King County
Department of
Natural Resources and Parks
Solid Waste Division

Single-Family Residential Solid Waste Collection Practices in King County

Collection Program Characteristics and Best Practices for Waste Minimization and Diversion Maximization

Final Report – December 2003

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I. Executive Summary

King County Department of Natural Resources and Parks' Solid Waste Division contracted with Sound Resource Management Group, Inc. (SRMG) to conduct a study of the characteristics of solid waste collection services provided to single-family residential households in the county, and the successes and challenges of those services in minimizing waste generation and maximizing diversion of waste from disposal. This executive summary and the following report are the result of that study.

In the year 2000 every single-family residential household in King County had access to solid waste collection services, with the exception of several thousand households located in remote mountainous areas. During 2000, 90% of those single-family households -- 400,000 in total -- subscribed to garbage collection service. Most single-family garbage collection service subscribers also had available curbside recycling and yard debris collections.

In fact, over 387,000 single-family households had curbside recycling collection available at no additional charge beyond what they paid for garbage collection, and over 70,000 of these households also had available no-additional-charge yard debris collection. These counts for no-charge service illuminate the fact that less than 20% of single-family households had both recycling and yard debris collections bundled with their garbage service fees. In addition, households in several cities did not have curbside recycling service available, and households in several cities plus one unincorporated county hauler service area (HSA) had no curbside yard debris collection available. Other characteristics of solid waste collection services in the year 2000 -- such as garbage collection fees, recycling and yard debris collection frequency and recycling collection container sizes -- also varied substantially among King County's 39 incorporated cities (including Seattle) and 9 unincorporated county solid waste collection HSAs.[1]

In the 32 cities and 8 unincorporated county HSAs where all three collection services were available in 2000, the average household generated 2,924.5 pounds of solid waste for collections, including 1,469.3 pounds for curbside/alley garbage collection, 797.8 pounds for curbside recycling and 657.4 pounds for curbside yard debris collection. This represents an average diversion rate for collected solid waste of 49.8%.

As shown in Figure ES-1, *Average Collected Waste Generation & Diversion Per Household in 2000*, generation of waste for collection by the average household ranged from a low of 1,508 pounds in the City of Snoqualmie to a high of 4,796 pounds in the City of Clyde Hill.[2] Garbage collections for the average household ranged between 952 pounds in Snoqualmie and 2,566 pounds in the City of Auburn. Annual curbside recycling collection for the average household ranged from a low of 130 pounds in SeaTac Disposal's portion of the City of SeaTac to a high of

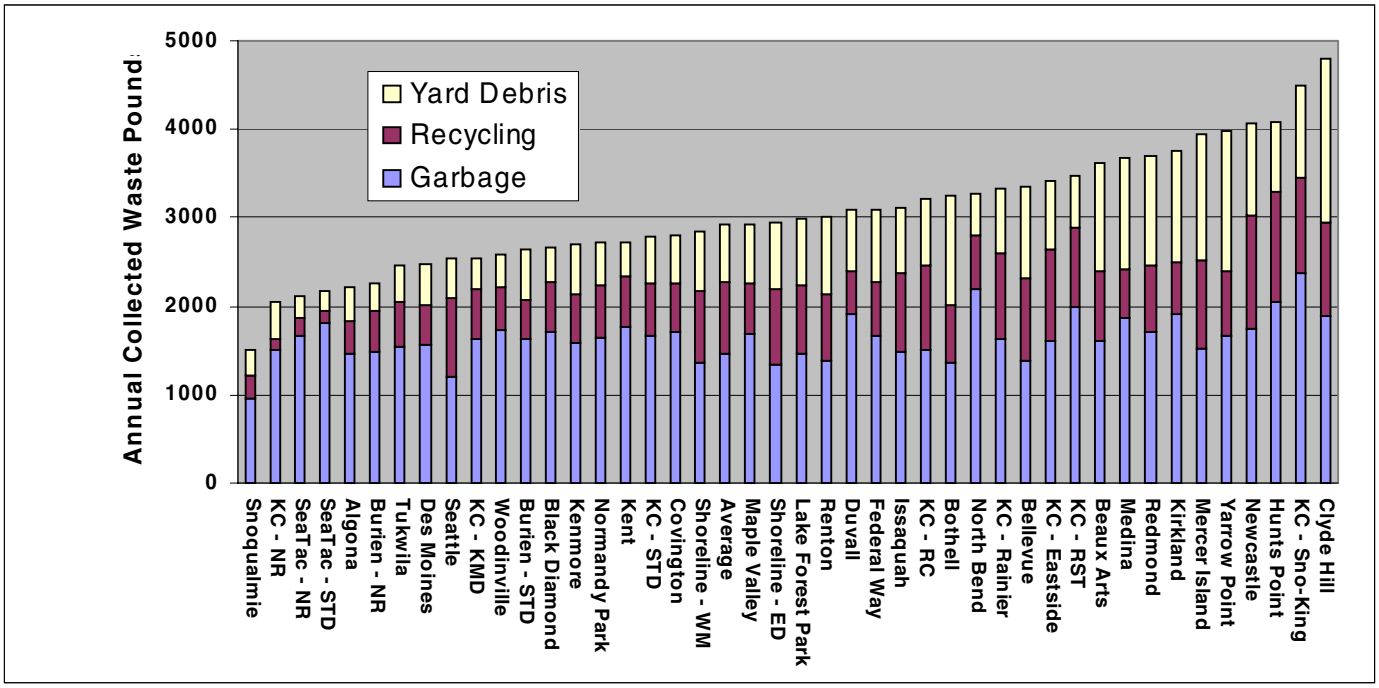
[1] The King County solid waste system does not include the City of Seattle, which prepares and is guided by its own solid waste management plan. We have included Seattle in this analysis because good data are available and because Seattle's collection system is comparable to systems used in parts of King County.

[2] The actual cities and unincorporated areas displayed in a particular graph vary from figure to figure throughout this report depending on availability of the service offering depicted in a particular graph and/or the availability of data used to compute the quantitative measure displayed in a particular graph.

1,280 pounds in the City of Newcastle. Curbside yard debris collections for the average household ranged between 222 pounds for the year in SeaTac Disposal's HSA in SeaTac and 1,853 pounds in Clyde Hill.

Mercer Island households diverted the most collected waste from disposal, achieving a diversion rate of 61.4%. At 16.2% SeaTac Disposal's service area in the City of SeaTac came in with the lowest diversion rate for collected solid waste.

Figure ES-1
Average Collected Waste Generation & Diversion per Household in 2000
King County City (32) and Unincorporated County (8) Hauler Service Areas



This diversity among city and unincorporated county HSAs in collection quantities and diversion rates is also typical of the variation in demographic and geographic characteristics for households in the various areas, as well as for solid waste collection program characteristics and collection fees. These differences among service areas provide fertile ground for one of this study's main objectives – sorting out what worked best in the year 2000 to minimize solid waste generation and maximize diversion for single-family residential solid waste collection service subscribers.

To this end SRMG and Solid Waste Division staff drew up a survey instrument. Solid Waste Division interns and staff carried out much of the actual survey work and provided that information to SRMG so that we could:

- Create graphical and tabular portrayals of solid waste collection system characteristics, as well as of demographic and geographic characteristics, for single-family households.

- Conduct statistical analyses that identify best solid waste collection practices.
- Produce this report.

King County Department of Natural Resources and Parks' Geographic Information Systems Center staff contributed to the effort by developing Census 2000 census block level data, along with information on lot size and house footprint from the King County Assessor's Office, into measures of average (mean and/or median) single-family residential household size, yard size, appraised valuation, income, and English speaking capabilities for each of the cities and unincorporated county HSAs.[3] These averages for each jurisdiction were used as control variables in SRMG's statistically based identification of best solid waste collection practices. For example, income and yard size were used as control variables to help prevent best practices from being incorrectly associated too strongly with collection program characteristics and collection fees and fee structures used in those jurisdictions having the highest incomes and largest yards.

I.A. Solid Waste Collection Program Characteristics and Fees in King County Communities

With one exception, King County cities and unincorporated HSAs in 2000 provided refuse collection services to single-family households on a user pay basis at fees that varied with the volume of refuse set out for collection. The one city Kirkland that in 2000 provided collection of a basically unlimited quantity of refuse for a flat monthly fee switched to volume based collection fees beginning April 2002.

Figure ES-2, *Average Monthly Bill for Garbage Collection in 2000*, shows the average monthly bill for refuse collection paid by single-family household residential solid waste collection service subscribers in the county's cities and unincorporated areas. Average monthly bills ranged from $12.84 in Auburn to $29.41 in the City of Carnation. With the exception of the two cities that averaged above $25 and the five that averaged below $15, households in city and unincorporated county service areas paid garbage bills that averaged between $15 and $25 per month.

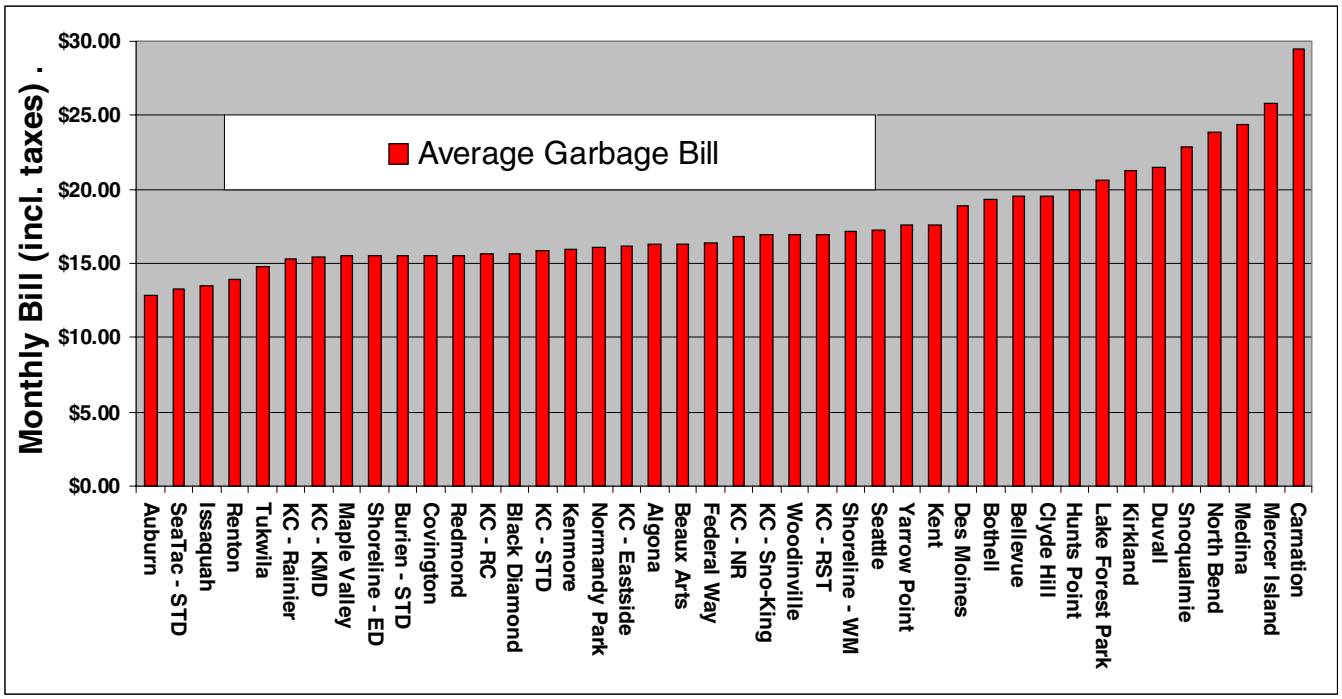
With very few exceptions, households that subscribed for refuse collection service also received curbside recycling collection at no additional charge – i.e., in the parlance of the solid waste management industry, recycling collection was typically bundled with refuse collection so that recycling costs were embedded in refuse collection fees. Two of the four cities, Auburn and Carnation, that provided no curbside recycling in 2000, instead offering households the opportunity to use drop-off recycling locations for no charge, began providing curbside recycling at no additional charge to refuse collection households in January 2002.[4] The one city, SeaTac, which

[3] Graphs portraying each city and unincorporated HSA's average per household for these demographic and geographic characteristics are in Appendix 1.

[4] For the twelve months July 2002 through June 2003, the average single-family household in Auburn generated 3,256 pounds of collected waste, including 1,673 pounds of garbage, 694 recycling, and 889 pounds of yard debris, for a diversion rate of 48.6%. This compares with 2,566 pounds of collected refuse and 755 for yard debris in 2000 when Auburn did not offer curbside recycling collection. Although this is a single example, it still tends to illustrate the impact on refuse collection and diversion of curbside recycling compared with drop-off recycling, even when the drop sites are so numerous that no household is more than a mile from a drop site as was the case for Auburn in 2000.

in 2000 charged a subscription fee to households that signed up for curbside recycling, began in April 2001 to offer that service at no additional charge to refuse collection subscribers.[5]

Figure ES-2
Average Monthly Bill for Garbage Collection in 2000
King County City (33) and Unincorporated County (8) Hauler Service Areas



In addition, eight cities provided yard debris collection to single family refuse collection subscribers at no additional charge beyond the monthly fee that each household had to pay for refuse pick up.

At the present time only one HSA in the unincorporated county, Vashon Island, still charges a subscription fee for curbside recycling. Pacific and Skykomish remain the only cities not offering curbside recycling. In those two cities curbside recycling remains unavailable either bundled with refuse collection or on a separate subscription fee basis. Finally, several thousand households in remote mountainous regions of the county continue to have to self-haul their discards to convenience sites, transfer stations and/or privately operated drop-off recycling centers.

[5] For the twelve months July 2002 through June 2003, the average single-family household in SeaTac Disposal's HSA in SeaTac generated 2,464 pounds of collected waste, including 1,688 pounds of garbage, 483 recycling, and 292 pounds of yard debris, for a diversion rate of 31.5%. This compares with generation of 2,168 pounds, including 1,816 for refuse, 130 for recycling, and 213 for yard debris in 2000 for a diversion rate of 18.9% when SeaTac Disposal charged a subscription fee for curbside recycling collection. The fact that both generation and recycling increased while garbage decreased, but by less than the increase in recycling, is again a single example but still illustrative of the trade off between generation and diversion that appears to result from current collection program characteristics and fees. This is discussed in this Executive Summary and in greater detail in the following report.

In addition to the level of garbage collection fees, another aspect of collection fee rate structures that proved significant for explaining the level of waste collection quantities in 2000 was the degree to which garbage collection fees increased as garbage collection container and collection frequency increased. One way to characterize this aspect of rate structures is by the ratio of the fee for weekly collection of two 32-gallon cans of refuse to the fee for one can. 54% of single-family residential garbage service subscribers in King County used the one can weekly service level in 2000. The ratio of the two-can to one-can fees is, thus, a natural indicator of the incentive provided by a community's rate structure to motivate households not to go above the service level used by a majority of King County single-family households.

Figure ES-3
Incremental Rate Incentives in Garbage Fees in 2000
King County City (35) and Unincorporated County (8) Hauler Service Areas

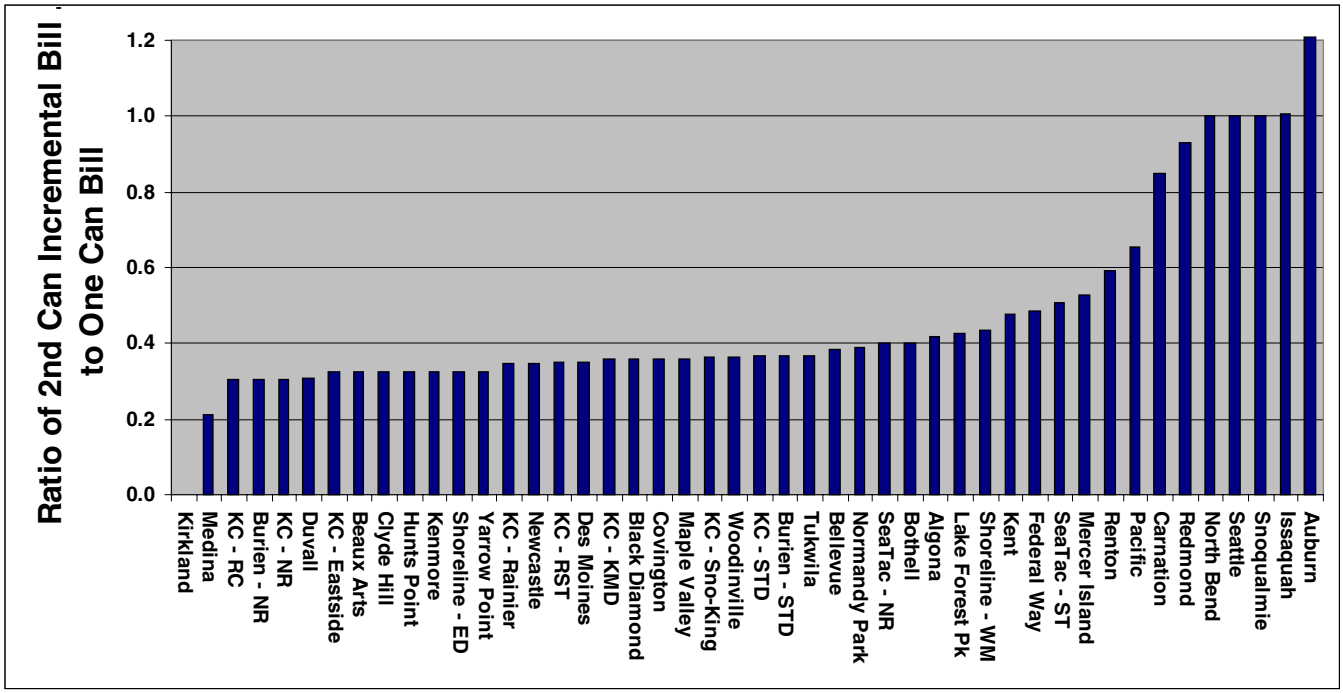


Figure ES-3, *Incremental Rate Incentives in Garbage Fees in 2000*, shows a variant of the two-can to one-can fee ratio. The index shown in Figure ES-3 was calculated by subtracting one from the two-can to one-can fee ratio, so that a zero indicates that two cans cost the same as one can service. For example, Kirkland had a flat rate structure in 2000 with households paying the same fee regardless of how much garbage they set out for collection each week. Its incremental fee for two cans versus one can is zero, as indicated in Figure ES-3.

Collection rate structures that have collection fees that are directly proportional to collection container size and collection frequency are often called "linear" rate structures. As indicated by communities with a one in Figure ES-3, four cities had strictly linear rate structures in 2000, while Auburn had a more than linear structure and Redmond and Carnation were close in that their incremental-second-can to one-can fee ratio was above 0.8.

Garbage rate structures with collection fees that directly reflect local costs of managing refuse set out in a particular collection container size at a particular collection frequency are often called "cost-of-service" rate structures. The Washington Utilities and Transportation Commission requires haulers serving regulated areas within Washington, such as the unincorporated areas of King County, to use cost-of-service rate structures. The unincorporated county HSAs in 2000 had rate structures with ratios in Figure ES-3 between 0.30 and 0.37. In addition, as shown by areas with ratios between 0.4 and 0.8 in Figure ES-3, eleven cities in 2000 used rate structures that were between the strictly cost-of-service and linear or nearly linear.

Besides availability of the three collection services and the level and structure of fees charged for those services, there are numerous other characteristics of collection programs that were surveyed and that are discussed in the following report. These include refuse collection frequency and container size options, mandatory refuse collection, collection frequency and container sizes for recyclables and yard debris, type of materials targeted for recycling, and quantity limits on yard debris and the imposition of extra charges for amounts of yard debris that exceed those limits. We leave it to interested readers to peruse our report for details on whether and to what extent these program characteristics affected collection quantities.

I.B. Determinants of Collection Quantities in 2000

By employing a statistical technique called multiple linear regression analysis, we were able to use the demographic and geographic data on households and the survey data on collection system characteristics and collection fees to sort out which of many possible factors actually had a significant impact on collection quantities. Statistical analysis identified the following factors as significant determinants of collection quantities for at least one of the three collection streams -- garbage, recycling or yard debris -- in King County cities and unincorporated county HSAs in 2000:

- Demographics – Household size and income.
- Geographics – yard size.
- Prices – subscription prices for garbage, recycling and yard debris collections, and the incremental charge for weekly collection of a second 32-gallon can of garbage.
- Garbage rates designs – linear versus cost-of-service rate structures.
- Collection frequencies – weekly vs. biweekly curbside recycling and weekly vs. biweekly curbside yard debris collections.
- Collection container sizes for biweekly recycling – 90/96-gallon wheeled carts vs. smaller containers.[6]

Table 1 in the following report lists the significant estimates for per unit impacts from each of these variables on the three collection streams. Figure ES-4, *Determinants of Garbage, Recycling & Yard Debris Collections in 2000*, summarizes the average impact of each variable on collection quantities. The figure shows how variables such as household size that increase collection quantities for all three streams stack up against other variables such as garbage collection

[6] In 2000 all weekly curbside recycling programs in King County used bins; none used large wheeled carts. For this reason we were not able to evaluate the effect of using large wheeled carts in a weekly curbside recycling program.

prices that decrease garbage quantities and at the same time increase yard debris quantities. The shorter, solid-colored bars shown in Figure ES-4 for each collection stream portray how these increases and decreases net together to yield the averages shown at the top of each solid-colored bar for household garbage, recycling and yard debris collection quantities in 2000 for the 36 collection areas in our statistical analyses.[7]

As indicated on Figure ES-4, the number of persons in a household had the biggest effect on garbage collection quantity, and also had a substantial effect on recycling and yard debris collections. After household size, garbage and yard debris collection fees accounted for the next biggest effects on collection quantities, followed closely by household median income and yard size.

Diversion program characteristics such as collection frequency for recycling and yard debris had smaller effects. The height of bar sections shown in Figure ES-4 depends on both the impact coefficient and the average value for the variable. The average value for yes-no characteristics, such as does the community use weekly collection or not (biweekly collection being the alternative for King County communities not using weekly collection), is the proportion of communities employing that characteristic. Despite the fact that these characteristics had big impacts for those communities that used them, as indicated by the coefficient estimates in Table 1 of the following report, relatively few communities employed any given one of these characteristics.

