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RESOURCE RECYCLING

The Seattle Story

An in-depth study of commercial and residential disposal numbers over the past three decades shows how the Emerald City has progressed toward zero waste. **BY JEFF MORRIS AND LUIS HILLON**

Seattle's 2014 single-family recycling rate was 71.1 percent. And the city's overall rate when including multi-family, commercial and self-haul was 57.1 percent. How has the City hit those numbers?

Seattle Public Utilities uses economic and econometric modeling to better understand costs, benefits and trends in solid waste generation, and to measure results of programs to prevent waste and divert discards from disposal. One of these models is called QUIDPRO, short for quantitatively understanding the impacts of diversion programs for recyclables and organics.

QUIDPRO encompasses seven econometric equations tracking residential garbage, curbside recycling, curbside organics, apartment recycling, commercial garbage, self-haul garbage and self-haul yard debris. Each equation shows variations in monthly waste quantities as a function of a number of explanatory variables including collection days per month, household counts, business sales tax receipts, weather, season, collection fees, disposal fees, collection program characteristics and disposal bans.

Results for residential collections

Figure 1 on the next page portrays actual and estimated residential (single-family plus multi-family) monthly waste generation and disposal per household, per collection day. Dividing collection quantities by collection days adjusts for monthly differences in number of collection days. Dividing by household count separates out the effect of growth in the number of households from effects of other waste generation variables, such as household size, household income and weather.

Seattle's tracking of residential waste generation began in January 1989, when curbside recycling, apartment recycling and yard debris collections were all available. After Seattle instituted curbside diversion programs, collection quantities of single-family recyclables, apartment recyclables and subscription-based yard debris, along with collection quantities for residential garbage, accurately portray household waste generation. Garbage collection in Seattle is mandatory for all households and self-haul garbage quantities per household are not substantial.

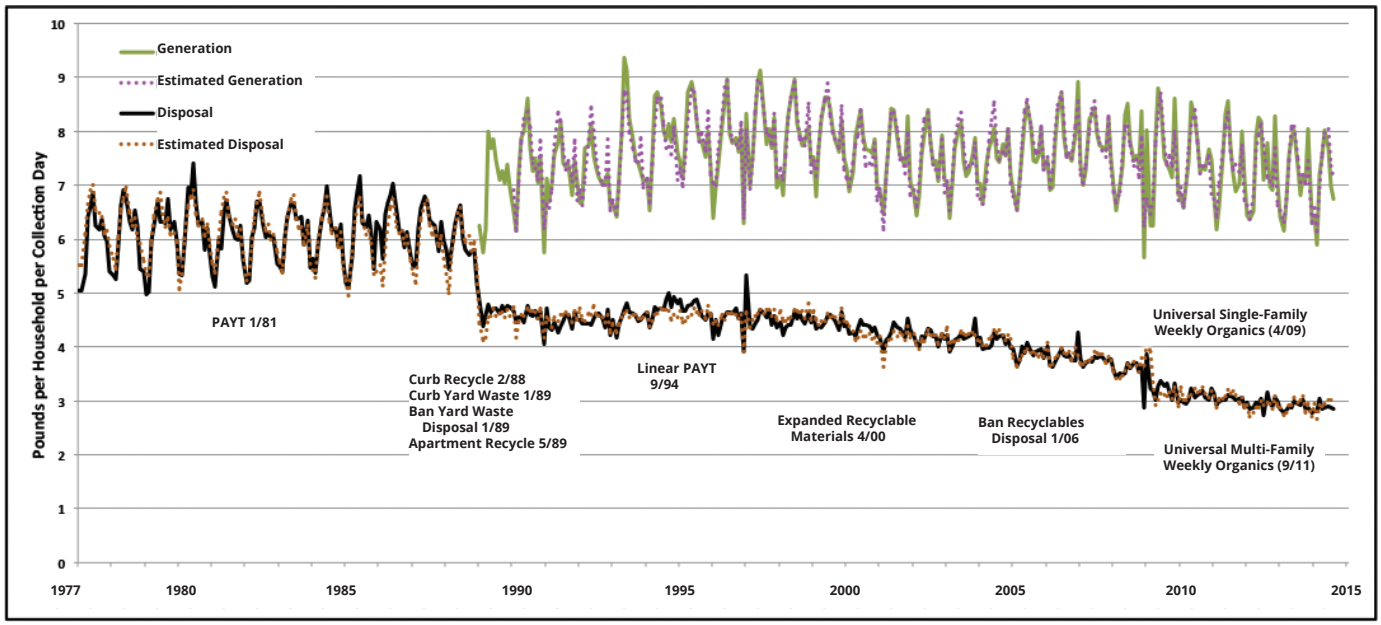
The first important result to note is that garbage disposal per household has dropped more than 50 percent, from 6.0 pounds per household per collection day in 1977 to 2.9 pounds in the most recent 12 months, shown on Figure 1.

