THE BRAKE PAD PARTNERSHIP

Compilation of Technical Reviewers' and Stakeholders Comments' on Air Deposition Modeling Draft Report

October 11, 2005 ***(updated October 13, 1005)***

Background

Copper in the San Francisco Bay has been a pollutant of concern since the State of California listed the Bay as a high-priority impaired water body in 1996. In 1998, the State of California listed copper and several other metals as pollutants of concern for the San Francisco Bay. These listings triggered a regulatory requirement that Total Maximum Daily Loads (TMDLs) be developed for copper and the other pollutants of concern. Since then, site specific objectives for copper have been established for the bay south of the Dumbarton Bridge, and a copper TMDL process is currently underway for the bay north of Dumbarton Bridge.

The Brake Pad Partnership's efforts are aimed at evaluating the potential impact of copper from brake pads on water quality in the South San Francisco Bay. On behalf of the Brake Pad Partnership, AER will conduct atmospheric transport and deposition modeling of copper originating from vehicle brake pad wear debris to better understand how copper in brake pad wear debris (BPWD) travels through the environment and the potential impacts on water quality in the San Francisco Bay for which copper is a pollutant of concern.

Three environmental modeling studies are at the core of the Partnership's effort, including an air deposition model, watershed model and Bay model.

The air deposition modeling study will provide the following: 1) Estimates of the amount of air deposition of copper from BPWD directly onto the Bay, 2) Estimates of the deposition of copper from BPWD onto other parts of the watershed. The results of this modeling effort will provide inputs to the watershed model. The watershed model will estimate the amount of copper from brake wear debris that is discharged from the watershed in runoff, providing inputs to the bay model, which will estimate short- and long-term concentrations of copper in the South San Francisco Bay.

The air deposition model has two time scales. For the regional background, the model uses a 5-year average set of meteorology and the temporal resolution is going to be a month. For the local (Castro Valley) scale model, the model is based on one-year daily meteorology that will be used to drive the model, with the goal to compare against air deposition monitoring data. The watershed and Bay model uses daily mean output values for multiple years, which may include roughly 1989-2003.

The Brake Pad Partnership Steering Committee is seeking an independent expert review of the Draft Report for air deposition modeling for the environmental fate and transport of copper from vehicle brake pad wear debris to ensure that the approach and results of this element of the Partnership's work are technically sound, to determine if there are feasible opportunities to strengthen this work, and to help build in-depth understanding of and confidence in the technical studies on the part of the Steering Committee and the stakeholder communities.

Charge

With the aim of meeting these objectives, the Steering Committee has developed the following questions on which it is seeking specific comments from the reviewers:

1. What is your assessment of the analysis performed and its reliability for estimating the amount of air deposition of BPWD directly onto the Bay and other parts of the watershed?

2. Does the report clearly describe the uncertainties and sensitivities in the analysis?

3. Based on your experience with similar fate and transport of modeling pollutants do you have any suggestions for how results could be improved using available data?

4. Are the data generated by the air deposition model appropriate inputs for the watershed model?

5. Additional comment and question from Betty Pun (AER):

   One of the most intriguing aspects of the results was that wet deposition fluxes have a much stronger regional component than dry deposition fluxes. Predicted dry deposition fluxes were very sensitive to emissions from near-by roadways. We tend to overpredict dry deposition at Redwood, which is located right next to I580, and underpredict at the other sites, which are located close to surface roads. These results raise the possibility that perhaps we need to rethink how brake pad emissions are spatially allocated. I believe Kirsten's (Rosselot) estimates were based on an emissions factor multiplied by VMT. It is conceivable that on a per VMT basis, highway traffic emit less brake wear than local traffic (more stops associated with local driving because of traffic lights and stop signs).

   <u>Question:</u> I would appreciate receiving some guidance from the BPP and reviewers to see if such a possibility is worth trying to model (if so, how) in our "best estimate" run where deposition results will be provided to the watershed and bay modelers.

Comments Received

Comments of Lynn Hildemann, Environmental Engineering and Science; Stanford University (September 28, 2005)

This report describes the approach used to model wet and dry deposition of copper in the Castro Valley area, and presents the modeling results obtained. Due to uncertainties in a number of areas, considerable effort was made to perform sensitivity analyses, and to methodically consider what might be causing the over- and under-predictions. Given the difficulties in obtaining accurate inputs, the value of exploring further modeling scenarios seems limited to me. Instead, the most valuable result of this work, in my view, is highlighting which input uncertainties lead to the greatest uncertainties in the predictions.