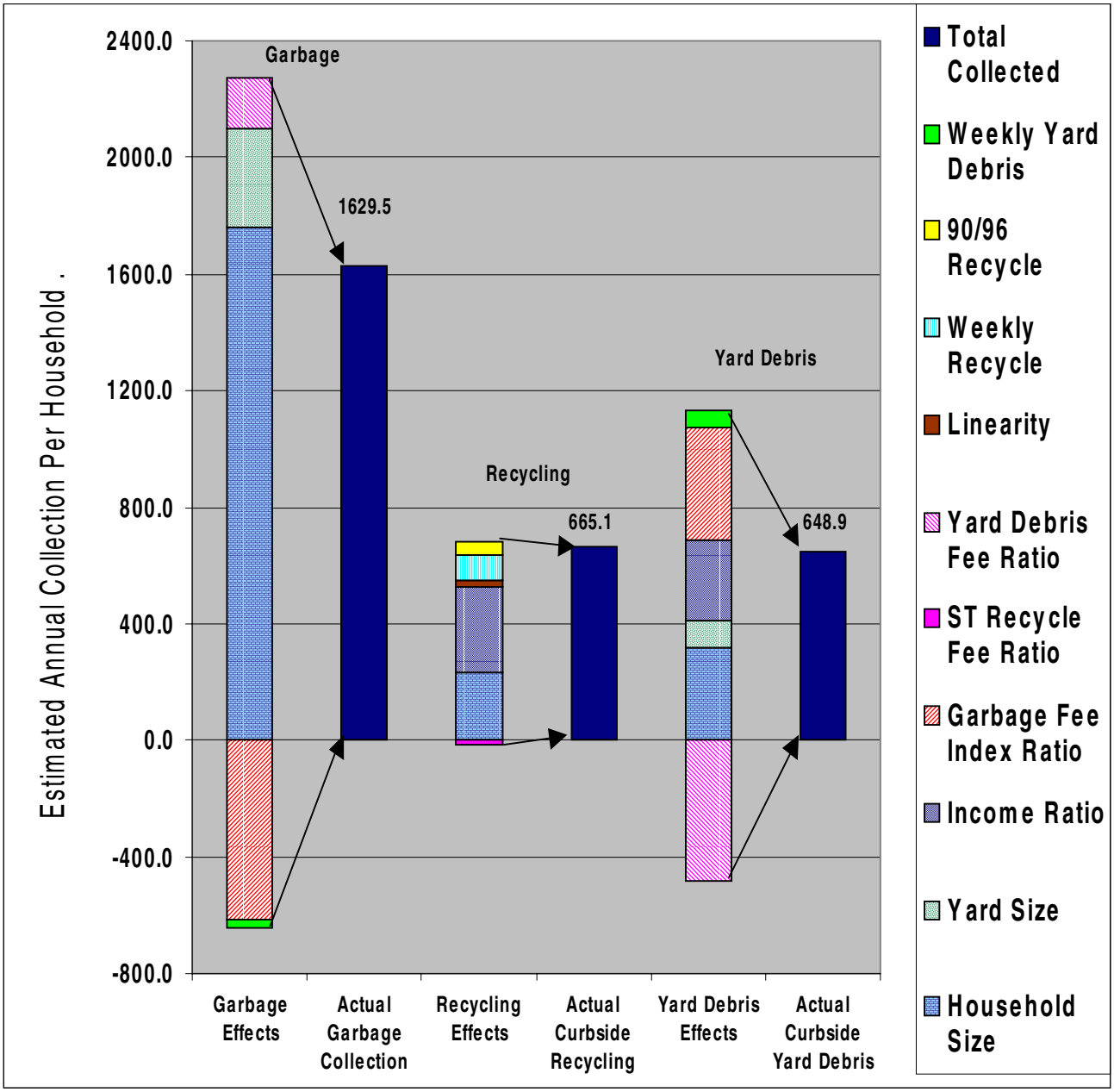
The statistical analysis also sorted out collection program characteristics that did not turn out to be significant for any of the collection streams in 2000. These were:

- Mandatory garbage collection.
- No availability of reduced frequency garbage collection services, such as one 32-gallon can collected biweekly or monthly.
- Yard debris collection of more than one 90/96-gallon container only at an additional charge.
- Unlimited yard debris set out quantities.
- Weekly yard debris collection throughout the year rather than decreasing to biweekly December through February.
- Percentage of households in the collection service area that are linguistically isolated.[8]

[7] Multiple linear regression analysis yields per unit impact estimates that add up to the actual sample average collection quantities when the estimated impacts per unit are multiplied by sample average levels for each determinant, as was done to produce Figure ES-4. The averages shown in Figure ES-4 are averages across the 36-area subsample of city and unincorporated county HSAs used for our statistical analyses. These averages are, thus, averages of household averages for each city and unincorporated area. They are simple averages in that they were not weighted by the number of household garbage subscribers in each city. By contrast, the countywide average collection quantities per household reported earlier in this Executive Summary are weighted averages, because in computing the countywide average each jurisdiction's average was weighted by the number of garbage subscribers in that jurisdiction. Unlike simple averages, weighted averages are heavily influenced by larger cities, such as Bellevue and Seattle.

[8] As defined for the 2000 Census, a household is linguistically isolated if all persons in the household 14 years or older speak a non-English language and all these persons also have difficulty with English

Figure ES-4
Determinants of Garbage, Recycling & Yard Debris Collections in 2000
(Pounds per household per year)



The statistical significance of one variable was indeterminate -- collection for recycling of materials in addition to the countywide standard targets (newspaper, cardboard, mixed paper, glass containers, steel and aluminum containers, and PET and HDPE plastic bottles). The difficulty is that the cities that target additional materials -- such as all plastic containers, aseptic and poly-coated drink containers, small scrap metal, or plastic shopping bags -- are for the most part the same ones that use linear garbage rates. This made it impossible to statistically sort out the separate impacts of both linear rates and targeting non-standard materials.

I.C. Best Practices for Minimizing Waste Generation and Maximizing Waste Diversion

As indicated in Figure ES-4, demographic and geographic variables have substantial impacts on collection quantities. These variables are outside the control of those responsible for designing, managing, and operating solid waste collection and diversion programs in King County cities and unincorporated county areas. The collection program characteristics and fees that do matter for determining collection quantities were laid out in the previous section of this Executive Summary. This section discusses the successes and challenges for communities in using those best practices.

In order to quantify how individual jurisdictions were doing at minimizing collected waste generation and maximizing waste diversion by single-family residential households in 2000, we looked to the collection surveys to define a "baseline" for collection program characteristics and fees typically used in King County. We then used this baseline collection program as the standard against which to measure community performance in 2000. The baseline program is:

- Embedded curbside recycling, i.e., curbside recycling available at no additional charge to all garbage collection service subscribers. (Used by most jurisdictions in 2000.)
- Weekly curbside recycling collection or use of a 90/96-gallon cart in the case of biweekly curbside recycling. (In 2000 a majority of jurisdictions either offered weekly curbside recycling or offered biweekly curbside using a 90/96-gallon cart.)
- Subscription-based biweekly curbside yard debris collection. (Only 8 jurisdictions embedded curbside yard debris costs in garbage collection service fees in the year 2000; and just 14 provided weekly, as opposed to biweekly, service.)
- A yard debris collection fee of $7.07. (This was the average monthly subscription fee for subscription-based yard debris collection in 2000.)
- A garbage rate structure that does not have linear or better rates. (Only 6 jurisdictions had linear or better rate structures in 2000.)
- A second garbage can incremental fee of $6.63. (This was the average incremental monthly charge in 2000 for a second 32-gallon can of garbage collected weekly.)
- A garbage fee level of $17.28. (This was the average value for the garbage bill index in 2000. The methodology for calculating this index for each jurisdiction is discussed in the following report.)

Figure ES-5
Actual vs. Baseline Generation of Collected Waste in 2000
King County City (32) and Unincorporated County (8) Hauler Service Areas

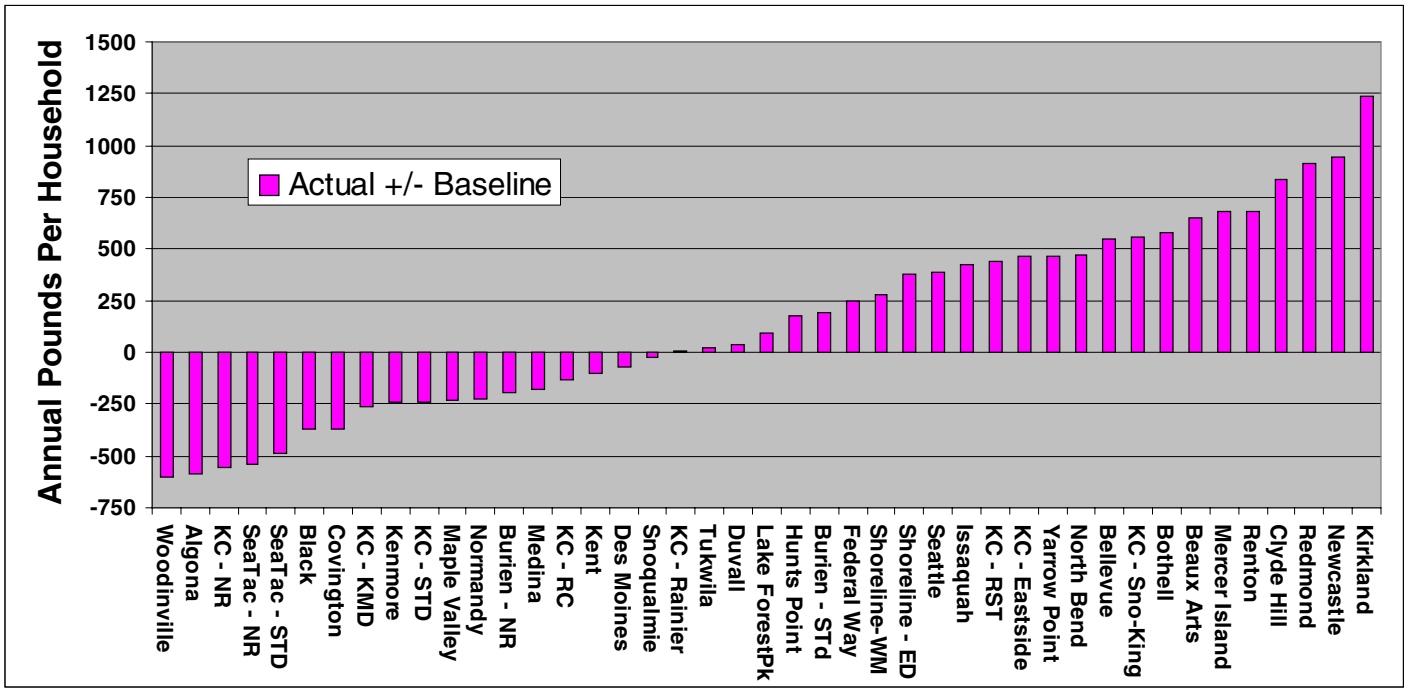


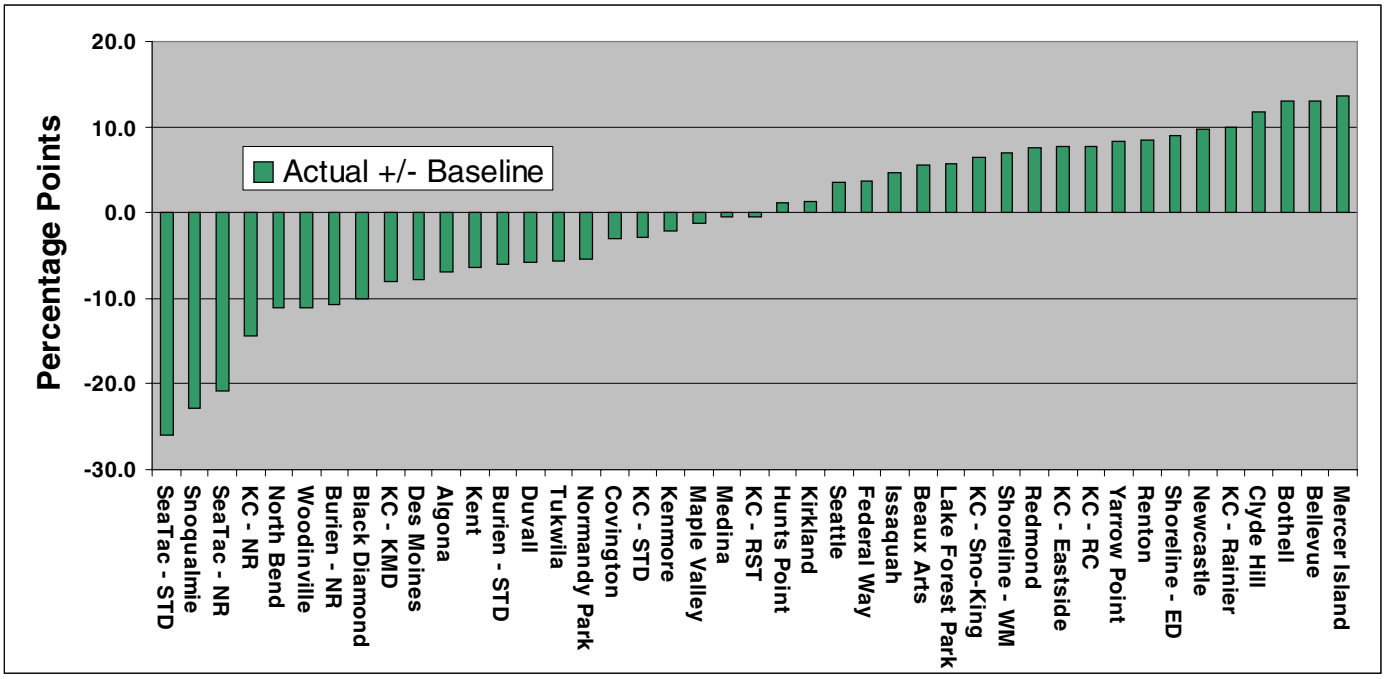
Figure ES-5, *Actual vs. Baseline Generation of Collected Waste in 2000*, shows the difference between each community's actual generation of collected waste and estimated generation if each community had used baseline collection program characteristics and collection fees, given their actual levels for household size, household income, and yard size. As indicated by bars stretching down from zero in Figure ES-5, eighteen communities made choices for their collection programs and fees such that they reduced waste generation below the baseline. The bars stretching up from zero indicate the twenty-five communities in which single-family households generated levels of collected waste that exceeded their baseline level.

Figure ES-6, *Actual vs. Baseline Diversion Rates for Collected Waste in 2000*, shows the difference between each community's actual diversion rate for collected waste and their estimated diversion rate if that community had used baseline collection program characteristics and collection fees, given their actual levels for household size, household income, and yard size. As indicated by bars stretching down from zero in Figure ES-5, twenty-two communities made choices for their collection programs and fees such that they had diversion rates below the baseline. The bars stretching up from zero indicate the twenty-one communities in which single-family households attained diversion rates that exceeded their baseline level.

There are a number of observations and conclusions that follow from the rankings of communities shown in Figures ES-5 and ES-6. Many of these are discussed in detail in the following report. Here we emphasize the most important.

Inspection of the two figures readily reveals that communities with collection program characteristics and fees such that they attained higher diversion rates than their baseline rates tend to be the same communities in which households generated more waste for collection than their baseline generation estimates. The opposite relationship holds for the underachieving diversion rate communities, which also tend to be the success stories for collected waste generation. That is, the difference between actual generation level and baseline generation level is positively correlated with the difference between the actual diversion rate and the baseline diversion rate.[9]

Figure ES-6
Actual vs. Baseline Diversion Rates for Collected Waste in 2000
King County City (32) and Unincorporated County (8) Hauler Service Areas



What this correlation points out is that the choices for program characteristics and collection fees used by solid waste program designers and managers in 2000 to promote diversion tended to also promote increased waste generation. The impacts of garbage and yard debris collection fees on refuse and yard debris collection quantities illustrate this trade-off most dramatically.

According to our statistical analysis somewhere between 35% and 63% of the impact on yard debris collection caused by increasing garbage or decreasing yard debris collection fees comes from diverting yard debris material out of the garbage stream and into the yard debris stream. The remaining portion represents additional generation of yard debris that is stimulated by the change in collection fees.

[9] In fact, the simple correlation between actual vs. baseline generation and actual vs. baseline diversion rate is 0.70, a positive correlation rate that is significantly greater than zero at more than a 99% significance level.

This waste generation effect may occur because once a household begins to use the yard debris collection service, or increases its use of that service, the household is tempted to cut back to some extent on existing yard debris minimization activities such as grasscycling, backyard composting and/or zeriscaping. At any rate, this example illustrates the complexities involved when attempting to simultaneously maximize waste diversion and minimize waste generation. Most actions that make diversion cheaper and/or more convenient than garbage collection and disposal also make the household's overall solid waste management task cheaper and/or easier. This naturally tends to induce rather than reduce waste generation.

In addition to the substantial trade off between generation and diversion that results from a community's choice of collection program characteristics and collection fees, the other important conclusions that we deduced from the rankings in Figures ES-5 and ES-6 are:

- ***Importance of Variable Rates:*** Kirkland's actual generation of collected waste is much higher than its estimated baseline because in 2000 that city charged a single, flat rate for collection of basically unlimited quantities of the three streams -- garbage, recycling and yard debris.
- ***Importance of Recycling and Yard Debris Collection Frequency:*** Nine of the ten jurisdictions shown in Figure ES-6 that provided weekly collection of both recyclables and yard debris had actual diversion rates in 2000 that exceed their estimated baseline diversion rates. All but one of the other twelve out of the twenty-one jurisdictions in which diversion exceeded baseline either had weekly recycling or weekly yard debris collection, or, in the case of those with both biweekly recycling and yard debris, they used the 90/96-gallon cart as their recycling collection container.
- ***Importance of Recycling Collection Container Size:*** Fourteen of the twenty two jurisdictions shown in Figure ES-6 with diversion rates below baseline provided biweekly recycling without at the same time providing the 90/96-gallon cart as a collection container. These jurisdictions are also fourteen of the sixteen biweekly recycling programs that did not use the large cart as a recycling collection container.
- ***Importance of Collection Fee Levels & Collection Fee Incremental Incentives:*** The remaining eight of the twenty-two underperforming jurisdictions identified in Figure ES-6 either had yard debris fees that exceeded their incremental charge for the second 32-gallon can of garbage (five of the eight), or they had a garbage bill index ratio that was below average (the other three of the eight). In addition, linear rate structures had a significant and substantial positive incremental impact on recycling collection quantity.

I.D. Significant Changes in Collection Practices Since 2000

Table ES-1, Average Annual Household Collected Waste Quantities in 2000 Compared with a Recent Twelve Month Period for Four Cities That Implemented Major Changes in Collection Practices, compares average household collection quantities in 2000 against a recent twelve month period for the four King County cities that substantially upgraded their collection practices for single-family residential waste after 2000, the year for which collection survey data was gathered for this report. Auburn, which in 2000 had no curbside recycling at all, upgraded to embedded curbside recycling in 2002. The data in Table ES-1 indicate that Auburn's household garbage collection quantities went down by 34.8%, and Auburn now has a 48.8% diversion rate.

Carnation had neither curbside recycling nor curbside yard debris collections in 2000. Carnation upgraded to embedded recycling and subscription-based yard debris collections in 2002. The data in Table ES-1 indicate that Carnation's garbage collection quantity for the average household remained essentially unchanged. Carnation's diversion rate is now 49.7%

Table ES-1
Average Annual Household Collected Waste Quantities in 2000
Compared with a Recent Twelve Month Period for Four Cities
That Implemented Major Changes in Collection Practices

					Diversion		
	Garbage	Recycling	Yard Debris	Total	Pounds	Percent	Policies Then and Now
Auburn							
Jan 00 thru Dec 00	2,566	No Curbside	756	-	-	-	No curbside recycling
Jul 02 thru Jun 03	1,673	694	889	3,256	1,583	48.6%	Embedded curbside recycling
Change	(893)		133				
Carnation							
Jan 00 thru Dec 00	1,686	No Curbside	No Curbside				No curbside recycling or yard debris
Oct 02 thru Sep 03	1,699	704	976	3,379	1,680	49.7%	Embedded curbside recycling & subscription-based yard debris collection
Change	13						
Kirkland							
Jan 00 thru Dec 00	1,902	593	1,266	3,760	1,859	49.4%	Flat garbage collection rates
Jul 02 thru Jun 03	1,817	931	1,355	4,103	2,286	55.7%	Variable (volume-based) rates
Change	(85)	338	89	343	427	+6.3 pp	
SeaTac							
STD Service Area							
Jan 00 thru Dec 00	1,816	130	222	2,168	352	16.2%	Subscription curbside recycling
Jul 02 thru Jun 03	1,688	483	292	2,464	775	31.5%	Embedded curbside recycling
Change	(128)	353	70	296	423	+15.2 pp	

Kirkland had flat garbage collection fees in 2000 and upgraded to variable rates in 2002. As indicated in Table ES-1, average household garbage collection quantity went down, recycling and yard debris quantities went up, and the city's diversion rate increased from 49.4% to 55.7% after the change.

SeaTac had subscription-based curbside recycling in 2000 and upgraded to embedded curbside in 2001. Table ES-1 shows data only for SeaTac Disposal's service area in the City of SeaTac; recent data for the other service area are not available. Average household garbage collection went down, recycling went up substantially, and yard debris increased somewhat over 2000 levels in SeaTac Disposal's service area. As a result, diversion increased from 16.2% to 31.5%.

II. Introduction and Description of Research Methodology

Every single-family residential household in King County had access during the year 2000 to solid waste collection services on a user pay basis, with the exception of several thousand households located in remote mountainous areas. During that year 90% of single-family households[10], 400,000 in total, subscribed to garbage collection service. Most single-family garbage collection service subscribers also had available curbside recycling and yard debris collections. In fact, over 387,000 single-family households had curbside recycling collection available at no additional charge beyond what they paid for garbage collection, and over 70,000 of these also had available no-additional-charge yard debris collection.

These counts for no-charge service illuminate the fact that less than 20% of single-family households had both recycling and yard debris collections bundled with their garbage service fees. Other characteristics of solid waste collection services in the year 2000 -- such as garbage collection fees, recycling and yard debris collection frequency and recycling collection container sizes -- also varied substantially among King County's 39 incorporated city (including Seattle) and 9 unincorporated county solid waste collection hauler service areas (HSAs). This report describes and delineates these varying collection service offerings in some detail.

Differences among service areas in collection service characteristics and collection fees provide fertile ground for this report's main objective – to sort out what is working best in King County to minimize solid waste generation and maximize waste diversion among single-family solid waste collection service subscribers. Census 2000 block level income, household size and language barrier data, as well as data on yard size from the King County Assessor's Office, tabulated for this effort by King County Department of Natural Resources and Parks' Geographic Information Systems Center staff, provided demographic and geographic control variables in this analysis. These controls were necessary to make sure that household size, income, yard size or language barrier differences among service areas did not obscure or bias our findings as to what solid waste program characteristics and practices most effectively motivate waste reduction and recycling.

II.A. Research Methodology

Information and data for descriptive and analytical results in this report came from six main sources:

- A survey of all cities in King County regarding single-family residential solid waste collection practices, characteristics, quantities and fees in the year 2000 conducted via mail, telephone, email and/or in-person interviews with solid waste or public works program staff in the cities.

[10] For solid waste collection the term single-family usually includes all households that have their waste collected from individual household containers. This most often means all households living in detached single-family structures, plus households living in duplexes, triplexes and fourplexes. Single-family collection can also include households in mobile home courts, as well as households in multi-family structures with more than four units, as long as each household is serviced and billed separately.

- Hauler reports to the King County Solid Waste Division on residential single-family collection quantities and customer counts for garbage, recycling and yard debris collections in each jurisdiction in King County, including HSAs in unincorporated King County.
- Tariff filings to the Washington Utilities and Transportation Commission by haulers operating in unincorporated King County HSAs.
- Census 2000 block level data on household size, household income, and English language barriers for each block containing single-family households within each of the 39 cities and 9 unincorporated HSAs, aggregated up to city and unincorporated area averages by King County's GIS unit.
- King County Assessor's Office data on lot size, house footprint and appraised value for each single-family home in King County, aggregated up to city and unincorporated area means and medians by King County's GIS unit.
- Knowledge of King County Solid Waste Division staff and SRMG regarding solid waste collection practices in the county.
- Tonnage and collection system data for the City of Seattle provided by Seattle Public Utilities staff.

These data are the basis for the descriptive statistics and graphs we developed for this report, as well as for the statistical analyses we used to identify significant determinants of collection quantities and sort out which collection program characteristics and collection fee structures work best to minimize generation of collected waste and maximize diversion of collected waste from disposal. For the descriptive characterization of collection programs and fees, we computed and reported averages for the cities and unincorporated county service areas. In order to indicate the great diversity and range in collection quantities and collection program characteristics, we also developed graphical representations that rank the cities and unincorporated areas by collection quantities and by program characteristics such as refuse collection fees.

For the more analytical portion of our work, we relied heavily on standard multiple linear regression analysis to sort out the quantitative influences of the various demographic, geographic, program characteristic, and collection fee factors on average levels of refuse, recycling and yard debris collection quantities in each city and unincorporated HSA. This technique uses mathematical and statistical procedures to, in effect, perform the kinds of tests one would do in a rigorous scientific experiment. For example, we can estimate what impact increasing garbage fees by a dollar in all areas while holding all other influences constant has on refuse, recycling and yard debris collection quantities.

Regression analysis works quite well at mimicking science in the laboratory, given certain standard assumptions. One of these is that the explanatory factors are not highly correlated amongst themselves. As discussed in Chapter IV, there was correlation – multicollinearity is the technical term for this problem – among several variables that made estimation of impacts somewhat problematic. For example, yard size and income were each important for explaining yard debris collection quantities, but their correlation made estimates of their separate influences less precise than might be ideal. Nevertheless, the estimates reported in Table 1 in Chapter IV for these impacts are precise enough to indicate the relative influence of each factor on yard debris collection quantities in King County cities and unincorporated areas during the year 2000.

