

Analysis of the Probability of Complying with the National Ambient Air Quality Standard for CO in Anchorage between 2007 and 2023

Background

In October 2007, the Anchorage Assembly voted to discontinue the vehicle inspection and maintenance (I/M) program in Anchorage. As a result, the Anchorage CO Maintenance Plan must be revised, incorporated into the Alaska State Implementation Plan (SIP) for air quality and approved by the EPA. As part of these revisions, a new probabilistic maintenance demonstration must be prepared. This demonstration must include the effect of any changes to the CO control measures proposed in the revised Plan. In particular, the impact of the planned discontinuation of the Anchorage vehicle inspection and maintenance (I/M) on prospects for future compliance with the national ambient air quality standard (NAAQS) must be assessed.

Prior to the preparation of the previous Anchorage CO Maintenance Plan in 2004, the Municipality of Anchorage (MOA), the Alaska Department of Environmental Conservation (ADEC) and EPA Region 10 staff agreed that a probabilistic approach should be used in the Anchorage maintenance demonstration. The MOA, ADEC and EPA agreed that this demonstration must show a 90% or greater probability of meeting the national ambient air quality standard (NAAQS) in each year during the 2007-2023 lifetime of the Maintenance Plan.

The MOA is using the same methodology used in the 2004 Plan in this revised maintenance demonstration. This methodology relies on conventional statistical methods to estimate the probability of complying with the NAAQS in the year 2007, the base year for the analysis. The "roll forward" technique, used in the previous maintenance demonstration, is used to estimate probability of complying with the standard in future years. This technique relies on CO emissions projections for years 2008 through 2023 to help estimate the probability of complying with the NAAQS during this time period.

Method

Estimating the Probability of Complying with the NAAQS in Base Year 2007

The NAAQS for CO is set at 9 ppm for an 8-hour average not to be exceeded more than once per year. Because the NAAQS effectively disregards the highest 8-hour average in determining compliance, *the measure of whether a community meets the standard is determined by the magnitude of the second highest 8-hour average, or second maximum.* For this reason, this analysis focuses on the probability of the second maximum being above or below the 9 ppm NAAQS.

Standard regression analysis techniques can be used to estimate the probability of complying with the CO NAAQS in 2007. By definition, a violation occurs when the second maximum concentration is higher than 9 ppm. The probability that this will or will not occur can be computed using the prediction interval. The prediction interval is defined mathematically as follows:

Equation 1 $y_p = y_h + t_{(\alpha; n-2)} \cdot s\{pred\}$

where $s\{pred\} = \sqrt{MSE \left[1 + \frac{1}{n} + \frac{(X_k - \bar{X})^2}{\sum (X_i - \bar{X})^2} \right]}$

In this circumstance, we are interested only in the upper limit of the prediction interval*. In this case we want to compute the value corresponding to the upper 90th percentile interval in base year 2007. If 2007 could be “repeated” numerous times, with the “normal” variety of meteorological conditions and other variables that effect CO concentrations, the second maximum concentration would fall at or below this value 90% of the time. This value is the base year 2007 design value (2007 DV_{90%}).

Over the past 30 years, CO monitoring has been conducted at ten permanent CO stations† and at numerous additional temporary stations throughout Anchorage and Eagle River. Data suggest that the Turnagain monitor, located in a residential area in west Anchorage, has the highest CO concentrations of the four monitors in the current network. (See analysis in the Attachment at the end of this report.) Although it is difficult to compare recent data from Turnagain with data collected from other sites a decade or more earlier, studies suggest that the CO concentrations at Turnagain are likely representative of the highest ambient CO concentrations encountered in Anchorage. For this reason, Turnagain was selected as the site for the maintenance demonstration.

First and second maximum 8-hour CO concentrations measured at Turnagain are shown in Table 1.‡

Table 1
1st and 2nd Maximum CO Concentrations at Turnagain Station (1999-2007)