<u>Responses to Charge Questions:</u>

1) ***Assessment of analysis performed and its reliability****:* While it is clear to me that better input data would be valuable, it seems that such data are not readily available. The report gives the impression of a careful effort to do a thorough job with the data that was readily available. I would encourage the authors to summarize at the end of their writeup which sources of uncertainty <u>they</u> view as most important to pin down.

2) ***Clarity of uncertainties and sensitivities:*** Overall, the authors have done a solid job of examining the uncertainties and sensitivities in a structured, logical fashion. However, I would like to see:

   (a) More discussion of what the 31-33% uncertainty range for the BPWD emissions (e.g., p.10) does and does not include. The authors themselves appear to suspect that BPWD emissions may vary greatly with traffic density, congestion, and the type of roadway. Factors such as these could (at least, in this reviewer's opinion) cause variations of as much as an order in magnitude in the emission rates. Thus, it appears that the 31-33% uncertainty value cited in the report considers a much more limited set of uncertainties.

   (b) More discussion of the particle size distribution assumed. Specifically, is the distribution given in Table 3 based on particle counts or particle mass? Assuming that the Cu size distribution is the same as the PM size distribution is potentially quite problematic – it would be helpful to compare this distribution with the Cu mass distribution measured inside a Milwaukee tunnel that was published by Lough et al (ES&T 39:826, 2005). And why did the sensitivity analysis consider a slightly smaller size distribution based on Table 3, instead of testing one of the other published size distributions as an alternative?

3) *Possible ways to improve results with existing data:* I wonder whether some government agency might have more spatially and/or temporally resolved roadway emission (or congestion) data that could help refine the local model inputs. The Metropolitan Transportation Commission regularly publicizes assessments of which freeways are the most congested – might they perhaps have vehicle trip data and/or congestion on city streets as well? Even something like comparing the average travel speed reported for a given roadway with the speed limit might allow an estimate of whether to assume a number of brakings/mile at the low end or the high end.

www.arb.ca.gov/msei/on-road/downloads/docs/**brake_wear**_pm_memo.doc offers a discussion of how brake wear may vary with vehicle type – this could offer an improvement over the standard AP-42 methodology if there was information available on the fleet composition for different roadways. [This same website suggests that there are, on average, 5.1 brake applications per mile.]

Betty Pun asks whether additional effort should be expended to try and determine how BPWD emission rates vary for local vs. highway roadways. This might be worthwhile, but I would only support a limited effort – in my opinion, there are just too many other sources of uncertainty to devote lots of time and effort to this one variable. But perhaps there is data on brake wear rates for primarily highway vs. primarily city driving? Not the most scientific resource, but a "Car Talk" forum claims that congested city driving may use up a set of brakes in as little as 10,000 miles, whereas noncongested highway driving may get up to 80,000 miles on a set of brakes. And a 2002 report generated by the New Zealand government www.transport.govt.nz/downloads/stormwater-emission-factors.pdf assumes (albeit, without a lot of obvious documentation for where their numbers came from) that "moderate" braking environments generate 1.5X as much brake dust as "average" conditions, whereas "low" braking environments generate 0.5X as much brake dust as "average" – perhaps this might serve "in a pinch" as input for the additional run suggested by Betty?

4) ***Appropriateness of model outputs as inputs for the watershed model:*** With only limited comparisons to monitoring sites, it is difficult to assess how reliable the model outputs are. The fact that there are both over- and under-predictions, and quite sizeable confidence bounds, does not inspire a great deal of confidence – it makes me worry about how much (or little) can really be determined at this stage from a watershed analysis. But I suppose it depends on whether you are trying to get an order-of-magnitude estimate, or something more quantitative.

Comments of Kirsten Rosselot, BPP Copper Loading Estimates Consultant, Process Profiles (September 13, 2005)

Response to Betty Pun's comment and question:

I remember the vmt/freeway/surface street issue coming up last year when the work plan was being written. There were a couple of reasons why vmt was expected to work well for the freeway and for surface streets, if I remember right -- one being that a lot of the vmt on the freeways in the watershed does not take place in free-flowing traffic. Also, stops from high speeds generate much more wear debris than stops at low speeds, so even though brakes are applied less often in free-flowing traffic on the freeway, much more debris is released when they are applied (Anderson 1998 says for semi- mets, four brake stops from 100 mph produced as much lining wear as +500 brake stops at 30, 40, 60, and 80 mph). But there was also something about calipers and disc brake wear at freeway speeds. I'll try to find it, maybe one of the brake guys has already responded.