III. Characteristics of Single-Family Residential Solid Waste Collection Practices in King County

III.A. Generation of Collected Waste per Household

Figure 1, *Average Collected Waste Generation & Diversion Per Household in 2000*, shows the considerable variation among 32 city and 8 hauler service areas for the year 2000 in waste collected per household.[11], [12] The figure also shows the distribution of waste collection quantities among the three collection streams – garbage, recycling and yard debris. For the cities and unincorporated county HSAs shown in Figure 1, generation of waste for collection averaged 2,924.5 pounds per household over the year, including 1,469.3 pounds for collected garbage, 797.8 for curbside recycling and 657.4 pounds for curbside yard debris.

As shown in Figure 1, single-family residences in the small city of Clyde Hill generated the most collected waste per household, 4,796 pounds, and had the second highest diversion rate, 60.6%, just below Mercer Island's 61.4%. This is because Clyde Hill's households set out the highest amount of yard debris, averaging 1,853 pounds per household during 2000, 2.8 times the countywide average. In addition, Clyde Hill households averaged 1,055 pounds of recyclables, 32% above the countywide average, and 1,888 pounds of garbage, 29% above the countywide average.

The small city of Snoqualmie had the lowest collected waste per household at 1,508 pounds, only 31% of the average collected waste generation rate for Clyde Hill households. Garbage set outs accounted for 952 pounds of Snoqualmie's collected waste, with 258 pounds of recyclables and 298 pounds of separately collected yard debris making up the remainder. These garbage,

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[11] The 7 King County cities not shown in Figure 1 are Auburn, Carnation, Enumclaw, Milton, Pacific, Sammamish, and Skykomish. These cities were excluded from the ranking of household collected waste generation for a variety of reasons. Auburn, Pacific, and Skykomish did not offer curbside recycling in 2000. Carnation provided neither curbside recycling nor yard debris collection. Record keeping at recycling drop-off sites located in these cities, as well as at King County transfer stations, typically is such that it is impossible to determine what portion of material collected through these sites was generated by single-family households in a specific jurisdiction. Enumclaw collects household and business garbage on the same truck and so does not report household garbage collection tonnage separately. Milton lies mostly in Pierce county and is part of that county's solid waste collection area. Sammamish was incorporated in 1999 and did not report annual solid waste collection tonnage data as of 2000.

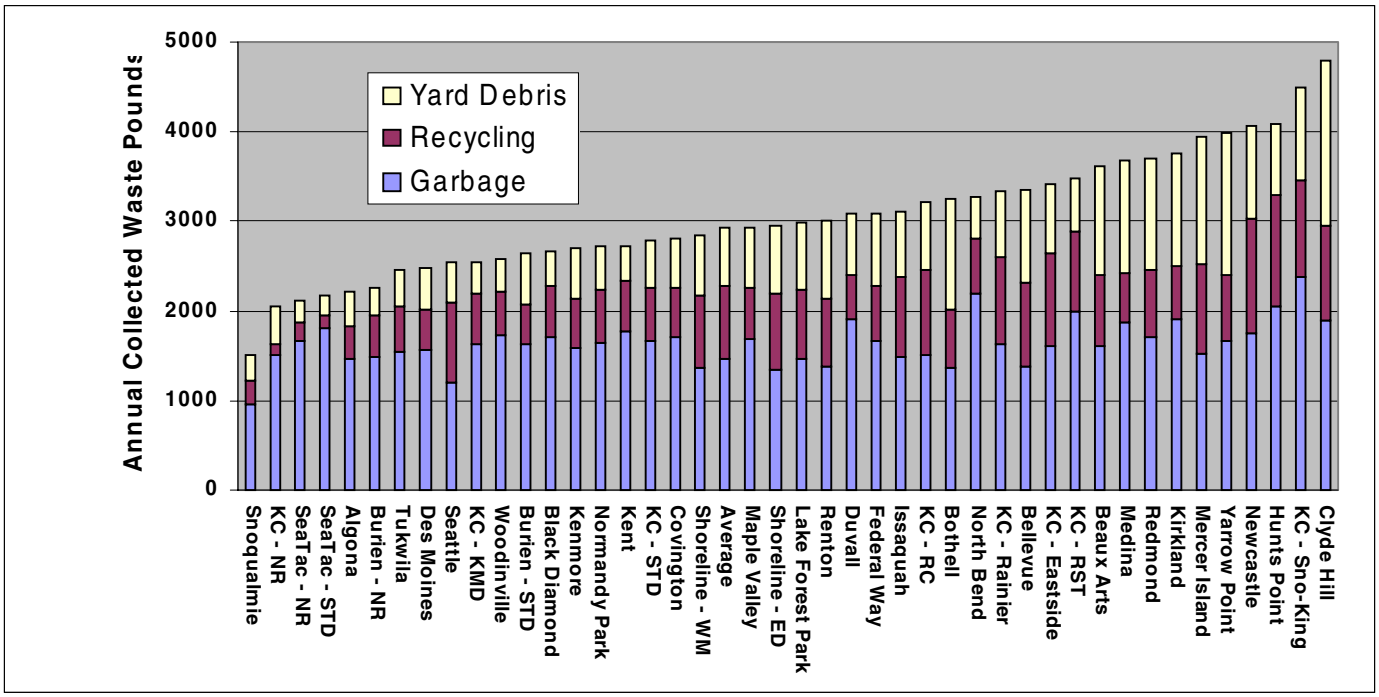
The Vashon unincorporated hauler service area also is not shown in Figure 1 because there was no curbside yard debris collection available there in 2000. In addition, garbage collection customer counts were not available for either Skykomish or Vashon. Finally, the careful reader may have noted that besides the countywide average bar there are another 43 bars shown in Figure 1 for 32 cities and 8 unincorporated county hauler service areas. This is because in three of the cities portrayed in Figure 1 – Burien, SeaTac and Shoreline, solid waste collection is provided by two different haulers, each of which reports separate data on household waste collection for their geographically distinct service areas. Because the two haulers in each city had differing collection service characteristics, we had to keep their data separate for our statistical analyses.

[12] The unincorporated county HSAs are denoted in Figure 1, as follows: KC – Eastside = Eastside Disposal, KC - KMD = Kent-Meridian Disposal, KC - NR = Nick Raffo Garbage Company, KC - RC = Rabanco Connections, KC - RST = RST Disposal, KC - STD = SeaTac Disposal, KC - Rainier = Waste Management – Rainier, and KC - Sno-King = Waste Management – Sno King.

recycling and yard debris set out quantities are, respectively, 35%, 68% and 55% below county-wide averages.

Households in Seattle generated the second lowest amount of collected garbage – just 1,203 pounds each on average, but this amount still exceeded Snoqualmie's household average by 26%. Households in Waste Management – Sno King's unincorporated county service area, denoted by KC - SK in Figure 1, and in North Bend set out the highest average amounts of collected garbage, over a ton each at 2,385 and 2,194 pounds, respectively. Households in these two areas along with Auburn[13], Hunts Point and RST Disposal's unincorporated county service area, denoted by KC - RST, were the only ones to generate a ton or more of garbage on average for collection during 2000.

Figure 1
Average Collected Waste Generation & Diversion per Household in 2000
King County City (32) and Unincorporated County (8) Hauler Service Areas



Households in the portion of SeaTac served by SeaTac Disposal, denoted by SeaTac - STD, generated the lowest amount of collected recyclables and yard debris – averaging, respectively, just 130 and 222 pounds per household. That service area in SeaTac also had the lowest diversion rate at 16.2%.

On average, households in King County during the year 2000, including Seattle, diverted 49.8% of their collected municipal solid waste through curbside recycling and yard debris. Kirkland at 49.4% and Hunts Point at 50.1% came the closest among King County cities and unincorporated areas to mirroring average countywide diversion performance.

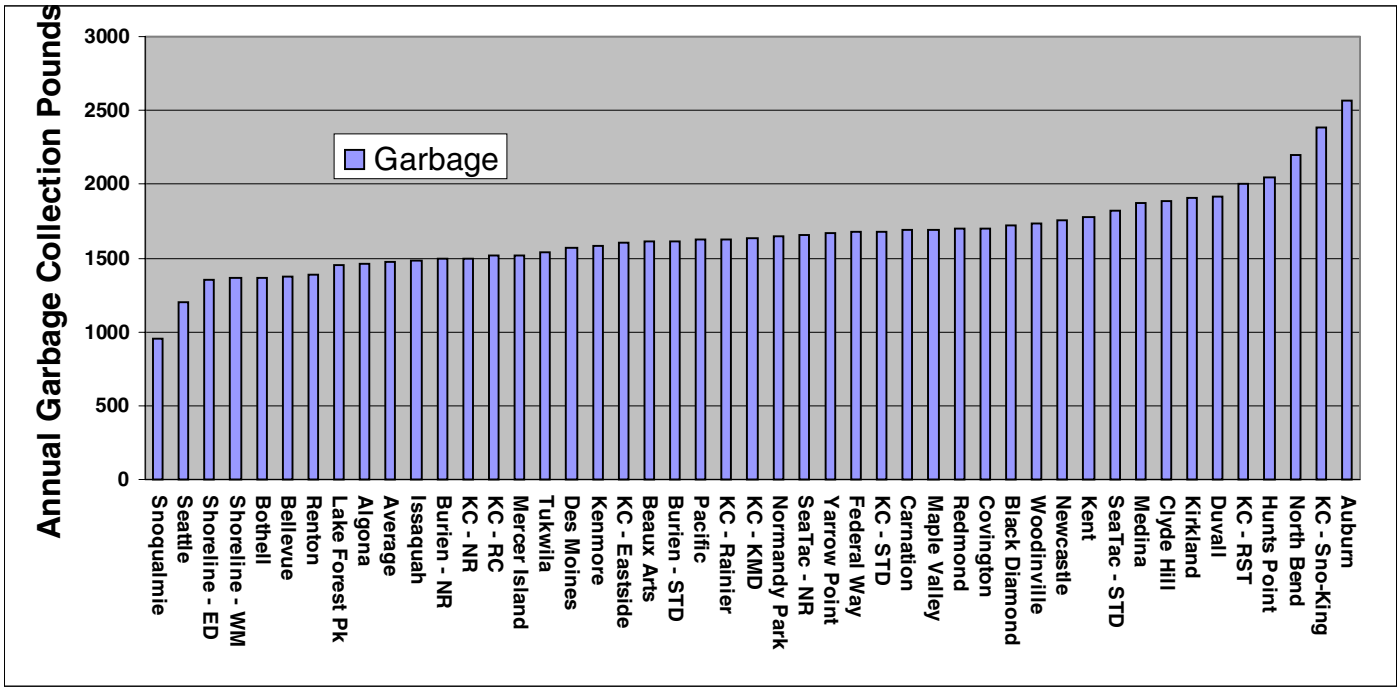
[13] Auburn is not shown in Figure 1 because, as explained in footnote 2, that city did not offer curbside recycling in 2000. Partly as a result, in terms of average garbage collection quantity per household, Auburn tops the list at 2,566 as shown in Figure 2.

Newcastle single-family households recycled the most on average at 1,280 pounds, 60% more than the countywide average. Hunts Point households were a close second, recycling 1,242 pounds on average during 2000. As we will see when we analyze the factors that contribute to generation of lots of recyclables, it's no accident that these two high recycling communities also rank among the top ten in terms of average household income for King County cities.[14]

III.B. Characteristics of Curbside/Alley Garbage Collection

Figure 2, *Average Garbage Collection Per Household in 2000*, shows annual garbage collection pounds for the average household in each of 35 King County cities and 8 unincorporated county HSAs, as well as the countywide average annual 1,469 pounds of garbage collected per household.[15] Snoqualmie with an average household generation of 952 pounds for garbage collection and Auburn at 2,566 pounds per household demarcate the low and high end of the distribution of average household garbage collection pounds for King County jurisdictions.

Figure 2
Average Garbage Collection Per Household in 2000
King County City (35) and Unincorporated County (8) Hauler Service Areas



[14] Average collection quantities per single-family household for each King County city and unincorporated HSA are listed in Appendix Table 1 at the end of this report for all areas for which these data were available.

[15] Figure 2 excludes data for Enumclaw, Milton, Sammamish, Skykomish and the Vashon unincorporated service area for reasons explained in footnote 11. It includes two bars each for Burien, SeaTac and Shoreline, as also explained in footnote 11. The countywide household average is closer to the Seattle end of the household garbage collection pounds distribution because Seattle accounts for 37% of single-family garbage collection customers in the county. The reader should note that countywide averages reported in this chapter are weighted averages of the individual jurisdiction averages, using number of garbage subscribers as the weights.

Important characteristics of solid waste collection services that might explain some of the variation shown in Figure 2 include the following: whether garbage collection service is mandatory; whether curbside recycling and/or yard debris collection is available at no additional charge or only on a subscription basis; the cost for garbage collection service; and the incremental cost for set outs of additional amounts of garbage each week.

III.B.1. Mandatory Garbage Collection

Fourteen cities in King County had mandatory garbage collection for single-family households in 2000:

- Algona
- Auburn
- Bothell
- Carnation
- Duvall
- Kent (excl. annexed areas)
- Kirkland
- Medina
- Normandy Park
- North Bend
- Pacific
- Renton
- Seattle
- Snoqualmie

One might expect mandatory collection to lower a city's average for household garbage generation. This would be based on assuming that many of the residents that would otherwise have chosen not to use collection services generate small amounts of garbage, making self-haul or other management options more attractive. At the same time, one might also expect mandatory collection to reduce per household costs for collection due to greater route efficiencies when the truck stops at every house along its daily route. This could lead to lower garbage collection fees, which in turn might stimulate garbage generation.

Given these competing impacts from mandatory collection, we are unlikely to be able to sort out the net effect by simply graphing the relative ranks of cities with and without mandatory garbage collection. Rather, we need to use more precise analytical statistical methods as we do in Chapter IV to make a reliable conclusion regarding the influence of mandatory collection.

III.B.2. No-Additional-Charge Recycling and Yard Debris Collections

Availability of a low cost diversion alternative for material that accounts for a substantial portion of household waste should enable households to reduce the amount of garbage they set out for collection. By contrast households in cities that do not provide any curbside diversion opportunities at any price – Auburn and Pacific for recyclables and Carnation for both recyclables and yard debris – could be expected to rank higher in garbage generation, other factors being equal.

In fact, as shown on Figure 2, Auburn at 2,566 pounds in 2000 tops the list for average garbage generation by single-family households. Similarly, as also shown in Figure 2, households in one of SeaTac's HSAs also ranked high in collected garbage generation. SeaTac was the only city in 2000 that imposed an additional charge, separate from the garbage collection fee, on households that wanted curbside recycling service. At the same time, Carnation and Pacific households set out on average only 1,686 and 1,622 pounds, respectively, for garbage collection during the year.

Thus, other factors besides just non-availability of curbside recycling or charging subscription fees for recycling also influenced household garbage generation in King County during 2000.

In contrast to Auburn and SeaTac, households in the eight cities that provided no-additional-charge curbside yard debris collection to garbage collection subscribers generated less than 1,520 pounds of garbage on average in 2000, with the exception of Kirkland and Redmond. These eight cities are:

- Bellevue
- Bothell
- Issaquah
- Kirkland
- Lake Forest Park
- Mercer Island
- Redmond
- Renton

To precisely determine the exact correlation between no-additional-charge yard debris collection and lower garbage generation, we again need to turn to the use of statistical methods. As reported in Chapter IV, these methods yielded precise numeric estimates for the impacts of no-additional-charge curbside yard debris collections on garbage generation, waste minimization and waste diversion.

III.B.3. Garbage Collection Service Fees

An interesting hypothesis regarding what drives garbage generation rates is that higher garbage collection fees will drive down garbage generation rates by, for example, motivating waste reduction/minimization efforts by households. However, figuring out how to compare garbage collection charges is not exactly a straightforward matter. This section illustrates some ways to compare garbage fees. These comparisons will be useful in the analytical work of determining what is working best to promote minimization and diversion. Results of that analysis are reported in Chapter IV. This section simply addresses the issue of how to compare garbage fees in the different King County cities and unincorporated HSAs.

Perhaps the simplest method of comparing garbage rates in different jurisdictions is to pick a basic service level and chart the fee for that service level for all cities and unincorporated areas. In King County weekly collection of one 32-gallon can or 35-gallon cart is the garbage service level used by 54% of garbage collection subscribers.

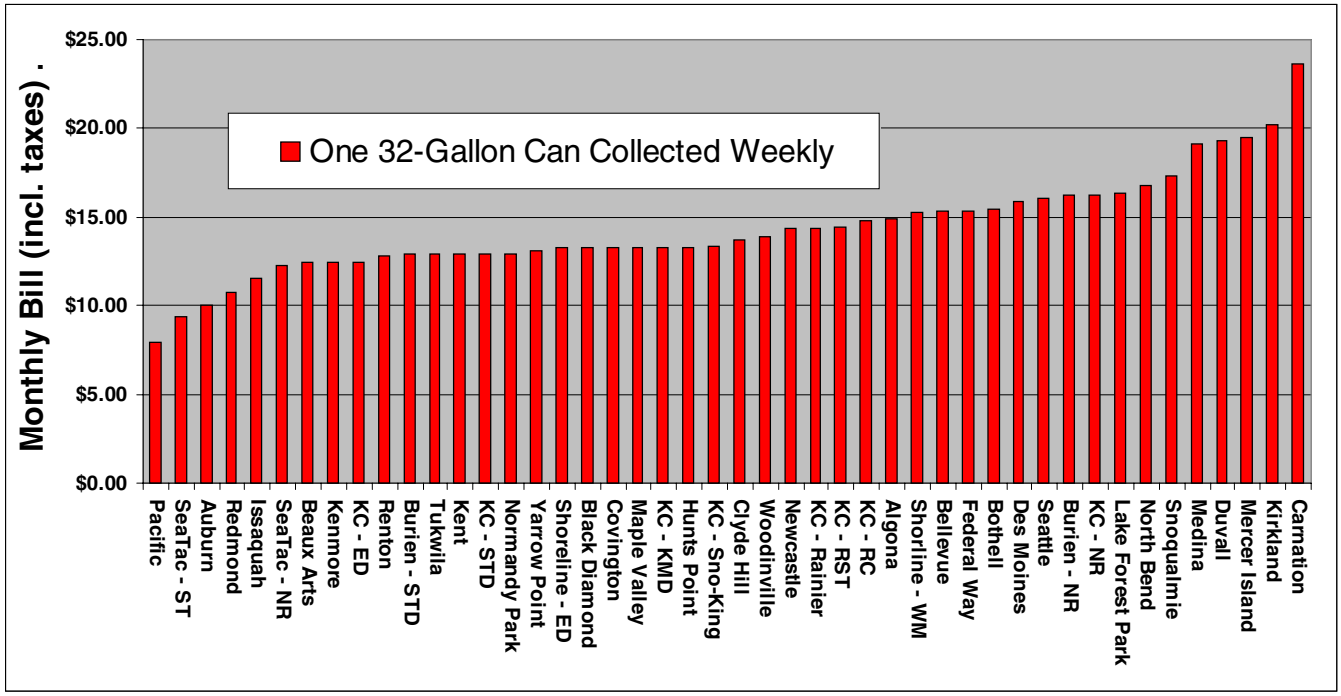
Figure 3, *Monthly Bill for One Can Garbage Collection in 2000*, charts monthly bills, including all taxes and fees (King County's household hazardous waste management fee of $0.60 per household per month, the State of Washington's refuse tax of 3.6%, and any city solid waste utility or city general fund taxes), for weekly collection of one 32-gallon can of garbage in each of the same 43 service areas portrayed in Figure 2.

As indicated in Figure 3, monthly bills in King County during the year 2000 for weekly collection of one can of garbage varied from a low of $7.93 in Pacific to a high of $23.61 in Carnation. All but five of the solid waste collection service areas shown in Figure 3 charged between $10 and $20 for weekly collection of a single can.

However, accurately and fairly comparing the cost of garbage collection services is a bit more complicated than just looking at fees for a single, basic service level. With the exception of Kirkland, which charged the same fee for any volume of garbage up to five 32-gallon cans a household set out for collection, in 2000 all cities and unincorporated HSAs in King County charged fees for garbage collection that varied according to the size of container(s) used for garbage collection and the collection frequency for that container(s).

The complication this introduces for rate comparisons is that the structure of those charges for the various size containers in one city may promote proportionately more households to use smaller containers than in another city. In this case, households in that city on average would pay less for their garbage collection because they tend to use smaller containers. The smaller containers may contain heavier amounts of garbage or households may actually find ways to reduce their garbage generation as a result of the rate incentives provided in their city. Either way, their average bill would be lower.

Figure 3
Monthly Bill for One Can Garbage Collection in 2000
King County City (35) and Unincorporated County (8) Hauler Service Areas



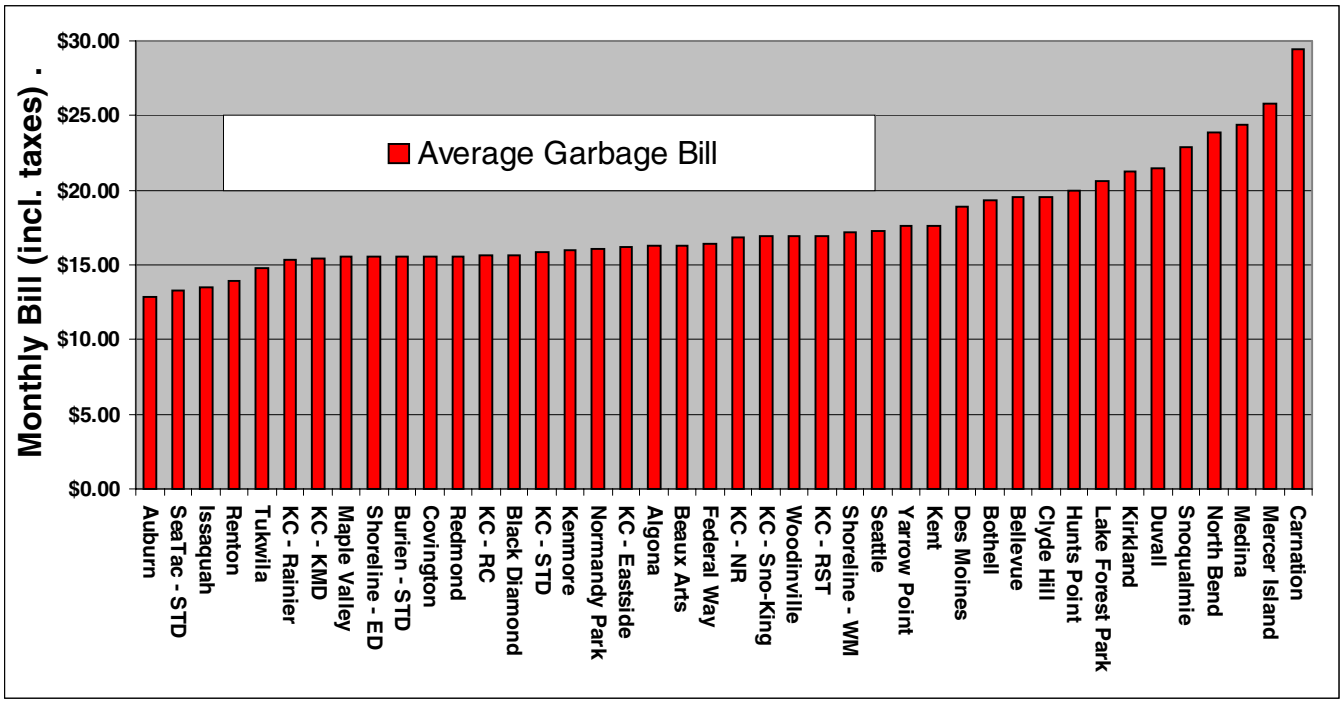
To complicate matters further, some jurisdictions provided more, and some less, services as part of the package that came with the fee paid for a household's garbage subscription. For example, SeaTac households had to pay an additional fee for curbside recycling, while Auburn, Carnation and Pacific households could not get curbside during the year 2000 even if they were willing to pay extra for it. On the other hand, households in the eight cities listed in Section III.B.2 got curbside yard debris collection at no additional charge. Carnation and Vashon Island households did not have curbside yard debris collection available. Households in all other cities and unincorporated areas had to pay an additional subscription fee for curbside yard debris collection.