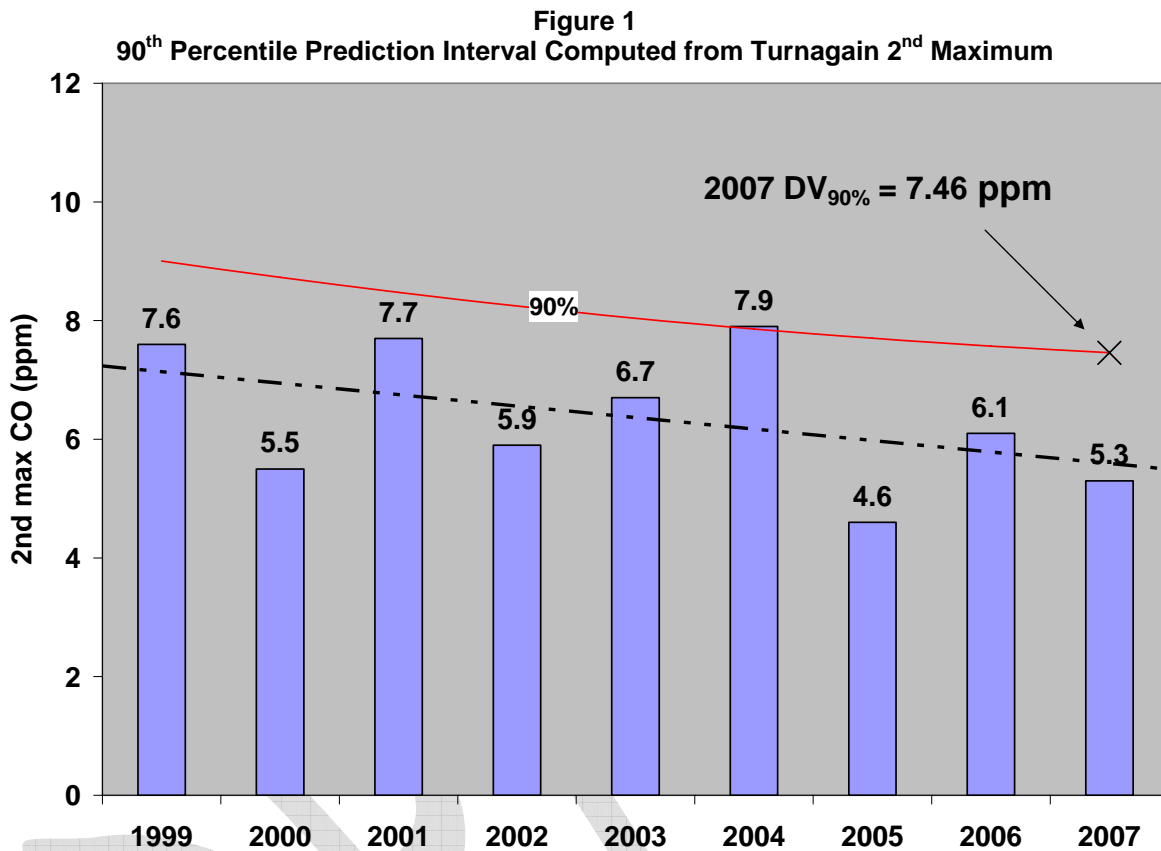
	Highest 8-hour average CO Concentration (ppm)	2 nd Highest 8-hour average CO Concentration (ppm)
1999	10.1	7.6
2000	7.2	5.5
2001	9.8	7.7
2002	6.5	5.9
2003	8.3	6.7
2004	8.1	7.9
2005	5.7	4.6
2006	6.5	6.1
2007	5.5	5.3

* This is known as a one-sided prediction interval. In this case we use the one-sided t-statistic when using Equation 1.

† For the purposes of this discussion, we define a permanent monitoring station as one that has employed Federal Reference Method monitors over the course of at least one CO season. Temporary monitoring was conducted with bag samplers in the 1980’s and more recently with portable industrial hygiene-type CO monitors. Temporary monitoring has been conducted at more than 30 locations in the Municipality.

‡ The Turnagain station began operation October 16, 1998; thus 1999 was the first complete year of data collected at this site.

An Excel spreadsheet was used to compute the upper 90th percentile prediction interval from the second maximum concentrations at Turnagain using Equation 1. The results of this computation are plotted in Figure 1. Figure 1 shows that there was a 90% probability that the base year 2007 value would be less than or equal to 7.46 ppm. This computed concentration will serve as the base year 2007 design value for the roll forward analysis discussed later in this report.



The precise probability of complying with the 9 ppm NAAQS in 2007 was also estimated with the spreadsheet. The probability associated with a second maximum of less than or equal to 9.0 ppm can be estimated through iteration. The one sided t-statistic associated with various probabilities can be used in Equation 1 until the desired 9.0 ppm value is bracketed within two prediction intervals (see Table 2). In this case the two prediction intervals bounding a 9.0 ppm second maximum in 2007 were the 97.5% and 99% intervals with corresponding second maximums of 8.71 ppm and 9.54 ppm. The precise probability associated with a second maximum of less than or equal to 9.0 ppm was estimated by interpolating between these two prediction intervals. The probability of complying with the NAAQS was estimated to be approximately 98.1%. Thus, there was an estimated 1-in-50 chance of violating the NAAQS in 2007.

