

**APPENDIX E**

**SOLID WASTE COLLECTION VEHICLE  
EMISSIONS INVENTORY**

## I. Methodology

The EMFAC model used by the Air Resource Board (ARB) does not specifically address the emissions inventory of solid waste collection vehicles (collection vehicles), including these trucks as part of the heavy heavy-duty diesel (HHD) truck fleet. This is largely because of the lack of emission and activity data specific to collection vehicles, which operate differently on local streets from trucks driving on highways or freeways. In addition, ARB has not previously needed a detailed specific inventory for these vehicles. As ARB developed this regulation, however, staff required a more detailed inventory of emissions than was previously available.

A number of studies have been carried out recently to explore the effects of emission control technologies and to test collection vehicles for emission data. Staff has reviewed available collection vehicle activity information and emission testing data and has estimated an emissions inventory for collection vehicles. The following sections discuss the collection vehicle activity and emission data and present an emissions inventory for collection vehicles in California.

### A. Collection Vehicle Activity Data

The following collection vehicle activity data were gathered from different sources and analyzed:

- Accrual rate and cumulative mileage;
- Population (POP) and age distribution; and
- Vehicle mile traveled (VMT).

The accrual rate for collection vehicles, estimated to be 15,635 miles per year, is based on the annual mileage data gathered from three solid waste collection companies. Staff assumes that this average annual mileage would apply to collection vehicles of all model years. The cumulative mileage for collection vehicles with age  $i$  is then the sum of accrual rates of collection vehicles with ages 1 through  $i$ .

A statewide collection vehicle population (POP) of 11,778 vehicles in year 2000 was obtained from the Department of Motor Vehicle (DMV) annual vehicle registration database. Collection vehicle populations for future years were projected from the following linear growth rate equation:

$$\text{Population} = 1.2 \times 10^6 (\text{Calendar Year}) - 2.34 \times 10^9. \quad (1)$$

Equation 1 is derived from the statewide annual solid waste generation from 1989 to 2000, which was provided by the California Integrated Waste Management Board. The projected future populations were adjusted with the survival rates of urban diesel buses used in EMFAC model.

The age distribution for collection vehicles was determined from the year 2000 DMV registration data. The populations of individual model years were obtained by applying the age distribution to the total collection vehicle population for a given year.

The collection vehicle daily VMT for a given year was estimated from the collection vehicle POP and accrual rate using the following equation:

$$VMT = \sum (POP_i \times \text{Accrual Rate}_i), i = 1 \text{ to } 45 \quad (2)$$

The collection vehicle accrual rate, cumulative mileage, and age distribution are shown in Table 3.

## B. Collection Vehicle Emission Rates

In estimating the emissions inventory for collection vehicles, both the HHD truck emission rates and emission rates derived from collection vehicle testing cycle were used (Table 1). HHD truck emission rates, which were based on test data collected over the Urban Dynamometer Driving Schedule (UDDS), were taken directly from EMFAC2000. In EMFAC2000, all HHD trucks were grouped into different model year groups based on emission characteristics and emission standards. Vehicles within the same model year group were assumed to have the same emission rates.

**Table 1. NYGTC and EMFAC2000 HHD Truck Emission Rates (g/mi)**

Model Year Group	Avg. NYGTC Emission Rates				EMFAC2000 HHD Truck Emission Rates*							
	HC	CO	NOx	PM	HC		CO		NOx		PM	
					ZM	DR	ZM	DR	ZM	DR	ZM	DR
Pre 1975	47.6	104	158	11.66	1.60	0.017	8.36	0.095	28.5	0.013	1.98	0.016
1975-76	43.2	97.0	150	10.89	1.45	0.017	7.81	0.095	27.2	0.013	1.85	0.016
1977-79	43.2	97.0	150	10.89	1.45	0.017	7.81	0.095	27.2	0.013	1.85	0.016
1980-83	43.2	97.0	150	10.89	1.45	0.017	7.81	0.095	27.2	0.013	1.85	0.016
1984-86	22.0	60.5	112	6.947	0.74	0.017	4.87	0.095	20.2	0.013	1.18	0.016
1987-90	10.1	30.8	92.9	4.945	0.34	0.009	2.48	0.065	16.8	0.015	0.84	0.008
1991-93	8.33	21.6	88.4	3.002	0.28	0.009	1.74	0.056	16.0	0.030	0.51	0.009
1994-97	3.21	13.2	92.1	1.050	0.19	0.016	0.84	0.068	19.1	0.042	0.32	0.010
1998	3.05	9.86	111	0.853	0.18	0.014	0.63	0.049	23.0	0.037	0.26	0.007
1999-02	3.05	9.86	64.5	0.853	0.18	0.009	0.63	0.031	13.4	0.013	0.26	0.003
2003-06	2.37	15.8	32.3	0.853	0.14	0.003	1.01	0.023	6.68	0.007	0.26	0.003
2007+	0.663	4.43	3.23	0.0853	0.039	0.003	0.283	0.023	0.668	0.007	0.026	0.003

\* ZM = Zero mile emission rate; DR = Deterioration rate per 10,000 miles.