One way to adjust for rate structure incentives and for differing charges for different garbage container sizes and collection frequencies is to compute the weighted average garbage bill in each area. This is done by weighting the collection fee for each service level by the number of customers using each service level.

Figure 4, *Average Monthly Bill for Garbage Collection in 2000*, shows the average monthly bill including all taxes and fees paid during the year 2000 in 33 cities and 8 unincorporated HSAs.[16] Average monthly bills ranged between $12.84 in Auburn and $29.41 in the City of Carnation. With the exception of the two cities that averaged above $25 and the five that averaged below $15, households in city and unincorporated county service areas paid garbage bills that averaged between $15 and $25 per month.

Interestingly, a comparison of Figure 3 with Figure 4 indicates that rankings did not change as much as one might have expected when the more comprehensive average garbage bill was used in place of the fee for the single can service level to rank the city and unincorporated areas. Carnation and Mercer island are still at the top. One reason that Carnation's fees were higher than fees in other cities is that Carnation garbage collection rates included between $3.60 and $5.95 per month, depending on service level, to cover the city's landfill closure costs. With the exception of Carnation and Seattle, other city and unincorporated county service areas were not directly paying any costs during the year 2000 for old landfill closures. Indirectly, however, all cities (except Seattle) and all unincorporated service areas paid for closure of King County landfills through amounts included in the tipping fee charged at King County transfer stations.

Figure 4
Average Monthly Bill for Garbage Collection in 2000
King County City (33) and Unincorporated County (8) Hauler Service Areas



[16] Newcastle and Pacific, as well as the Nick Raffo Garbage Company's service area in Burien and SeaTac, are not included in Figure 4 because we were unable to obtain garbage collection customer counts for the various service levels offered in those four areas.

Auburn, Issaquah and the portion of SeaTac served by SeaTac Disposal rank at the bottom for both one can and average fees. We could not compute an average for Pacific, which had the lowest monthly bill for the weekly 32-gallon service level, because we were not able to obtain service level counts for that city.

Some of the changes in ranking between Figures 3 and 4 are fairly easy to explain. For example, Kirkland has moved down because households in that city during 2000 paid the same fee regardless of whether they generated only one or up to five cans of garbage for collection. Thus, a comparison against a lower service level such as one can weekly makes Kirkland garbage collection seem more expensive relative to other cities than it actually was.

We could make the rate comparison even more accurate by adding in amounts paid for subscription-based recycling and yard debris collection services in each jurisdiction. This could be done either by adding the recycling and yard debris subscription fees to the garbage collection fee averages computed for Figure 4. Or it could be done by computing the weighted average subscription fee obtained by multiplying the subscription fee by the proportion of garbage collection customers subscribing to the optional service, and then adding that smaller amount to the averages from Figure 4.

This is another tricky issue because curbside recycling or yard debris subscription fees tend to be much higher than the curbside costs embedded in garbage collection fees in cities that provide those services at no additional charge to all their garbage collection service subscribers. Subscription fees are higher because of the self-fulfilling belief that many households will not choose to pay an extra fee for curbside recycling or yard debris collection service, yet the costs of sending a truck through the neighborhoods must be covered by the few who might subscribe. So the curbside collection subscription fee is set high, and, as a result, many households do find it cheaper to continue throwing recyclables or yard debris in their garbage container. Because of the high subscription fee, the amount a household can save by switching to a smaller garbage container is often less than the added cost of the subscription-based curbside recycling or yard debris collection service.

We chose to compute the weighted average amount spent for subscription-based curbside recycling and yard debris collections in those cities and unincorporated county HSAs where these waste diversion services were not embedded in garbage fees. Upon adding weighted average expenditures for subscription-based diversion to weighted average garbage fees, and re-ranking, we found no dramatic change from the relative rankings shown in Figure 4. The data on subscription sign-ups was spottier and probably less accurate than the garbage service level data used to compute the average garbage bills for Figure 4, so we decided to leave it to Figure 4 to tell the story on relative solid waste collection fees in King County.

III.B.4. Garbage Collection Service Rate Structures

Another seemingly reasonable hypothesis about the relationship between garbage collection fees and waste minimization or diversion is that higher incremental charges for setting out additional amounts of garbage each week will motivate household's to reduce their garbage set outs

through wasting less and/or diverting more. King County jurisdictions use a wide variety of garbage rate structures, and this section provides descriptive information on these rate structures.

During 2000 Kirkland was the one jurisdiction that charged a garbage collection service user fee that did not vary according to the volume of garbage collected from each household. By contrast, a few jurisdictions – Issaquah, North Bend, Redmond, Seattle, and Snoqualmie -- charged fees that were closely proportional to the size of the garbage container that a household chose to use for garbage collection. Garbage rate structures are often classified as "linear" rate structures when fees vary in a straight-line (i.e., constant proportional) relationship with container size. Carnation would be included in the list of jurisdictions using linear or near-linear rate structures, except that its garbage fees have an embedded amount for landfill closure that is not proportional to garbage container volume.

Auburn's rate structure was even more aggressively oriented toward motivating waste minimization and diversion than purely linear rates. The incremental charge in the year 2000 for weekly collection of a second can of garbage in Auburn was 121% of the charge for one can.

In many other cities and in all unincorporated areas, on the other hand, garbage collection fees varied more closely according to the estimated cost of collecting, hauling and disposing waste from the household's chosen garbage container(s), with the disposal cost based on the estimated amount of waste typically set out in a container of each given size. A garbage fee structure that strictly adheres to the principal of charging each household on the basis of the estimated cost of collecting, hauling and disposing of that household's garbage is often classified as a "cost-of-service" rate structure. Of course, there also are cities with rate structures that fall in between the strictly linear and strictly cost-of-service types.

One fairly simple way to portray differences among garbage rate structures is to compare the monthly fee charged for weekly collection of waste from two 32-gallon garbage cans to the monthly fee for weekly collection of one 32-gallon can. Figure 5, *Incremental Rate Incentives in Garbage Fees in 2000*, shows this comparison for King County city and unincorporated county service areas in 2000. The data for Figure 5 are calibrated so that a zero indicates that two cans cost the same as one can. That is, there is a zero increment in garbage fees for households that set out two cans rather than one, so the second can is free. With its flat rate structure in 2000 Kirkland had a zero increment and thus ranked at the bottom in Figure 5.

A one in Figure 5 indicates that two-can service costs twice as much as one-can. That is, the second can costs the same is the first can. This is the linear relationship between garbage volume and garbage fees, because each can costs the same regardless of whether the household subscribes to set out two cans each week, and pays twice as much, or subscribes to just set out one can.

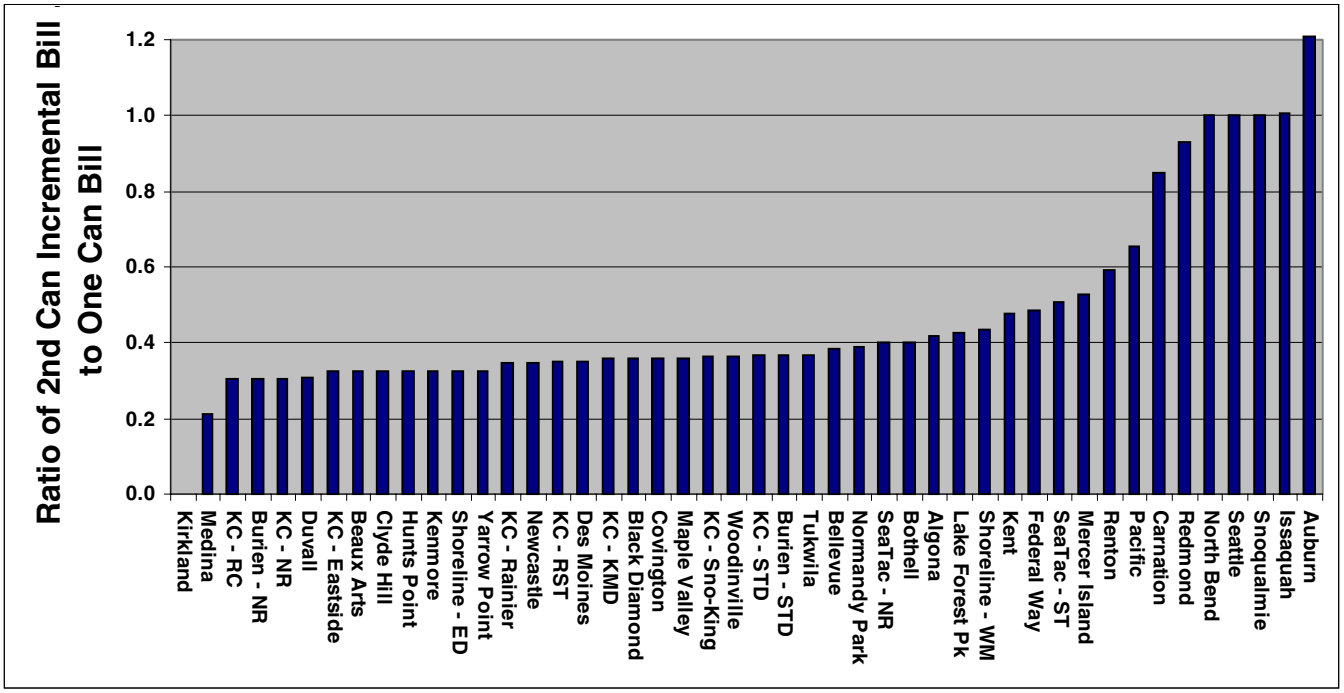
The cost-of-service rate structure, as defined and regulated by the Washington Utilities and Transportation Commission for haulers serving unincorporated areas of the county, is indicated by ratios between .30 and .37 in Figure 5. That is, in unincorporated county HSAs during 2000, incremental cost for the second 32-gallon can was only between 30% and 37% of the cost for the first can. The range is due to differences in the increment of additional waste a hauler estimates

is set out in the second can, and differences in estimates of the time required to carry the second can to the truck, empty and return it to the household's set out location, as well as other cost estimation differences among the solid waste collection companies.

Figure 5 shows that Redmond garbage bills were not quite linear in 2000. This is because the King County household hazardous waste fee of $0.60 per month per household did not vary with garbage container size. Thus, when that fee is added on top of the linear fee structure used by Redmond's garbage contractor it somewhat decreases linearity for customers' after-tax bills. In the other cities that used linear rate structures, fees were set to be linear after inclusion of the County's household hazardous waste charge.

Another interesting feature of the incremental can rankings shown in Figure 5 is that three of the six top-ranked cities in Figure 5 are the same as three of the bottom-ranked five cities in Figure 3 -- Auburn, Issaquah and Redmond. It's no accident that some cities with linear or better rate structures had low one-can fees. There is a limit as to how much a city can charge for, say, five 32-gallon cans, as well as a limit on how much total cost a city wants to charge households for garbage collection service. These two constraints help keep the one-can fee low, so that the fees for additional cans, which are set as multiples of that one can fee, will not be too high. Other factors being equal, then, we expect cities with linear rate structures to charge rather modest fees for one-can and lower service levels.[17]

Figure 5
Incremental Rate Incentives in Garbage Fees in 2000
King County City (35) and Unincorporated County (8) Hauler Service Areas



[17] One of the factors that is not always equal and can cause one-can fees to be higher is old landfill closure and post-closure maintenance fees such as those included in garbage rates in Carnation and Seattle.

III.B.5. Service Levels Below One-Can Weekly

Every King County garbage collection service, other than Carnation and perhaps Skykomish, offered weekly collection of a 10-gallon micro-can or 20-gallon mini-can. Most provided just the 20-gallon option. Renton provided only the 10-gallon. Auburn, Federal Way, SeaTac, and Seattle, along with Nick Raffo Garbage Company and RST Disposal in their unincorporated county service areas, offered both.

In addition, many offered the 32-gallon can with collection frequency reduced to monthly. Duvall also provided monthly collection of a 20-gallon mini-can, while American Disposal and Rabanco Connections offered both biweekly and monthly 32-gallon can collection in their unincorporated county service areas.

The twelve cities that did not offer any reduced frequency garbage service options were: Auburn, Bellevue, Bothell, Carnation, Enumclaw, Issaquah, North Bend, Pacific, Renton, Seattle, perhaps Skykomish, and Snoqualmie. Chapter IV reports a test of whether these cities were depriving their residents of a waste minimization or diversion opportunity by not offering reduced frequency collections.

III.C. Characteristics of Curbside Recycling Collection

All cities and unincorporated areas in King County had available curbside recycling collection services in 2000, with the exception of Auburn, Carnation and Pacific, which offered their residents drop-off recycling instead, and the Town of Skykomish. All areas with available curbside recycling, with the exception of the City of SeaTac and the Vashon unincorporated service area, also embedded that curbside recycling service in garbage fees. That is, curbside recycling was available to households on a voluntary participation basis at no additional charge beyond what the household was already paying to subscribe for garbage collection service.

Figure 6, *Average Curbside Recycling Collection Per Household in 2000*, shows average curbside recycling quantity per household for 33 city and 8 unincorporated county HSAs.[18] As indicated in Figure 6, average curbside recycling per household varied between a low of 130 pounds in the portion of SeaTac served by SeaTac Disposal and a high of 1,280 pounds in the City of Newcastle. Countywide, single-family households subscribing to garbage collection service on average diverted 798 pounds through curbside recycling in 2000.

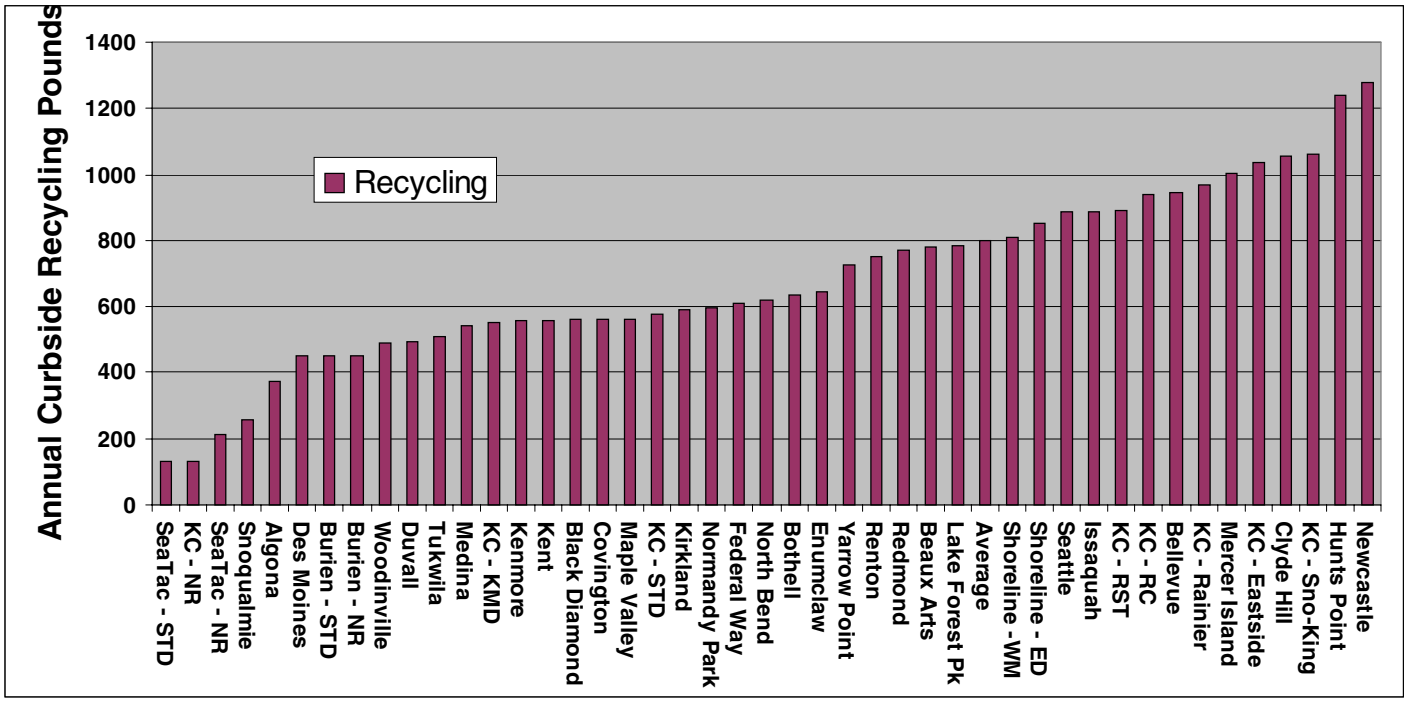
On its face, Figure 6 reinforces the commonly held belief that higher income communities recycle more than lower income communities do, as can be seen by noting the tendency for higher income cities and unincorporated county service areas to fall at the high end of the chart, with lower income jurisdictions farther down the ranking. It also should come as no surprise that both hauler service areas in SeaTac, where participation in curbside recycling requires an additional subscription fee, fall at the bottom of the curbside diversion ranking shown in Figure 6. It remains for the statistical analysis covered in Chapter IV to lay out just how significant income and

[18] Not included in Figure 6 are six cities -- Auburn, Carnation, Milton, Pacific, Sammamish, and Skykomish, as well as the Vashon unincorporated area, for reasons that have been discussed previously in text or footnotes in this report.

subscription fees are in, respectively, driving and discouraging diversion of waste through curbside recycling.

There are other factors that either may drive recycling diversion or that are of intrinsic interest in and of themselves that were chronicled in our survey of solid waste collection practices. These are enumerated in the remainder of this subsection characterizing recycling in King County.

Figure 6
Average Curbside Recycling Collection per Household in 2000
King County City (33) and Unincorporated County (8) Hauler Service Areas



III.C.1. Curbside Recycling Collection Frequency

In the year 2000 curbside recycling collection was weekly in eleven of the cities portrayed in Figure 6 – Bellevue, Bothell, Duvall, Issaquah, Kirkland, Newcastle, North Bend, Redmond, Renton, Snoqualmie, and Woodinville. Curbside also was weekly within Waste Management's service area in the City of Shoreline, in the unincorporated county areas served by Rabanco Connections, Waste Management – Rainier, and Waste Management – Sno King, and in the newest city Sammamish, although no data on solid waste collections were available for the year 2000 for Sammamish. All other jurisdictions offering curbside recycling in King County provided collection every other week (biweekly). Seattle used to be the exception to these two categories for recycling frequency when Seattle's south end received only monthly curbside recycling. But that

was changed with Seattle's new solid waste collection contracts that went into effect April 1, 2000.[19]

III.C.2. Curbside Recycling Material Targets

All King County jurisdictions that provided curbside recycling in 2000 targeted a basic list of materials – all recyclable paper fiber types (mixed paper, newspaper, cardboard, boxboard, magazines, and junk mail), glass containers, tin and aluminum food and beverage cans, and polyethylene terephthalate (PET) and high density polyethylene (HDPE) plastic bottles. Several cities also targeted small pieces of scrap metal – Bellevue, Issaquah, North Bend, Seattle and Snoqualmie; aseptic drink containers – Issaquah, North Bend, Redmond, Seattle and Snoqualmie; and polycoated drink containers and freezer cartons – Bellevue, Issaquah, North Bend, Redmond, Seattle and Snoqualmie. In addition, under its new collection contracts Seattle households could recycle all types of plastic bottles, not just PET (#1) and HDPE (#2); all types of plastic jugs, jars and round dairy tubs; and plastic shopping bags.

III.C.3. Curbside Recycling Containerization

Twelve of the twenty-eight jurisdictions that provided biweekly recycling also provided 90/96-gallon wheeled carts for a household's basic recycling container. These were Beaux Arts, Clyde Hill, Des Moines, Hunts Point, Kenmore, Kent, Lake Forest Park, Medina, Mercer Island, Seattle, Yarrow Point, and the unincorporated county area serviced by Eastside Disposal. All these areas other than Kent also provided an 18-gallon bin for glass, while using the 90/96-gallon wheeled cart to contain all other recycled materials. Kent used a 90-gallon wheeled cart for all materials other than glass, a 20-gallon bin for glass, and an additional 32-gallon cart for overflow containerization in case the 90-gallon wheeled cart filled up in less than two weeks.

Biweekly recycling jurisdictions that provided a two-bin, 34-gallon and 18-gallon, configuration for curbside collection included Algona, Black Diamond, the portion of Burien served by SeaTac Disposal, Covington, Maple Valley, Normandy Park, the portion of SeaTac served by SeaTac Disposal, the portion of Shoreline served by Eastside Disposal, Tukwila, and unincorporated county areas serviced by Kent-Meridian Disposal and SeaTac Disposal. Material sorts in these two bins were the same as for jurisdictions using 90/96-gallon wheeled cart and 18-gallon bin containerization.

[19] Seattle actually used three different curbside recycling collection frequencies in 2000. Under previous contracts in effect through the end of March 2000, households in the south end received recycling collection once a month using a 96-gallon wheeled cart for most materials and a small bin for glass and scrap metal, while households in the north end received weekly pickup from three 18-gallon stacking bins – one for mixed paper, one for newspaper and one for bottles, cans and scrap metal. The descriptive and statistical results summarized in this report assume that for all of 2000 all single-family households in Seattle had biweekly recycling collection from their choice of either a 64- or a 96-gallon wheeled cart for most targeted materials and a separate 18-gallon bin for glass and scrap metal. We believe that this assumption does not bias any of the results reported herein. Further, we would have had to make numerous assumptions to separate garbage and yard debris collection quantities and household counts, not to mention the Census 2000 information and King County Assessor's Office data on yard size, to match the city areas having the two different types of curbside collection during the first three months of the year.

The portions of Burien, SeaTac and unincorporated King County served by Nick Raffo Garbage Company used three fifteen gallon bins for their biweekly collection, with mixed paper in one, newspaper in another, and glass/metal/plastic in the third. The City of Federal Way and the portion of unincorporated King County served by RST Disposal used three bins, sized at 14 and 15 gallons, respectively, with the same sort of materials as Nick Raffo for their biweekly collections. Enumclaw used three 9-gallon bins, with one for mixed paper, including newspaper, one for glass, and the third for metal and plastic containers. In the unincorporated portion of King County that lies on Vashon island, American Disposal used four bins and five sorts (six if we count cardboard set out loose, the procedure by which cardboard is typically recycled in all King County curbside recycling programs) for biweekly collection of mixed paper in a bag, newspaper in one bin, glass containers in another, aluminum and tin cans in a third, and PET and HDPE plastic bottles in the fourth bin.

The remaining jurisdictions collected weekly in three 14- or 15-gallon bins using the typical three-bin sort of mixed paper in one bin, newspaper in another, and all containers -- including glass, as well as aseptic, polycoat, and/or scrap metal where targeted, in the third, with cardboard bundled separately. These jurisdictions were Bellevue, Bothell, Duvall, Issaquah, Kirkland, Newcastle, North Bend, Redmond, Renton, Sammamish, the portion of Shoreline served by Waste Management - Northwest, Snoqualmie, Woodinville, and the areas of unincorporated King County serviced by Rabanco Connections, Waste Management-Rainier, and Waste Management-Sno King.

Enumclaw is the only jurisdiction that further sorted materials before loading them into the curbside recycling collection vehicle. In all other jurisdictions the collector loaded materials into bins or racks on the truck that matched the sort categories and containers used by households.