I only found one place that correlated driving speed and brake wear, and that was in the UN document by Ntziachristos. He has a speed-based correction factor. Brake wear is supposedly flat from 0-25 mph, and then drops to about a tenth of the 0-25 mph rate at 60 mph. His correction factor is unsubstantiated -- he doesn't cite his source. But if his correction factor is accurate, then freeway driving would make brakes last ten times longer. And it doesn't. In fact, people who don't drive on the freeway at all tend to get the most miles out of their pads.

I couldn't find anything in the attached report that gave much detail on the locations of the monitoring sites. I did see that the Redwood site is "less than 50 meters" from I580. What's been seen by other researchers is that copper concentrations fall to background levels within a few tens of meters (or even ten meters) from the roadway. Jim Carleton's report has that stuff (bulk and dry deposition sampling taken along transects has documented Cu deposition flux which decreases to near background levels within a few tens of meters of the road (Harrison and Johnston, 1985; Hewitt and Rashed, 1991), where soil sampling has taken place along transects, Cu contamination has been shown to be mostly concentrated within a zone of about 20 m width adjacent to road (Heath et al, 1999; Sutherland and Tolosa, 2001)). If the Redwood monitoring site is 45 meters from I580, one wouldn't expect contributions from I580 to be significant.

Comments of Kevin Reinert, AMEC Earth & Environmental (October 5, 2005)

I thought the effort was for San Francisco Bay – this report only addresses the deposition in the South SF Bay. In order to understand the bay dynamics for copper, the entire bay and input and output needs to be understood.

p. 4, last para, line 3 – industrial **atmospheric** releases

p. 4, last para – is calibration correct? Should the model undergo verification or a series of validation trials?

p. 6, para 1, line 2 – should cite as in review or in press and not as personal communication if possible (and p. 17); line 7 – should introduce the Castro Valley watershed and why it is used here

p. 6, para 1 – seems that one is double counting if both regional and local inputs are counted? This is not apparently done for the Castro Valley watershed info

p. 10, 2nd last para – I agree with the dismissal of the in-cloud scavenging, but the < 2.5 um fraction can remain in the air for days (Table 3, p. 17 shows about 24% of the BPWD $\leq$ 1.8 um – these particles could remain in the air for some time)

p. 11, para 2, lines 3-4 – reference for road associated with coarse BPWD? Could some of the finer particles also be found on the road and roadsides?

p. 11, para 2, 5th last line – Rosselot is misspelled – numerous places in the report section 4.3 – good additional discussion

p. 32, last para, 2nd last line – affects → effects

Comments of Don Yee, BPP Air Deposition Monitoring consultant, San Francisco Estuary Institute (October 6, 2005)

Editorial note: Not clear why in Figure 11 CVCC doesn't have an average for UC rainfall predicted wet deposition- other predictions were present.

<u>Responses to Charge Questions:</u>

1) **What is your assessment of the analysis performed and its reliability for estimating the amount of air deposition of BPWD directly onto the Bay and other parts of the watershed?**

The wet deposition model predictions for CVCC and CVE look reasonable, and within the uncertainty of the model and the temporal variability of the field measurements, are a close enough match to the measured wet deposition (both from Castro Valley data specifically, and other suburban data for SF Bay area).

Although there are no wet deposition data for the other two sites (Madison and Redwood), it would be good to show the predicted wet deposition for those two sites. This could be compared to the collected bulk deposition data for those sites (particularly for periods of very high rainfall where the dry deposition contribution would be smaller) at least as an upper limit of possible wet deposition. If the wet deposition predictions exceeded the bulk deposition measurements for those sites/events, that would suggest an issue with model assumptions. I don't expect that there would be significant differences however, since it appears the wet deposition is dominated by the regional scale air Cu concentration.