The closely aligned movements between actual and estimated show the second important result: Generation and disposal are accurately tracked by variables used in the four QUIDPRO equations to explain fluctuations and trends in residential waste generation and disposal. All four equations identify significant seasonal effects. In addition, as indicated in Figure 1, residential garbage had significantly higher monthly variations prior to the advent of curbside yard debris collection in 1989.

All four equations identify at least one significant weather-related explanatory variable. For example, monthly precipitation, average temperature and snow all have statistically significant impacts on monthly residential garbage disposal. Organics collection is significantly affected by the preceding month's precipitation.

The third important finding is that collection fees are import-

Figure 1 | Seattle monthly residential (SF&MF) collected waste generation and disposal per household per collection day, 1977-2014



Residential garbage had significantly higher monthly variations prior to the advent of curbside yard waste collection in 1989.

ant for reducing disposal, but only when convenient diversion options are available. In 1977, the marginal (i.e., extra) cost for extra garbage was zero because Seattle charged a fixed fee for garbage unrelated to the garbage quantity that a household set out for pick-up on collection day. That changed in 1981 with pay-as-you-throw (PAYT) fees that required households to pay extra to set out larger collection containers. Marginal garbage costs increased periodically throughout the 1980s. In 1994, marginal costs went higher still when linear rates were instituted – for example, if a resident doubled a garbage container size, the garbage collection fee also doubled.

Marginal cost for garbage collection had statistically significant impacts on garbage collection quantities only after implementation of curbside recycling and yard debris collections in 1989, even though PAYT collection fees based on garbage container size took effect in 1981. In the absence of curbside diversion opportunities, PAYT's main effect was to reduce garbage container sizes without reducing the weight of garbage households put in those containers. This result of Seattle's initial PAYT fee structure was widely characterized in local and national media as the "Seattle Stomp" (because residents were clearly shoving as much material as possible into smaller containers). After 1988, price elasticity for single-family garbage collection has proved to be statistically significant at -0.16. That means, for example, a 10 percent increase in marginal cost reduces the single-family portion of residential garbage collection by 1.6 percent.

Meanwhile, the cross-price elasticity for curbside recycling with respect to marginal garbage fees is 0.40. So a 10 percent increase in marginal trash fees increases recycling collection by 4 percent. Curbside recycling is provided at no additional charge as one of the services bundled with garbage collection so there is no direct price elasticity for curbside recycling.

The price elasticity for single-family organics collection with respect to the price for extra yard debris materials is -0.07. The prices for curbside organics and single-family garbage collection were not statistically significant for the curbside organics equation. This is likely because a yard debris disposal ban was instituted when curbside yard debris collection began. In addition, mandatory pay organics collection for single-family households began in April 2009. An organics disposal ban instituted in January 2015 likely will further decouple organics diversion quantities from organics collection mandatory pay fees.

There are no significant explanatory price variables for multi-family recycling. Most likely this is because apartment building households do not see a direct connection between their monthly rental payments and the fees their building owner has to pay for garbage collection.