Table 2
Second Maximum CO Concentration Associated with Various Upper Bound Prediction Intervals

Probability that 2007 CO Concentration will be less than Computed 2nd Max Concentration	Computed Second Maximum CO Concentration (ppm)
80.0%	6.77
90.0%	7.46
95.0%	8.09
97.5%	8.71
98.1%*	9.00
99.0%	9.54
99.9%	11.90

* interpolated between adjacent 97.5% and 99.0% values.

Estimating the Probability of Complying with the NAAQS between 2007 - 2023

One assumption implicit in using the roll forward method is that the second maximum CO concentration in any future year will be proportional to the magnitude of the CO emissions in that year relative to base year emissions in 2007. In other words, if CO emissions in a future year are projected to decrease by 10% relative to base year 2007, the expected CO concentration in that future year will also decrease by 10%. If this occurs, there will be concurrent increase in the probability of complying with the NAAQS in that year.

CO emissions were estimated for the 9 kilometer² area surrounding the Turnagain CO monitoring station for base year 2007 using EPA-prescribed models such as the MOBILE6, NONROAD, AP-42 and the FHWA model EDMS to estimate CO emissions.[§]

CO emissions in 2007 were estimated to be 5.99 tons per day (tpd) in the “micro-inventory area” surrounding Turnagain. The computed 90th percentile concentration or 2007 DV_{90%} was 7.46 ppm. If one assumes that CO concentrations increase in direct proportion to emissions, the amount of CO that could be emitted in the Turnagain area and retain a 90% probability of complying with the standard can be computed as follows:

$$\begin{aligned}
 \text{Amount of CO emissions associated with a} \\
 \text{90\% probability of complying with the NAAQS} &= (9.0 \text{ ppm} / 2007 \text{ DV}_{2007}) \times \text{CO emissions in 2007} \\
 &= (9.0 \text{ ppm} / 7.46 \text{ ppm}) \times 5.99 \text{ tpd} = \mathbf{7.23 \text{ tpd}}
 \end{aligned}$$

This computation suggests that if CO emissions in the Turnagain area increased from 5.99 tpd to 7.23 tpd, the probability of complying with the NAAQS would be 90%. In the same manner as shown above, the amount of emissions corresponding with other probabilities of compliance (i.e. 90%, 95%, 99%, etc.) can be readily computed with the spreadsheet. The spreadsheet was used to create a lookup table listing probabilities along with corresponding quantity of emissions. Table 3 shows the results of these spreadsheet computations. As would be expected, the probability of complying with the NAAQS increases with lower emission rates.

[§] MOBILE6 is used to estimate vehicle emissions, NONROAD us used to estimate various nonroad sources such as snowmobiles and portable electrical generators, EDMS is used for airport operations and AP-42 is used to estimate various area sources such as natural gas space heating, fireplaces and wood stoves. These models and emission inventory procedures are described more fully in the *Anchorage CO Emission Inventory and Emission Projections 2007-2023*, included as Appendix A of the Anchorage SIP submittal.

Table 3
CO Emission Rates Associated with Varying Probabilities of Compliance
with the NAAQS at the Turnagain Station

Probability that 2 nd Max CO Concentration will be less than 9.0 ppm	Corresponding CO Emission Rate (tpd)
99.0%	5.65
98.0%	6.00
97.0%	6.28
96.0%	6.47
95.0%	6.67
94.0%	6.77
93.0%	6.88
92.0%	7.00
91.0%	7.11
90.0%	7.23
89.0%	7.30
88.0%	7.37
87.0%	7.44

In addition to estimating base year 2007 CO emissions in the 9 kilometer² area surrounding Turnagain, emissions were projected through the year 2023. Projections were prepared using the aforementioned MOBILE6, NONROAD, AP-42, and EDMS modeling procedures. Population and employment forecasts prepared by the University of Alaska Institute of Economic and Social Research (ISER) were used to estimate key parameters necessary to estimate growth in vehicle travel^{**}, space heating, fireplace and woodstove use and other CO emission sources. The MOBILE6 model was configured to reflect that the I/M Program is slated to be discontinued in December 2009.

The results of this “micro-inventory” and forecast of CO emissions in the Turnagain area are shown in Table 4. The probability of complying with the NAAQS at the level of emissions projected for each year was determined from the lookup table (Table 3). Note that, in contrast to the general trend of increasing probability of compliance over time, there is a slight *decrease* in the compliance probability between 2009 and 2013. This is a result of a slight increase in projected CO emissions as a result of the discontinuation of I/M in 2009.

^{**} The Anchorage Transportation Model was used to provide information on vehicle travel. It relies in large part on ISER projections in the development of travel forecasts.