2) **Does the report clearly describe the uncertainties and sensitivities in the analysis?**

Yes, the report clearly describes the sources of uncertainty and the sensitivity of the model to changes in various parameters. The observed dry deposition rates are *nearly* within the uncertainty of many of the model parameter assumptions for CVCC and CVE, but the base case predictions for Madison and Redwood seem to suggest a much stronger gradient in deposition than evident in the field data. As the authors noted, in general, adjusting the model parameters does not appear to address the major uncertainty as they tended to increase or decrease deposition at all sites.

The one aspect of the sensitivity analysis that I could not fully understand was the addressing of re-emissions. Intuitively, it would seem local re-emission would result in increase of deposition at all sites, but most so (relative to base case deposition) at sites furthest from the source. If you model a continuous emission from a single source, initially points distant would have little deposition, but dispersion through re-emission would increase concentrations and deposition at distant points up to a steady state. Even if only a small portion is re-emitted, with each time step, areas more distant from the source will accumulate material, and re-emission from those areas contribute a small portion to the distant receptor, in addition to any ongoing emissions directly from the source. Therefore, it is not clear how the local re-emissions scenario (4.2.7) could result in no change at the Madison site. The authors could perhaps be more explicit in describing how deposited material is either removed (irreversible deposition or aerial advection out of the modeled area) or re-emitted in the model under the scenario with local re-emission.

3) Based on your experience with similar fate and transport of modeling pollutants do you have any suggestions for how results could be improved using available data?

The redistribution of area sources in one of the hypothetical investigations, to include the Columbia development (where Madison is) as an area to distribute the surface street area source makes sense. Having it uniformly distributed probably overestimates the area source for some areas however. If one models a set number of car trips per day to each residence within Castro Valley, from the nearest main artery out of the area (CV Blvd, Redwood Rd, 580, Grove St) there would be a higher density of vehicle trips for sections of road near those arteries. That may be beyond the scope of this project, but at the least perhaps the area can be divided into two (or more) zones, those who live by the arteries (Zone 1), and those who have to travel through Zone 1 to reach their residences (Zone 2). As a first cut, area emissions in Zone 1 would be double those in Zone 2, as Zone 2 residents pass through Zone 1 to get home.

The authors also consider a case for reduced emissions on the highway segments (~50%). A first cut assumption would be to assume that for periods where highway speeds were less than or equal surface street speeds (~30 mph), braking frequency, intensity, and emissions would be comparable to surface streets. At full highway speeds (55+) emissions could be scaled to an assumed background level. Intermediate speeds could be assigned an intermediate emission factor. Perhaps if there is Caltrans data on vehicle counts and speeds over the course of a day on 580/238 (e.g. for speeds there appear to be current data from Fastrak for display on 511.org, perhaps if they are archived and compiled one can get a yearly/seasonal average for different hours of the weekends and or weekdays), more accurate emission estimates for the 580 corridor can be generated. It seems like even if overall emission factors are uncertain by a factor of 1.4, how they are distributed between local and regional source has an even bigger impact. There is the Garg et al data which measured brake material emissions in terms of mass per stop rather than per vehicle mile: *Garg et al 2000. Brake Wear Particulate Matter Emissions, Environmental Science & Technology Vol. 34, No. 21, 2000 p4463*. Their range of airborne brake material is around 0.1mg/stop to somewhere around 1mg/stop. They estimate about 6-9mg/mi airborne material for small and large cars (30% of total wear) which would be about 10-12 stops/mile on average. Stopping frequency can be much higher in heavy traffic whether on highway or surface streets, and nearly zero in low traffic periods, so an allocation made on number of stops would result in a very different distribution of emissions among highway and surface road, and over the course of a day for the highway.

4) Are the data generated by the air deposition model appropriate inputs for the watershed model?

The figures and graphs could be more explicit in showing that the flux rates are expressed per day, although the report text inconsistently indicates it (e.g. as 8.8 ug/m2/day for the field data cited in section 4.3.1, but as just ug/m2 in the rest of the report, e.g. in section 4.1 "The average observed wet deposition flux at CVCC was 2.15 ug/m2 for seven two-week samples". The latter example makes it seem like on average 2.15 ug/m2 fell over the course of a two week collection, rather than a daily rate.