Multi-family organics collection quantities are reported with single-family organics collection quantities. Mandatory pay organics collection for multi-family households was instituted in September 2011. As a result, multi-family organics are increasing as a portion of overall organics diversion quantities.

Other statistically significant variables for residential collections include:

- Real household income, with income elasticities of 0.50 and 0.08 for single-family and multi-family recycling, respectively. In other words, as single-family household incomes increase by 10 percent, recycling raises by 5 percent. In the multi-family realm, a 10 percent income rise equates to a 0.8 percent increase in recycling.
- Unemployment rates, which reduce multi-family recycling by a few percentage points for every percentage point increase. (Unemployment did not prove to be significant for the other three residential collection equations.)
- Household size for residential garbage and single-family recycling.
- Economic events and City of Seattle regulatory requirements.

Economic events and regulatory requirements were interrelated during 2008

through 2014. Most recyclables were banned from disposal beginning in 2006 with early warnings on the ban throughout 2005. Mandatory pay single-family organics collection began in April 2009, with mandatory pay for multi-family organics collection following in September 2011. The 2008 financial crash and resulting economic recession, along with the closing of one of Seattle's two major newspapers in March 2009, were other important economic occurrences. Waste prevention measures such as packaging reductions/lightweighting and decreased printing and paper use also had impacts on generation and disposal in recent years.

Table 1 on page 16 shows the impacts of economic events, efforts by Seattle Public Utilities to continually reduce disposal and increase diversion, and other statistically significant influences. Residential garbage declined by 1.66 pounds per household per collection day, or 37 percent, between 1990 and 2014. Regulatory, programmatic and economic incentives/disincentives drove over 90 percent of this decrease. The closure of the major newspaper in 2009 may also have contributed to the decline in residential garbage, but the closure's garbage impact was muted because Seattle households already were diverting over 90 percent of newspapers from disposal. In any event, the overall decrease would have been even greater had demographic and weather variables not increased garbage disposal.

In that same 1990 to 2014 period, curbside recycling saw a 0.35 pound, or 14 percent, increase per single-family household per collection day. The newspaper closure, the influence of waste prevention measures and packaging material choices favoring lighter materials all caused decreases in curbside recycling collection quantities. Household income, household size and weather were associated with increased collection to an extent that almost offset the decreases from newspaper closure and packaging lightweighting efforts. The city's recyclables ban and increases in the marginal cost of garbage collection provided an increase in curbside of 0.40 pounds per household per collection day, offsetting the net decrease caused by external influences.

In addition, curbside organics collection grew by 1.94 pounds, or 101 percent, per single-family household, per collection day. Seattle Public Utilities initiatives explained more than half of the increase, with higher precipitation and temperatures in 2014 versus 1990 causing just under half. The comparison of 2014 with 1990 understates the importance of city initiatives in driving organics diversion because precipitation for 2014 was higher than in 80 percent of the years from 1990 through 2014.

The apartment recycling increase is mostly explained by on-site recycling availability. Less than 10 percent of multi-family households had on-site recycling access in 1990, but more than 97 percent had access by 2014. The ban on disposal of recyclables in garbage also aided the apartment recycling increase. These initiatives explain virtually all the 14-fold increase in apartment recycling per household per collection day to 1.31 pounds by 2014.

Table 1 | Explanation of changes from 1990 to 2014 in residential collection quantities