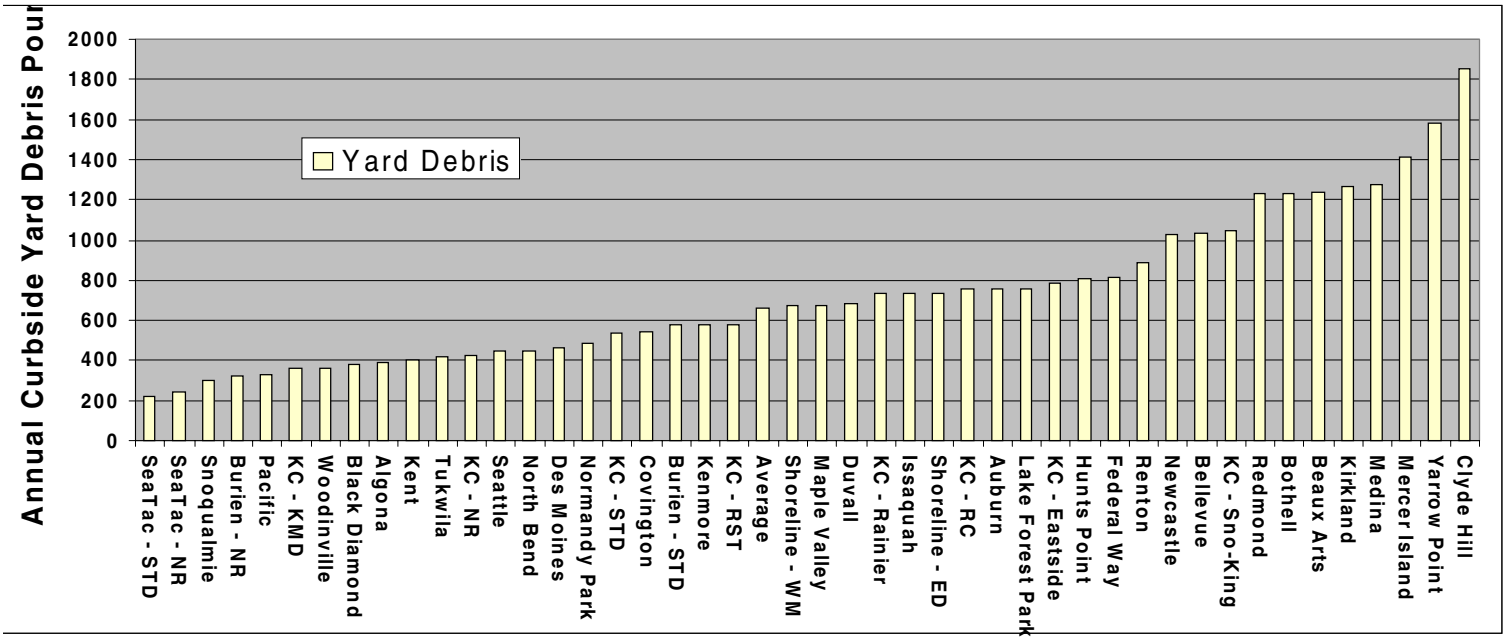
III.D. Characteristics of Curbside Yard Debris Collection

All cities and unincorporated areas in King County had available curbside yard debris collection services in 2000, with the exception of Carnation, Skykomish, and the unincorporated area of the county encompassing Vashon Island. Eight cities, listed in subsection II.B.2, embedded that curbside yard debris service in garbage fees. That is, yard debris collection was available to households in these cities on a voluntary participation basis at no additional charge beyond what the household was already paying to subscribe for garbage collection service.

Figure 7, *Average Yard Debris Collection per Household in 2000*, shows average curbside yard debris collection quantity per household for 34 city and 8 unincorporated county HSAs.[20] As indicated in Figure 7, average curbside yard debris collection per household varied between a low of 222 pounds in the portion of SeaTac served by SeaTac Disposal and a high of 1,853 pounds in the City of Clyde Hill. Countywide, single-family households subscribing to garbage collection service on average diverted 657 pounds through curbside yard debris collections in 2000.

[20] Not included in Figure 6 are five cities -- Carnation, Enumclaw, Milton, Sammamish, and Skykomish, as well as the Vashon unincorporated area, for reasons that have been discussed previously in text or footnotes in this report.

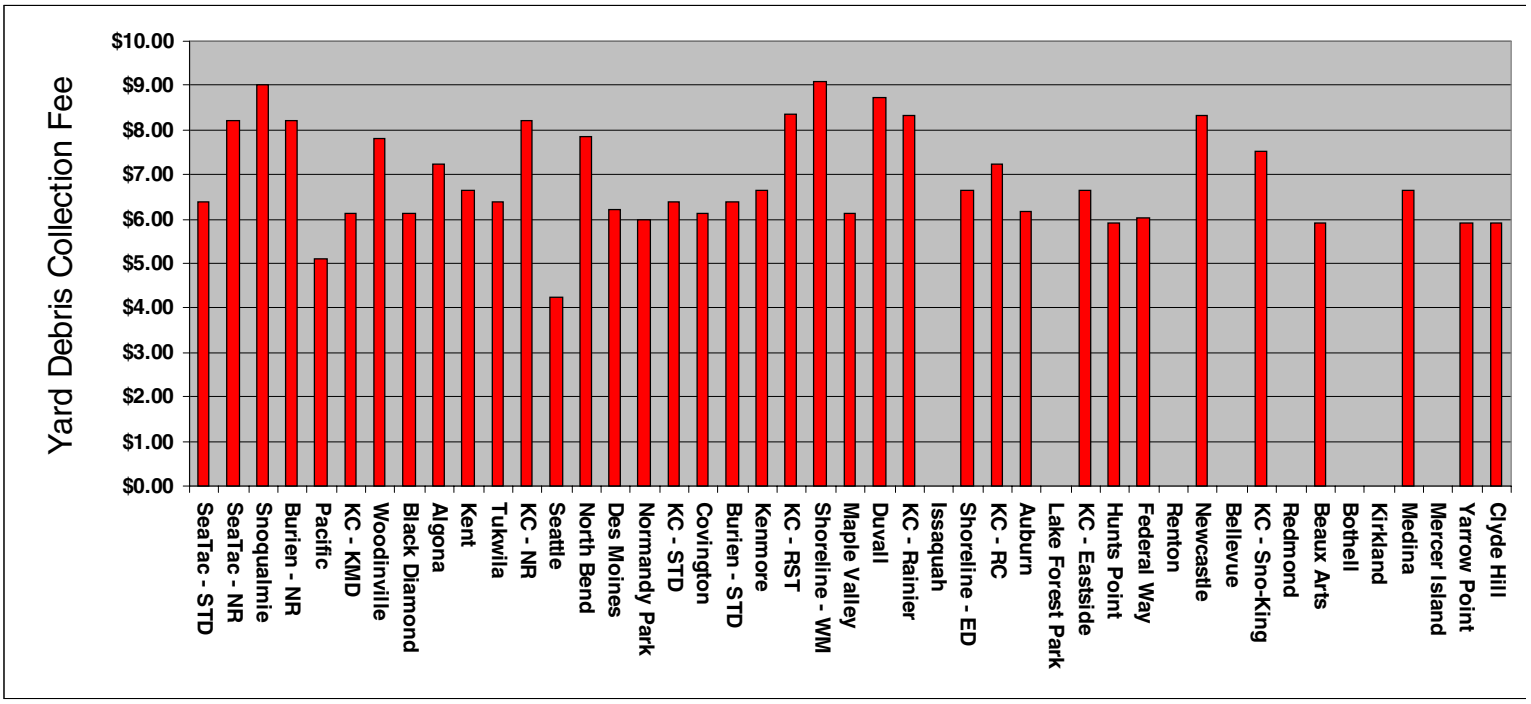
Figure 7
Average Curbside Yard Debris Collection per Household in 2000
King County City (34) and Unincorporated County (8) Hauler Service Areas



As was the case for curbside recycling, household income apparently was an important driver of curbside yard debris diversion in 2000. Whether yard debris collection was included with garbage collection or required a separate additional subscription fee also appears to be an important factor. Figure 8, *Monthly Curbside Yard Debris Collection Fees in 2000*, shows the monthly fee in 2000 for yard debris collection for the cities and unincorporated county areas displayed in the same order as they appear in Figure 7. It will remain for Chapter IV to sort out statistically the exact relationship between yard debris diversion through curbside collection and the monthly fee. But a casual comparison of Figures 7 and 8 indicates that the collection fee must be an important determinant of the quantity of yard debris diverted from garbage collection, especially after adjusting for differences in household income and yard size.

Other factors that either may drive yard debris diversion or that are of intrinsic interest in and of themselves were revealed by our survey of solid waste collection practices. These are enumerated in the remainder of this subsection characterizing yard debris recycling in King County.

Figure 8
Monthly Curbside Yard Debris Collection Fees in 2000
King County City (34) and Unincorporated County (8) Hauler Service Areas



III.D.1. Yard Debris Collection Frequency

Yard debris collection was more often biweekly than weekly, but fourteen jurisdictions did collect yard debris weekly during the year 2000. These were: Auburn, Bothell, Federal Way, Issaquah, Kent, Kirkland, Newcastle, Redmond, Sammamish, the portion of Shoreline served by West Management - Northwest, Woodinville, and the unincorporated county areas serviced by Rabanco Connections, Waste Management - Rainier, and Waste Management - Sno King. Six of these jurisdictions dropped back to biweekly collection during the winter months (typically December through February), seven dropped back to monthly, and Issaquah remained at the weekly frequency year round.

For the 31 jurisdictions that collected yard debris every other week, 23 dropped back to monthly during the winter months, including the portions of Burien and SeaTac served by Sea Tac Disposal, and the portion of Shoreline served by Eastside Disposal. Bellevue, the portions of Burien and SeaTac serviced by Nick Raffo, Duvall, Enumclaw, Medina, Pacific, Renton, and unincorporated county areas serviced by Raffo and RST remained biweekly year round.

III.D.2. Curbside Yard Debris Containerization & Quantity Limits

Every yard debris collection program in King County used a 90/96-gallon wheeled cart as the basic container, with the exceptions of Seattle -- where households used 32-gallon or smaller cans/bins, kraft paper bags or reusable polyethylene bags, and Issaquah, where households supplied their own containers unless they opted to rent a wheeled cart. Other than Seattle's reusable bags, plastic bags are prohibited for use in yard debris collection in King County cities and unincorporated county HSAs.

Ten cities – Auburn, Bothell, Clyde Hill, Enumclaw, Hunts Point, Issaquah, Kent, Kirkland, Lake Forest Park, and Renton had no limitation on the amount of yard debris that a household could set out for curbside collection. Bellevue had a 320-gallon limit, Mercer Island 270, Snoqualmie 180, North Bend 154, and Seattle a 128-gallon limit. The limit was 90/96 gallons everywhere else. 32 gallons was the unit of choice for extra yard debris quantities that incurred extra-quantity charges.

IV. Statistical Analysis of What Motivates Waste Minimization & Diversion in King County Cities and Unincorporated County Hauler Service Areas

This chapter reports statistical results that sort out which factors did and which ones apparently did not affect the quantities of solid waste that a single-family household set out for curbside or alley garbage, curbside recycling, and curbside yard debris collections in King County cities and unincorporated areas during 2000.[21] These statistical results are based on our survey data on solid waste collection quantities and program characteristics, along with demographic and yard size data gathered from the 2000 Census and the King County Assessor's Office.

This chapter also discusses which program characteristic and collection fee configurations worked best to maximize diversion, or to minimize waste generation. As we will see, some methods that increased waste diversion also caused a concomitant increase in waste generation. We will also examine the extent to which these factors that determine a household's waste minimization and diversion performance can be influenced by solid waste program managers. For example, we estimate the extent to which household size, income and yard size, factors that are clearly not within the purview and control of a recycling program coordinator, determined how much waste a household diverted through available curbside diversion programs.

IV.A. Determinants of Solid Waste Collection Quantities

Table 1, *Estimated Impacts of Significant Collection Quantity Determinants*, shows the significant[22] determinants of single-family garbage, recycling and yard debris collection quantities per household for cities and unincorporated areas in King County in the year 2000. Impacts on collection quantities shown in Table 1 are for a change of one unit in each of the demographic/geographic factors, collection fee ratios, or collection system characteristics listed at the top of the table. These impact estimates shown in Table 1 are for factors that our statistical analysis identified as significant drivers of collection quantities. We estimated these impacts by using multiple linear regression statistical analysis, a statistical technique for sorting out the

[21] The subsample we used for our statistical analysis consisted of 36 service areas out of the 52 service areas in 39 cities and 9 unincorporated King County HSAs. Excluded service areas included Enumclaw, Milton, Skykomish, Sammamish with two areas inside its city limits, and Vashon Island in unincorporated King County. These jurisdictions were excluded for reasons already enumerated in footnote 11. The cities of Auburn, Carnation and Pacific were excluded because curbside recycling was not available there in 2000. Also, curbside yard debris collection was not available in Carnation. Five other cities were excluded – Beaux Arts, Clyde Hill, Hunts Point, Medina, and Yarrow Point – because they had relatively few garbage subscribers and their average household incomes were all above $140,000. We did not want to have our sample tilted toward extremely high-income small cities. The City of Kirkland was excluded because in 2000 that city had basically unlimited quantity weekly garbage collection at a single fee for all single-family households. Thus, there was no can 2 charge in Kirkland to use for calculating collection price ratios. Lastly, Snoqualmie was excluded because of its extremely low household person count of 1.8. The 36 areas in the sample have household person counts ranging smoothly between 2.4 and 3.1 (see Figure A2 in Appendix 1).

[22] "Significant" is used here in the statistical sense. That is, we determined that a variable that is hypothesized to be an important driver of solid waste collection quantities was empirically important based on whether we found a statistically significant relationship between that variable and collection quantity for one or more of the three solid waste collection streams (garbage, recyclables, and yard debris). In most cases we used a 95% confidence level to demarcate significant from not significant, unless otherwise noted in the text or footnotes.

separate quantitative impacts of variables that simultaneously drove collection quantities during 2000.[23]

Table 1
Estimated Impacts of Significant Collection Quantity Determinants
(Pounds per household per year per unit of each variable)

Collection Stream	House-hold Size (persons)	Yard Size (acres)	Large Yard Step Effect (for Very Rural Areas)	Annual Median Income Ratio	Garbage Fee Index Ratio	Yard Debris Fee Ratio	SeaTac Re-cycling Fees Ratio	Linear (or bet-ter) Rates	Weekly Recy-cling	90/96 Biweekly Recy-cling Con-tainer	Weekly Yard Debris
Garbage	634.5	1634.9	-525.2	n.s.	-210.6	159.3	n.s.	n.s.	n.s.	n.s.	-90.3*
	(80.8)	(403.4)	(209.9)		(78.1)	(45.9)					(61.1)
Recycling	83.4	n.s.	n.s.	0.0274	n.s.	n.s.	-386.9	212.5	239.5	211.3	n.s.
	(47.9)			(0.010)			(98.2)	(106.1)	(82.0)	(99.8)	
Yard Debris	115.2	483.6**	-284.2**	0.0329	130.6	-447.7		n.s.			195.2
	(54.2)	(513.8)	(293.4)	(0.009)	(61.7)	(76.8)					(87.9)

Notes: The number shown in parentheses under each coefficient estimate is the standard error for that coefficient estimate. All coefficient estimates are significant at 95% unless otherwise noted, except for weekly recycling's estimated impact on annual recycling collection quantities, which is significant at 92%.

n.s. = not significantly different from 0 at 90% confidence level. That is, there is at least a 10% chance that the impact is zero.

* Significant at 85%.

** Household income and yard size were too closely correlated in determining yard debris collection quantity to be able to sort out statistically significant effects for both variables simultaneously. However, both were statistically significant when included separately in the yard debris equation.[24] Thus, we included both in the yard debris equation shown in Table 1 even though yard size is not statistically significant at a 95% confidence level when the household income variable is also included. This is an example of how the usual test of statistical significance can be misleading for variables that each separately are highly significant in explaining variation in yard debris collection quantities, yet are themselves too correlated with each other to be able to precisely allocate their separate influences out from their combined influence. In this situation the large standard error for the estimate of the impact of yard size signals that the estimate is imprecise, rather than signaling that the estimate is statistically not significantly different from zero.

As indicated in Table 1, the factors that influenced collection quantities in 2000 were:

- Demographics – Household size and income.[25]
- Geographics – yard size.
- Prices – subscription prices for garbage, recycling and yard debris collections.
- Garbage rate structure design – linear or better versus cost-of-service rate structure.

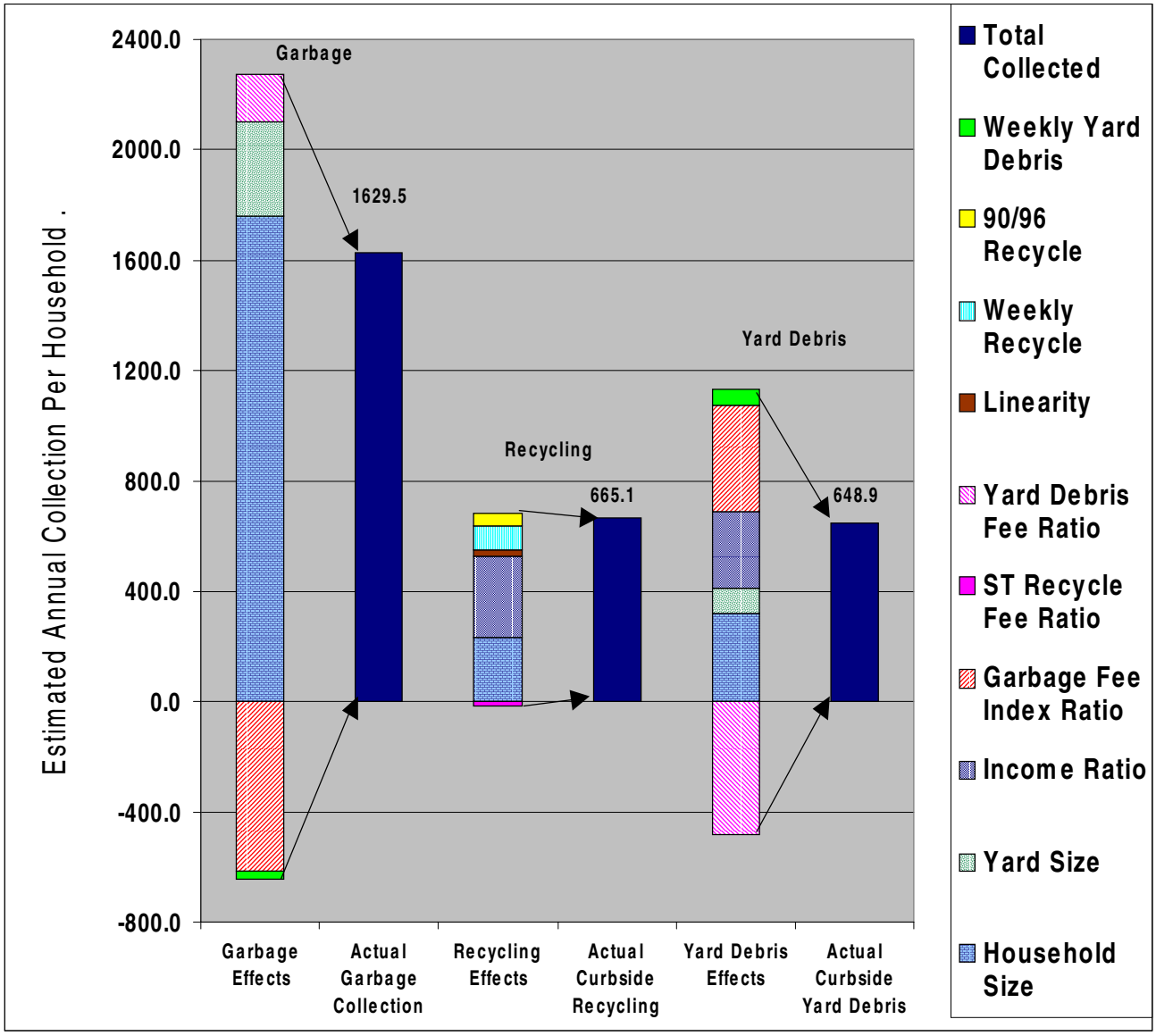
[23] The particular type of regression analysis used here was two stage least squares (TSLS). For the estimation problem at hand TSLS more accurately determines the statistical significance of factors that drive collection quantities than does ordinary least squares (OLSQ).

[24] By contrast, income was not statistically significant either with or without yard size in the garbage collection equation. For the recycling collection equation, yard size was not statistically significant either with or without income in the equation.

[25] The measure for income that we used for the regression results shown in Table 1 was the weighted average of median incomes for the census blocks in each area, where the weights were the number of households in the census block. This measure is less subject to high income extremes than the weighted average of census block means. Also, the regression results were similar for both income measures, but the variability of coefficient estimates for several variables was smaller for the weighted average medians.

- Collection frequency – weekly vs. biweekly curbside recycling and weekly vs. biweekly curbside yard debris collections.
- Collection container size – 90/96-gallon wheeled carts for biweekly curbside recycling vs. smaller containers for biweekly curbside.[26]

Figure 9
Determinants of Garbage, Recycling & Yard Debris Collections in 2000
(Pounds per household per year)



[26] The biweekly recycling collection systems for the most part used either the 90/96-gallon cart or a 34-gallon bin as their primary container for holding most targeted recyclables, along with a separate second container for glass and perhaps a few other targeted materials. In addition, as discussed in Subsection III.C.3., several biweekly systems used three bins for containerization. One of the biweekly systems used just a single container into which all targeted materials were commingled.

Figure 9, *Determinants of Garbage, Recycling and Yard Debris Collections in 2000*, is derived by multiplying the per unit impact estimates shown in Table 1 by the 36-area subsample average value for each collection quantity determinant.[27] This shows how variables such as income stack up against other variables such as garbage collection prices in terms of average plus or minus impact on collection quantities. The shorter, solid-colored bars shown in Figure 9 for each collection stream portray how these increases and decreases net together to yield the averages shown at the top of each solid-colored bar for household garbage, recycling and yard debris collection quantities in 2000 for the 36 collection areas used for our statistical analyses. [28]

As an example of the derivation of one of the slices that comprise the stacked bars in Figure 9, consider that the 36-collection-areas subsample average for single-family household size in 2000 was 2.8 persons. Based on the estimate reported in Table 1 for the impact of household size on garbage collection quantity of 634.5 pounds per person, 2.8 persons accounted for 1,762.1 pounds[29] of garbage in 2000, as indicated by the Household Size portion of the stacked bar for Garbage Effects shown in Figure 9. After household size, garbage and yard debris collection fees accounted for the next biggest effects on collection quantities, followed closely by income and yard size.

Diversion program characteristics such as weekly versus biweekly collection frequency had much smaller effects. This is because each of the significant diversion program characteristics was employed in relatively few jurisdictions. Thus, the relatively large impact listed in Table 1 for jurisdictions making use of one of these characteristics was muted by all those that did not use it when we computed the average impact across all 36 jurisdictions in our sample, as portrayed in the Recycling Effects and Yard Debris Effects stacked bars shown in Figure 9.

The following sections discuss the estimates shown in Table 1 and Figure 9, and how they were derived, in more detail. These sections also enumerate a number of collection program characteristics that are not shown in Table 1 or Figure 9 because they did not significantly impact collection quantities in 2000.

IV.A.1. Measuring Collection Prices and Income on a Common Denominator

The garbage and yard debris fee ratio variables reported in Table 1 are based on the ratio of garbage or yard debris subscription prices (also referred to herein as "fees" or "rates") to the incremental subscription price for weekly collection of a second 32-gallon can of garbage. During 2000 the majority (54%) of single-family household garbage service subscribers in King County

[27] Throughout this chapter whenever we speak about averages we will be referring to an average across the sample or subsample of city and unincorporated county HSAs. These averages will be of quantities that are themselves averages per household (or medians in the case of yard size and income) for each city and unincorporated area. Thus, the averages reported in this chapter are simple averages of the city and unincorporated area averages for single-family households – that is, they were not weighted by the number of household garbage subscribers in each city. By contrast, the countywide average collection quantities per household reported in Chapter III are weighted averages, because in computing the countywide average each jurisdiction's average was weighted by the number of garbage subscribers in that jurisdiction.

[28] Multiple linear regression analysis yields per unit impact estimates that have the desirable property of adding up to the actual sample average collection quantities when the estimated impacts per unit are multiplied by sample average levels for each determinant.

[29] 1,762.1 pounds = 2.777 persons * 634.53 pounds of garbage set outs per person.

signed up for weekly collection of a single 32-gallon can or 35-gallon cart. As a result, the economic choice between putting additional quantities of generated solid waste out for garbage collection each week, or diverting those quantities to recycling and/or yard debris collections, in most cases involved comparing the cost for a second 32-gallon can against the cost for curbside recycling and yard debris collections. The ratio of the curbside recycling or yard debris subscription price (which price is zero for those jurisdictions that embed that diversion service in garbage fees) to the fee for a second can provides a simple statistic for defining which choice is most economical. If the ratio is smaller than one, diversion is cheaper. If the ratio is greater than one, collection for disposal is cheaper.

