OR 140 Exit 35 to Blackwell Road Intersection

Attachment #3
(Agenda Item 5)

Rogue Valley Metropolitan Planning Organization

Rogue Valley Council of Governments

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Date: July 11, 2014

To: David Collier, Oregon Department of Environmental Quality (ODEQ)

From: Jonathan David, Rogue Valley Metropolitan Planning Organization (RVMPO)

Subject: Critical Issues with the RVMPO's Current Carbon Monoxide Budget

Attached is a memo prepared for RVCOG by Sierra Research, which is currently under contract to perform air quality modeling for the RVMPO. In the memo, Sierra Research presents a detailed discussion of results from the new MOVES2010b model showing CO emissions 2 to 3 times greater than what the RVMPO, DEQ, ODOT, FHWA, and FTA have understood our CO levels to be for well over a decade. These levels are also 2 to 3 times greater than our current CO budget would allow, which raises the very real near-term possibility that our region's air quality conformity could be threatened as a result. From what Sierra Research has been able to ascertain, this difference in CO levels is due to prior models (MOBILE5b and MOBIL6) not including, or significantly underestimating, CO emissions from cold starts (i.e., starting exhaust). In no way do these results indicate that the ambient CO air quality levels are worsening; in fact, the newly calculated CO levels continue to be well below the National Ambient Air Quality Standards.

What these newly calculated CO levels do indicate is an urgent need for the current CO budget to be adjusted to reflect a higher baseline share of vehicle emissions. Without this revision, we consider our current CO budget, based as it is on the flawed data, to be invalid. A determination of non-conformity for CO based on that invalid budget would therefore also, by extension, be invalid. In addition, should a determination of non-conformity based on a fundamentally inaccurate CO budget nonetheless be allowed to proceed, the region would see its ability to have the RVMPO's approved list of projects included in its entirety in the STIP severely compromised, which would significantly impact the federally mandated scope and nature of the RVMPO's responsibilities.

With this memo, we are formally requesting a revised CO budget for the RVMPO, and intend to immediately call for a meeting of the Air Quality Consultation Group to discuss this request as well as other options to preclude a determination of non-conformity. We will also be inviting representatives from ODOT and the Governor's office (which is being included due to its statutory responsibility to resolve intractable air quality conformity conflicts among state agencies or between state agencies and an MPO) to participate in that initial consultation.

Thank you for your attention to this matter.

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July 8, 2014

Memo to: Dan Moore and Jonathan David, RVCOG

From: Tom Carlson

Subject: RVMPO 2015-2018 TIP Conformity Findings

Under contract to RVCOG, Sierra Research (Sierra) performed vehicle emissions modeling to support the regional conformity analysis for the Rogue Valley Metropolitan Planning Organization (RVMPO) 2015-2018 Transportation Improvement Program (TIP) and 2013-2038 Regional Transportation Plan (RTP). For the first time, TIP emissions modeling was performed using EPA's new MOVES vehicle emissions model. (Prior TIP and RTP conformity analyses were performed using EPA's MOBILE series of models, the predecessor to MOVES.) As explained in detail later, succession and use of different EPA emissions models over time plays a critical role in our findings.

The crux of this analysis consisted of generating estimates of on-road vehicle CO and PM_{10} emissions reflecting travel activity forecasted in the TIP using EPA's latest MOVES2010b model and comparing those TIP emissions to motor vehicle emission budgets established in the existing 2001 CO Maintenance Plan (MP)[1] and 2004 PM_{10} SIP[2] for the pollutant-specific Medford planning areas.

Statement of Problem

Table 1 summarizes the results of this analysis, comparing TIP emissions by calendar year to the applicable CO and PM_{10} emission budgets established in the prior plans (budgets are shown in yellow-shaded **boldface** rows). As shown in the upper half of Table 1, CO emissions under both TIP transit scenarios were estimated to be 2-3 times higher than their applicable budgets, while PM_{10} emissions are comfortably below their applicable budgets for all years and TIP scenarios.

Two obvious questions arise from these findings: "Why are the CO emissions so much higher than their budgets when there isn't a problem for PM_{10}, especially since VMT (vehicle miles travel) forecasted in this TIP is not dramatically different from that in earlier TIPs or the MP/SIP?" and "Is there an error in the current analysis?"