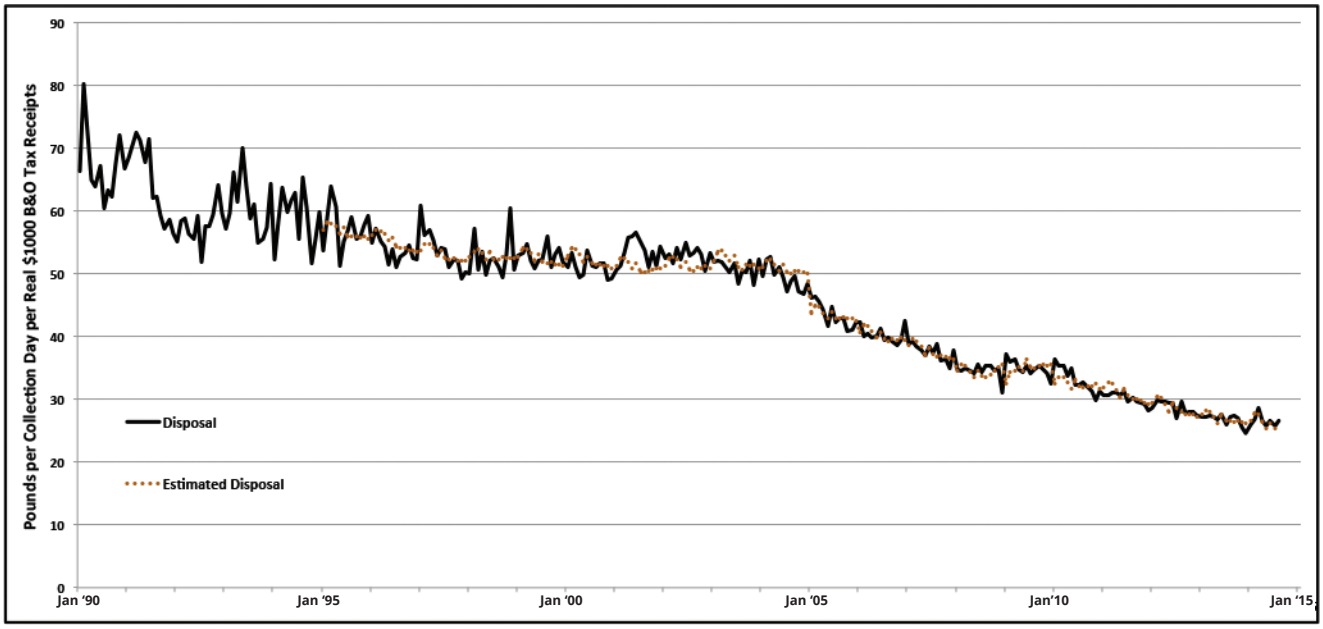
Time frame for averages	Average pounds per household per collection day			
	Garbage per SF + MF household	Curbside recycling per SF household	Curbside organics per SF household	Apartment recycling per MF household
January 1977 to December 1977	5.96	NA	NA	NA
January 1987 to December 1987	6.18	NA	NA	NA
January 1990 to December 1990	4.54	2.44	1.92	0.09
September 2013 to August 2014	2.88	2.79	3.86	1.31
2014 vs. 1990 change in averages	(1.66)	0.35	1.94	1.22
Explanatory variables	Increase/(decrease) in averages caused by indicated variable			
Regulatory/programmatic				
Mandatory pay SF organics	(0.92)	NA	1.42	NA
Recyclables ban	(0.33)	0.12	NA	0.11
Biweekly recycling, carts, materials	(0.28)	*	NA	NA
Mandatory pay MF organics	(0.12)	NA	0.13	NA
Miscellaneous waste prevention	(0.12)	(0.27)	NA	*
Apartment recycling availability	NA	NA	NA	1.16
Economic				
Marginal garbage collection cost	(0.05)	0.28	*	NA
Organics extras cost	NA	NA	(0.52)	NA
Real household income	*	0.46	*	0.02
Unemployment rate	*	*	*	(0.02)
Newspaper closure	*	(0.30)	NA	(0.02)
Demographic				
Household size	0.11	0.01	*	*
Weather				
Precipitation	(0.00)	*	0.91	*
Temperature	0.02	*	0.02	*
Snow	0.03	0.02	*	*
Other/unexplained	0.00	0.03	(0.02)	(0.04)

Notes: * = not statistically significant; NA = not applicable; SF = single-family; MF = multi-family

