPI from BLS.

The contractor presented the draft versions of these indicators to EPA using the limited available in-house data before purchasing any data sets. The correlation between recycling rate and commodity value was very weak or non-existent for every commodity with the exception of OCC; however, this time period coincided with a period where many of the recycling markets were relatively new and expanding quickly. Therefore, commodity value data was purchased for a period with a more stable recycling market (2005-2011) to explore whether there may be a stronger correlation once the recycling market was more established. Figures 6-10 show the graphs of recycling rate versus commodity value for each commodity.

For PET (Figures 6a and 6b) and Aluminum UBC (Figures 8a and 8b), there is almost no correlation between recycling rate and commodity value for either the 1990-1996 or 2005-2011 time periods. The indicator data for all material commodities (PET, HDPE, aluminum UBC, and steel cans) were shown in separate figures because the older in-house data used end-user pricing and the more recent data used intermediate processor pricing for picked up or delivered commodities.

The HDPE regression shows a weak correlation between recycling rates and commodity value from 1990-1996 (Figure 6a) and almost no correlation between 2005 and 2011 (Figure 6b).

During both time periods (Figures 7a and 7b), there is a weak correlation showing that the recycling rate of steel cans actually decreases as the commodity value increases, which does not make intuitive sense and may further indicate that commodity values are not a major driver for recycling rates.

For ONP (Figure 9a) and OCC (Figure 10a) the two commodity value data sets were combined in the figures because they used the same pricing reference point (at the seller's dock). These figures show the regression of recycling rate versus commodity value from 1990-2011 with a slight data gap from 1997 to 2002 for ONP. These regressions show a very weak correlation between recycling rate and commodity value for ONP and a weak but relatively stronger correlation for OCC. In exploring this relationship further, Figures 9b for ONP and 10b for OCC were developed to explore the relationship of recycling rate and commodity values during a more mature recycling market. Figure 9b shows that the correlation between recycling rate and commodity value is also very weak for ONP during the 2003-2011 time frame, but Figure 10b shows there is a stronger correlation between these two measurements as the correlation coefficient increases from 0.26 to 0.37when excluding data from 1990-1995 during the maturing recycling market.

One reason for the lack of correlation between recycling rates and commodity values for HDPE, PET, aluminum UBC, steel cans, and ONP may be that, in many cases, those who recycle the materials may not see the monetary shift of the commodity markets. Residents pay a contracted amount that does not move up or down in response to market values.

Additionally, many other influences such as recycling awareness, increase of pay-as-you-throw recycling, and the increase of curbside recycling may be a much greater driver on recycling rates. Figures 11-13 show recycling

rates over the years, which show, in many cases, a rapidly expanding recycling market in the early 1990s. Aluminum recycling rates (Figure 12), however, had already been relatively high compared to other commodities in 1990.

Based on the weak or non-existent correlation between recycling rates and commodity values for HDPE, PET, aluminum UBC, steel cans, and ONP during two separate time periods, it was decided not to purchase data to back fill the missing years of data. Additionally, this would be the third different data set to cover the 1990-present time frame, which may include different pricing reference points.

OCC, on the other hand, is primarily recovered from the commercial sector. Commercial OCC recovery through paper brokers may be more sensitive to movement in the commodity market; recovery from small-sized businesses becomes more economically feasible as the commodity value increases. Conversely, as the commodity value decreases recovery from smaller generators will drop off. Additionally, both recyclers and "unauthorized recyclers" or "scavengers" are more likely to collect CCC from smaller businesses when market prices rise significantly.

Although, this should be true for other commodities, OCC is the only commodity reviewed in this analysis that is mainly recovered from the more market- sensitive commercial sector. In other words, fluctuation of commercial sector recovery of other materials may be masked by the relative stable residential sector recovery through curbside programs.

The recycling rate to commodity value relationship was further explored by showing the indexed (1990 values equal one) OCC recycling rates versus commodity values in Figure 14. This figure shows how these two metrics change over the years, which cannot be determined in Figures 10a and 10b. Starting in about 1996, while the commodity values are slightly more volatile, the two indexed values track reasonably closely with each.

References

BEA. 2013. Current-Dollar and "Real" Gross Domestic Product: 1929–2012. http://www.bea.gov/national/index.htm#gdp.

BLS. 2013. Table Containing History of CPI-U U.S. All Items Indexes and Annual Percent Changes From 1913 to Present. Released June 2013. http://www.bls.gov/cpi/

National Solid Wastes Management Association (NSWMA). 2012. Municipal Solid Waste Landfill Facts. October 2012.

SFP and SMP. 2013. Secondary Materials Pricing and Secondary Fiber Pricing. Released July 2013. Available at http://www.recyclingmarkets.net/ (for purchase data).

U.S. Census Bureau. 2000. Historical National Population Estimates: July 1, 1900 to July 1, 1999. Released April 2000. http://www.census.gov/popest/data/national/totals/pre-1980/tables/popclockest.txt.

U.S. Census Bureau. 2001. Intercensal Estimates of the United States Resident Population by Age and Sex: 1990 to 2000 (US-EST90INT). http://www.census.gov/popest/data/intercensal/national/index.html.