Table 4
Projected CO Emissions and Probabilities for Compliance with the NAAQS (2007-2023)

CO Emissions from Various Sources in the 9 km² Area Surrounding the Turnagain Station (all emissions in tons per day)						
Year	Motor Vehicles	Fireplace or Woodstove	Space Heating	Other	TOTAL CO EMISSIONS	Probability of Compliance
2007	4.40	0.62	0.28	0.70	5.99	98.1%
2008	4.12	0.62	0.28	0.70	5.72	98.8%
2009	3.84	0.63	0.28	0.71	5.45	99.2%
2010	4.03	0.63	0.28	0.71	5.66	99.0%
2011	4.23	0.64	0.28	0.71	5.86	98.4%
2012	4.10	0.65	0.28	0.72	5.74	98.8%
2013	3.96	0.65	0.28	0.72	5.62	99.1%
2014	3.87	0.66	0.28	0.73	5.54	99.1%
2015	3.78	0.66	0.29	0.73	5.45	99.2%
2016	3.69	0.67	0.29	0.73	5.38	99.2%
2017	3.61	0.67	0.29	0.74	5.30	99.3%
2018	3.50	0.68	0.29	0.74	5.21	99.4%
2019	3.40	0.68	0.29	0.74	5.11	99.4%
2020	3.33	0.68	0.29	0.75	5.05	99.5%
2021	3.25	0.68	0.29	0.75	4.98	99.5%
2022	3.20	0.69	0.29	0.75	4.93	99.6%
2023	3.14	0.69	0.30	0.76	4.89	99.6%

Table 4 suggests that there is a high likelihood of complying with the NAAQS at the Turnagain station. Although not shown here, a similar analysis was performed for the Garden station. That analysis indicated that there is an even greater likelihood of compliance at that site. The probability of compliance was greater than 99.9% each year between 2007 and 2023.

Sensitivity Analysis

The roll forward probability analysis presented in the last section relies on modeled projections of future emissions. What happens to the estimated probabilities if these projections underestimated the growth in CO emissions between 2007 and 2023?

This sensitivity analysis investigates the sensitivity of the probability estimates presented in Table 4 to assumptions regarding:

1. the impact of discontinuing I/M in December 2009;
2. future growth in vehicle miles traveled (VMT), vehicle starts and idling, and;
3. future growth of wood stove and fireplace use.

For the purpose of this analysis, we will adjust initial assumptions regarding I/M, VMT, and wood stove and fireplace use and re-compute the estimated probability of complying with the NAAQS during the 2007-2023 period. The manner in which each of these assumptions was revised is described in the next section.

Revised Assumptions Used in Sensitivity Analysis:

Impact of Discontinuing I/M in December 2009

Depending on the year, MOBILE6 modeling suggests that discontinuing I/M will increase motor vehicle emissions by approximately 20%. Although this estimate of the I/M CO reduction is higher than the value estimated (about 12%) by Sierra Research in 2006 in the *Municipality of Anchorage I/M Program Evaluation Study*, for the purpose of this sensitivity analysis we will assume that I/M reduces CO by *double* the amount estimated by MOBILE6 modeling. In other words, we will examine what will happen to the probability of compliance with the NAAQS when we assume that motor vehicle CO emissions will increase by about 40% when I/M is discontinued in December 2009.^{††}

Future Growth in VMT, Vehicle Starts and Idling

Imbedded in these emission computations is the assumption that amount of vehicle miles traveled (VMT) on streets in the 9 kilometer² area surrounding the Turnagain station will grow by about than 4% from 2007 levels. Although this appears to be a sensible assumption because the Turnagain area is an older area with little opportunity for significant growth in population, in this sensitivity analysis we will assume that the growth in VMT will be three times that projected by the Anchorage Transportation Model. In other words, we will assume that VMT and vehicle starts and idling will grow by 12% between 2007 and 2023 and determine how this affects the probability of compliance.

Future Growth in Wood Stoves and Fireplace Use

Woodstove and fireplace emissions were assumed to grow in proportion to the growth in the number of households in the Turnagain micro-inventory area. During the 2007-2023 inventory period, wood heating emissions were projected increase by about 11%. Although recent telephone data suggest that Anchorage households do not plan to change their habits with regard to wood burning, there is a possibility that wood burning rates could increase in the next decade if households decide to heat with wood to avoid rising costs of heating with natural gas. For the purpose of this analysis we will assume that wood heating will grow 2% per year per household during the inventory period.