My presumption is that the model output is daily wet and dry deposition on each grid of the modeled area, since that is the type of data the model is compared to. What is not clear is how re-emissions/buildup is handled. What happens to the material on impervious surfaces after rain events? Is it presumed partially/totally removed? After extended periods without washoff, how much of the deposited material from a given day stays on the road and other impervious surfaces? Can the watershed model handle different net deposition on impervious versus pervious surfaces (the description of model re-emission from only impervious surface suggests pervious areas continuously only accumulate, i.e. even if the hourly deposition is the same, the yearly net deposition would be greater on pervious area)?

The watershed modelers presumably are weighing in on how they want the air deposition as input (e.g. do they want wet deposition as concentration or area flux, is there a need to distinguish net deposition on pervious or impervious surface).

Comments of ***Keith Stolzenbach, Department of Civil and Environmental Engineering, UCLA (October 9, 2005)***

1. If I understand the modeling assumptions correctly, vehicular emissions were apportioned into a fraction light enough to enter the atmosphere and a fraction too heavy to be transported in the air. The former were used as inputs to the model. Furthermore, all material depositing on roadways was assumed to be completely resuspended. Resuspension from unpaved roads and agricultural areas were neglected. I have two comments on these assumptions. First, in the LA area, Cu emissions related to resuspended dust from unpaved roads, unpaved areas, agricultural areas, and construction areas were estimated by the ARB and AQMD to be 46 kg/day out of a total of 142 kg/day regionally, so I am not sure resuspension from these surfaces can be neglected. Second, our research in the LA area indicates that dust is efficiently resuspended from impervious surfaces that may constitute a much larger percentage of the land surface than do the paved roads. For this reason, I suspect that the resuspended Cu used in the modeling may be underestimated, leading to the low predictions of dry deposition at most sites.
2. Page 11 – although I do not think temporal variations are so important to this study, I was surprised to read that there was no information about seasonal, etc. variations. The ARB/AQMD emissions database for the LA area contains very specific assumptions about temporal variability.
3. The results of the model predictions with observed values are qualitatively consistent with our LA findings. We were able to obtain agreement within +/- about 50%, but only for annual and regional averages of seasonal predictions and samples. Errors in predictions for individual samples, taken seasonally, were much larger. Overall, I would judge the model-data comparison presented in this report to be good.

Comments of Kelly Moran, representing Bay Area Storm water Management Agencies, TDC Environmental (October 10, 2005)

It is a pleasure to have the opportunity to review the draft of first of the Brake Pad Partnership's (BPP) three major modeling reports. This report appears to be thorough and well-written, giving me confidence in the quality of the work done by the modeling team. In addition to providing inputs to the watershed and Bay models, this modeling work includes valuable efforts to explore our conceptual model for brake pad transport and to understand how uncertainties in the available information affect the overall meaning of the results. I'm pleased to see how well this report integrates data that the BPP has spent years developing through its cooperative process. Overall, I believe that this modeling effort will serve the BPP well.

Below I have outlined questions and issues that I identified in my review of the report. I have also included input from Arleen Feng of the Alameda Countywide Clean Water Program (ACCWP). If you or AER have questions about these comments, please feel free to contact me.

A. Resuspension

Just before reviewing this report, I found a recent journal article that suggests that resuspension of previously deposited pollutants has the potential to affect significantly current air deposition rates of those pollutants (Harris, A. R. and C. I. Davidson (2005). "The Role of Resuspended Soil in Lead Flows in the California South Coast Air Basin." *Environ. Sci. Technol.* **39**(19): 7410-7415.) While this article is about lead rather than copper, its findings and its methodology could potentially be helpful to understanding the environmental transport of copper from brake pad wear debris. What I found particularly interesting in this paper was that re-emission of lead from soil surfaces (which were lead-enriched from past emissions of lead, primarily from gasoline) were found to be the major source of lead deposited today in Southern California. The authors indicate that this finding is probably a consequence of the small current lead emissions and significant past enrichment of urban surface soils from historic lead emissions. Since copper has different chemistry, lesser soil surface enrichment values, and is currently emitted in urban areas, these findings may not be relevant to the BPP's work. However, if they are relevant, they could contribute to our understanding of the difference between the modeled and measured deposition values, particularly at locations away from I-580.