U.S. Census Bureau. 2011. Intercensal Estimates of the Resident Population by Sex and Age for the United States: April 1, 2000 to July 1, 2010 (US-EST00INT-01). Released September 2011. http://www.census.gov/popest/data/intercensal/national/nat2010.html.

U.S. Census Bureau. 2013. Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2012 (NST-EST2012-01). http://www.census.gov/popest/data/national/totals/2012/index.html.

U.S. EPA. 2013. Municipal Solid Waste in the United States: 2011 Facts and Figures. May 2013.

The recycling graphs are shown below.[1]

Figure 6a: Plastic Recycling vs Commodity Values (1990-1996)
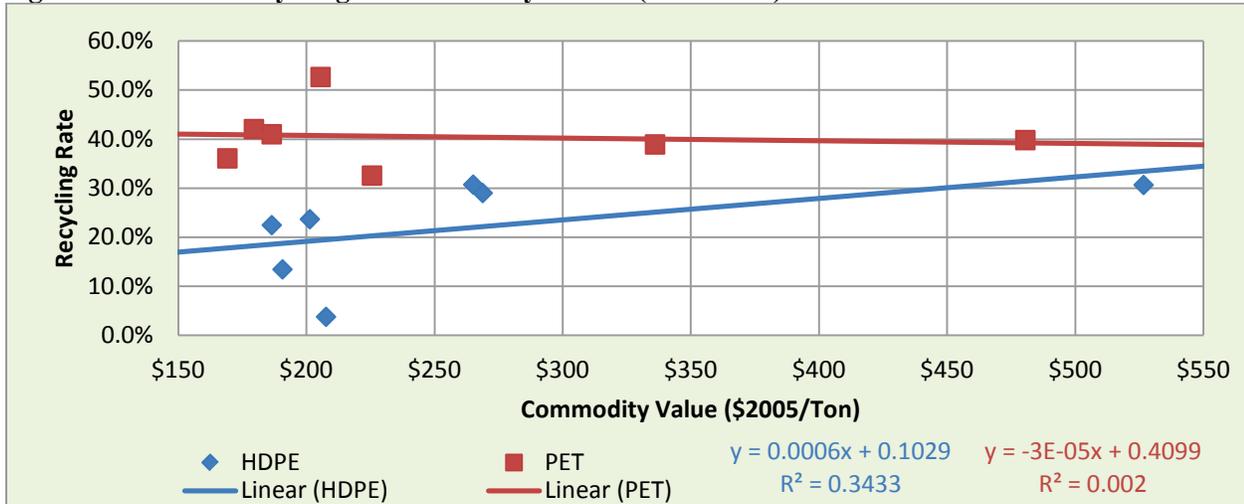
Figure 6b: Plastic Recycling vs Commodity Values (2005-2011)

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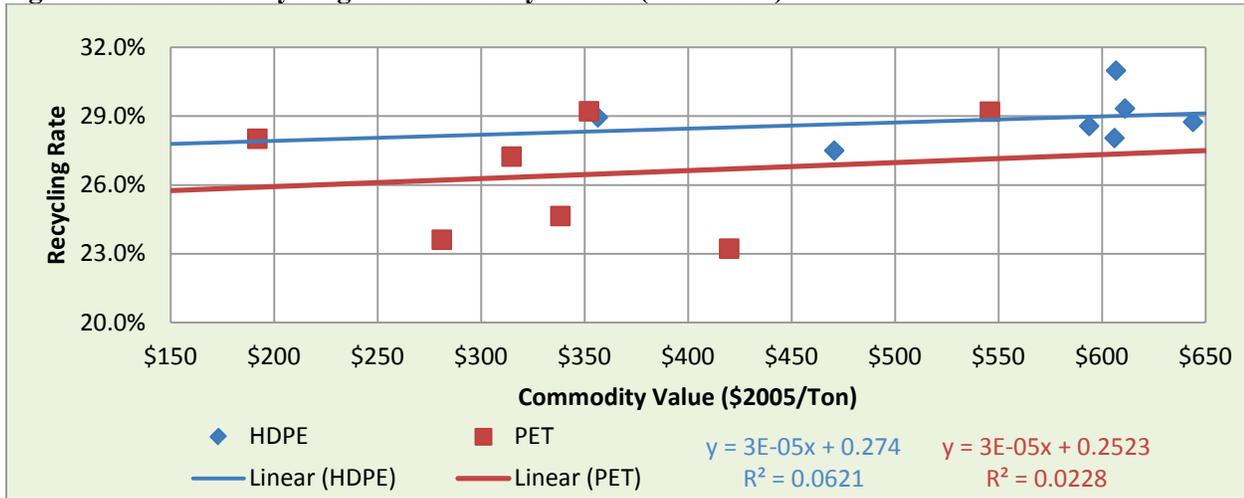
[1] Data could be off because at least some of the increases are due to significant single stream contamination and resulting items discarded.