Results of Sensitivity Analysis

The three revised assumptions used in this sensitivity analysis are summarized in Table 5. The *combined* impact of these revised assumptions on CO emissions in the Turnagain micro-inventory area and the consequent effect on probabilities of compliance during the 2007-2023 maintenance plan period is shown in Table 6.

Table 6 suggests that even when the assumptions used in the sensitivity analysis are combined to create a “worst case scenario”, the probability of compliance with NAAQS is above 90% each year. Worst case estimates of the probability of meeting the standard vary from a low of 94.7% (after the termination of I/M) to a high of 99.1% in 2009 (just prior to the termination of I/M). In 2023 the estimated probability of compliance using the worst case assumptions in the sensitivity analysis assumptions is 98.1%. Using original assumptions regarding the impact of eliminating I/M and the growth in motor vehicle and wood burning activity, this probability is estimated to be 99.6%.

^{††} It is difficult to see this 40% increase reflected in Table 3. This is because MOBILE6 projects a continual reduction of CO emissions every year due to the replacement of older vehicles with newer vehicles. Between 2009 and 2013 MOBILE6 predicts that emission improvements from a newer fleet will reduce vehicle emissions by about 15%; this partially offsets the assumed 40% increase due to the termination of I/M.

Table 5
Comparison of Original Assumptions used in Maintenance Demonstration with Revised Assumptions used in Sensitivity Analysis

	Original Assumptions used in Maintenance Demonstration and Probability Computations	Revised “Worst Case” Assumptions Used in Sensitivity Analysis
Discontinuation of I/M	Motor vehicle emissions increase by roughly 20%	Motor vehicle emissions increase by roughly 40%
Growth in VMT and Vehicle Starts and Idling	4% increase between 2007 and 2023	12% increase between 2007 and 2023
Fireplace and Woodstove Use	No change in wood burning rates per household between 2007-2023	2% growth in wood heating per year

Table 6
Comparison of CO Emissions and Probabilities of Compliance with the NAAQS
Original Assumptions used in Maintenance Demonstration vs.
Revised Assumptions used in Sensitivity Analysis

	Original Assumptions		Revised Assumptions in Sensitivity Analysis	
	Estimated Total CO Emissions (tpd)	Probability of Compliance	Estimated Total CO Emissions (tpd)	Probability of Compliance
2007	5.99	98.1%	5.99	98.1%
2008	5.72	98.8%	5.76	98.7%
2009	5.45	99.2%	5.52	99.1%
2010	5.66	99.0%	6.11	97.8%
2011	5.86	98.4%	6.71	94.7%
2012	5.74	98.8%	6.61	95.3%
2013	5.62	99.1%	6.51	95.8%
2014	5.54	99.1%	6.45	96.2%
2015	5.45	99.2%	6.39	96.5%
2016	5.38	99.2%	6.33	96.8%
2017	5.30	99.3%	6.28	97.1%
2018	5.21	99.4%	6.20	97.5%
2019	5.11	99.4%	6.12	97.7%
2020	5.05	99.5%	6.08	97.8%
2021	4.98	99.5%	6.04	98.0%
2022	4.93	99.6%	6.01	98.0%
2023	4.89	99.6%	5.99	98.1%

Attachment

Rank-Pair Order Comparison of CO Concentrations at Turnagain with Garden and Seward Highway Monitoring Stations

Permanent monitoring at Turnagain station began in October 1998 following the completion of a CO Saturation Monitoring Study during the winter of 1997-98. This study monitored CO concentrations at some 20 locations using temporary industrial hygiene-type monitoring devices. The saturation study indicated that the Turnagain site had the highest concentrations of all the sites in the study.

The permanent monitoring stations at Turnagain and Garden are located in older residential neighborhoods with relatively low traffic volumes on the roadways adjacent to the monitoring probe. The Seward Highway station (decommissioned in December 2004) was located at the intersection of two heavily traveled arterials, the Seward Highway and Benson Boulevard. In Anchorage CO monitoring is conducted at these permanent stations during the winter months defined as October through March.

Non-overlapping 8-hour maximum CO concentrations measured at the Turnagain, Garden and Seward Highway monitors were compared in rank-order to determine which site has the highest CO concentrations and the greatest potential for exceeding the national ambient air quality standard (NAAQS) for CO. A rank-order comparison involves sequentially ranking non-overlapping 8-hour average concentrations at the two sites being compared in descending order. In other words, the highest concentration measured at one site is compared to the highest concentration at the other, the second highest at the one site is compared to the second highest at the other, the third highest at one site is compared to the third highest at the other, and so on.