[1] "State Implementation Plan Revision for Carbon Monoxide in the Medford Urban Growth Boundary, A Plan for Maintaining the National Ambient Air Quality Standards for Carbon Monoxide," Oregon Department of Environmental Conservation, Air Quality Division, March 9, 2001.
[2] "State Implementation Plan Revision for Particulate Matter (PM_{10}) in the Medford-Ashland Air Quality Maintenance Area," Oregon Department of Environmental Conservation, Air Quality Division, December 10, 2004.

Table 1 Comparison of 2018 TIP Emissions to Vehicle Emission Budgets				
	Calendar Year			
	2015	2020	2028	2038
CO Emissions Budget (lb/day)	**26,693**	**32,640**	**32,640**	**32,640**
TIP CO Emissions, Without Transit (lb/day)	83,820	65,999	62,673	62,654
TIP CO Emissions, With Transit (lb/day)	83,763	65,946	62,630	62,600
PM_{10} Emissions Budget (tons/year)	**3,754**	**3,754**	**3,754**	**3,754**
TIP PM_{10} Emissions, Without Transit (tons/year)	1,622	1,706	1,853	2,049
TIP PM_{10} Emissions, With Transit (tons/year)	1,621	1,618	1,643	1,709

Note: PM10 emission budgets and TIP emissions include both exhaust and fugitive dust.

Upon completing the emissions modeling, Sierra then began an exhaustive process of examining its current analysis for inadvertent errors (none were found) and reviewing similar vehicle emissions modeling conducted under earlier TIP Air Quality Conformity Determinations (AQCDs) as well as the CO MP and PM_{10} SIP from which the emission budgets were developed, to ascertain "how we got here."

The key findings from our detailed review of these historical analyses and results are summarized as follows:

1. CO emissions are much higher under this TIP primarily due to significant upward revisions of starting exhaust emission factors (i.e., grams per mile) in today's MOVES model compared to its MOBILE6 and MOBILE5b predecessors.

2. The effects of EPA releases of newer emission factor models over time (from the MOBILE5b Cold CO model used for the 2001 CO MP through MOBILE6 used for subsequent TIP/RTP conformity analyses until now) with successively higher CO starting emission factors has been masked by what we believe were errors in prior TIP/RTP CO emissions calculations that inadvertently omitted the starting exhaust component.

3. The budget exceedance issue does not affect PM_{10} because vehicle PM_{10} emissions in the planning area are dominated by fugitive road dust, rather than exhaust (and brake/tire wear) emissions. Though not shown in Table 1, fugitive dust emissions on paved on unpaved road represent over 90% of total on-road vehicle emissions, based on the latest AP-42 methods coupled with locally-estimated road silt loading factors. Thus upward revisions to exhaust (and brake/tire wear) emission factors between MOBILE and MOVES are masked or damped by their very small share of total on-road PM_{10}.

The findings that CO emissions are well above their Plan budgets because of upward revisions to the starting exhaust component of historically developed EPA vehicle emission models **do not** imply that ambient CO air quality levels are worsening. Since CO air quality levels forecast to 2015 in the 2001 Maintenance Plan were extrapolated from baseline ambient measurements and emissions inventory projections using now-outdated (and upwardly revised) vehicle emission factors, these Maintenance Plan forecasts simply need to be updated to reflect a higher baseline share of vehicle emissions that still decline over time (even with VMT growth) due to ever-tighter new vehicle emission standards.

The following section provides a detailed description of the methods and sources Sierra used to reach these findings.

Review and Analysis Methodology

Three areas of review were performed to determine the reason(s) behind the CO budget exceedances using MOVES and to ensure the MOVES modeling was properly executed:

1. Prior TIP Conformity Analysis Review,
2. Maintenance Plan Emission Budgets Review, and
3. MOVES Modeling Review.

Each of these review elements is discussed separately below.

