Condensed Version of Comments on ARB's Workplan for "Weekend Effect" Research

(Bold letters and numerals after comment identify section of plan where issue addressed)

Brent Bailey, Coordinating Research Council (7/15/99)

Have the uniform ozone reductions observed at all sites on all days of the week in SoCAB and SFBAAB been due to VOC controls or have there also been significant NOx controls in parallel? **(I.p1)** I assume the ARB hearing was held in 1998 and not 1999. **(I.p1)** It appears that ARB is expecting a great deal of insight from Project AQ-6 based on hypotheses concerning differences in traffic emission activity and inventory. Can AQ-6 really answer all these questions? In previous meetings at ARB we heard that weekend traffic flows see the same number of trips per vehicle used, but fewer vehicles used on the weekend. This information would seem to reject some of the hypotheses proposed which indicate similar emission loading on the weekends. I agree that projects are needed to investigate the hypothesis concerning weekend emission activity and inventory. Can't simple ambient VOC concentration data currently available answer some of these questions and could source characterization and chemical tracer work help out here? On the hypotheses concerning the influence of carryover of ozone and precursors, it seems that Project AQ-5 gave contradictory indications. **(II.B.AQ-7 & AQ-9)**

Leon Dolislager, ARB-Research (7/9/99)

SUMMARY section

1) conclusion #3 - If there is no Weekend Effect in the Greater Sacramento Area (GSA), then the plan should include an aspect that addresses emission/transport differences between the GSA and the SC & SFBA Air Basins. These differences should provide some insights into the cause(s) of the weekend effect. **(Summary)**

INTRODUCTION section

1) third sentence notes that the Weekend Effect coincides with "<u>presumably lower</u> emissions" than on weekdays; the analysis plan must address the validity of any assumptions. **(I.p1)**

2) fifth sentence notes "almost uniform decline in ozone levels at all sites for all days of the week" - this statement is not consistent with later discussions. Replace "almost uniform decline" with "downward trend". **(I.p1)**

3) in the first sentence of the "NO_X Limitation" Hypothesis, "weekends" should be changed to "weekdays" and "are" to "occur". Also, the phrase "further downwind" although permissable for the three areas studied, might not be appropriate in all cases (e.g., when bulk of residences/suburbs are upwind of the urban/business center). **(I.2.)**

4) in the next-to-last paragraph, Hypothesis #1 can also be used to explain some of the WD/WE differences in trends if weekends are progressively becoming more NO_X-limited compared to weekdays. Until more definitive analyses are completed, I'm reluctant to rule it out as a contributing factor. **(I.4.)**

5) in the last paragraph, reword the next-to-last sentence to reflect the workshop in the past tense and identify any hypotheses/research from non-ARB sources in a separate paragraph/sub-section. If significant work identified from outside ARB, we should indicate how ARB will consider/integrate it into the workplan. **(I.p$_{last}$)**

AIR QUALITY ELEMENT section

1) second paragraph - notes that analysis of other regions of state will be performed as time and resources allow. Make the San Joaquin Valley the highest priority of other areas to investigate because it has relatively high ozone concentrations, the trend has been flat, has a setting different than the other three areas studied so far (i.e., a string of urban areas interspersed with rural areas), etc. These factors present alternative scenarios to the areas studied so far and could help elucidate/differentiate some of the various WD/WE influences. **(II.A.)**

2) Task AQ-4, 2nd part to the approach - Why limit the analysis to PM10 by TEOMs; for trending purposes, BAM data should also be helpful (the SCAQMD has operated 4(?) BAM sites for several years; if the data are not all on ADAM or AIRS, the District would likely provide it for this purpose). Also, there should be sufficient data to look at summer means which could shed more light on the ozone WD/WE effect and the relationship between particles and ozone. **(II.B.AQ-4)**

3) Task AQ-5 - here the type of PM10 measurements was not specified;specify "continuous" PM10 measurements and include BAM data in addition to TEOM data. In the 2nd part of the approach, I recommend individual years over fixed 3-year means to permit analysis of RFG impacts, etc. **(II.B.AQ-5)**