Rank-pair comparisons of data were performed only in time periods when data were available from both sites. In other words, in order to perform a fair comparison between two sites, the data compared was limited to periods when both sites were in operation and collecting valid data. Table 1 show the time periods when paired-data from Turnagain was compared to the other two stations.^{##}

Table A-1
Comparison Periods for Rank-Pair Analysis

Stations Compared	Comparison Period
Turnagain with Garden	10/16/98 – 12/31/07
Turnagain with Seward Hwy	10/16/98 – 12/31/05

A spreadsheet program was constructed to identify the highest 50 non-overlapping 8-hour maximum CO concentrations at each site for the comparison periods shown in Table 1.

^{##} The Turnagain site did not begin operating until October 16, 1998 and monitoring was discontinued at the Seward Highway site on December 31, 2004. Garden has been in more-or-less continuous operation since late 1970's. When data comparisons between two sites were performed the analysis was limited to time periods when both sites were collecting data.

**Comparison of Turnagain and Garden Station CO Concentrations -
October 1998 through December 2007**

Results of the rank-order comparison between the Turnagain and Garden CO stations are shown in Figure 1. (Data used to construct this plot can be found at the end of this report.)

Figure A-1
Rank-Order Comparison of Highest Fifty Non-Overlapping 8-hour Average CO Concentrations
Measured at the Turnagain and Garden Monitoring Stations
October 1998–December 2007

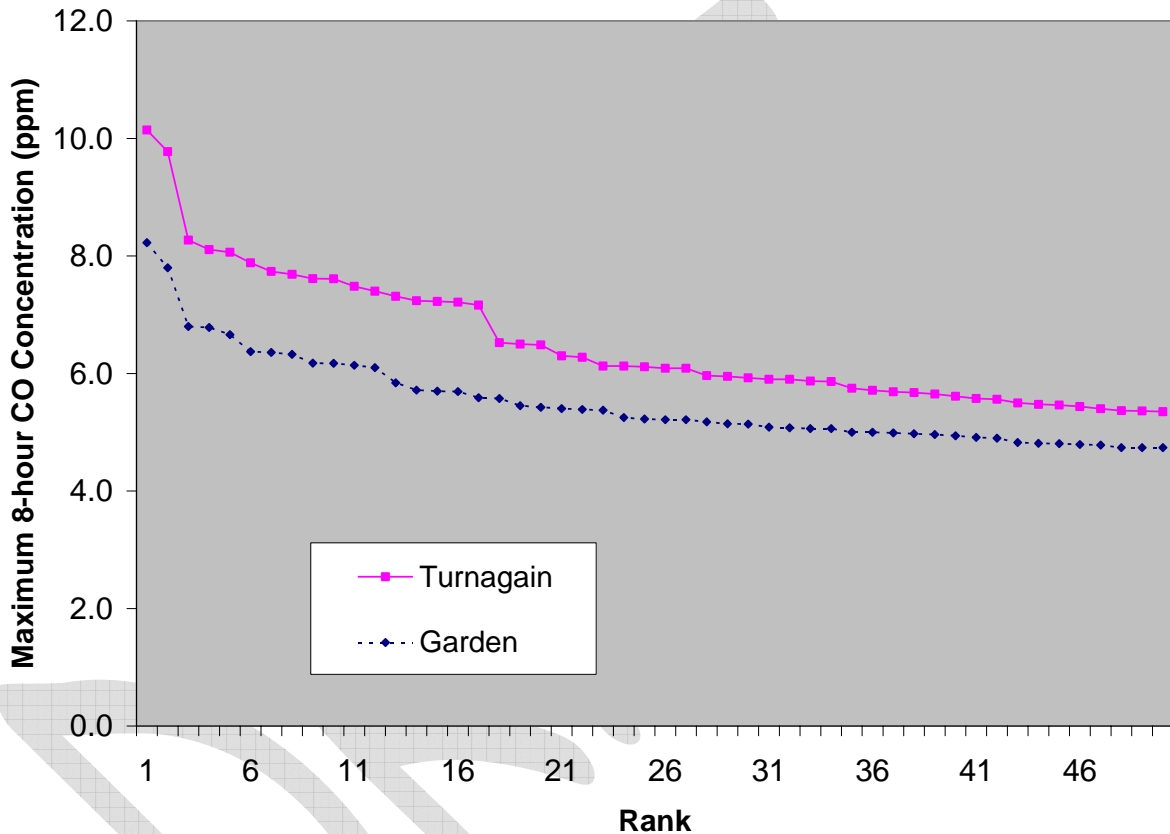
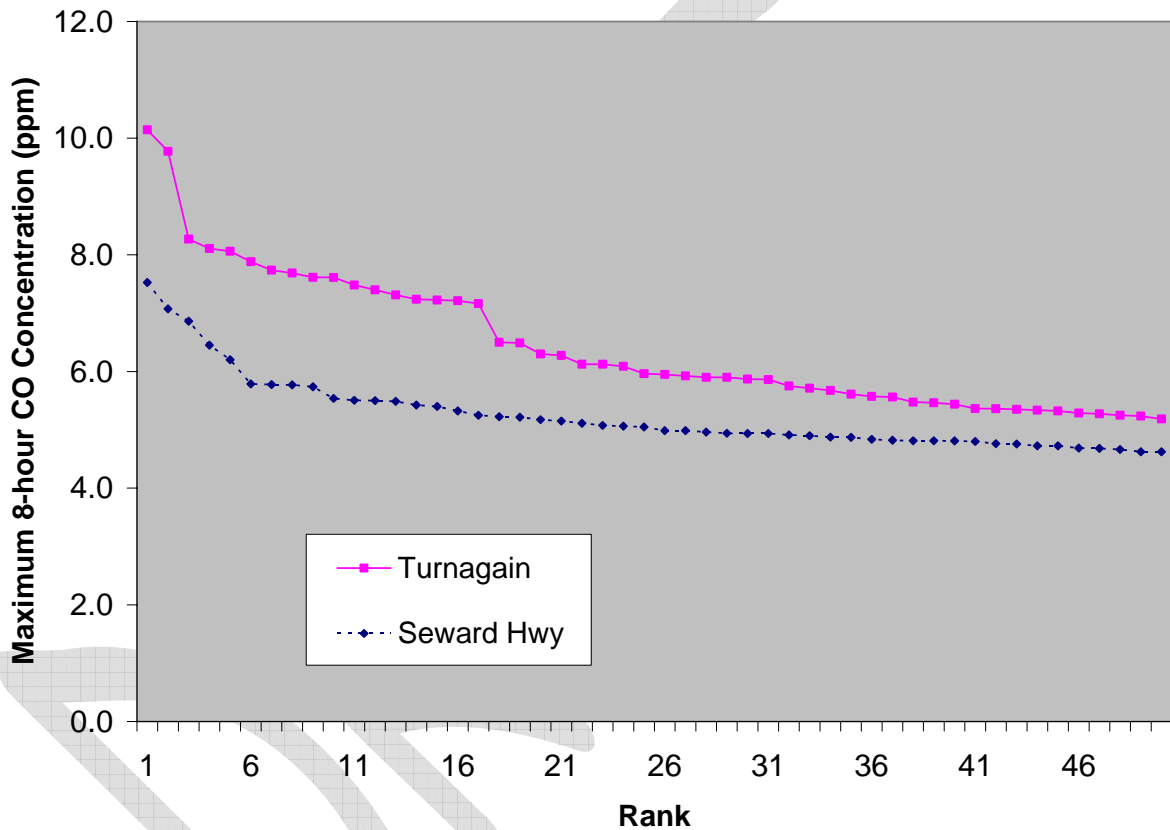