Prior TIP Conformity Analysis Review – The review process began by examining (where available) detailed modeling inputs, outputs and emission calculations from earlier TIP/RTP AQCD documents, beginning with the most recent document—the 2012-2015 TIP AQCD.[3] Appendix C of that AQCD document contains detailed CO emissions calculations by roadway type (freeway, arterial, etc.) showing travel-model based vehicle activity (in VMT per day) as well as MOBILE6-based emission factors (in grams/mile) for each roadway type (based on average speed for each type) on pages C-2 (With Transit Service) and C-3 (Without Transit Service). Figure 1 is a copy of the "With Transit" calculations from Page C-2. (Without Transit calculations are very similar, using the same emission factors with nominally higher VMT.) As shown in Figure 1, MOBILE6.2-based emission factors by roadway type range from 6.35 g/mile (Local) to 9.29 g/mile (Ramps) for the calendar year 2015 fleet and decrease to a range from 4.61 g/mi (Arterial) to 6.37 g/mi (Ramps) for the 2038 fleet.

[3] "Rogue Valley Metropolitan Planning Organization Air Quality Conformity Determination for 2013-2038 Regional Transportation Plan, 2012-2015 Metropolitan Transportation Improvement Program as Amended," Rouge Valley Council of Governments, March 26, 2013.

Figure 1
2015 TIP AQCD CO Emission Calculations, With Transit
(Appendix C, Page C-2)

Emissions Estimated with Continuing Transit Service

2015	Mobile6.2 EF (g/VMT)	VMT Estimates: Model VMT	VMT Estimates: local adjust (+10%)	Emissions Estimates: Grams CO/day	Emissions Estimates: Lbs. CO/day
Freeway	7.864	419,486.0		3,298,708.655	7,272
Arterial	6.420	928,004.0	1,020,804.4	6,553,232.826	14,447
Local	6.352	39,687.0	43,655.7	277,291.101	611
Ramps	9.288	19,654.0		182,538.166	402
Total Estimated		1,406,831.0	1,503,600.1	10,311,770.747	22,734

2020	Mobile6.2 EF (g/VMT)	VMT Estimates: Model VMT	VMT Estimates: local adjust (+10%)	Emissions Estimates: Grams CO/day	Emissions Estimates: Lbs. CO/day
Freeway	6.727	442,587.0		2,977,157.684	6,564
Arterial	5.461	1,009,655.0	1,110,620.5	6,065,119.848	13,371
Local	5.613	47,612.0	52,373.2	293,984.344	648
Ramps	7.677	19,813.0		152,107.449	335
Total Estimated		1,519,667.0	1,625,393.7	9,488,369.324	20,918

2028	Mobile6.2 EF (g/VMT)	VMT Estimates: Model VMT	VMT Estimates: local adjust (+10%)	Emissions Estimates: Grams CO/day	Emissions Estimates: Lbs. CO/day
Freeway	5.369	503,130.0		2,701,492.231	5,956
Arterial	4.300	1,120,920.0	1,233,012.0	5,302,381.921	11,690
Local	4.553	46,304.0	50,934.4	231,896.504	511
Ramps	5.985	24,734.0		148,042.091	326
Total Estimated		1,695,088.0	1,811,810.4	8,383,812.748	18,483

2038	Mobile6.2 EF (g/VMT)	VMT Estimates: Model VMT	VMT Estimates: local adjust (+10%)	Emissions Estimates: Grams CO/day	Emissions Estimates: Lbs. CO/day
Freeway	5.717	550,051.0		3,144,679.505	6,933
Arterial	4.610	1,256,870.0	1,382,557.0	6,374,238.450	14,053
Local	4.920	54,933.0	60,426.3	297,305.749	655
Ramps	6.366	26,615.0		169,427.578	374
Total Estimated		1,888,469.0	2,019,649.3	9,985,651.282	22,015

Appendix C also contains a single set of MOBILE6.2 input and output files, for the calendar year 2038 fleet, spanning pages C-4 through C-10. The MOBILE6.2 inputs shown on pages C-4 to C-9 (age distributions, VMT mix, fuel and I/M properties, and ambient conditions) were examined and roughly compared to similar inputs developed for the current MOVES modeling and were found to be in general agreement. The MOBILE6.2 output shown on page C-10 was also examined. It is a MOBILE6.2 "composite" output, showing the composite average CO emission factor calculated by the model across all roadway types, but, more importantly, showing the breakdown of total exhaust CO emission by its two component processes:

1. Start exhaust – representing incremental emissions (in g/mile) resulting from catalyst and engine warm-up when a vehicle is started; and

2. Running exhaust – representing fully warmed-up or stabilized vehicle emissions (in g/mile).

Figure 2 contains an excerpt of this calendar year 2038 MOBILE6.2 composite output, showing CO emission factors by vehicle type and process (start and running exhaust). Although the output table "wraps" the columns for the Motorcycle (MC) and composite (All Veh) fleet emission factors on a new line, it can be seen that running exhaust factors for the light-duty gasoline vehicle types[4] range from 5.27 to 6.28 g/mile, which are in good agreement with the range of 2038 exhaust emission factors by roadway type in Figure 1.