4) Task AQ-7 - in the title, consider changing "trends" to "data" as the most definitive data probably come from special studies and not long-term monitoring sites. Also in the title and in the discussion, change "elevated" to "high-altitude" to avoid the interpretation of sites with "elevated concentrations of ozone". [In the 1st part of the approach, consider including transport corridor sites (e.g., Banning, Cajon Pass) and some of the unique sites in operation during the 1995 Mojave Desert Ozone Study (e.g., Quartzite Mtn, Shadow Mtn). Also, as another potential approach, I was amazed

how high and spatially pervasive the background (minimum ozone concentrations were during the MDOS95. One could look at the early morning data from the temporary and routine sites in the Mojave Desert during the summer of 1995 for a day-of-week effect as the pollution from the SoCAB is vented to the Mojave Desert. The day-of-week signal at these sites would likely be much less impacted by local influences than sites within the SoCAB.] **(II.B.AQ-7)**

5) Task AQ-8 - this analysis should also recognize that monitoring sites near major recreation corridors (e.g., I-15, I-5, US-2) might also have high ozone concentrations on Monday in response to carryover of emissions during the evening commute home. **(II.B.AQ-8)**

EMISSION ACTIVITY AND INVENTORY ELEMENT section

1) although data likely are or will be available in Tasks EI-3, EI-5, EI-6, EI-8, EI-9, EI-10 to address WD/WE differences, the write-ups don't specifically note whether the contractor or ARB staff will be analyzing for the purpose of better understanding the WD/WE differences. **(III.A.)**

PHOTOCHEMICAL MODELING ELEMENT section

1) for Task MD-1, include RD staff in the resources as they may have more familiarity with the quality and nature of lidar data than others. **(III.B.MD-1)**

HYPOTHESIS TESTING section

1) Sub-section C on WE emission activity is not as developed as the other sections and rightly notes that we may not have the tools/information to test the hypotheses at this time. However, it might be useful to group the hypotheses of increased WE emissions by some preconceived estimate of the likelihood of significant impact on WE ozone concentrations. For example, I might place hypotheses 6, 9, & 12 into the most likely group; hypotheses 3, 7, 8, 10, & 11 in a group of intermediate probability; and hypotheses 1, 2, 4, 5, & 13 into the least likely group based on my experiences and perceptions. The plan could also suggest an approach or two (e.g., surveys, activity data) to address each hypothesis. **(V.C.)**

Alan Dunker, General Motors (by phone 8/2/99)

NOx disbenefit hypothesis incomplete; not just ozone scavenging. Milford IR sensitivity shows that NO_2 + OH termination reaction has largest effect on MIRs and MOIRs. Under NO_X limitation, HO_2 and RO_2 pool increases, H_2O_2 increases, and consequently ozone increases with NOx decreases. **(I.1., V.E.2)**

Bryan Lambeth, Texas Natural Resources Conservation Commission (7-21-99)

Ozone by day-of-week data file for ozone nonattainment areas in Texas during 1987-1994 shows Dallas-Fort Worth with no 1-hour ozone exceedances on Sunday; El Paso had only two exceedances on Sunday; and Houston and Beaumont-Port Arthur showed no significant day-of-week tendencies, probably because of the large influence of industrial sources in those areas.

Gail Tonnesen, University of California, Riverside (7/15/99)

The NOx carry-over theory seems problematic - in the data I've looked at, NOx concentrations are higher Friday nights, but at most sites NOx is lower again by Saturday morning and remains low throughout the day. Perhaps there is something more complex going on with Friday night NOx emissions sequestering radicals and releasing them Saturday morning - we would need PAN and HONO data to evaluate this. In any case, I think the indicators would be the most useful approach for assessing the temporal variability in O_3 production sensitivity, and this will be useful for evaluating carry-over and the other theories as well. **(Summary p1, II.B.AQ-8)**

Steve Ziman, Chevron (7/14/99)

I am not sure I agree in general with the tone and implied direction of the workplan. It appears to be aimed at disproving anything doing with potential disbenefits of NOx reductions rather than trying to really identify why we see what we do. That approach would not reflect science. **(I.p1)**

In terms of one of the statements that proports that progress in reduction of ozone has occurred throughout the state, I would challenge it. If one looks at the peak monitors in Sacramento, Fresno, Bakersfield (Edison and Arvin), and the Bay Area (Livermore), there is no significant downward trend over the last decade. Monitors in the urban core of these areas may have gone down, but many of them were either in attainment or barely nonattainment. But the high monitors downwind of the urban core have not responded. **(I.p1)**

Prepared for Alliance of Automobile Manufacturers by Jon M. Heuss, Air Improvement Resource, Inc. (7/15/99)

<u>Comments on Introduction</u>

The Alliance agrees with the objectives of the Work Plan:

Understand the causes of the “weekend effect” on ozone
Explore the relationship between particulate matter (PM) and day of the week
Examine the implications of such effects on pollutant mitigation strategies

The Alliance also agrees that, because of the complex nature of the phenomenon involved, “the temporal and spatial patterns of emission activity, the overall emission inventory, meteorology, and photochemistry need to be woven together.” (WP at page 2)

After positing four hypotheses (NO_X-disbenefit, NO_X-limitation, Overnight carryover, and Increased weekend emissions), the WP (at 3) indicates that the last three hypotheses can explain the long-term trend of a faster rate of progress for weekdays in comparison to weekend days in the 1990s. The WP goes on to indicate that the four hypotheses are not necessarily mutually exclusive and that as research progresses, other hypotheses may be proposed.

There are several problems and logical inconsistencies in the way the staff has set up the issue. First, there is a logical inconsistency between the statement on page one claiming an almost uniform decline in ozone levels at all sites for all days of the week in the SoCAB and the SFBAAB and the statement on page three that there has been a long-term trend of a faster rate of progress for weekdays in comparison to weekend days in the 1990s. While the staff may have many reasons to consider the acceptance of the NOx disbenefit hypothesis premature, the reason given in the first paragraph is not consistent with the data. **(I.p1)**

Second, as was suggested at the public meeting, the first two hypotheses (which are related to NO_X-effects) are really variations on the same hypothesis. The first two ARB hypotheses separate the chemical and activity differences related to NO_X emissions. For example, the first hypothesis mentions scavenging and truck emissions, while the second mentions radical enhancement and light-duty vehicle emissions. In reality, the NO_X precursor reductions are caused by both lower car and truck activity on weekends, and both scavenging and radical inhibition and enhancement effects need to be considered holistically. **(I.1. & I.2.)**

Rather than mixing different aspects of $_{NOX}$-effects in different hypotheses, use one NO_X-related hypothesis that the higher ozone on weekends is due to a NO_X disbenefit arising from the lower NO_X emissions from cars and trucks on weekends compared to weekdays. **(I.1. & I.2.)**

For this hypothesis to be viable, the SoCAB on weekdays must be primarily in the VOC-limited regime, where NO_X reductions can increase ozone. If the hypothesis is

true, then it would predict that the weekend precursor reductions move the smog chemistry toward the ridge of maximum ozone. Since there are lower VOC emissions as well as lower NO_X emissions on weekends, this must also be taken into account. For there to be a net increase in ozone on weekends according to this hypothesis, the increase in ozone from NO_X reductions must more than offset the reduction in ozone due to lower VOC emissions.

Any explanation for the weekend effect must also be consistent with the observation that ozone has been reduced substantially in the SoCAB on both weekdays and weekends. This means that it must be able to explain why the overall NO_X reductions associated with the on-going control program are not increasing ozone. The hypothesis should also be able to explain the observations that the spatial extent of the weekend effect has become larger in recent years[1] and that there has been a tendency to have the maximum ozone occur on Sundays rather than Saturdays in recent years.[2]

For the Alliance hypothesis to be true, as noted above, the emission shift from weekdays to weekends must be primarily a NO_X control strategy. To explain the general improvement in ozone, the long-term trend in emission precursor changes should have a significant VOC component, at least as large as the NO_X component. To explain the recent increase in spatial extent and Sunday effects, the emission changes during this time period (primarily continuing fleet turnover plus the introduction of reformulated gasoline) should have a greater VOC than NO_X component pushing the Basin further into the VOC-limited regime. These predictions that arise from the hypothesis and our general understanding of ozone formation chemistry can and should be tested by the ARB and others.

The responses to the NREL RFP may generate additional hypotheses that can be tested. The Alliance urges ARB to work with NREL, CRC, and other interested parties to develop as full a set of hypotheses and as rigorous a set of tests of those hypotheses as possible. The Introduction indicates that ARB has set up its WP to pursue fundamental information that can be assembled flexibly to answer many alternative and complex hypotheses, rather than to define the tasks according to the complicated hypotheses such as ARB has already listed. While the generation and sharing of fundamental information is particularly important, the Alliance urges ARB to develop as many predictions (such as those noted above for the NO_X-disbenefit hypothesis) from the various hypotheses as possible, and to test those predictions as rigorously as possible.