Figure 7a: Steel Can Recycling vs Commodity Values (1990-1996)

Recycling Rate vs Commodity Value ($2005/Ton)

y = -0.0067x + 1.0205
R² = 0.3311
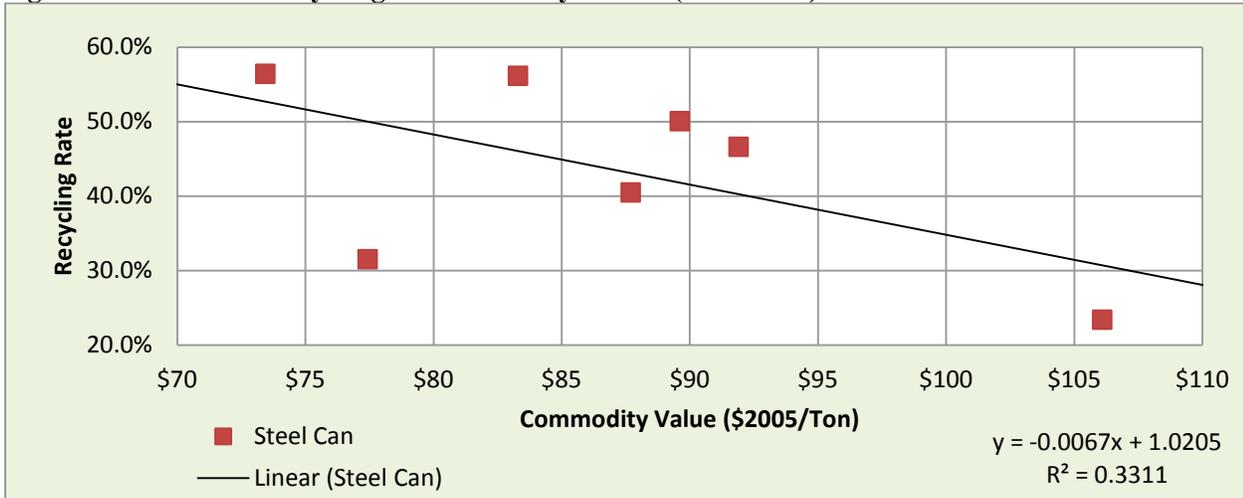
Figure 7b: Steel Can Recycling vs Commodity Values (2005-2011)

Recycling Rate vs Commodity Value ($2005/Ton)

y = -0.0005x + 0.7159
R² = 0.4535
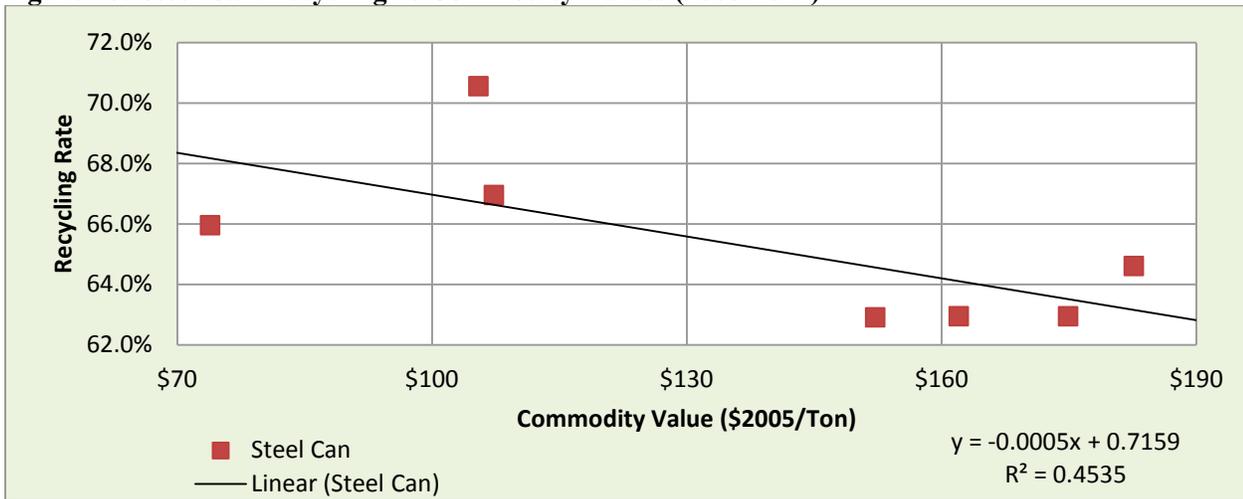
Figure 8a: Aluminum UBC Recycling vs Commodity Values (1990-1996)

