Bay Area Air Quality Management District
939 Ellis Street
San Francisco, California 94109

APPROVED MINUTES

Advisory Council Technical Committee Meeting
9:30 a.m., Tuesday, December 9, 2003

1. **Call to Order/Roll Call.** 9:37 a.m. Quorum Present: Robert Harley, Ph.D. Chairperson, Sam Altshuler, P.E., Louise Bedsworth, Ph.D., William Hanna, Stan Hayes, John Holtzclaw, Ph.D. Absent: Norman A. Lapera, Jr.

2. **Public Comment Period.** There were no public comments.

3. **Approval of Minutes of October 20, 2003.** Dr. Holtzclaw moved approval of the minutes; seconded by Mr. Hayes; carried unanimously.

4. **Ozone, Nitric Oxide (NOx) and Hydrocarbon (HC) Ambient Concentration Trends in the Bay Area.** Richard Duker, Supervising Air Quality Meteorologist, stated that from 1965 to 2003 excesses of the national 1-hour and 8-hour ozone standards have decreased in the levels of ozone over the standard, as well as the number of excess days and stations per episode. Excesses of the state ozone standard also decreased from 1965 to 2000, but thereafter have slightly increased due to the increasing number of days with temperatures between 90-95ºF. In 2003, there were few ozone excesses in Marin and San Francisco counties where the sea breeze is strong. Ozone excesses are the most numerous in the South and East Bay, with Livermore recording the most excesses of the national 1-hour standard. From 1994-2003, data in the Livermore area indicates a correlation between temperature at or above 95ºF and excesses of the 8-hour standard. However, excesses of the 1-hour standard in Livermore have been decreasing despite high temperature situations.

   With regard to meteorological conditions and their relation to ozone formation in the Bay Area, atmospheric pressure readings on May 31, 2003 showed a high-pressure trough off the coast. A maximum of 59 parts per billion (ppb) ozone was measured. Any excess of the 8-hour standard of 85 ppb was unlikely under such conditions. On June 1, 2003 a high-pressure ridge began to form over the Bay Area, with temperatures reaching 93ºF and ozone levels increasing to 74 ppb. On June 2, 2003, the amplitude of the ridge increased and the maximum temperature reached 98ºF. Ozone levels were measured at 93 ppb and therefore exceeded the 8-hour standard. On July 17, 2003, an "extended four corners high" developed with the center of high pressure forming over the intersection of Colorado, New Mexico, Utah and Arizona. A maximum temperature of 105ºF was recorded in the Bay Area and an excess of the 8-hour ozone standard occurred at 89 ppb. The 1-hour ozone standard of 125 ppb was also exceeded with levels reaching 128 ppb in Livermore. This weather pattern, which wedges a wave of high pressure between Oregon and California, tends to produce federal ozone excesses, particularly as the on-shore flow pressure gradient is reduced, producing stagnant air conditions. On July 18, 2003, when the pressure gradient did not impede on-shore wind flow, even with high pressure and a maximum high temperature of 103ºF, a reading of only 61 ppb occurred for the 8-hour standard. Therefore, the District meteorological staff did not forecast a Spare the Air Day.

The District uses a forecast equation to calculate the ozone concentration relative to the 8-hour standard that includes these factors: maximum expected temperature, ozone concentration at 7:00 a.m., wind speed at the Kregor Peak monitoring site, previous day maximum ozone temperature, coastal monitoring site wind speeds, an El Nino factor, the pressure gradient between Medford, Oregon and San Francisco, maximum nitric oxide (NO) morning concentrations, and a vertical temperature gradient between 850-1000 millibars for Medford/San Francisco at 4:00 a.m. Chairperson Harley suggested evaluating maximum weekday and weekend NO concentrations, which should be lower by 30-40% on the weekends.

Dr. David Fairley, Statistician, stated that progress in reducing ozone excesses in the Bay Bay Area was made between 1970 and 1990. Progress since the 1990's is evident on a smaller scale. Ozone levels in the District are very close to the federal standards, rendering attainment susceptible to small variations in meteorological conditions or emissions. The 1-hour federal standard allows that a site may exceed 124 ppb once per year averaged over the latest three years. If a single site records four excesses in a three-year period, the entire region is declared out of attainment.

A design value for each site has been developed. It is the average excess ozone concentration that would occur once annually under normal weather conditions. This value is the fourth highest daily maximum ozone level measured over the last three years. The design value for the District is the maximum of the design values among all of the District's air monitoring sites.

Bay Area design values from the 1970s to the 1990s show a discernable decrease but remain fairly constant in the 1990s. The design value went below the national standard in 1993 and 1994. The increase in the design value for 1995 was probably a combination of meteorology and reformulated gasoline, but has not been definitively explained. The decrease in design value from 1999 to 2000 was due to meteorology. Population exposure to ozone in the South Bay has decreased overall.