Figure 2
2015 TIP AQCD Calendar Year 2038 MOBILE6.2 Composite Output Excerpt
(Appendix C, Page C-10)

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      Vehicle Type:      LDGV    LDGT12   LDGT34     LDGT      HDGV      LDDV      LDDT      HDDV
MC   All Veh
              GVWR:              <6000    >6000     (All)
                        ------   ------   ------    ------    ------    ------    ------    ------    -----
-    ------
   VMT Distribution:    0.2840   0.4105   0.1573              0.0457    0.0003    0.0023    0.0952
0.0047    1.0000
   ------------------------------------------------------------------------------------------------------
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 Composite Emission Factors (g/mi):
     Composite CO  :     13.66    13.37    14.02     13.55      7.19     0.695     0.400     0.215
14.60    11.994
   ------------------------------------------------------------------------------------------------------
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Exhaust emissions (g/mi):

          CO Start:      8.39     8.00     7.74      7.93               0.292     0.152
5.200
        CO Running:      5.27     5.38     6.28      5.63               0.403     0.248
9.399
   CO Total Exhaust:    13.66    13.37    14.02     13.55      7.19     0.695     0.400     0.215
14.60    11.994
   ------------------------------------------------------------------------------------------------------
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The problem is that the total exhaust emission factors shown in Figure 2 are much higher, ranging from about 13-14 g/mile for light-duty gasoline vehicles and 11.99 g/mile for the "All Veh" fleet composite. As shown in Figure 2, this is because the starting exhaust component is roughly 7-8 g/mile for those vehicle types for which it is reported.

Based on a comparison of the process-specific 2038 emission factors shown in Figure 2 with those for 2038 in the emission calculation tables shown earlier in Figure 1, Sierra believes that the incremental starting exhaust component was inadvertently left out of the emission calculations by roadway type shown in Figure 1 and reflected on pages C-2 and C-3 of the AQCD. When run in "facility-specific" emission factor mode, as was done in the AQCD to generate emission factors by facility/roadway type, MOBILE6 also includes a "NONE" roadway category that, according to its Users Guide (pg. 77):

[4] MOBILE6.2 reports process-specific factors only for light-duty gasoline vehicles and motorcycles since starting exhaust data did not exist or were believed to be small. In this output, light-duty gasoline vehicles represent over 80% of the fleet and thus roughly represent fleet-average starting emission factors.

> *"…represents emissions that occur independent of roadway type. These include **<u>engine start emissions</u>** and all evaporative emissions except running losses."* (emphasis added)

If performed properly, starting exhaust emission factors using the NONE category would have been incorporated as an additional row in the AQCD page C-2 and C-3 calculation tables and multiplied by total VMT (since the starting emissions factors output by MOBILE6 are averages over all miles traveled). If this had been done, TIP emissions would have been calculated to be more than twice as high at those shown apparently based only on warmed-up running exhaust emission factors and would have been found to exceed the MP-based budgets for most, if not all, calendar years.

Similar AQCD documentation provided by RVCOG for several earlier TIP and MTP analyses—dating back to that developed and approved in 2009 for the 2009-2034 RTP and Amended 2008-2011 MTIP—was also reviewed. It was found that the same CO emission calculation approach and inadvertent exclusion of the starting exhaust component was conducted in each of the earlier TIP/RTP AQCDs.

Sierra also acquired some of the MOBILE6 input files using in the most recent AQCD from RVCOG and was able to reproduce the output emission factors listed in Appendix C by independently executing the MOBILE6.2 model.

At this point, Sierra's review was independently confirmed by Wayne Elson, our subcontractor who was earlier employed by EPA Region 10 and performed transportation conformity review for MPOs within Region 10's jurisdiction. Upon reviewing these detailed appendix materials, Mr. Elson reached the same conclusion.