y = 8E-05x + 0.461
R² = 0.0806
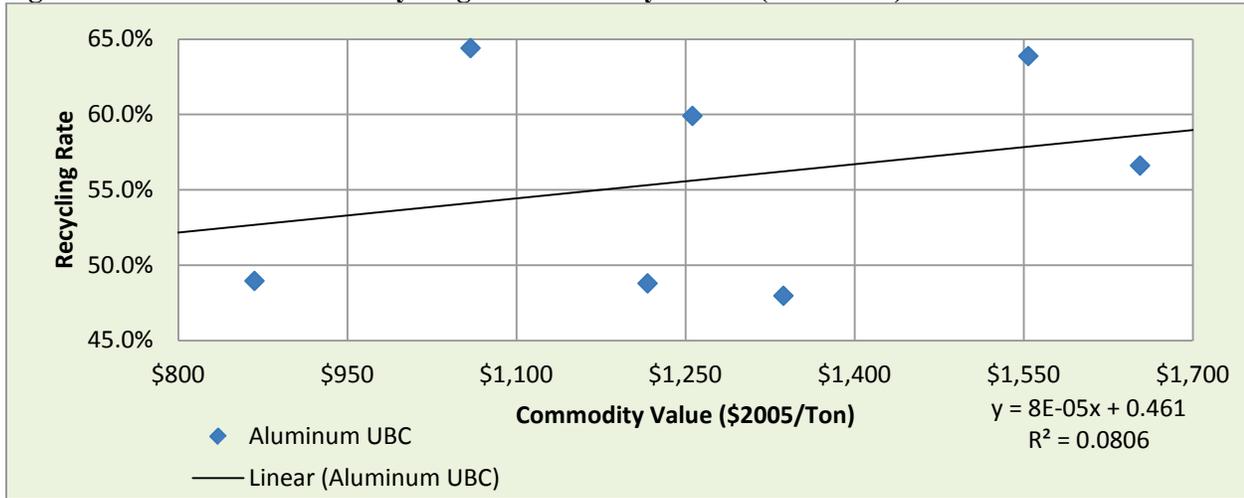
Figure 8b: Aluminum UBC Recycling vs Commodity Values (2005-2011)

y = -2E-05x + 0.5209
R² = 0.0262
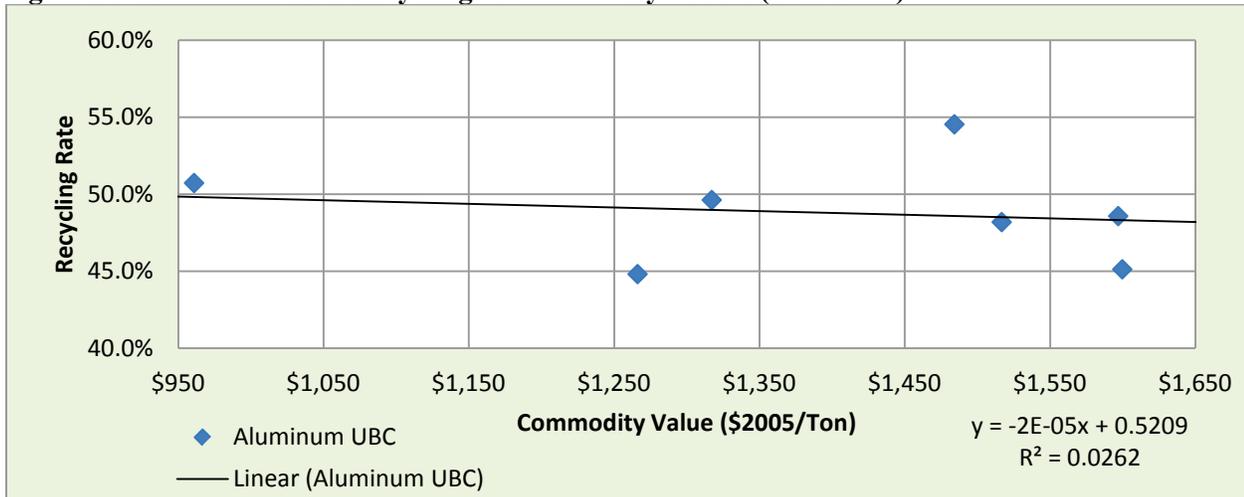
Figure 9a: Old Newspaper Recycling vs Commodity Values (1990-2011)

y = 0.0022x + 0.4991
R² = 0.1612

ONP

Linear (ONP)

* No data available for 1997-2002
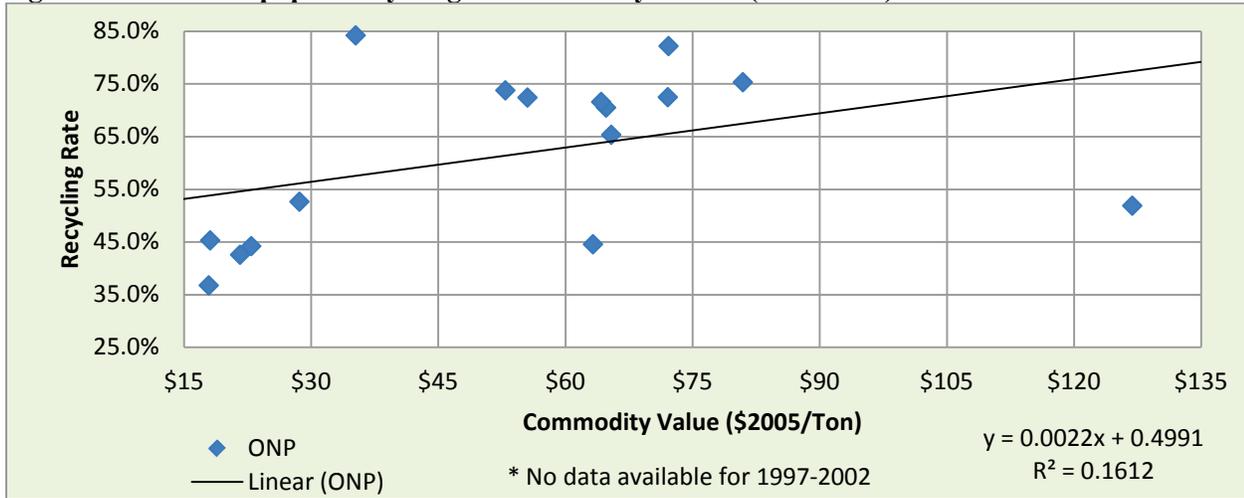
Figure 9b: Old Newspaper Recycling vs Commodity Values (2003-2011)