Collection vehicle specific average emission rates were calculated from test data collected over the New York Garbage Truck Cycle (NYGTC; Table 1). Test data from six 1992 model year and eight 1994 model year collection vehicles were obtained from National Renewable Energy Laboratory heavy-duty truck database. Emission rates for other model years were estimated from the rates of 1991 to 1993 and 1994 to 1997 groups using ratios of the emission rates of 1991 to 1993 or 1994 to 1997 HHD truck groups and the rates of other HHD truck groups.

The NYGTC simulates the operation of a collection vehicle on a metropolitan local street; that is, stop-and-go travel at low speed, picking up and emptying trash containers and compacting waste. The NYGTC does not include a collection vehicle's trip from its collection location to its designated dump site. Such a trip is typically highway or freeway type of driving and may be similar to the operation of a HHD truck. Operation information from solid waste collection companies shows the typical waste collection trip of a collection vehicle consists of activities on both local streets and driving on highways, although the fractions of the two can vary from location to location.

To reflect this observation, the NYGTC emission rates and EMFAC2000 HHD truck emission rates were combined using fractions of local street versus highway driving. The composite BER for a given model year group was calculated as follows:

$$BER_x = fBER_{NYGTC} + (1-f) BER_{HDD} \quad (3)$$

Where,  $BER_x$  is the composite basic emission rate for model year group x;  $BER_{NYGTC}$  and  $BER_{HDD}$  are, respectively, the NYGTC and EMFAC2000 HHD truck rates for model year group x; and  $f$  is the fraction of trip on local streets. Data furnished by three solid waste collection companies showed that about half of a collection vehicle's travel was spent on local street picking up and compacting waste and the other half spent on highway en route to a dump site. Staff has initiated a project utilizing GPS (global position system) data loggers to study the collection vehicle activities and the data will be used in a future update.

## II. Collection Vehicle Emission Inventory

Table 2 shows the collection vehicle emissions inventory for calendar years 2005, 2010, and 2020. In calculating the inventory, an  $f$  value of 0.47 was used in Equation 3; i.e., on average 47 percent of a typical collection vehicle's trip would be on local streets and 53 percent on highways or freeways. The inventory given in Table 3 includes the U.S. EPA 2007 heavy-duty diesel engine regulations and U.S. EPA 2006 low sulfur diesel fuel regulation.

**Table 2. Statewide Collection Vehicle Emissions Inventory (tons/day)**

<b>Pollutant</b>	<b>2005</b>	<b>2010</b>	<b>2020</b>
HC	4.20	4.10	3.04
CO	11.9	11.8	9.59
NOx	33.8	27.4	27.5

PM

1.57

1.42

1.12

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**Table 3. Accrual Rate, Cumulative Mileage, and Population Distribution for SWCV**

<b>Age</b>	<b>Accrual Rate (mi/year)</b>	<b>Cumulative Mileage</b>	<b>Population*</b>
0	15,635	15,635	306
1	15,635	31,270	586
2	15,635	46,905	361
3	15,635	62,540	287
4	15,635	78,175	728
5	15,635	93,810	707
6	15,635	109,445	592
7	15,635	125,080	632
8	15,635	140,715	355
9	15,635	156,350	977
10	15,635	171,985	686
11	15,635	187,620	987
12	15,635	203,255	503
13	15,635	218,890	455
14	15,635	234,525	460
15	15,635	250,160	431
16	15,635	265,795	522
17	15,635	281,430	186
18	15,635	297,065	344
19	15,635	312,700	290
20	15,635	328,335	297
21	15,635	343,970	420
22	15,635	359,605	212
23	15,635	375,240	147
24	15,635	390,875	80
25	15,635	406,510	56
26	15,635	422,145	42
27	15,635	437,780	36
28	15,635	453,415	32
29	15,635	469,050	15
30	15,635	484,685	12
31	15,635	500,320	12
32	15,635	515,955	5
33	15,635	531,590	4
34	15,635	547,225	3
35	15,635	562,860	1
36	15,635	578,495	3
37	15,635	594,130	3
38	15,635	609,765	3
39	15,635	625,400	0
40	15,635	641,035	0
41	15,635	656,670	0
42	15,635	672,305	0
43	15,635	687,940	0
44	15,635	703,575	0
<b>TOTAL</b>	<b>703,575</b>	<b>16,182,225</b>	<b>11,778</b>

\*Year 2000 population in California.