<u>Maintenance Plan Emission Budgets Review</u> – The next element of our review focused on trying to understand the vehicle CO emission calculations performed by the Oregon Department of Environmental Quality (ODEQ) in the 2001 CO Maintenance Plan that established the 1993 baseline and 2015 forecasted emission inventories, and specifically the vehicle emission budgets developed from them.

At the time the CO Plan was developed (circa 2001), MOBILE6 had not yet been released and EPA was in the process of extensively revising the current model—MOBILE5b—to, among other things, better account for starting emissions. A modified version of MOBILE5b originally developed by Air Improvement Resource (AIR) and further revised by Sierra Research to specifically model CO emissions under cold ambient temperatures and account for effects of then-new 20°F exhaust emission standards was approved by EPA as a transitional tool for modeling winter CO emissions until MOBILE6 was released (in early 2002). This transitional "MOBILE5b Cold CO" or Cold CO model was used to generate the CO emission factors upon which the vehicle emission inventories and budgets in the 2001 CO Plan were developed.

Sierra reviewed both the CO Plan document itself (as posted on ODEQ's web site), as well several hundred scanned pages of material encompassing Tables D-1 and D-2 in Appendix D that were not part of the main document but provided by RVCOG. Since electronic versions of the input and output files listed in these scanned pages were not readily available, our review of the CO Plan calculations using the Cold CO model could not be performed as rigorously as those performed for the TIP/RTP AQCD review.

It is unclear from this review whether the CO Plan calculations also inadvertently excluded the starting exhaust component because the starting component is not explicitly output by the Cold CO model as it is in the later MOBILE6 and MOVES models. The Cold CO modeling methodology uses “parallel” executions of the model to calculate what was then referred to as “off-cycle” emissions that accounts for effects of vehicles meeting or not meeting the 20°F exhaust standards. This off-cycle increment is then added to “standard” MOBILE5b-based emission factors reflecting local conditions but not explicitly separating starting from running exhaust as in MOBILE6 and MOVES.

At this point, we deemed further investigation to be of low value and simply concluded that the Cold CO emission factors upon which the vehicle emissions budgets were based appear to be significantly lower (on a fleet average gram per mile basis) that those contained in either MOBILE6 or MOVES for the same calendar year fleet.

<u>MOVES Modeling Review</u> – Finally, a detailed review of each of the MOVES modeling inputs as well as analysis of highly disaggregated outputs (by model year, vehicle type, and emission process) was performed to determine if inadvertent errors were made by Sierra in setting up the MOVES inputs and performing the model executions. In short, no errors were identified.

Sierra further reviewed what appear to be significantly higher per vehicle-mile CO emission factors in MOVES compared to its predecessor models by examining published MOVES-based vehicle emission inventories recently developed by county for the neighboring state of Washington.[5] Calendar year 2011 county-by-county MOVES-based vehicle CO emissions published in this study were divided by county VMT levels that were also provided. Fleet CO emission factors in 2011 range from roughly 12 g/mile to 40 g/mile across several Washington counties for which emission factors were back-calculated as described. Given the effects of fleet age and composition variations by county as well as other factors (control programs, ambient conditions, etc.), these estimates are in the same range as that estimated for the 2015 Medford fleet (roughly 26 g/mile) in the 2018 TIP MOVES modeling.

We therefore conclude (as was independently verified from the Washington MOVES-based inventories) that our MOVES estimates are correct and reflect what appear to be higher CO emission factors in MOVES vs. MOBILE6 under cold wintertime ambient conditions.

<u>Conclusions and Recommendations</u>

Given the currently mandated use of EPA’s latest MOVES emission factor model, the Cold CO-based emission factors and budgets appear to be outdated and will render

[5] S. Otterson, et. al., “Washington State 2011 County Emissions Inventory,” Washington State Department of Ecology, April 25, 2014.

budget-based conformity determinations highly problematic. As stated earlier, air quality in Medford is not being projected to worsen. Rather, the budget exceedances simply result from what have been upwardly revised CO emission factors in EPA's evolution of emission factors over the last decade and a half.

Thus, it is recommended that ODEQ be engaged to pursue revising the existing CO Maintenance Plan, redeveloping the budget based on the current MOVES model, or better, developing a Limited Maintenance Plan (LMP) for CO since the ten-year planning horizon of the existing maintenance plan has been reached and ambient CO levels are still well below the National Ambient Air Quality Standards.