A comparison of Bay Area with Livermore design values from 1970-2003 shows that sites in the east and south Bay have not made much progress. Livermore design values remain fairly constant, although some minor progress is discernable. The more recent excesses of the federal 1-hour standard at Livermore occurred on days over 100ºF, whereas in the early 1990's excesses occurred at lower temperatures starting at 95ºF. If wind speeds are taken into account during the period from 1990-2003, ozone excesses at Livermore occur when the temperature is either above 98ºF, or above 95ºF with wind speeds at Travis ranging from 5-8 mph. These are necessary but not sufficient conditions for excesses and may be labeled "ozone conducive days" (OCDs).

There were 27 OCDs at Livermore in 1984 but only two in 1995. A comparison of ozone excesses at Livermore in relation to OCDs over recent decades reveals that more extreme conditions are needed to exceed the 1-hour standard. When temperature is isolated in this analysis, there is a steady decrease in the potential for ozone per given temperature increment. Where 110 ppb would have been expected in earlier years, 100 ppb would now be expected. This constitutes persuasive statistical evidence that progress has been made.

This conclusion is confirmed by multiple regression analysis that accounts for maximum temperature, Travis mid-day winds, a weekend/holiday effect, and previous day afternoon aloft winds. Averages evaluated over a 25-year period show that in recent years there are fewer ozone exceedances on OCDs, while in the 1980s there would have been many more excesses on such days. When meteorological adjustments are made, statistically significant progress is evident.

A review of design values adjusted for meteorology reveals that in the early 1990s the conditions were more conducive to producing high ozone, while in recent years conditions are less conducive to generating high ozone. Based on a variety of methods to estimate design values, the Bay Area's design value is slightly above 125 ppb. However, even if it were 123 ppb, attainment of the 1-hour standard would be susceptible to minor variation in temperature or emission levels. A design value of 123 ppb provides a 50% probability that the region would exceed the standard. If the region were to reduce ozone by one ppb annually there is an 80% chance of exceeding the standard.

Data for Bay Area 24-hour averages of nitric oxide (NOx) in the emission inventory track well with ambient data and show a continuous reduction from 1980. Similar comparison of data for volatile organic compounds (VOCs) show a steeper downward trend for ambient data at the San Jose, Livermore and Fremont sites than in the Bay Area generally. Ratios of VOC/NOx from 1985 to the present are fairly consistent.

Chairperson Harley inquired as to why the 30-40% reduction in ozone precursors over the last 25 years does not show corresponding reductions in ozone excesses. Dr. Fairley replied that further research is necessary, especially regarding the influence of population growth and changes in the dynamics of reactivity. Peter Hess, Deputy Air Pollution Control Officer, added that transport from the Central Bay may be an additional factor. Mr. Altshuler agreed, noting that photochemical reactivity appears to be slower now than in previous years. Most violations now occur in June and July rather than September or October as in earlier years. Dr. Fairley observed that in more recent years the months of May and October have started to drop out as ozone excess months.

In discussion of the presentations, Mr. Hayes noted:

- The Livermore design value is resistant to efforts to reduce it.
- Trends in population-weighted exposure should also be included in this analysis, especially as this category was included in the most recent version of the State Implementation Plan.
- How the trends identified by staff will be affected by increases in vehicle miles traveled and population increase also requires evaluation.
- The residual probability of exceeding the standard even if the District is below it is important.

Mr. Altshuler added that the equation for the forecasting the 8-hour ozone standard requires further sensitivity analysis to determine the key variable and help identify whether or not the District can control it. Chairperson Harley stated that it now appears that meteorology played a greater role than emission reductions in the 2003 ozone attainment record. On the other hand, however, while the 30-40% reduction in precursors over the last 25 years may not register in Livermore, the zone of high ozone is being compressed both in space and time. This shows how the trends in reducing ozone precursors are being reflected. This also has an impact in terms of population exposure metrics, and offers a positive public health message.

Dr. Bedsworth added that 2003 was also the worst summer ozone season on record for the Central Valley. This raises questions about pollutant transport. Mr. Hanna added that slower reactivity geographically places peak ozone concentrations further downwind. As it appears that ozone reductions will only be incremental from stationary sources given the increased number of vehicles on the road, increased ridership in public transit will play an important role in achieving further ozone reductions in the future. Mr. Altshuler added that three other factors will influence ozone formation: Smog Check II, the removal of MTBE from fuel, and the retrofitting of diesel engines with particulate matter traps, which will influence emissions of NOx.

5. **Update on the District's Modeling Efforts.** Saffet Tanrikulu, Ph.D., Research & Modeling Manager, stated that the Central California Ozone Study (CCOS) modeling team is comprised of staff from the District, Environ Corporation, the Air Resources Board (ARB), Desert Research Institute, Alpine Geophysics, and U.C. Riverside. The field program conducted surface and aloft meteorological measurements for wind speed, wind direction and temperature, to provide modeling inputs and evaluate modeling outputs. Dr. Tanrikulu displayed a map of the study and model domain, and identified 300 surface meteorological stations sponsored by the various CCOS participants. He described the deployment of the diverse monitoring stations and how they are targeted to measure specific compounds. Mr. Hess added that with regard to Dr. Bedsworth's previous observation on transport, the stations adjacent to the Bay Area have met the 1-hour and 8-hour standards, while the stations east of Metropolitan Sacramento are prone to exceedances.