ONP

Linear (ONP)

y = -0.0015x + 0.8356
R² = 0.1183
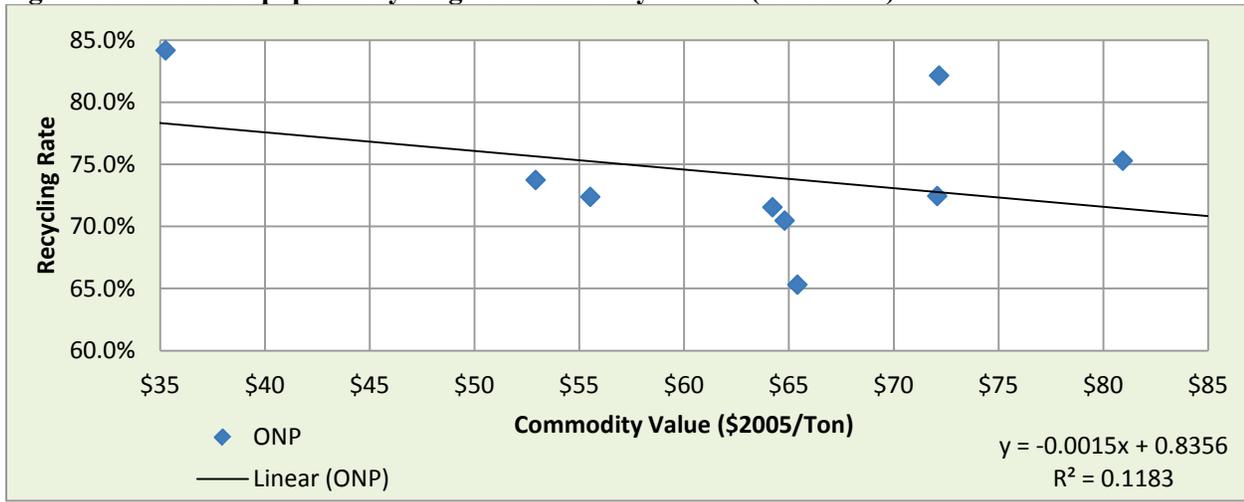
Figure 10a: Old Corrugated Container Recycling vs Commodity Values (1990-2011)

$y = 0.0017x + 0.5341$
$R^2 = 0.2647$
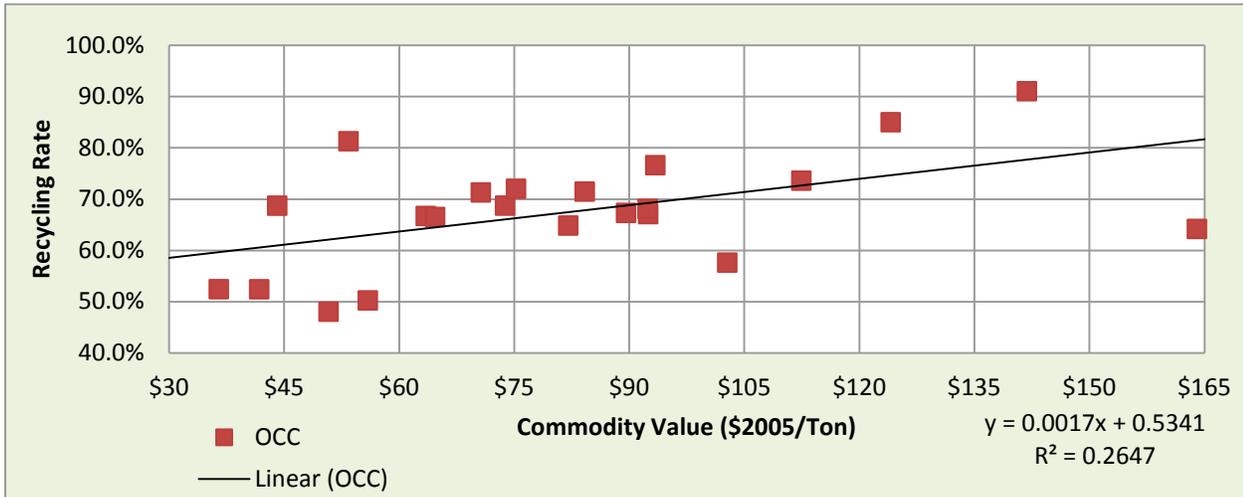
Figure 10b: Old Corrugated Container Recycling vs Commodity Values (1996-2011)