Figure 1 shows that the 50 highest 8-hour average concentrations at the Turnagain station are about 12% to 25% higher than the corresponding rank-pair value at Garden. The greatest differences occur among the highest ranks. For example the highest 8-hour concentration at Turnagain is 23% higher than the highest value at Garden while the 50th highest value at Turnagain is 13% higher than the corresponding 50th highest value at Garden. On a rank-pair basis, the values at Turnagain are significantly and consistently higher than those at Garden. This is particularly true at the extreme (i.e. highest) concentrations. This would suggest that Turnagain has a greater potential of exceeding or violating the NAAQS than Garden. For this reason, data from the Turnagain station were used to perform the probabilistic analysis for the maintenance demonstration.

**Comparison of Turnagain and Seward Highway Station CO Concentrations
October 1998 through December 2004**

A similar analysis was performed comparing data from the Turnagain station to Seward Highway. In this case the analysis was confined to the period October 16, 1998 to December 31, 2004 because the Seward Highway station was decommissioned at the end of 2004. The results of this analysis are shown in Figure 2.

Figure A-2
**Rank-Order Comparison of Highest Fifty Non-overlapping 8-hour Average CO Concentrations
measured at the Turnagain and Seward Highway Monitoring Stations
October 1998 – December 2004**



Among the highest 50 paired 8-hour concentrations, concentrations at Turnagain are 12% to 38% higher than Seward. The largest differences between the two sites are observed in the very highest 8-hour concentrations where differences between rank-pairs are typically 30% or more. This would suggest that Turnagain has a considerably greater potential of exceeding or violating the NAAQS than Seward.