Only the two hauler service areas inside the city limits of SeaTac and American Disposal's service area on Vashon Island actually charged subscription fees for curbside recycling in 2000. Every other city and all unincorporated areas that provided curbside recycling collection offered that service at no additional charge – i.e., zero price -- to all garbage subscription service users. On the other hand, most areas charged a subscription fee for yard debris collection. So we were able to estimate a price impact for yard debris subscription fees, but not for recycling. Two sample points do not provide sufficient evidence on which to base an estimate for the generalized impact of recycling subscription fees. Thus, the recycling fee effect reported in Table 1 is a measure of the impact of recycling fees in SeaTac's two HSAs on average recycling quantities in those two areas.

In addition to defining the cost for yard debris diversion as a ratio using as its denominator the price for a second can of garbage, we also defined the cost for garbage collection and the magnitude of a household's income in terms of a second can of garbage as well. That is, we divided a garbage subscription price index, as defined in the following paragraph, and annual household income by the price for a second can of garbage, just as we did for the subscription price for yard debris collection. This provides the symmetry of having all economic values in the statistical analysis based on a common numeraire – second cans of garbage rather than dollars -- that is useful and also intrinsically interesting for our analysis of solid waste collection programs.

In order to come up with figures to compare fees for garbage collection services among cities and unincorporated county service areas, we had to somehow summarize the numerous prices for the different garbage collection service levels available in each King County jurisdiction. These service offerings during the year 2000 ranged from one 32-gallon can collected monthly to one 10- or 20-gallon can collected weekly to one 32-gallon can collected weekly, on up to one or more 90/96-gallon wheeled carts collected weekly, with not all offerings available in every area. So to create the garbage subscription price index (sometimes referred to herein as the garbage bill or fee index), we calculated the percentage of countywide garbage service subscribers using each service level. We then used those percentages as weights to compute a cost index for garbage collection in each jurisdiction. This index measures garbage fee levels in the various jurisdictions while holding constant differences in the distribution of service level choices made by garbage subscribers in each jurisdiction.

Given these definitions of the price ratios, the estimates of price effects shown in Table 1 and Figure 9 indicate that:

- Areas with higher subscription fees for yard debris collection and/or lower incremental fees for collection of a second can of garbage have higher garbage collection quantities and lower quantities of yard debris diverted from garbage collection into yard debris collection.
- Areas with higher garbage fees have lower garbage collection quantities and higher yard debris collection quantities.
- SeaTac has lower diversion of recyclables from garbage collection into curbside recycling due at least in part to its use of subscription fees for recycling collection.

These price effects are all consistent with the tenets of modern economic theory.

We also estimated the effect of linear or better rate structures for those jurisdictions using this rate structure to incentivize waste reduction and diversion. As indicated in the Linearity column in Table 1, linear rate structures were significant at increasing recycling, but insignificant at affecting garbage or yard debris collection quantities. A caveat to this latter conclusion is that linear rate structures tended to have higher incremental fees for a second can of garbage. Thus, linear rates also have an impact through impacts from garbage and yard debris collection fee ratios as shown in Table 1.

IV.A.2. Relative Importance of Demographic/Geographic Variables, Collection Fees, and Collection Program Characteristics for Diversion Levels in 2000

As suggested by the impacts coefficients in Table 1 and demonstrated for the year 2000 by the average effects bars in Figure 9, demographic and geographic variables drive a significant portion of solid waste collection quantities. In fact, these three variables accounted for 73%, 76%, and 43%, respectively, of the average effects from significant determinant variables on single-family household garbage, recycling and yard debris set outs during the year 2000. In the case of garbage and recycling collections, another way of saying this is that collection program characteristics and pricing, variables which can be controlled by solid waste collection program managers and designers, accounted for only about 25% of collection quantity effects. However, as the following discussion indicates, the implications of the relative importance for demographic/geographic variables versus collection program characteristics and pricing displayed in Figure 9 are quite different for the garbage and recycling streams, as well as for yard debris.

For garbage collection, Table 1 indicates that the garbage and yard debris price ratios and yard debris collection frequency are the only variables that impact garbage collection quantities other than the demographic and geographic variables. There are constraints on solid waste program managers in using these three control variables:

- Embedding yard debris collection in garbage fees, thereby reducing the price for yard debris collection to zero, in all 40 (out of 48) King County collection jurisdictions that charged a subscription fee for yard debris collection in 2000 would reduce the average garbage collection quantity by 11%. That would be the maximum impact available from that variable.

- Doubling garbage fees in all King County jurisdictions would reduce average garbage collection quantity by 38%, but this size rate increase would hardly be acceptable to ratepayers.
- Increasing yard debris collection frequency to weekly in all jurisdictions would reduce garbage collection by just 4%.

Thus, we estimate that solid waste program managers actually have control over just about 25% of garbage collection quantities, with 75% being determined by household size and income and yard size.

The story for recycling collection quantity, where pricing and program characteristics also determined about 25% of collection quantities in 2000, is quite different than for garbage collection. This is because all but two jurisdictions had embedded curbside recycling in garbage collection fees prior to 2000. Thus, the impact of pricing variables for recycling collections had already been exercised to nearly its maximum level. For this reason pricing effects for recycling are non-existent in our data for 2000, other than for the two collection areas in SeaTac.[30]

As indicated in Table 1, the impact estimate for SeaTac recycling is of similar magnitude to yard debris pricing impacts. So one might conclude that pricing is just as important for recycling as it is for yard debris. However, with only the two SeaTac subscription price data points providing the pricing impacts coefficient estimate for recycling, we cannot rule out the possibility that the estimate is also picking up other characteristics of SeaTac's customer base and/or collection program that could be either amplifying or muting the actual underlying price effect.

On the other hand, linear or better garbage rate structures did have a significant and substantial impact on recycling collection quantity in 2000, as indicated by the coefficient estimate for linearity in Table 1. According to this estimate, if all King County jurisdictions used linear or better rate structures, instead of just seven of 48, recycling collection could have been 28% higher.

Similarly, collection frequency and collection container size also had significant and substantial estimated impacts for 2000, as shown in Table 1. The absence of any weekly collection program that also used the 90/96-gallon wheeled cart as a collection container prevents any conclusion about the combined impact. But, for example, if all biweekly programs switched to weekly, recycling collection would have been increased by 17%.

The conclusion for recycling is that solid waste program managers probably have influence over about half of recycling collection quantities.[31] The other half is a function of household size and income. The fact that these demographic variables determined 76% of recycling collection quantities in 2000 is due to program managers choosing not to use effective program control variables at their disposal – namely, collection frequency, collection container size, and linear or better garbage collection fees.

[30] The unincorporated service area on Vashon Island also charged for recycling collection, but data measuring customer counts and collection quantities were not available for Vashon.

[31] In the 36-areas subsample we used for our statistical analysis only 13 jurisdictions provided weekly recycling, while 23 used biweekly. Just 7 of these 23 biweekly programs used the 90/96-gallon wheeled cart (plus a separate bin for glass).

Finally, for yard debris Figure 9 shows that in 2000 program managers were using pricing and program control variables to determine over half, in fact 57%, of yard debris collection quantities. Unfortunately, some of this control resulted in lower yard debris collections. For example, only eight of 48 jurisdictions embedded yard debris collection in garbage fees in 2000.

The potential for increasing yard debris diversion by embedding yard debris collection costs in garbage fees (i.e., offering yard debris diversion at no additional charge to garbage service subscribers) is very interesting for two reasons – (1) currently most jurisdictions charge a subscription fee for yard debris collection that is ***higher*** than their incremental fee for collection of a second 32-gallon can of garbage each week, and (2) the possibility of expanding yard debris collection programs to include a wider range of organic materials such as food scraps and soiled paper could in combination with embedded organics collection provide the potential to substantially boost diversion levels.

To elaborate a bit on yard debris collection fees during 2000, of the 47 King County jurisdictions other than Milton, 31 charged a subscription fee that was greater than their 2nd garbage can fee, 8 embedded yard debris collection in garbage fees, 7 (Auburn, Enumclaw, Federal Way, North Bend, Pacific, Seattle, and Snoqualmie) charged a subscription fee that was less than their incremental fee for the second can of garbage, and Carnation did not offer curbside yard debris collection. This indicates that there is ample opportunity to increase yard debris diversion through a restructuring of collection fees.

Besides garbage and yard debris collection fee levels, Table 1 also indicates that yard debris collection frequency is an important driver of increased yard debris diversion. For example, if all King County jurisdictions collected yard debris every week, collection quantities could be expected to increase by 21%.

The conclusion for yard debris is that despite the importance of household size and income and yard size, there is ample opportunity for program managers to affect yard debris collection quantities, either positively or negatively. In the year 2000 program managers chose pricing levels and collection frequencies such that the negative effect of yard debris subscription prices more than offset the positive effect of garbage fees and weekly collection frequencies, resulting in a 6% lower average for yard debris collection per household.

IV.A.3. Disposal versus Diversion Impacts of Yard Debris Collection Fees

A very interesting characteristic of the collection fee effect estimates shown in Table 1 is how collection fees affect garbage collection quantities and yard debris diversion quantities in opposite directions. These are examples of what economists call the cross substitution effects of relative prices.

Consider a one-unit ***decrease*** in the yard debris subscription fee to garbage can 2 fee ratio, which for ease of exposition we will refer to as a one unit decrease in the yard debris fee ratio. Such a decrease would result in an increase of 447.6 pounds in yard debris collections, and a 159.3-pound drop in garbage collection, according to the estimates shown in Table 1.

The fact that the change in diversion quantity is greater in absolute magnitude than the change in garbage collection quantity is noteworthy. It suggests that yard debris collection fees have both waste diversion and waste generation effects, and that these effects run in opposite directions. This means that yard debris collection fees cannot be used to simultaneously minimize waste generation and maximize waste diversion. This discussion will be developed further in Section B of this chapter.

IV.A.4. Non-Linear Yard Size Impacts

As indicated by the yard size effect estimates shown in Table 1 and portrayed in Figure 9, bigger yards generate higher set out quantities for both garbage and yard debris collections. This relationship certainly passes the common sense test. Except that we also casually observe that once household lot sizes get big enough, households more often handle more of their yard debris on site through a variety of methods.

As shown in Figure A1, *Single-Family Household Median Yard Size (Acres)*, in Appendix 1, the median yard size for King County collection service areas turns exponentially upward above the quarter acre median yard size. The distribution jumps up very dramatically above four tenths of an acre for a jurisdiction's median yard size, with the county unincorporated areas serviced by American Disposal (KC - AD), Kent-Meridian Disposal (KC - KMD), and Waste-Management Sno King (KC – Sno-King) having median yard sizes of 0.95, 0.52 and 0.86 acres, respectively. We determined through our statistical analysis that it was in these areas that enough households apparently have access to and actually use on-site yard debris management methods that a linear relationship between yard size and collection quantity does not accurately capture the relationship between yard size and yard debris collection quantity.

Our statistical estimates accounted for this non-linear impact from larger yard sizes by estimating a second variable for the KC - KMD and KC – Sno-King service areas, both of which are included in the subsample we used for the statistical analyses discussed in this chapter. This step variable provides an estimate of the offset to the linear yard size effect, so as to capture impacts from the decreased generation of yard debris for collection that occurs when a household has a big enough lot to readily manage their yard debris on site. As shown in Table 1, these collection quantity offsets for the KC - KMD and KC – Sno-King areas are estimated at 525.2 pounds for garbage and 284.2 pounds for yard debris. These offsets are reflected in the yard size impact bars shown in Figure 9.

IV.A.5. Collection System Characteristics That Are Not Significant Determinants

Besides collection fees and the curbside recycling collection program characteristics that had the significant impacts called out in Table 1, there were other collection program characteristics that we tested to find out whether they also might significantly impact collection quantities. We also tested for the impact of non-English speaking populations. For all three collection streams these variables were not significant at the 90% confidence level. In most cases they were not significant even at well below the 90% confidence level. These non-significant characteristics and factors for collection quantities in the year 2000 are:

- Mandatory garbage collection.
- No reduced frequency garbage collection services, such as one 32-gallon can collected biweekly or monthly.
- Collection for recycling of materials in addition to the countywide standard targets – newspaper, cardboard, mixed paper, glass containers, steel and aluminum containers, and PET and HDPE plastic bottles.
- Yard debris collection of more than one 90/96-gallon container only at an additional charge.
- Unlimited yard debris set out quantities.
- Weekly yard debris collection throughout the year rather than decreasing to biweekly December through February.
- Percentage of households in the collection service area that are linguistically isolated.[32]

The conclusion that targeting of non-standard materials did not significantly increase year 2000 recycling quantities in our sample of jurisdictions merits some comment. In the 36-areas subsample used for statistical analyses, just five cities targeted additional materials – Bellevue, Issaquah, North Bend, Redmond and Seattle. All of these cities other than Bellevue also had linear garbage collection rate structures.[33] Thus, in a statistical sense it is difficult to distinguish between the effects of targeting extra materials and linear rates, especially given the fact that Bellevue's recycling collection program substantially exceeds baseline expectations, as elucidated in Section B of this chapter. Each variable alone was significant for recycling in the subsample of 36 jurisdictions, but not both. So we had to make a judgment call as to which to include as significant and which to reject as insignificant. We chose to include linearity, primarily because the coefficient estimate for other materials was an order of magnitude larger than the amount of these materials collected per household in communities that target them. This meant that the variable had to be serving as a surrogate for other impacts in addition to the targeting of additional materials. The linearity variable's coefficient, on the other hand, is the same order of magnitude as for other pricing variables, as Table 1 shows.

The conclusion that charging for extra amounts of yard debris beyond a full 90/96-gallon container doesn't affect diversion levels is less problematic and probably sound for at least two reasons:

- The significance levels for our estimates of the impacts on yard debris collection quantity from allowing unlimited collection quantities or for charging for extras beyond 90/96-gallons were both below 80%.
- A study by Sound Resource Management in 1994 for the City of Redmond, *Financial Analysis of City of Redmond Solid Waste Program*, included an analysis of yard debris generation quantities for single-family homes in that city. This analysis concluded that 94% of single-family homes were on lots no bigger than 0.5 acres, and that most of these lots would generate well less than 50 gallons of yard debris per week. This suggests that

[32] A household is linguistically isolated if all persons in the household 14 years or older speak a non-English language and all these persons also have difficulty with English

[33] In addition to cities in the statistical subsample, Snoqualmie also targeted additional materials, and Auburn and Snoqualmie also had linear or better rate structures.

very few households ever need more than 90/96 gallons of yard debris capacity, even if collection is biweekly. On this basis charging or not charging for yard debris extras beyond 90/96 gallons likely affects too few households to generate a statistically significant impact on average yard debris collection quantities in King County jurisdictions.

Mandatory garbage and the non-availability of reduced frequency garbage collection were both not significant at even the 35% confidence level. Thus, one is well justified in concluding that these variables did not affect collection quantities one way or the other in King County during the year 2000.

Finally, solid waste collection program managers are always conscious that their educational and promotional campaigns and outreach materials need to be accessible and communicative to all the cultural groups that make up their communities. One measure of a community's need for materials that communicate with more than the majority English-speaking population is the extent to which there are groups who do not readily communicate in English. We used the 2000 Census block level figures for linguistic isolation to measure the proportion of single-family households in each census block in each King County city and unincorporated area that might need outreach and educational materials in languages other than English.

Collection program managers and others involved in promoting solid waste collection and diversion programs in King County apparently are doing a sufficient job of communicating with their non-English speaking constituents. The proportion of linguistically isolated households in a jurisdiction was not a significant factor for explaining any of the variation among jurisdictions in garbage, recycling or yard debris collection quantities in 2000.

IV.B. Determinants of Solid Waste Generation and Diversion

Table 2, *Estimated Waste Generation Impacts of Collection Quantity Determinants*, shows the significant determinants of total waste generated by each jurisdiction's average single-family household for collection during the year 2000.[34] Impacts on waste generated for collection shown in Table 2 are for a change of one unit in each of the demographic/geographic, collection fee and program characteristic variables that are statistically significant as drivers of generation of waste for collection. These influences on generation of waste for collection were identified using multiple linear regression analysis in order to sort out the separate effects of these variables that simultaneously determine collected waste generation.

As indicated in Table 2, the variables in our sample that influenced collected waste generation in 2000 are:

- Demographics – Household size and income.
- Geographics – yard size.
- Prices – subscription prices for garbage, recycling and yard debris collections.
- Program Characteristics – recycling collection frequency.

[34] The regression estimates for the generation equation shown in Table 2 are based on the same 36-King-County-service-areas subsample we used to obtain the regression estimates shown in Table 1 for the garbage, recycling, and yard debris collection quantity equations.

Collection program characteristics that were significant drivers of curbside and yard debris collection quantities in 2000 – use of a 90/96-gallon cart for biweekly collection, and weekly collection for yard debris -- were not significant for overall collected waste generation. This result tends to indicate that these diversion program convenience characteristics captured material from the garbage stream without impacting total generation of waste for collection. However, we were unable to confirm this hypothesis for the 90/96-gallon recycling cart. As indicated in Table 1, this variable was not significant in reducing garbage collection quantities in our sample for the year 2000. The same is true for linear garbage fees, which significantly impacted recycling but not garbage or yard debris collections.

Table 2
Estimated Waste Generation Impacts of Collection Quantity Determinants
(Pounds per household per year per unit of each variable)

Collection Stream	House-hold Size	Yard Size (acres)	Large Yard Step Effect (for Very Rural Areas)	Annual Median Income Ratio	Garbage Fee Index Ratio	SeaTac Recycling Fees Ratio	Yard Debris Fee Ratio	Weekly Recycling
Total Waste Generated for Collection	1018.3 (88.9)	2130.9 (959.6)	-946.9 (483.2)	0.0670 (0.028)	-262.3 (155.5)	-637.4 (180.1)	-326.3 (137.8)	296.0 (165.7)

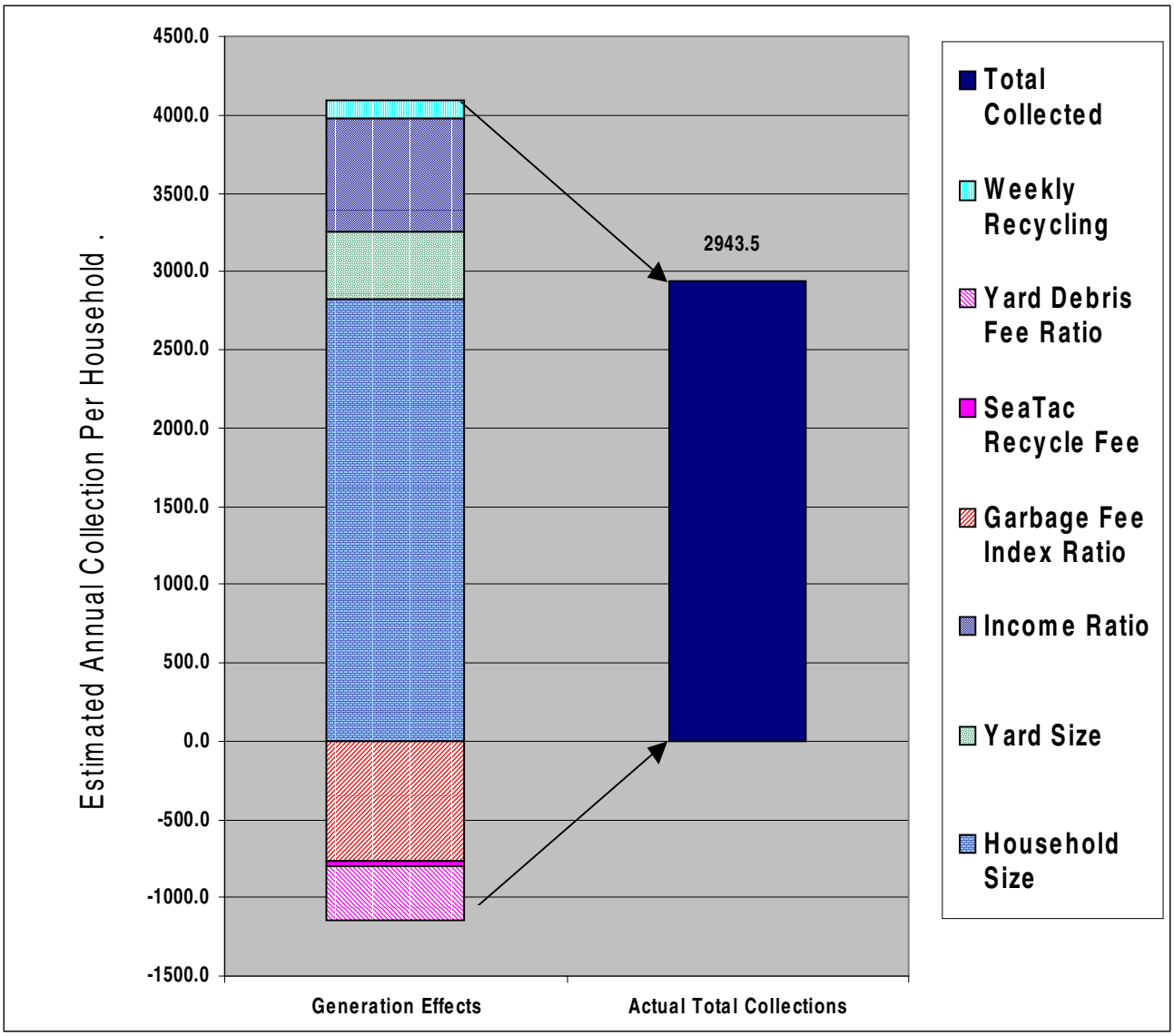
Notes: The number shown in parentheses under each coefficient estimate is the standard error for that coefficient estimate. All estimates are statistically significant at 95% or higher confidence level, except for weekly recycling at 92%.

IV.B.1. Generation & Diversion Impacts of Household Size, Income and Yard Size

Figure 10, *Determinants of Total Collection Quantity in 2000*, is derived by multiplying the per unit impact estimates shown in Table 2 by average values for each variable. This shows how factors such as income that increase generation of waste for collection stack up against other variables such as garbage collection prices that decrease generation of waste for collection. The shorter, solid-colored bar in Figure 10 portrays how these increases and decreases net together to yield the average of 2,943.5 pounds of collected solid waste per household in 2000.

The stacked bar in Figure 10 also illustrates the relative influences of household size, household income, yard size, collection fees and recycling collection frequency on solid waste generation for collection. From the Generation Effects stacked bar in Figure 10 and from the Recycle Effects and Yard Debris Effects stacked bars shown in Figure 9, it is apparent that demographic/geographic variables are very important in determining a jurisdiction's waste generation and diversion levels. In addition, diversion is driven more by income level than by household size or yard size because garbage collection quantity is insensitive to income, whereas income has substantial impacts on generation through its effect on recycling and yard debris collection quantities. Household size and yard size, on the other hand, drive generation more through their impacts on garbage collection quantity than through their impacts on recycling and yard debris collection quantities.

Figure 10
Determinants of Total Collection Quantity in 2000
(Pounds per household per year)



These findings give some support to the casual observation made by some that higher income households tend to divert more waste. At the same time, our data is based on service area ave r-ages for household collection quantities, not on individual household collection quantities, so we are not observing household behavior directly. Instead we are observing only the aggregate, av-erage behavior of households in areas with higher average incomes versus areas with lower aver-age incomes. In addition, we cannot say whether the higher diversion is caused by higher in-come households having more recyclable material in their waste stream, or because higher in-come households are somehow diverting proportionately more material from a waste stream that is similar in composition to a lower income household's waste stream.

IV.B.2. Generation & Diversion Impacts of Each Jurisdiction's Collection Program Characteristics and Collection Pricing

The previous subsection's discussion highlighted the substantial impacts that household size, income and yard size have on waste generation and diversion levels. These demographic and geographic variables are outside the control of those responsible for managing solid waste collection and diversion programs in King County cities and unincorporated areas. In this subsection we want to analyze and compare how the various jurisdictions were doing in 2000 at promoting waste minimization and diversion maximization using those collection program characteristic and collection fee options that solid waste collection program managers do have at their disposal for influencing generation and diversion.