$y = 0.0018x + 0.5744$
$R^2 = 0.3678$
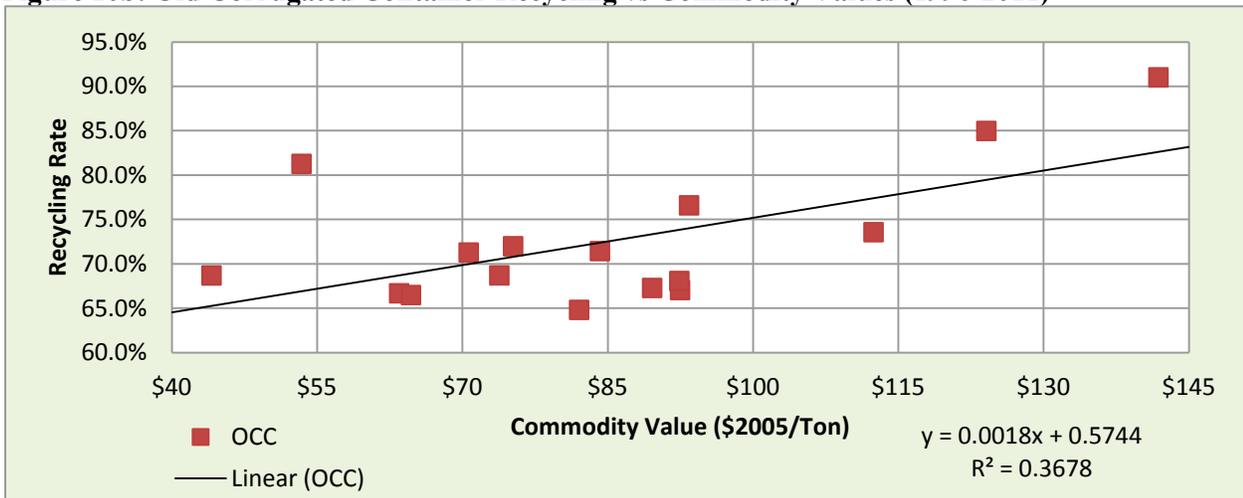
Figure 11: HDPE and PET Recycling Rates vs Time
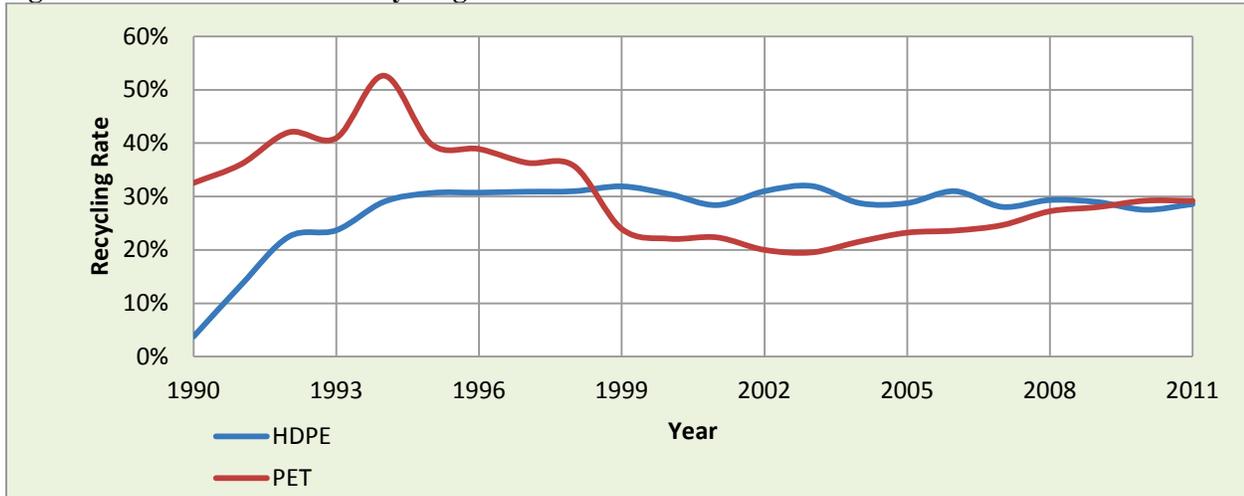
Figure 12: Aluminum UBC and Steel Can Recycling Rates vs Time
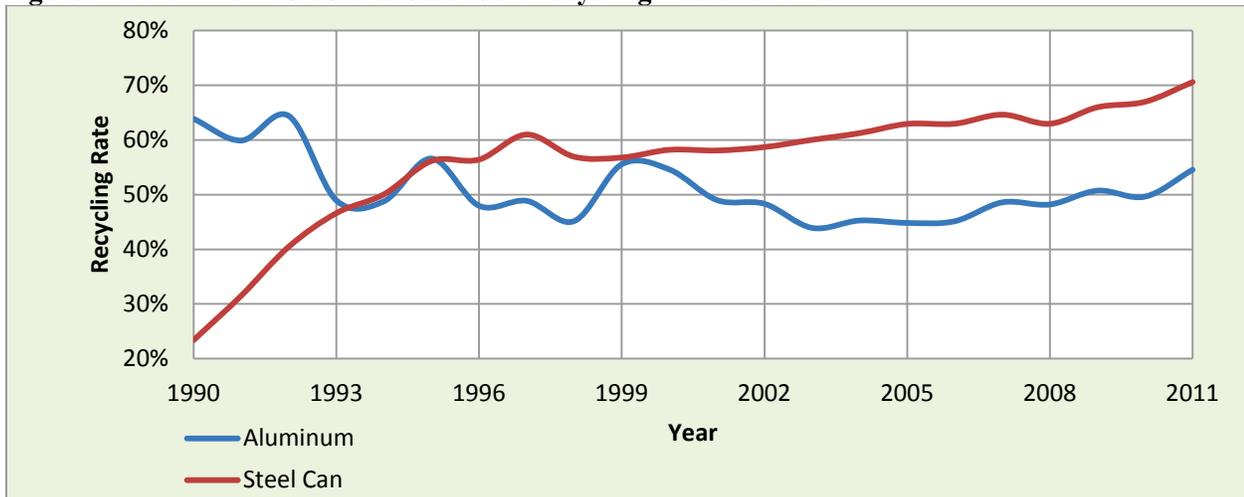