Harris & Davidson use input data from a 2002 article by Tom Young (who has previously assisted the BPP) and colleagues that includes data on copper and its enrichment in southern California soil (Young, T. M., D. A. Heeraman, et al. (2002). "Resuspension of soil as a source of airborne lead near industrial facilities and highways." *Environ Sci Technol* **36**(11): 2484-90.) I would appreciate it if AER and our scientific advisors (particularly Tom Young and Keith Stolzenbach, who apparently assisted Harris & Davidson with interpretation of their findings) could be consulted regarding the potential relevance of this topic generally—and the specific methods in this paper—for the BPP.

If these findings are indeed relevant to our work, these papers may also be helpful for us as we consider the conceptual model for the behavior of copper in Bay Area watersheds. In particular, I think it important to consider how long-term soil enrichment from copper deposition affects the time scale of our environmental models and the ultimate time scale of response in San Francisco Bay. Current plans call for consideration of response times in the Bay model, but not in the watershed model.

Two additional questions:

(1) Is re-suspension of all BPWD included in the analysis, or is resuspension only a consideration for the fraction of BPWD smaller than 2.5 µm? (It appears that equation (4) is only for PM 2.5.)

(2) Is resuspension of material deposited directly onto the roadway assumed negligible? It seems to me unlikely that none of this material is resuspended; however, it also seems unlikely that 100% of the material that deposits on the road after first being emitted to the air is resuspended (so maybe these assumptions offset?). If there is an obvious reason that the material deposited directly to the road is assumed not to resuspend (i.e., particle size), I would appreciate if this could be explained for those of us not familiar with the behavior of particles in air.

B. Road Area

What effect would change in the road surface area have on the overall results of the modeling exercise? Based on the review of land use/land cover data sources (see notes previously shared with the BPP Steering Committee), I am concerned that road area may have been underestimated. Available information suggests that the underestimate (if it exists) is probably less than a factor of two:

- For the Castro Valley watershed, this report estimated road area at about 8% of the study watershed plus highway area. For the Bay Area, this report estimated road area at about 3.3% of the watershed.
- A recent ACCWP estimate of road area—including both local streets and highways—was about 12% of the Castro Valley watershed (Source: AquaTerra, *Hydrologic Modeling of the Castro Valley Creek and Alameda Creek Watersheds with the U.S. EPA Hydrologic Simulation Program – FORTRAN (HSPF)*, review draft, June 2005). Another local analysis estimated road areas that were about 1.5 to two times higher than estimates for similar geographic sub areas that were used in developing the regional road area estimate (ACCWP, Watershed Management Integration Report, 2004).

Methods to address this uncertainty have previously been recommended. This topic needs to be resolved by the BPP prior to completion of the final air deposition modeling runs.

C. Reality Checks

In addition to the reality checks included in the report, I would like to see if it would be possible to explore two additional checks:

(1) Compare regional deposition estimates onto the Bay surface to the measurements and load estimates of copper deposition on the Bay completed by SFEI a few years ago (Tsai, P.; Hansen, E.; Lee, K.; Yee, D., Tucker, D.; Hoenicke, R. (San Francisco Estuary

Institute) "Atmospheric Deposition of Trace Metals in the San Francisco Bay Area," WEFTEC 2001 Conference Proceedings, October 2001. www.sfei.org/rmp/reports/air_dep/tracemetals/TM_WEFTEC.pdf)

(2) Explore a mass balance of copper emitted, deposited, and lost to the air basin (perhaps along the lines of Harris & Davidson 2005, if data gaps do not preclude the use of such approaches.)

D. Regional Model Design

Would recognition of the regional population/road density pattern in the regional model modify the results for Castro Valley? The model uses the simplifying assumption that copper emissions are distributed uniformly over the entire Bay Area. However, development is focused in a concentrated ring centered on the Bay (outer areas would likely have much lower emissions than this central core). Conceptually one could say that the Castro Valley Creek subwatershed is located near the eastern edge of the more developed ring area. Further, prevailing winds flow through the pass in the hills on I-580 just east of Castro Valley. Would including these types of considerations in the regional model be useful in addressing the differences between modeled and measured deposition rates?

E. Industrial Particles

It is probably possible to obtain total PM emissions from the Bay Area industrial facilities that had copper emissions (these data are likely in the TRI). Since industrial contributions to the total copper load are relatively small, however, it may not be worthwhile to revise the modeling with this additional source-specific information.