   Dr. Tanrikulu reviewed the flight patterns over the modeling domain of five aircraft obtaining aloft measurements during the selected ozone episodes. Such measurements were used to determine modeling boundary conditions for the region for a variety of compounds and were compared with the original CCOS boundary conditions. More recent aloft measurements of ozone were much lower than the boundary conditions sets in the original CCOS study. Aloft measurements of NO and NO_2 were slightly higher in the original CCOS study than what aircraft measurements showed. Formaldehyde was higher in the original CCOS study than what was observed in measurements aloft. Aircraft measurements over the ocean during the ozone episodes were somewhat limited, and whether or not these are ultimately representative of boundary conditions is therefore unclear.

   The Field Program focused on three episodes. The first was from June 14-15, 2000, during which an unusual 150 ppb of ozone was measured at Livermore. The second was from July 30-August 2, during which Livermore recorded an excess of 126 ppb on July 31, 2000. There were also high ozone concentrations in the San Joaquin Valley as well: 151 ppb. A third period was studied but no Bay Area excesses were recorded, although the San Joaquin Valley recorded 165 ppb.

   For the CCOS modeling emissions inventory, the ARB prepared the emission inventory and modeling inventory. However, a review of the data suggests that reactive organic compounds are somewhat underestimated at 410 tons per day (tpd) when the total has usually registered between 550-600 tpd. NOx is overestimated at 662 tpd, compared with previous inventory totals estimated at 550-600 tpd. Staff is currently discussing these disparities in the inventory with the ARB.

   Quality assurance review of CCOS data will compare model outputs with observed data. He described the models that are being used by the District and Environ Corporation with regard to the number of vertical layers and surface grid resolution. He noted that the District is comparing a four-kilometer grid resolution with a more detailed 300-meter horizontal grid resolution with the aim of improving the terrain feature of the model. This is important, as the simulated winds for late morning on the July 31, 2000 ozone episode do not correspond to observed data. If there are transport impacts from the North Bay to Livermore, this could be of particular concern.

   Dr. Tanrikulu noted that between 3,000-5,000 separate model simulations are being reviewed and cited several examples. For Bodega Bay on July 31, 2000, observed and simulated wind speed, wind direction and temperature data from the early morning hours show that observed wind speed averaged was two meters per second. However, the model estimates wind speeds at four to five meters per second, leading to an underestimation of ozone by the model due to the over-ventilation of the area.

With regard to wind direction, the model shows a westerly wind direction while observed data indicates a southerly direction. For July 29-31, 2000 at Livermore, the model is accurate on wind speed, but it underestimates temperature in the afternoon by 4-6ºC. This affects atmospheric photochemistry and may lead to an underestimation of ozone. Accurate measurements along the Highway 680 corridor are also important. Improved grid solution may assist the model in more closely approximating observed data. However, efforts to force four-dimensional simulated data toward observed data have not been successful. This may be due to the location of the stations, where more are found in the North Bay and Livermore but only one station along the 680 corridor.

At Bodega Bay on July 29, 2003, four-kilometer grid resolution simulations show light winds during the morning from ocean to land, while the observed data shows light winds flowing from land to ocean. This may lead to the over-ventilation of the area. On July 31, 2000 at Livermore, observed data show the sea breeze begins at noon but the model predicts it will start at 9:00 a.m. This may cause an overestimation of area ventilation and pollutant transport to the east. Temperature plots for simulated and observed data for Livermore on July 31, 2002 from 5:00 a.m. to midnight are cooler than observed data. At higher elevations in Livermore during the afternoon on the same day, the model predicts lower than observed temperatures as well. Model estimates of ozone on the same day are at 113 ppb but the observed data registered 126 ppb of ozone.

The Modeling Advisory Committee has created two working groups to address meteorology emissions inventory issues. They share data and simulate the same episode to understand the deficiencies in the model and make improvements. The groups use common data and evaluation methods and will identify the problems in the model and devise a plan to address the problems. The meteorological working group will focus on improving terrain and surface feature information to make the model as representative as possible. Categories include soil moisture, vegetative cover, deep soil temperature, surface roughness, soil heat capacity and surface albedo. Statistical methods to evaluate model performance on surface features will be conducted in three dimensions, with mixing heights, sea breeze and other mesoscale features.

The emissions working group is reviewing uncertainties in on-road mobile source emissions for heavy-duty and light-duty diesel NOx emissions. The group will improve documentation of all emission inventory processing, generate separate emission files for on-road heavy-duty diesel emissions, and conduct emissions scaling.

A tentative completion date has been set for February/March 2004 to implement the identified improvements to minimize ozone underestimation. Mid-range goals in 2004-2005 are to fully improve and evaluate the models. Long-term goals from 2005-2007 are to simulate the ozone episodes for the 1-hour and 8-hour standards, as well as for particulate matter episodes.

6. **Committee Member Comments**. The Technical Committee members expressed their esteem for Chairperson Harley for his leadership of the Committee and weighty contributions to the Council.

7. **Time and Place of Next Meeting**. At the call of the Chair.

8. **Adjournment.** 12:12 p.m.

James N. Corazza
Deputy Clerk of the Boards