Figure 13: Old Newspaper and Old Corrugated Container Recycling Rates vs Time
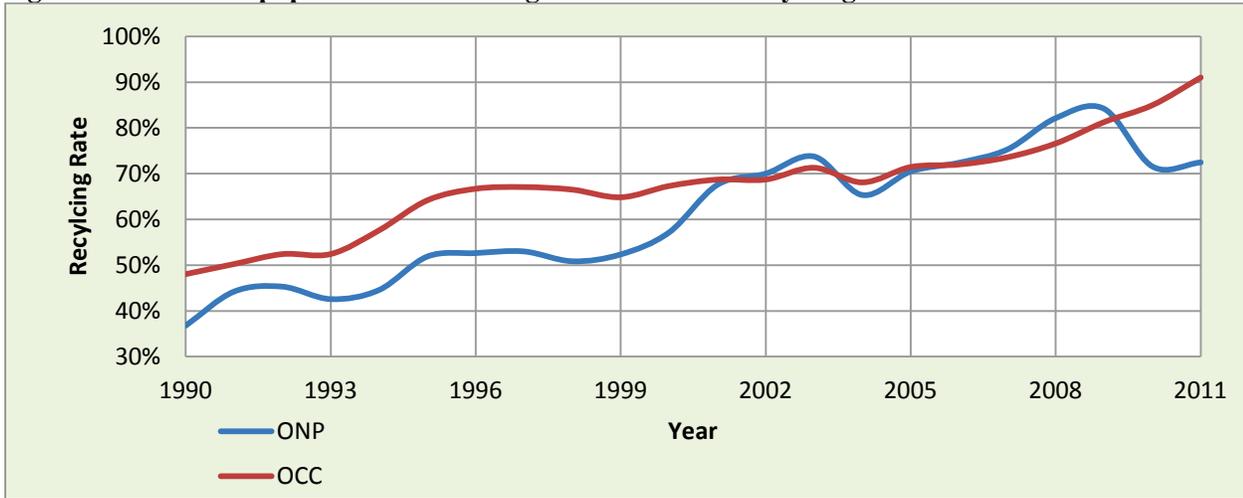
Figure 14: Indexed OCC Recycling Rates and Commodity Value
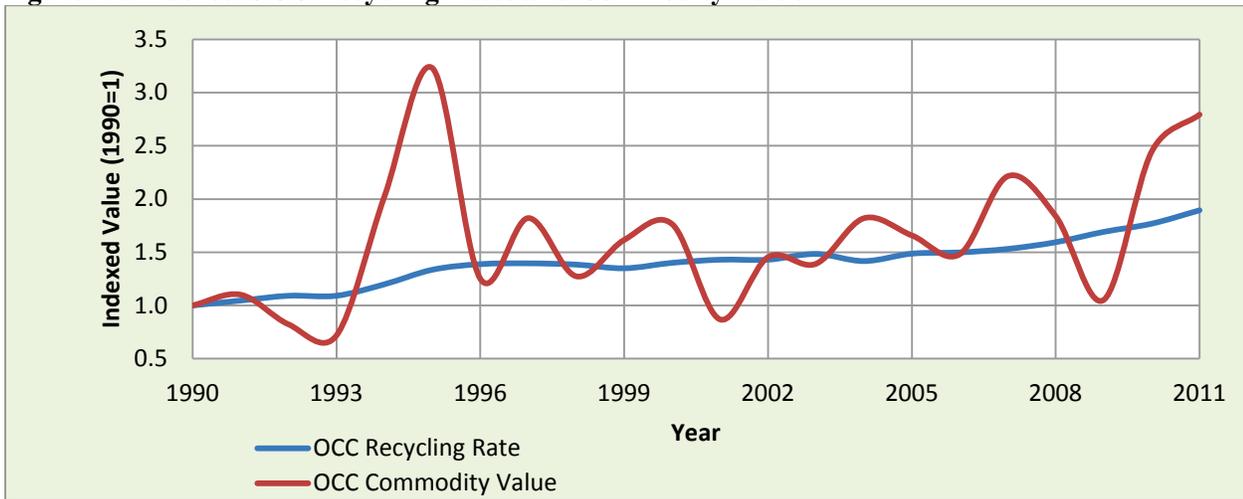
Appendix A: MSW Generation Versus Real PCE Insert