Conclusion

This analysis demonstrates that the Turnagain site exhibits the highest CO concentrations and greatest potential for violating the NAAQS in the Anchorage network. It is therefore appropriate to use this site for analysis of long-term prospects for continued compliance with the NAAQS.

Turnagain Oct 1998 – Dec 2007			
rank	8-hr avg (ppm)	date	end hour
1	10.14	1/6/99	19
2	9.78	12/16/01	20
3	8.27	12/6/03	1
4	8.11	1/5/04	18
5	8.06	12/24/98	23
6	7.88	1/4/04	20
7	7.74	11/14/01	12
8	7.69	12/16/98	24
9	7.61	1/3/04	21
10	7.61	2/23/99	12
11	7.48	1/1/04	22
12	7.40	12/18/01	17
13	7.31	2/8/99	11
14	7.24	12/6/99	14
15	7.23	12/5/01	15
16	7.21	1/16/00	3
17	7.16	11/28/99	1
18	6.53	11/29/06	16
19	6.50	2/23/99	3
20	6.49	2/6/02	12
21	6.30	12/3/01	16
22	6.28	12/8/01	1
23	6.13	2/18/01	6
24	6.13	11/14/01	3
25	6.11	1/24/06	12
26	6.09	2/11/99	9
27	6.09	1/17/06	14
28	5.96	2/22/99	13
29	5.95	12/4/01	16
30	5.93	11/10/99	12
31	5.90	1/4/99	24
32	5.90	12/1/01	5
33	5.87	1/13/04	1
34	5.86	1/25/02	12
35	5.75	12/27/98	4
36	5.71	12/1/01	24
37	5.69	1/28/05	11
38	5.68	11/15/98	24
39	5.65	11/25/06	12
40	5.61	2/9/99	13
41	5.58	12/14/01	15
42	5.56	12/12/99	3
43	5.50	12/19/07	14
44	5.48	11/7/98	2
45	5.46	1/12/00	13
46	5.44	2/1/02	13
47	5.40	11/25/06	3
48	5.37	1/14/04	2
49	5.36	12/26/03	16
50	5.35	12/27/02	15

Garden Oct 1998 – Dec 2007				
rank	8-hr avg (ppm)	date	end hour	% Diff
1	8.23	1/6/99	18	23.3%
2	7.80	12/6/99	14	25.3%
3	6.80	12/24/98	19	21.6%
4	6.78	1/13/04	21	19.5%
5	6.66	2/12/99	12	21.0%
6	6.37	2/9/99	14	23.7%
7	6.36	1/3/04	21	21.7%
8	6.33	1/5/04	20	21.5%
9	6.18	1/27/99	13	23.3%
10	6.17	1/4/04	21	23.3%
11	6.14	12/5/03	23	21.9%
12	6.10	12/16/01	22	21.3%
13	5.84	1/1/04	23	25.2%
14	5.72	1/2/04	22	26.6%
15	5.70	11/27/99	24	26.8%
16	5.69	12/20/03	19	26.7%
17	5.59	10/22/98	11	28.2%
18	5.58	12/3/01	15	17.0%
19	5.45	1/15/04	14	19.2%
20	5.43	1/5/99	13	19.6%
21	5.40	1/7/04	14	16.6%
22	5.39	1/13/00	14	16.5%
23	5.38	1/12/00	15	14.0%
24	5.25	3/18/02	23	16.7%
25	5.23	2/22/99	12	17.0%
26	5.21	12/26/98	24	16.8%
27	5.21	2/11/00	15	16.8%
28	5.18	1/15/00	24	15.2%
29	5.14	1/14/99	14	15.7%
30	5.14	2/10/00	13	15.3%
31	5.09	11/29/01	15	16.0%
32	5.08	11/14/01	13	16.3%
33	5.06	2/13/99	1	16.0%
34	5.06	1/17/06	14	15.8%
35	5.00	11/22/99	14	15.0%
36	5.00	1/23/03	14	14.3%
37	4.99	2/10/99	12	14.1%
38	4.98	1/16/00	17	14.1%
39	4.96	12/4/01	16	13.9%
40	4.94	12/14/04	20	13.6%
41	4.91	11/20/98	15	13.5%
42	4.90	1/22/03	14	13.5%
43	4.83	11/10/99	13	14.0%
44	4.81	2/8/99	12	13.8%
45	4.81	1/18/05	13	13.7%
46	4.79	1/27/05	14	13.5%
47	4.78	1/7/04	23	12.9%
48	4.74	2/9/99	2	13.3%
49	4.74	12/18/01	16	13.2%
50	4.74	2/6/02	13	12.9%