Results for commercial garbage collection

Figure 2 portrays actual and estimated monthly commercial garbage collection pounds per collection day, per price and

Figure 2 | Seattle monthly commercial collected waste disposal per collection day per real $1,000 B&O tax receipts, 1990-2014



tax rate adjusted $1,000 of business and occupation (B&O) tax receipts. Commercial garbage collection per business depends on business size. Hence normalization by a measure of business size such as sales activity provides a more accurate portrayal of garbage quantity for the average business than would normalization by number of businesses. The QUIDPRO equation for commercial garbage explains over 99 percent of the variations over time in commercial disposal.

Here's an example of how this math works out. Consider a business that has monthly sales of $1 million, disposal of 6,000 pounds for a month (20 collection days possible), and monthly B&O taxes (at 1.5 percent) of $15,000. Its normalized disposal figure is (6,000/20)/(15,000/1,000). This equates to 20 pounds per collection day in the month per $1,000 of B&O tax receipts. Compare that to a more disposal-intensive company that has monthly sales of $1 million and disposal of 15,000 pounds per month. Its normalized disposal is (15,000/20) divided by (15,000/1,000), or 50 pounds per collection day per $1,000 of tax receipts.

In Seattle, commercial garbage per $1,000 of tax receipts declined 52 percent between 1995 and the 12 months ending August 2014, from an average of 57.3 pounds to 26.4 pounds per collection day. As was the case for the decline in residential garbage, the decline in commercial garbage was mainly driven by city initiatives, especially the recyclables disposal ban beginning in 2006. The exact extent to which the disposal ban contributed to this decline, however, is difficult to estimate due to the coterminous financial crash in 2008 and the following recession, the newspaper closure in 2009, and industry-wide waste prevention measures that may have gained in extent as the recession began to wind down.

The real tip fee at Seattle transfer stations for garbage self-hauled in trucks is a significant explanatory variable. When that tip fee goes up, it tends to drive some self-haulers to make greater use of commercial garbage collection services. When the real tip fee falls due to price inflation over time, on the other hand, some commercial garbage generators eventually move back to self-hauling. Between 1995 and 2014 the real tip fee for self-hauled garbage actually declined by 4 percent due to price level inflation. The estimated cross-elasticity for commercial garbage collection with respect to real self-haul tip fees averaged 0.88 over this time period, indicating that commercial garbage collection quantities are sensitive to transfer station disposal fees.

A counterintuitive finding is that unemployment is positively correlated with commercial garbage collection quantities. This may be because commercial waste disposal lags behind sales increases or decreases. This would result, for example, in normalized commercial garbage not increasing right away when employment turns up. This lag effect could be extended or reinforced if a recession causes companies to pursue more efficient waste management practices that remain in effect when the economy recovers, resulting in permanently lower normalized garbage disposal. In that way recessions may work like permanent waste prevention programs.