To compare the impacts of differing choices for collection program characteristics and collection prices on generation and diversion we first needed to define a "baseline" collection program and "baseline" collection prices to provide a standard against which to measure the successes and challenges of actual programs in each jurisdiction. We had to identify this baseline or typical collection program for King County in order to use our regression equation results, shown in Tables 1 and 2, to isolate and calculate the effects of demographic and geographic variables separately from the effects of differing collection program characteristics and collection prices.

After reviewing results from our collection program surveys, the baseline collection program characteristics and collection prices we identified were:

- Embedded curbside recycling, i.e., curbside recycling available at no additional charge to all garbage collection service subscribers. (All jurisdictions that offered curbside recycling in 2000 embedded its costs in garbage fees, with the exception of the City of SeaTac and the unincorporated county service area on Vashon Island.)
- Weekly curbside recycling collection or use of a 90/96-gallon cart in the case of biweekly curbside recycling. (In 2000 a majority of jurisdictions either offered weekly curbside recycling or offered biweekly curbside using a 90/96-gallon cart.)
- Subscription-based biweekly curbside yard debris collection. (Only 8 jurisdictions embedded curbside yard debris costs in garbage collection service fees in the year 2000; and just 14 provided weekly, as opposed to biweekly, service.)
- A yard debris collection fee of $7.07. (This was the average monthly subscription fee for subscription-based yard debris collection in 2000.)
- A garbage rate structure that does not have linear or better rates. (Only 6 jurisdictions had linear or better rate structures in 2000.)
- A second garbage can incremental fee of $6.63. (This was the average incremental monthly charge in 2000 for a second 32-gallon can of garbage collected weekly.)
- A garbage fee level of $17.28. (This was the average value for the garbage bill index in 2000.)

Given this baseline collection program along with actual household size, yard size and income levels for each city and unincorporated collection area, we used the regression equation estimates shown in Tables 1 and 2 to estimate baseline generation and diversion levels for each jurisdiction. We then compared these baseline estimates against each jurisdiction's actual generation and diversion levels. This comparison is intended to reveal how each jurisdiction's actual col-

lection program stacks up against the baseline collection program, while holding constant the impacts on generation and diversion from each jurisdiction's actual average household size, yard size and income levels.

Table 3, *2000 Actual Household Generation & Diversion Versus Estimated Baseline*, lists actual generation for collection, diversion levels and diversion rates for the year 2000 for each King County jurisdiction. Actual figures for several cities and unincorporated hauler service areas are not listed in the table. These missing data are due to information not being available, the lack of a curbside collection program for recyclables and/or yard debris, or in the case of Milton because that city is part of Pierce County's solid waste system.[35]

For the cities and unincorporated HSAs for which actual data were available, generation of waste for collection in 2000 varied between a low of 1,508 pounds for the City of Snoqualmie to a high of 4,796 pounds for the average Clyde Hill household. Actual diversion varied between a low of 352 pounds for the average single-family household in the portion of SeaTac serviced by SeaTac Disposal and a high of 2,908 pounds for Clyde Hill's average household. Diversion rates for collected waste varied between a low of 16.2% in SeaTac Disposal's service area in SeaTac and a high of 61.4% for Mercer Island.

By contrast estimated generation and diversion levels for a baseline collection program in each area varied between lows of 1,534 pounds for Snoqualmie, 914 pounds for Snoqualmie, and 40.3% for American Disposal's service area on Vashon Island for generation, diversion, and diversion rate, respectively, and highs of 3,960 pounds for Clyde Hill, 1,934 pounds for Clyde Hill, and 59.6% for Snoqualmie, respectively.

Actual Versus Baseline Generation

Estimated baseline generation quantities shown in Table 3 are based on the per unit impact estimates on waste generation shown in Table 2 for household size, yard size, and the ratio of annual income to the incremental fee for a second 32-gallon can of garbage, multiplied by each jurisdiction's actual 2000 values for these three demographic/geographic variables. Generation impacts for all collection price and program characteristic variables, including the incremental fee for the second can of garbage that appears in the denominator of the annual income ratio, were evaluated at their baseline levels as defined at the beginning of this subsection. In short, the figure for estimated baseline generation in each city and unincorporated HSA represents our best estimate of generation for each jurisdiction:

- Given that jurisdiction's actual averages in the year 2000 for household size, yard size and household income, and
- Given the assumption that each jurisdiction provided only baseline collection services – embedded curbside recycling (i.e., no-additional-charge service) either biweekly using a 90/96-gallon wheeled cart or weekly using bins, subscription-based biweekly curbside yard debris (i.e., additional-charge service) at the subscription price average, and garbage collection at the garbage fee index average and at the average incremental charge for a second 32-gallon can of garbage.

[35] Most of the incorporated area of Milton actually lies in Pierce County rather than King County.

Table 3
2000 Actual Household Generation & Diversion Versus Estimated Baseline
King County City (39) and Unincorporated County (9) Hauler Service Areas

	Generation for Collection		Actual +/(-)	Diversion		Actual +/(-)	Diversion Rate		Actual +/(-)
Cities	**Actual**	**Est. Baseline**	**Baseline**	**Actual**	**Est. Baseline**	**Baseline**	**Actual**	**Est. Baseline**	**Baseline**
Algona	2219	2808	(590)	758	1156	(397)	34.2%	41.2%	-7.0%
Auburn	no curb R	2520		no curb R	1092			43.3%	
Beaux Arts	3628	2981	647	2017	1494	523	55.6%	50.1%	5.5%
Bellevue	3357	2811	546	1981	1290	691	59.0%	45.9%	13.1%
Black Diamond	2661	3035	(373)	944	1383	(439)	35.5%	45.6%	-10.1%
Bothell	3242	2662	581	1877	1192	685	57.9%	44.8%	13.1%
Burien - Nick Raffo	2263	2457	(194)	771	1100	(329)	34.1%	44.8%	-10.7%
Burien - SeaTac Disposal	2647	2457	190	1028	1100	(72)	38.8%	44.8%	-5.9%
Carnation	no curb R or Y	3019		no curb R or Y	1224			40.5%	
Clyde Hill	4796	3960	836	2908	1934	974	60.6%	48.8%	11.8%
Covington	2805	3173	(368)	1102	1344	(242)	39.3%	42.3%	-3.1%
Des Moines	2481	2547	(66)	912	1138	(226)	36.8%	44.7%	-7.9%
Duvall	3090	3055	35	1173	1337	(163)	38.0%	43.8%	-5.8%
Enumclaw	no data	2638		no data	1137			43.1%	
Federal Way	3099	2851	248	1425	1208	217	46.0%	42.4%	3.6%
Hunts Point	4093	3917	176	2050	1919	130	50.1%	49.0%	1.1%
Issaquah	3106	2678	428	1619	1275	345	52.1%	47.6%	4.5%
Kenmore	2711	2952	(240)	1133	1298	(165)	41.8%	44.0%	-2.2%
Kent	2732	2834	(103)	960	1176	(216)	35.1%	41.5%	-6.3%
Kirkland	3760	2525	1236	1858	1215	643	49.4%	48.1%	1.3%
Lake Forest Park	2995	2900	96	1540	1327	213	51.4%	45.8%	5.6%
Maple Valley	2927	3158	(231)	1240	1378	(138)	42.4%	43.6%	-1.3%
Medina	3689	3869	(181)	1820	1929	(109)	49.3%	49.9%	-0.5%
Mercer Island	3934	3253	682	2416	1557	859	61.4%	47.9%	13.5%
Milton	included in Pierce County solid waste system								
Newcastle	4065	3120	945	2308	1466	842	56.8%	47.0%	9.8%
Normandy Park	2720	2948	(228)	1078	1330	(252)	39.6%	45.1%	-5.5%
North Bend	3264	2790	474	1070	1224	(154)	32.8%	43.9%	-11.1%
Pacific	no curb R	2901		no curb R	1226			42.3%	
Redmond	3695	2780	916	1998	1293	705	54.1%	46.5%	7.5%
Renton	3017	2335	682	1636	1068	568	54.2%	45.7%	8.5%
Sammamish - RC	no data	3634		no data	1640			45.1%	
Sammamish - WMSK	no data	3634		no data	1640			45.1%	
SeaTac - Nick Raffo	2112	2655	(543)	451	1119	(668)	21.4%	42.2%	-20.8%
SeaTac - SeaTac Disposal	2168	2655	(487)	352	1119	(768)	16.2%	42.2%	-25.9%
Seattle	2532	2146	386	1330	1050	280	52.5%	48.9%	3.6%
Shoreline - Eastside Disposal	2938	2561	377	1587	1155	432	54.0%	45.1%	8.9%
Shoreline - WMNW	2843	2561	282	1480	1155	325	52.1%	45.1%	7.0%
Skykomish	no data	1964		no data	984			50.1%	
Snoqualmie	1508	1534	(26)	556	914	(359)	36.8%	59.6%	-22.8%
Tukwila	2464	2440	24	924	1053	(130)	37.5%	43.2%	-5.7%
Woodinville	2579	3182	(603)	848	1398	(550)	32.9%	43.9%	-11.1%
Yarrow Point	3983	3521	462	2314	1751	563	58.1%	49.7%	8.4%
Unincorporated Service Areas									
American Disposal (Vashon)	no data	3113		no data	1254			40.3%	
Eastside Disposal	3422	2961	461	1816	1345	471	53.1%	45.4%	7.7%
Kent-Meridian Disposal	2541	2800	(259)	909	1224	(315)	35.8%	43.7%	-7.9%
Nick Raffo Garbage Company	2052	2610	(558)	556	1086	(530)	27.1%	41.6%	-14.5%
Rabanco Connections	3207	3342	(135)	1695	1510	185	52.9%	45.2%	7.7%
RST Disposal	3468	3029	438	1468	1296	172	42.3%	42.8%	-0.5%
SeaTac Disposal	2789	3029	(240)	1113	1296	(183)	39.9%	42.8%	-2.9%
Waste Management - Rainier	3328	3322	7	1699	1368	332	51.1%	41.2%	9.9%
Waste Management - Sno King	4491	3936	555	2106	1592	514	46.9%	40.5%	6.4%

Thus, the estimated baseline generation figures shown in Table 3 for each area represent the expected variation in generation levels due to differing levels for single-family household size, yard size and household income for each jurisdiction, under the assumption that all areas offer solid waste collection programs that conform to the baseline.

In most cases each jurisdiction in fact offers a collection program that deviates in some or many respects from our defined baseline collection program. Thus, the difference between actual generation and estimated baseline generation provides an indication of the impact on generation of waste for collection that results from each jurisdiction's choices for collection program characteristics as compared with the baseline, while holding constant the impacts of differing household sizes, yard sizes and income levels.

Figure 11
Actual vs. Baseline Generation of Collected Waste in 2000
King County City (32) and Unincorporated County (8) Hauler Service Areas

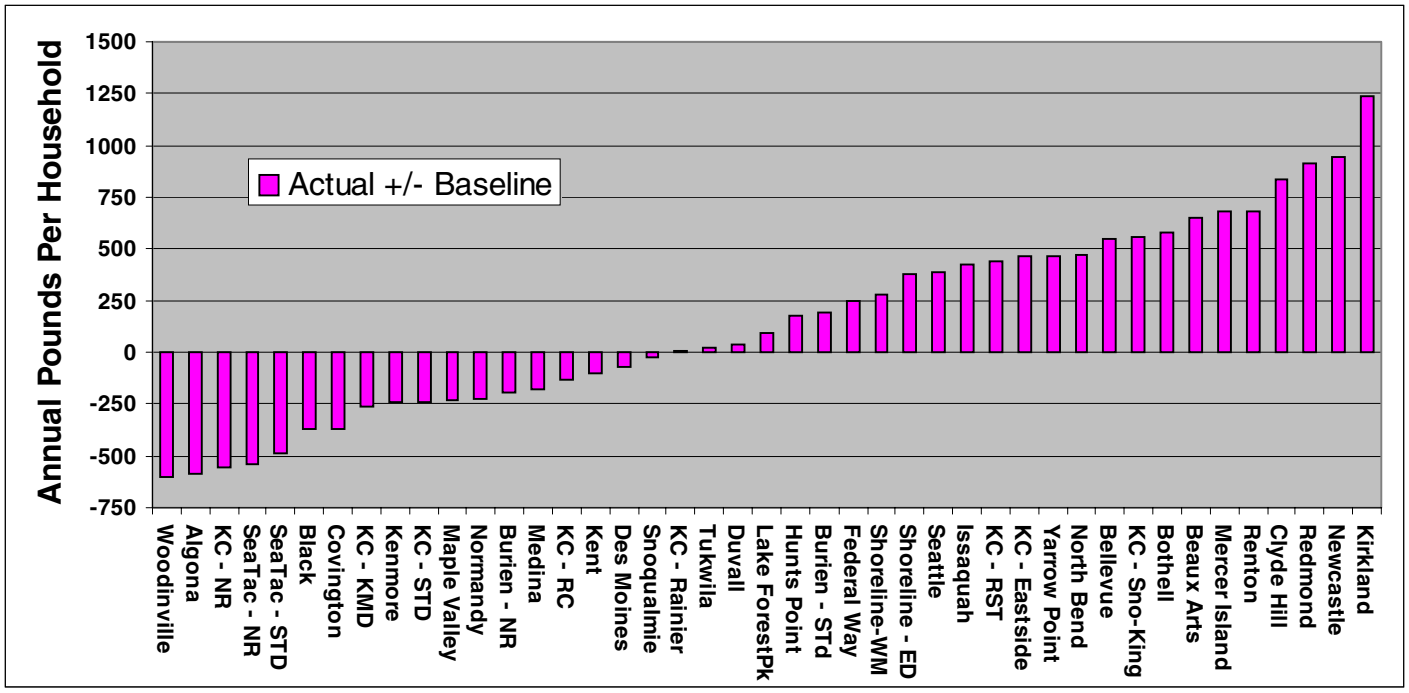


Figure 11, *Actual vs. Baseline Generation of Collected Waste in 2000*, shows the rankings for cities and unincorporated HSAs for the amount by which actual generation is above or below estimated baseline generation. These rankings shown in Figure 11 and the quantitative differences listed in the third column of Table 3 tend to be highly indicative of the choices jurisdictions made for their collection programs in 2000:

- Kirkland's actual generation of collected waste is much higher than its estimated baseline because in 2000 that city charged a single, flat rate for collection of basically unlimited quantities of the three streams -- garbage, recycling and yard debris.

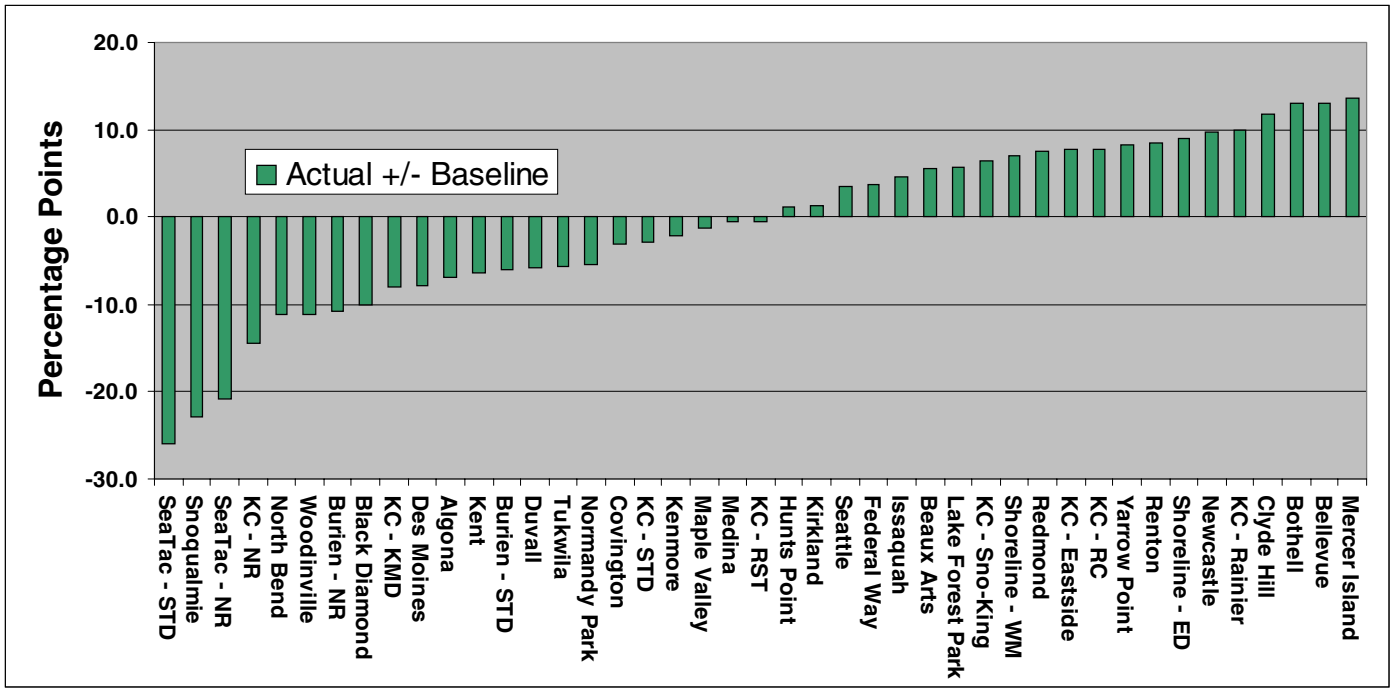
- The eight cities that provide embedded yard debris collection, all have actual waste generation that is greater than estimated baseline. This result is discussed further in Subsection IV.B.3. Waste Minimization and Waste Diversion Impacts of Collection Prices.
- Thirteen of the eighteen jurisdictions whose actual generation of collected waste is lower than their baseline have a ratio for their garbage bill index to their second can incremental charge that is higher than average.
- Sixteen of the eighteen with actual generation below baseline have a ratio for their yard debris fee to their second can incremental charge that is higher than average.

Actual Versus Baseline Diversion

The estimated equations for recycling and yard debris collection quantities shown in Table 1 were used to calculate estimated baseline quantities for diversion using the same procedures discussed above for generation. Thus, column 6 in Table 3 provides an indication of whether a particular King County community's recycling and yard debris diversion program characteristics and pricing in 2000 motivated households to divert at levels that were better or worse than the baseline diversion program.

For the most part, the pluses and minuses shown in column 6 appear to be indicative of what works best to promote diversion. For example, the City of SeaTac charged a subscription fee for curbside recycling in 2000 and, as a result, diversion levels for SeaTac's two haulers fell substantially short of diversion levels that would have been expected from the baseline program that included embedded curbside recycling.

Figure 12
Actual vs. Baseline Diversion Rates for Collected Waste in 2000
King County City (32) and Unincorporated County (8) Hauler Service Areas



The last three columns of Table 3 combine generation and diversion effects by comparing actual diversion rates against estimated baseline diversion rates. Figure 12, *Actual vs. Baseline Diversion Rates for Collected Waste in 2000*, shows the number of percentage points by which each jurisdiction's actual diversion rate exceeded or fell short of its baseline diversion rate. Figure 12 shows that SeaTac Disposal's hauling area in the City of SeaTac fell farthest below its baseline diversion rate, while Mercer Island exceeded its baseline diversion rate by the highest margin.

Table 4, *Comparison of Actual versus Baseline Diversion Rates, Collection Fee Ratios Above/Below Average, & Diversion Program Characteristics*, adds some additional insight into the reasons why actual diversion rates exceed or fall short of estimated baseline diversion rates. This table and Figure 12 help to identify successes and challenges for attainment of baseline diversion rates based on the choices jurisdictions made for their collection programs in 2000:

- The eight cities that provided embedded yard debris collection, all had actual diversion rates that are greater than estimated baseline.
- Kirkland's actual diversion rate exceeds its baseline by the least amount among the eight cities that provided embedded yard debris collections. This is at least in part due to the fact that in 2000 Kirkland charged a single, flat rate for collection of basically unlimited quantities of the three streams -- garbage, recycling and yard debris, whereas all other areas charged volume-based fees for garbage collection.
- Eleven of the thirteen jurisdictions shown in Figure 12 that provided weekly yard debris collection exceed their baseline diversion rates.
- Two of the three areas ranking lowest with respect to actual diversion versus baseline are the two areas in the City of SeaTac that are the only areas, other than Vashon which is not shown in Figure 12, that charged a subscription fee for recycling.
- Fourteen of the twenty-two jurisdictions whose diversion rates fall below baseline provided biweekly recycling without at the same time providing the 90/96-gallon cart as a collection container. These are also fourteen of the sixteen biweekly recycling jurisdictions that did not use the large cart as a recycling collection container.
- These fourteen jurisdictions that did not use the large cart for biweekly recycling also provided biweekly yard debris collection for which they charged subscription fees that were higher than the incremental fee they charged for weekly collection of a second 32-gallon can of garbage.
- The remaining eight of the twenty-two underperforming jurisdictions identified in Figure 12 and Table 4 either had yard debris fees that exceeded the incremental charge for their second 32-gallon can of garbage (five of the eight), or they had a garbage bill index ratio that was below average (the other three of the eight).
- Only one area in which the actual diversion rate exceeds baseline, Eastside's HSA in the City of Shoreline, did not employ any of the diversion enhancing characteristics listed in the five right-hand columns of Table 4.[36]

[36] As explained previously in the text of this report, linear rates and targeting of additional materials were mostly used by the same cities. This made it impossible to statistically identify the separate impacts of each. We determined that linear rates should be the variable to use in our statistical regression estimates. But those cities that did target additional materials also had somewhat higher diversion rates than they would have had without collection those materials. For this reason we included additional materials as a diversion enhancing program in Table 4.

- Of the 22 areas that exceed baseline diversion quantity by more than 100 pounds for the average household, 8 provided embedded yard debris collection, 2 (Federal Way and Seattle) charged a yard debris collection subscription fee that was less than their incremental fee for a second can of garbage, 4 were among the five small cities with average household incomes above $140,000 in 2000, and another 7 had higher than average ratios of income to their incremental fees for the second can of garbage.[37]

IV.B.3. Waste Minimization and Waste Diversion Impacts of Collection Prices

Figure 10 and Table 2 show substantial estimated impacts from collection fees on generation of waste for collection. As indicated on that chart, the average level of charges for collection of garbage and yard debris in the year 2000 reduced estimated waste generation by 27% from what it would have been if there were no charge for garbage and yard debris collections.

In addition, as indicated in Figure 9 and Table 1, garbage and yard debris collection fees each have significant but opposite impacts on garbage and yard debris collection quantities. These estimates have some interesting implications for waste minimization and diversion. According to the estimates shown in Table 1, decreases in yard debris fees increase yard debris collection quantity by 2.8 times as much as they decrease garbage collection quantity. On the other hand, increases in garbage collection fees decrease garbage collection quantity by 1.6 times as much as they increase yard debris collection quantity. Increases in garbage fees also undoubtedly have the effect of increasing recycling and reducing waste generation, even though the magnitude of these effects could not be estimated accurately in our sample. This all tends to indicate that somewhere between 35% and 65% of the impact on yard debris collection quantity from collection fees comes from diverting that material out of the garbage stream and into the yard debris stream. The remaining portion represents additional generation of waste in the form of yard debris that is stimulated by the change in collection fees.

Perhaps this waste generation effect occurs because once a household begins to use the yard debris collection service, or increases its use of that service, the household is tempted to cut back to some extent on existing yard debris minimization activities such as grasscycling, backyard composting and/or zeriscaping. At any rate, these estimates indicate the complexities involved when attempting to simultaneously maximize waste diversion and minimize waste generation. Most actions, such as the ones here exemplified by lowering yard debris collection fees or increasing garbage fees, that make diversion cheaper and/or more convenient than garbage collection and disposal also make the household's overall solid waste management task cheaper and/or easier. This naturally tends to induce rather than reduce waste generation.