<u>Comments on Research Tasks</u>

It is particularly important to characterize the hydrocarbon data that is available for the SoCAB. Even if there are limitations to the data, it must be analyzed and documented because it will be important in evaluating all the hypotheses. **(II.B.AQ-5, AQ-8, & AQ-9)**

It will be particularly important to evaluate day-of-week differences for PM2.5 as well as for the major chemical components. The evaluation should also include spatial and temporal trends to compare with the trends observed in the ozone data. **(II.B.AQ-3)**

Task AQ-4 is to analyze ozone and particulate matter trends to characterize the rate of improvement on weekdays and weekends. In addition to the trends in ozone and PM, it will be particularly important to document precursor trends. **(II.B.AQ-4)**

Task AQ-6 is to compare local traffic data with local air quality data to determine whether monitoring sites represent neighborhood and recreational activities. Such comparisons will be difficult because of reaction, advection, and vertical mixing. This task would be best accomplished in conjunction with photochemical modeling that can take these factors into account. **(II.B.AQ-6)**

Tasks AQ-7 and AQ-8 involve the evaluation of carryover aloft and at ground level. Since SCOS97 data will be used in these tasks, it will be important to make that data publicly available as soon as possible. John DaMassa indicated at the public meeting that the SCOS data should be released to the public in late Fall 1999 or early in 2000. **(Summary p2)**

The Alliance has two recommendations for additional work that can be used to discriminate among the hypotheses. The first is the use of "photochemical indicators." Photochemical indicators are compounds or ratios of compounds that have been found to delineate differences between VOC-limited regimes, NO_X-limited regimes, and the ridge of maximum ozone that separates the two limiting cases. This middle region is now often referred to as the transition region. Photochemical indicators are limited in that they only help diagnose a particular local situation and cannot be used to predict what might occur in the same locale on a different day or at some future time. They, however, can be useful diagnostic tools. ARB's hypothesis #2 would predict that observational indicators would show that weekday ozone is primarily VOC-limited but weekend ozone is NO_X-limited. The Alliance NO_X-disbenefit hypothesis would predict that photochemical indicators would indicate that weekday ozone is primarily VOC-limited but weekend ozone is in the transition region. **(II.B.AQ-5 & AQ-8)**

There are a number of photochemical indicators that have been proposed to discriminate among the various photochemical regimes, they include NOy, total reactive nitrogen, the ratio of ozone to NOz, where NOz is the sum of NO_X reaction products, and the ratio of H_2O_2 to HNO_3.[3] Their application is dependent on the availability of valid measurements of the species involved and assumptions concerning the influence of deposition that would need to be reviewed for the SoCAB. Several papers already report that different indicators show that, at specific times and places, the chemistry in the SoCAB is VOC-limited.[4] However, the situation on weekends is not known.

The second Alliance recommendation is to evaluate weekday/weekend ozone behavior

at all California locations. The comparisons should be limited to California to minimize any differences due to the motor vehicle control program and fuel. The major differences in activity should also be similar among California locations. In clean areas that have only background ozone, if there are any, one would expect no difference between weekday and weekend ozone levels. In NO_X-limited areas, one would expect the lower NO_X on weekends to result in lower ozone on weekends. In VOC-limited areas, one would expect the lower NO_X on weekends to result in higher ozone on weekends. **(I.p1, II.B.AQ-5)**

Emission activity and inventory studies All ten of the studies listed in the Work Plan involve gathering data or developing improved inventories for on-road motor vehicle emissions, with the emphasis on heavy-duty vehicles. However, one of the ARB hypotheses is that there are increased emissions, primarily of VOC, related to home maintenance and recreation. Indeed, the WP lists 13 categories of emissions that are hypothesized to have greater activity and emissions on weekends. (WP at 16) The WP indicates that it is unclear how many of these categories are being addressed with on-going inventory development activities, so this area appears to be the greatest unfulfilled research need. The Alliance agrees and urges ARB to aggressively move to add tasks to evaluate these categories. The main issue is to determine the relative magnitude of the possible increases from these 13 categories compared to the decreases that are already being established in the on-road vehicle inventory. **(V.C.)**

Photochemical modeling studies The four studies summarized in the WP are a realistic approach to understanding the weekend effect and its implications for current and future controls on both weekdays and weekends. They are listed for completion by June 2000. The Alliance encourages ARB to pursue these studies vigorously. With photochemical modeling, it is possible to separately evaluate the NO_X and the VOC changes from on-road vehicles and other sources to differentiate among the various hypotheses.