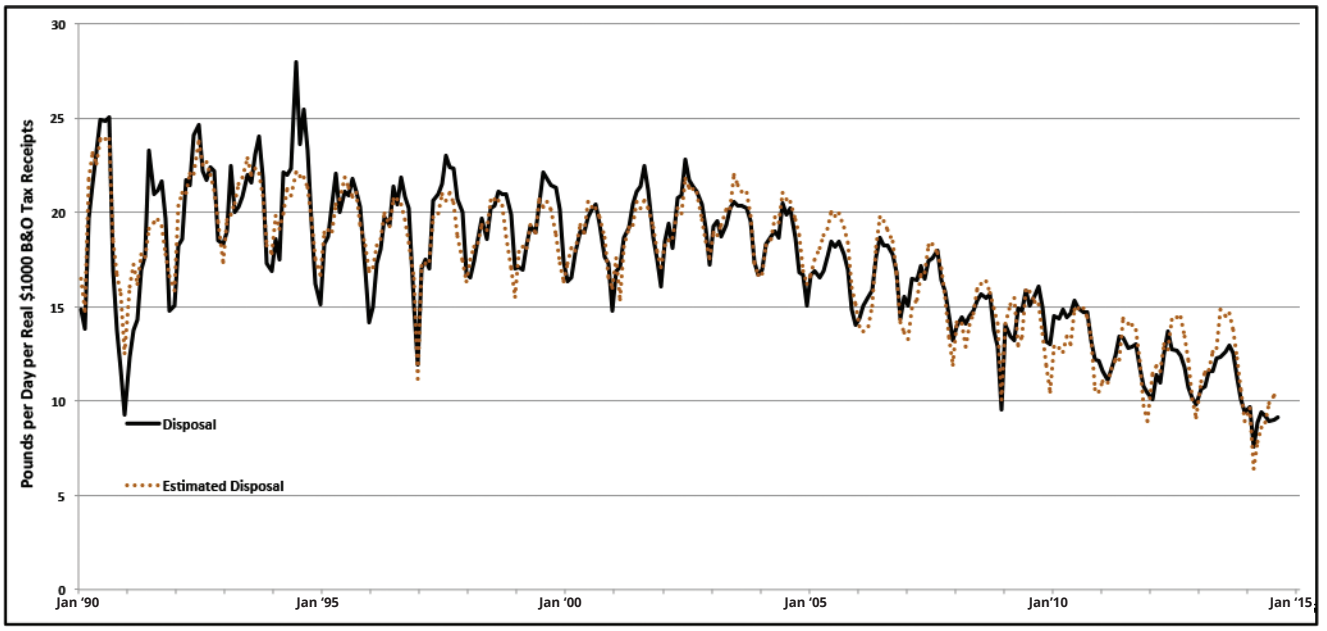
Results for self-haul garbage

Figure 3 on the next page portrays actual and estimated monthly self-haul garbage disposal pounds per day per price and tax rate adjusted $1,000 of B&O tax receipts. Self-haul garbage is well-normalized by tax receipts and number of days in a month that Seattle transfer stations are open. The QUIDPRO equation explains over 99 percent of variation over time in self-haul garbage.

Monthly self-haul garbage per $1,000 of tax receipts declined 48 percent between 1990 and the 12 months ending August 2014, from an average of 18.3 pounds to 9.6 pounds per day. This decline in self-haul garbage per $1,000 of tax receipts was mainly driven by initiatives implemented by the city, especially the recyclables disposal ban beginning in 2006 and mandatory pay single-family organics beginning spring 2009.

In addition, the closure of Seattle's

Figure 3 | Seattle monthly self-haul waste disposal per day per real $1,000 B&O tax receipts, 1990-2014



north transfer station for reconstruction beginning in January 2014 likely drove some self-haul garbage to King County transfer stations – the closure accounted for 35 percent of the decrease from 1990 to 2014. Decreases motivated by city initiatives and the transfer station closure totaled 11.0 pounds per day.

Decreases were offset somewhat by temperature increases and snowfall decreases as well as by an increase in the unemployment rate. Seattle's low flat rate for self-haul garbage delivered in cars compared with King County's transfer stations' tip fee also provided an increase in self-haul garbage approximately equal to the increases related to weather differences and increased unemployment. Weather caused a 0.3-pound increase; unemployment a 0.8-pound increase; and the comparative transfer station fees a 1.2-pound increase.

Finally, it is worth noting that for both commercial and self-haul garbage, the positive correlation with unemployment may be the result of some other factor (such as the composition of businesses serving Seattle) that is also positively correlated with the unemployment rate. Without time series data on garbage generation by business type and on business type employment, the QUIDPRO equations could not isolate the impacts of the shifting nature of businesses located in Seattle. RR

Jeffrey Morris, Ph.D., is an economist with Sound Resource Management Group in Olympia, Wash. He can be contacted at jeff.morris@zerowaste.com. Luis Hillon, MSc., is an economist with Seattle Public Utilities in Seattle.

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