We did not have the resources or data to measure the effectiveness of more complex actions, such as charging for yard debris collection at a fee that is substantially less than the incremental fee for weekly collection of a second 32-gallon can of garbage, while at the same time rigorously enforcing a ban against putting yard debris in the garbage stream. Such more complex methods for simultaneously increasing diversion and reducing generation need further analysis, because

[37] The latter two groups of jurisdictions may indicate that income has a nonlinear effect on diversion that is not well captured by simply using income as a linear explanatory variable in our estimation equations for collection quantities.

our statistical results clearly show the limits of using one-lever methods to attain multiple objec-tives.

IV.B.4. Impacts from Not Offering Curbside Recycling

During 2000 three King County cities did not offer curbside recycling collection at all – Auburn, Carnation, and Pacific. Of the three, Auburn provided the most extensive drop-off recycling network as an alternative. Auburn had drop-off recycling sites located in a sufficiently dense array that every household in the city was no further than a mile from the nearest recycling site.

One most interesting question about diversion levels in these three cities is the extent to which the lack of curbside recycling collection decreased any or all of those cities' diversion rates. It is, of course, notoriously difficult to track the origin of materials that are delivered to a drop site, unless the sites are staffed and each load delivered to the site is weighed and its origin noted. To our knowledge such an exacting effort has not been made; and so accurate allocations of drop site diversion quantities to in-area single-family households are not available. However, because our study is focused on single-family hauler-collected quantities, an alternative way to measure the impact of not having curbside recycling is to check whether household garbage collection quantities are higher than they would have been if the three cities had provided curbside recycling service.

We used two techniques to address this question. For the first technique we added a step function variable to the garbage quantity regression equation. This step function took the value one for the non-curbside cities Auburn and Pacific[38], and zero for all 36 areas that formed the original subsample used to produce the regression estimates in Table 1. We then re-estimated the garbage collection quantity equation over the expanded subsample that included the original 36-areas plus Auburn and Pacific, with the step function included as an additional explanatory variable. Estimates for the impacts of the original variables in this re-estimated garbage quantity equation remained consistent with the estimates shown in Table 1, except that the weekly yard debris variable became non-significant. The estimated impact for the step function came out to be an additional 266.0 pounds of garbage collection per household per year for Auburn and Pacific that was not accounted for by the other explanatory variables for garbage collection quantity.[39]

The second technique we employed in attempting to identify the impact of not having curbside recycling available in a community was to compute the difference between baseline generation and baseline diversion shown in Table 3 for Auburn, Carnation and Pacific. We then compared these baseline garbage quantity figures against actual per household garbage collection quantities in the three cities for 2000. The result was that actual garbage collection quantity per household exceeded baseline by 325 pounds on average for the three cities.

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[38] We could not include Carnation in this technique because that city also did not offer curbside yard debris collection during the year 2000. Thus there was no yard debris fee ratio for Carnation to use in obtaining regression estimates for the impact of yard debris fees on garbage collection quantity.

[39] This estimate was significant at only an 88% confidence level, somewhat below our cutoff levels of 90% or 95% significance for other variables.

While neither of our techniques yielded results in which one can place high statistical confidence – the regression technique is significant at only an 88% confidence level and the baseline versus actual technique is based on a sample size of just 3, both techniques did identify substantially larger garbage collection quantities in the cities not offering curbside recycling. In fact, at a sub-sample average level for household garbage collection of 1,629.5 pounds per household per year, the increase in garbage collection levels due to not offering curbside recycling in 2000 was between 16% and 20%.

Assuming that an increase in garbage collection would be reflected by at least the same level of decrease in recycling, the impact on recycling would amount to a 40% to 49% decrease due to lower levels of recycling through drop-off sites than would be obtained through curbside recycling collection. If curbside recycling is subject, at least to some extent, to the same generation effects that yard debris recycling appears to exhibit, as discussed in Subsection IV.B.3. above, then the percentage decrease in recycling quantities could be even bigger because the increase in garbage collection quantity per household would be smaller than the decrease in recycling quantity.

Actual data from the City of Auburn since that city instituted embedded curbside recycling beginning January 2002 tend to support our conclusion that drop-off recycling does not compensate for not having curbside recycling available. For the twelve months July 2002 through June 2003, the average single-family household in Auburn generated 3,256 pounds of collected waste, including 1,673 pounds of garbage, 694 pounds of recycling, and 889 pounds of yard debris. This compares with 2,566 pounds of collected refuse and 755 pounds for yard debris in 2000 when Auburn did not offer curbside recycling collection.

Although this is a single example, it still tends to illustrate the impact on refuse collection and diversion of curbside recycling compared with drop-off recycling, even when the drop sites are so numerous that no household is more than a mile from a drop site as was the case for Auburn in 2000. Auburn households currently are generating waste for collection at an annual rate per household of 3,256 pounds, which is less than the combined annual rates for garbage and yard debris collections per household in 2000. Furthermore, refuse collection has decreased by 893 pounds per household, and this decrease is greater than the 694 pounds now being collected annually on average per household for curbside recycling.

Table 4
Comparison of Actual Versus Baseline Diversion Rates, Collection Fee Ratios Above/Below Average, & Diversion Program Characteristics
King County City (39) and Unincorporated County (9) Hauler Service Areas

Cities	Actual Div. Rate +/- Baseline	Fee Ratio +/- Avg. G	Fee Ratio +/- Avg. YD	Linearity of Rates	Weekly R	Weekly YD	90/96 R	More Mtrls
Algona	-7.0%	below	above	0.41	no	no	no	no
Auburn	no applicable	below	below	1.21	no curb	yes	no curb	no curb
Beaux Arts	5.5%	above	above	0.32	no	no	yes	no
Bellevue	13.1%	above	no charge	0.39	yes	no	no	yes
Black Diamond	-10.1%	above	above	0.36	no	no	no	no
Bothell	13.1%	above	no charge	0.40	yes	yes	no	no
Burien - Nick Raffo	-10.7%	above	above	0.30	no	no	no	no
Burien - SeaTac Disposal	-5.9%	above	above	0.37	no	no	no	no
Carnation	no applicable	below	no curb	0.85	no curb	no curb	no curb	no curb
Clyde Hill	11.8%	above	above	0.32	no	no	yes	no
Covington	-3.1%	above	above	0.36	no	no	no	no
Des Moines	-7.9%	above	above	0.35	no	no	yes	no
Duvall	-5.8%	above	above	0.31	yes	no	no	no
Enumclaw	no data	no data	below	0.40	no	no	no	no
Federal Way	3.6%	below	below	0.48	no	yes	no	no
Hunts Point	1.1%	above	above	0.32	no	no	yes	no
Issaquah	4.5%	below	no charge	1.00	yes	yes	no	yes
Kenmore	-2.2%	above	above	0.32	no	no	yes	no
Kent	-6.3%	below	below	0.48	no	yes	yes	no
Kirkland	1.3%	flat rates	no charge	0.00	yes	yes	no	no
Lake Forest Park	5.6%	below	no charge	0.42	no	no	yes	no
Maple Valley	-1.3%	above	above	0.36	no	no	no	no
Medina	-0.5%	above	above	0.21	no	no	yes	no
Mercer Island	13.5%	below	no charge	0.53	no	no	yes	no
Milton	included in Pierce County solid waste system							
Newcastle	9.8%	above	above	0.37	yes	yes	no	no
Normandy Park	-5.5%	above	above	0.39	no	no	no	no
North Bend	-11.1%	below	below	1.00	yes	no	no	yes
Pacific	no applicable	below	below	0.65	no curb	no	no curb	no curb
Redmond	7.5%	below	no charge	0.93	yes	yes	no	yes
Renton	8.5%	below	no charge	0.59	yes	no	no	no
Sammamish - Rabanco Connections	no data	above	above	0.31	yes	yes	no	no
Sammamish - Waste Management-Sno King	no data	above	above	0.37	yes	yes	no	no
SeaTac - Nick Raffo	-20.8%	below	above	0.40	no	no	no	no
SeaTac - SeaTac Disposal	-25.9%	below	above	0.51	no	no	no	no
Seattle	3.6%	below	below	1.00	no	no	yes	yes
Shoreline - Eastside Disposal	8.9%	above	above	0.32	no	no	no	no
Shoreline - Waste Management Northwest	7.0%	below	above	0.44	yes	yes	no	no
Skykomish	no data	no data	no data	no data	no data	no data	no data	no data
Snoqualmie	-22.8%	below	below	1.00	yes	no	no	yes
Tukwila	-5.7%	above	above	0.37	no	no	no	no
Woodinville	-11.1%	above	above	0.37	yes	yes	no	no
Yarrow Point	8.4%	above	above	0.32	no	no	yes	no
Unincorporated Service Areas								
American Disposal (Vashon)	no applicable	no data	no curb	0.36	no	no curb	no	no
Eastside Disposal	7.7%	above	above	0.32	no	no	yes	no
Kent-Meridian Disposal	-7.9%	above	above	0.36	no	no	no	no
Nick Raffo Garbage Company	-14.5%	above	above	0.30	no	no	no	no
Rabanco Connections	7.7%	above	above	0.30	yes	yes	no	no
RST Disposal	-0.5%	above	above	0.35	no	no	no	no
SeaTac Disposal	-2.9%	above	above	0.37	no	no	no	no
Waste Management - Rainier	9.9%	above	above	0.35	yes	yes	no	no
Waste Management - Sno King	6.4%	above	above	0.37	yes	yes	no	no

Appendix 1: Tables & Graphs

Table A1
Single-Family Household Average Collected Waste Generation in 2000
King County City (39) and Unincorporated County (9) Hauler Service Areas

Cities	Generation	Garbage	Recycling	Yard Debris
Algona	2219	1460	371	387
Auburn	incomparable	2566	no curbside	755
Beaux Arts	3628	1611	779	1238
Bellevue	3357	1376	946	1035
Black Diamond	2661	1717	561	383
Bothell	3242	1365	637	1240
Burien - Nick Raffo	2263	1492	451	320
Burien - SeaTac Disposal	2647	1619	451	577
Carnation	incomparable	1686	no curbside	no curbside
Clyde Hill	4796	1888	1055	1853
Covington	2805	1703	562	540
Des Moines	2481	1569	448	464
Duvall	3090	1916	492	682
Enumclaw	no data	no data	642	no data
Federal Way	3099	1674	611	814
Hunts Point	4093	2044	1242	807
Issaquah	3106	1486	887	732
Kenmore	2711	1579	556	577
Kent	2732	1772	558	402
Kirkland	3760	1902	593	1266
Lake Forest Park	2995	1455	783	757
Maple Valley	2927	1687	563	677
Medina	3689	1868	544	1276
Mercer Island	3934	1518	1001	1415
Milton	included in Pierce County solid waste system			
Newcastle	4065	1757	1280	1028
Normandy Park	2720	1642	594	483
North Bend	3264	2194	621	449
Pacific	incomparable	1622	no curbside	327
Redmond	3695	1698	771	1227
Renton	3017	1382	749	887
Sammamish - Rabanco Connections	no data	no data	no data	no data
Sammamish - Waste Management-Sno King	no data	no data	no data	no data
SeaTac - Nick Raffo	2112	1661	213	238
SeaTac - SeaTac Disposal	2168	1816	130	222
Seattle	2532	1203	885	444
Shoreline - Eastside Disposal	2938	1350	854	733
Shoreline - Waste Management Northwest	2843	1363	808	673
Skykomish	no data	no data	no data	no data
Snoqualmie	1508	952	258	298
Tukwila	2464	1540	509	415
Woodinville	2579	1731	492	356
Yarrow Point	3983	1669	728	1585
Unincorporated Service Areas	**Generation**	**Garbage**	**Recycling**	**Yard Debris**
American Disposal (Vashon)	no data	no data	no data	no data
Eastside Disposal	3422	1605	1034	782
Kent-Meridian Disposal	2541	1632	553	356
Nick Raffo Garbage Company	2052	1496	133	423
Rabanco Connections	3207	1512	941	754
RST Disposal	3468	2000	890	577
SeaTac Disposal	2789	1676	577	536
Waste Management - Rainier	3328	1629	969	730
Waste Management - Sno King	4491	2385	1061	1045

Figure A1
Single-Family Household Median Yard Size (Acres)
King County City (39) and Unincorporated County (9) Hauler Service Areas

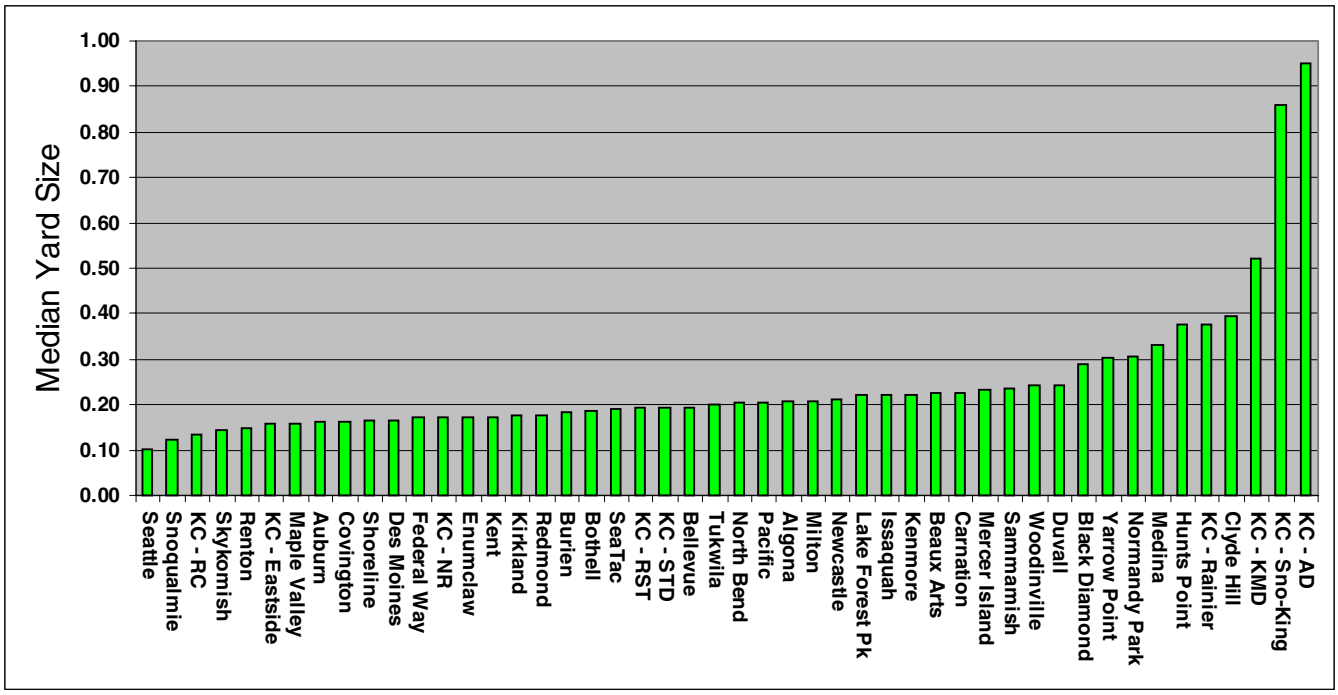

Figure A2
Single-Family Household Average Number of Persons (Census 2000)
King County City (39) and Unincorporated County (9) Hauler Service Areas

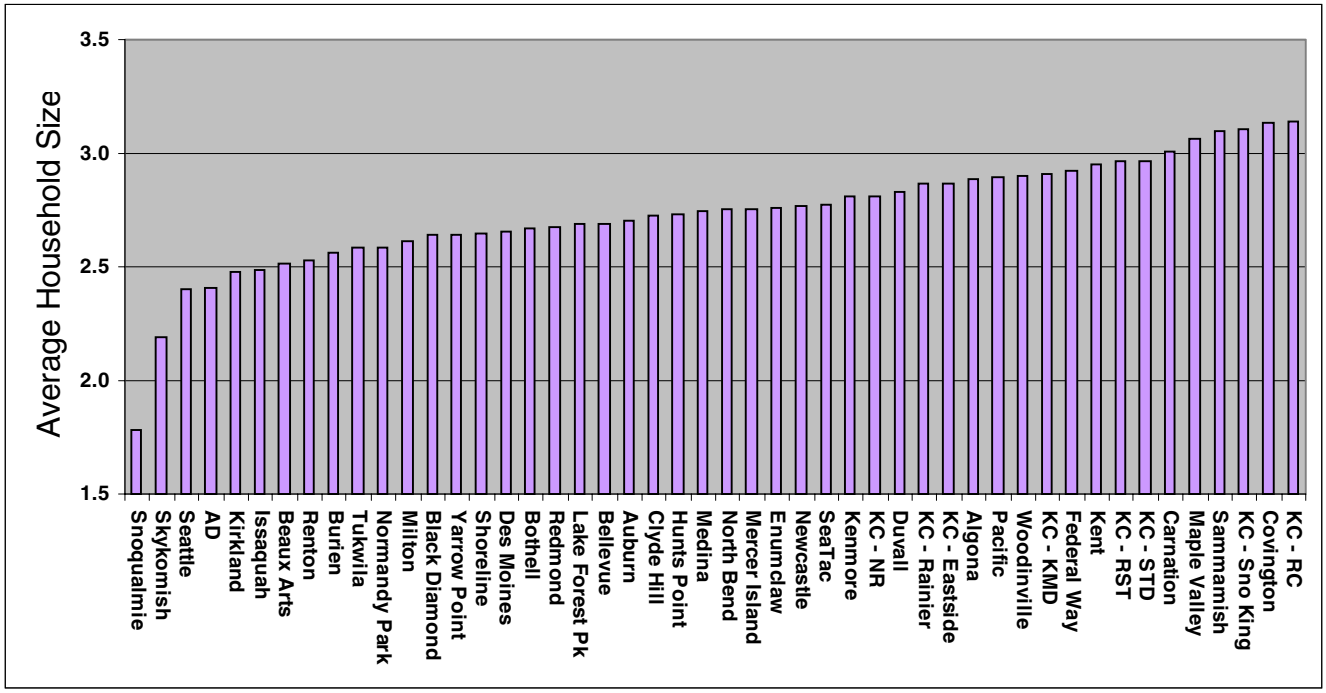

Figure A3
Single-Family Household Average Income (Census 2000)
King County City (39) and Unincorporated County (9) Hauler Service Areas

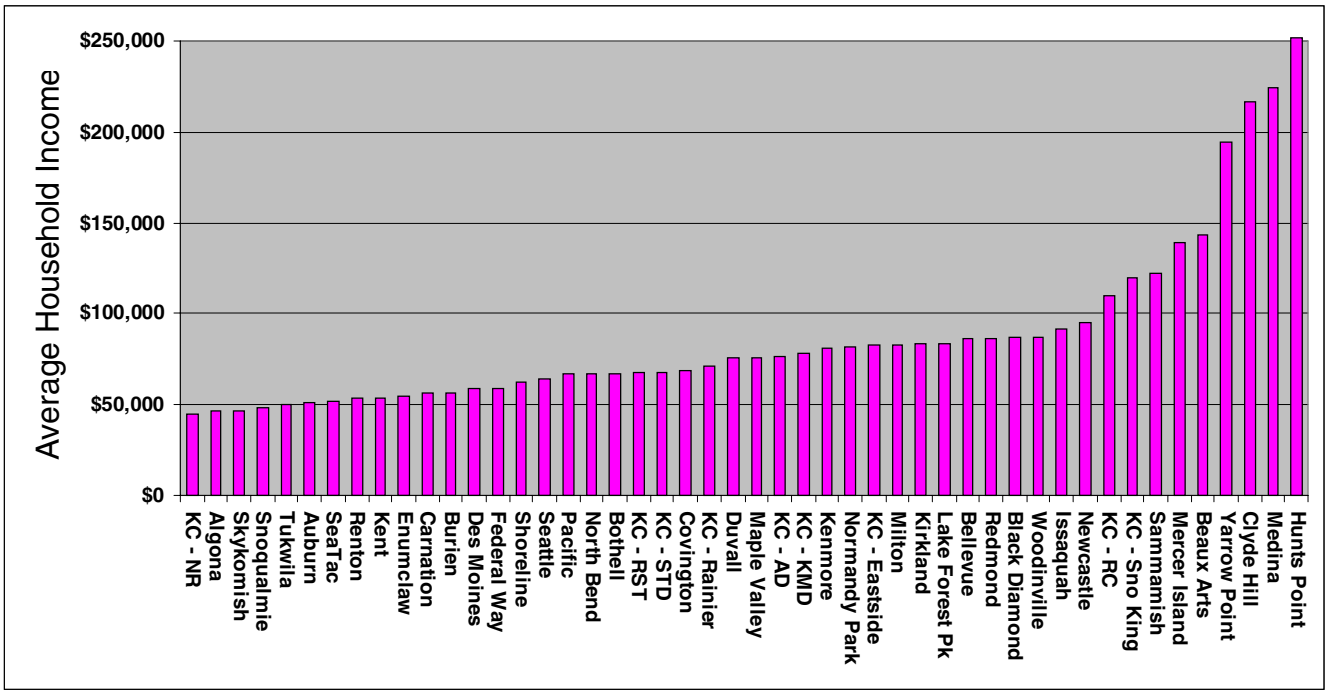

Figure A4
Single-Family Household Median Appraised Property Value
King County City (39) and Unincorporated County (9) Hauler Service Areas

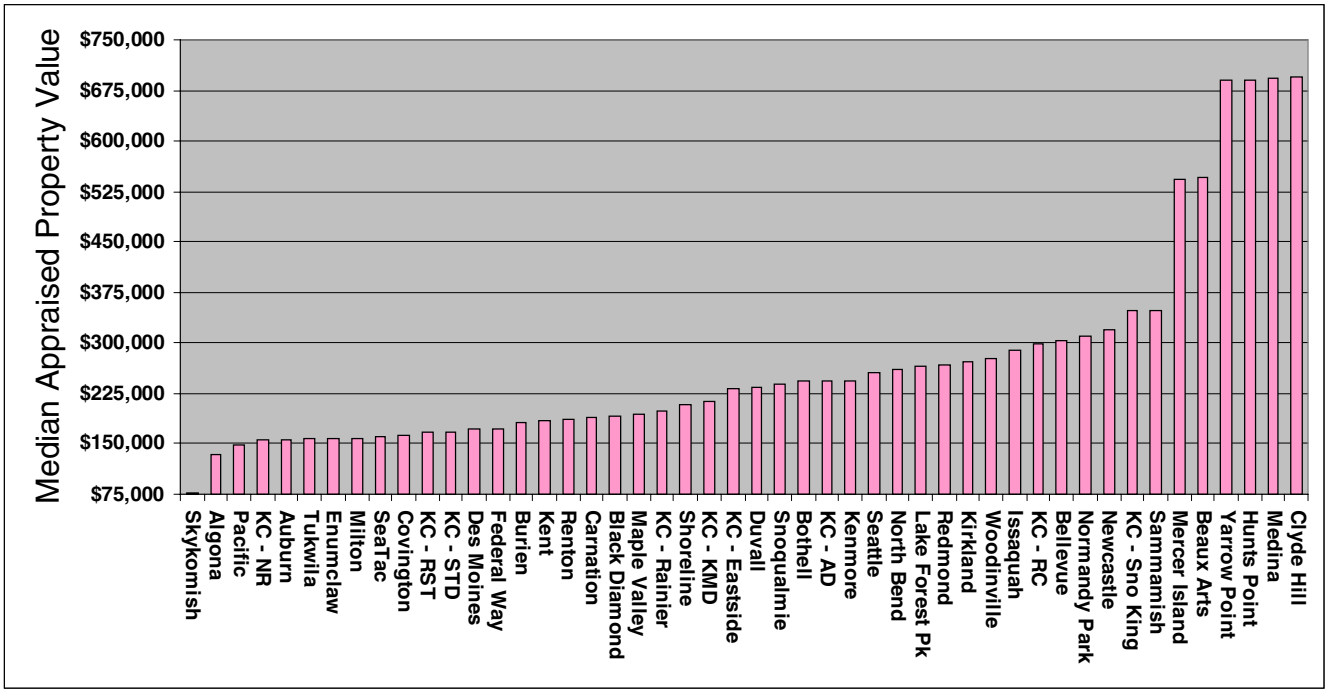

Figure A5
Linguistically Isolated Single-Family Households (Census 2000)
King County City (39) and Unincorporated County (9) Hauler Service Areas