Comments in Hypothesis Testing

The WP indicates that the four hypotheses identified in the Introduction are too complex for single tests (except through photochemical modeling). It then goes on to list four main aspects-traffic activity differences, emission activities that occur predominantly on weekends, carryover influences from Friday and Saturday evening, and differences in ozone formation chemistry-for which specific hypotheses suitable for testing are identified. This section is confusing. For each aspect, between zero and six additional hypotheses are listed and discussed. For carryover, six hypotheses are listed and three are already rejected. For increased emissions activity, no hypotheses are listed. In some cases, the hypotheses are not clear; in some cases the WP indicates the hypothesis is difficult to test.

Rather than list many sub-hypotheses that do not relate directly to the main causal

hypotheses, it would be preferable to refine the main hypotheses and indicate how they can or cannot be tested. The proposals to NREL should be helpful in this regard. **(V.A.)**

Comments on ARB Summary

The Summary of the Work Plan indicates that ARB is in the middle of a short-term (1-year) effort to use existing data to understand the causes and control implications of the weekend effect. The Summary goes on to state that none of the four hypotheses have been eliminated, and that the only hypothesis with unambiguous supporting evidence is that Friday and Saturday night ozone and ozone precursors appear to carry over to the following morning. It is only natural that none of the hypotheses would have been eliminated so early in the effort. However, the fact that there is carryover related to increased Friday and Saturday evening activity does not indicate what impact that carryover may have on ozone formation. Evidence of carryover is a necessary but not sufficient condition for that hypothesis to be verified. Because of the complex nature of ozone formation, sensitivity tests with a photochemical model will be required to test the ozone implications from enhanced carryover. **(V.D.)**

The Summary indicates that the short-term analysis effort "is unlikely to result in definitive conclusions because of the limitations of the HC database." (WP at 1) While the HC data base has limitations, there is ancillary information from ambient measurements of individual air toxic compounds and CO as well as tunnel studies, emission estimates and emission/air quality analyses that can be used to determine the extent of VOC reduction over time and from weekdays to weekends. The ARB should thoroughly document and evaluate the HC database as well as these other data sources as part of the WP.

The Summary indicates that there is a clear research need to develop accurate day-of-the-week inventories over the long term (2 to 3 years) before air quality modeling should be conducted to simulate the weekend effect. This statement is not supported by the balance of the WP that indicates that photochemical modeling will be carried out in 2000. The South Coast Air Quality Management District (SCAQMD) did two preliminary tests of substantial weekend emission reductions for the 1994 AQMP and found a peak ozone increase in one case and no change in the other. However, SCAQMD did not evaluate the impacts of the VOC and NO_X reductions separately. That should be done to test NO_X-effect hypotheses. Because of the limitations of photochemical models, all studies need to be conducted and evaluated carefully. For example, the NARSTO Synthesis Team Assessment of Ozone Pollution[5] documents several model applications where subtle differences in model inputs led to totally different control signals (in terms of VOC vs. NO_X control). Therefore, it will be important to evaluate the NO_X weekend emission reductions, carryover effects, and enhanced weekend emission changes for a range of credible inputs. **(IV.A.)**

Alliance Recommendations

The Alliance supports the thorough investigation of the causes and implications of the weekend effect. It is important to keep the process open, make data available to all interested parties, and have additional public discussion of the various hypotheses and projects that will be carried out over the next year or so. **(V.A.)**

Combine the first two hypotheses into a single NO_X disbenefit hypothesis. As pointed out in the workshop, the first two hypotheses are simply variations of one hypothesis that ozone increases on the weekends because of reduced NO_X emissions on weekends.

ARB staff should work with NREL and CRC to refine their hypotheses and develop as rigorous a set of tests as possible of those hypotheses. **(V.A.)**

To test NO_X-related hypotheses, evaluate observational indicators and evaluate the weekend effect in all the air basins in California. **(II.B.AQ-8)**

To evaluate the enhanced emissions hypothesis, additional studies of weekday versus weekend activity for recreational and home maintenance sources are needed. **(V.C.)**

To evaluate carryover and improve baseline modeling in the SoCAB, fully evaluate the SCOS97 data. Make the data available to all interested parties as soon as possible.

Finally, as hypotheses are defined and refined, the discussion of their implications will need to be added. ARB staff should follow through on its commitment to share a draft of the synthesis report via the Internet for public comment and should convene another public meeting in the fall of 1999 to provide for further discussion of this important issue. **(V.F.)**

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