This was submitted to EPA under Task 12 and is included for reference.

Municipal Solid Waste Generation and Household Spending

Over the years, increases and decreases in the amount of MSW generated has typically imitated trends in American household spending on goods and services. Personal Consumer Expenditures (PCE) measures U.S. household spending on goods and services such as food, clothing, vehicles, and recreation services and accounts for approximately 70 percent of U.S. Gross Domestic Product, a key indicator of economic growth. Figure A-1 is an indexed graph showing the relative changes in real PCE ($2005), MSW generated (per capita and total), population, and MSW generation per real dollar of PCE ($2005) since 1960. The figure shows that real PCE has increased at a faster rate than MSW generation and that MSW generation per real dollar of real PCE has steadily declined since 1960.

Figure A-1. Indexed MSW Generated, Real PCE, and Population over Time (1960-2012)
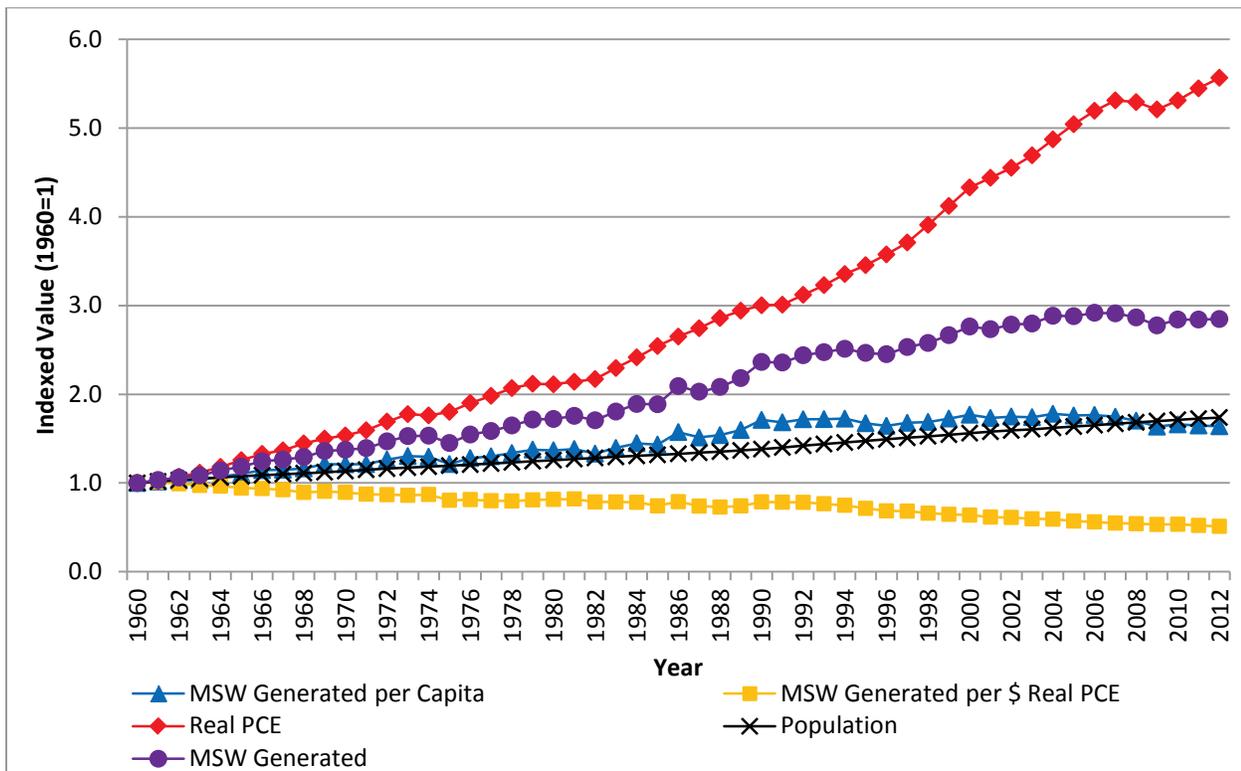

Figure A-2 shows a related figure of total MSW generation versus real PCE expenditures. This figure shows that MSW generation more than doubled from 100 million tons per year to 225 million tons per year as real PCE expenditures tripled from about $2 trillion to $6 trillion. Between real PCE expenditures of $6 trillion and $8 trillion, the increase in MSW generation versus real PCE is less drastic than at lower levels of real PCE. There appears to be little or no increase in MSW generation between real PCE expenditures from $8 trillion to $10 trillion.

Figure A-2. MSW Generate Versus Real PCE (1960-2012)