F. Other Items

There were a couple of small errors that should be corrected. In the first paragraph of the introduction “seven metals” should be replaced with “several metals” as seven is not the number of metals that were listed (I think a regulatory list that pre-dated the 303(d) list did include seven metals for the lower South San Francisco Bay; however, that list is no longer relevant). I noted misspellings of several of the cited information sources, including Arleen Feng and Jim Trainor. As a courtesy to our sources, I would appreciate it if the spellings of their names could be checked and verified throughout the report.

Finally, I urge that we quickly work to connect the watershed and Bay modelers with AER to ensure that AER knows exactly how to complete and format its outputs in a form that will be usable for the subsequent models.

Comments from Ken Schiff, Southern California Coastal Water Research Project, (October 10, 2005)

Responses to Charge Questions:

1) What is your assessment of the analysis performed and its reliability for estimating the amount of air deposition of BPWD directly onto the Bay and other parts of the watershed?

My overall assessment of the analysis performed mirrors the summary of results; wet deposition was modeled reasonably well and dry deposition had some issues. In the end, the flux of Cu from wet deposition was an order of magnitude smaller than dry deposition, and I am assuming that there are many more dry than wet days in this watershed, so the focus of my comments are on dry deposition.

The Cu flux estimates for dry deposition were within the range of estimates we have measured (and modeled) in the coastal Los Angeles airshed. Based on my own experience then, Betty is probably in the ballpark at larger spatial and temporal scales. If one examined the average observed flux rates relative to the average simulations, I bet the error bars from the measured dry deposition plates would overlap the modeled (she needs to produce this figure or table). In general, a short summary of the validation data would be helpful in her report and provide her greater context for interpreting the validation data.

Betty spends a tremendous amount of time examining the predictive ability of specific cases or specific sites. At this point in time, I feel that making predictions at small spatial or temporal scales is extremely difficult and may in fact not be possible with our current understanding (and available data) of emission inventories and deposition mechanisms. I don't feel that any deposition model, let alone this model, can possibly be predictive on the order of a single day.

Betty provides no estimate for Cu flux directly onto the Bay.

2) Does the report clearly describe the uncertainties and sensitivity in the analysis?

The report is moderately clear about the uncertainties and sensitivity in the analysis. Betty has done a thorough job of describing the under and overpredictions for dry deposition at specific sites. She certainly provides some effort trying to understand the mechanisms that could lead to these biases. Through this analysis, she provides some direction to examine the need for more data collection relative to more precise modeling estimates (i.e. Cu composition in BPDW).

3) Based on your experience with similar fate and transport of modeling pollutants do you have any suggestions for how the results could be improved using available data?

My largest concerns with the model are twofold. First is the lack of confidence in the emissions inventory. I assume that detailed measurements of BPDW exist. However, I assume that much less information is available for other components of the emissions inventory, including how to quantify emissions from vehicles (i.e. surface streets vs. highways). The second concern has to deal with resuspension. We have found this to be a major factor in modeling trace metal deposition. It appears that resuspension in her model is largely confined to roadways, but dusts can be generated by wind resuspension especially from other impervious surfaces. This may account for some of the underprediction at sites removed from the local sources. Betty may be limited in implementing these suggestions, however, due to lack of data.

4) Are the data generated by the air deposition model appropriate inputs for the watershed model?

My inclination at this point in time is that at larger temporal scales, the inputs from dry deposition may suffice. Annual time scales, for example may be adequate. If shorter time scales are necessary, we may be pushing the limit of the model capabilities. I cannot evaluate the spatial scale, since Betty has not presented information at the watershed scale (i.e. all watershed sites combined) to provide an estimate of the bias in localized vs. distant deposition.

Based on the validation presented, it appears that wet deposition would be appropriate at shorter time and spatial scales.

Comments from Brian Lamb, Civil and Environmental Engineering, Washington State University (October 13, 2005)

Responses to Charge Questions:

1. What is your assessment of the analysis performed and its reliability for estimating the amount of air deposition of BPWD directly onto the Bay and other parts of the watershed?

The modeling approach involved use of a box model to treat regional emissions and deposition superpositioned with the ISC Gaussian plume model to treat roadway sources within the Castro Valley Creek watershed. This seems to be a reasonable approach that takes into account near source impact for roadways very near the observation sites as well as sources well removed from the area of concern. The application of these methods appears to be appropriate and the technical details of using these models appears to be correct. The report emphasizes the evaluation of the model results with respect to two wet deposition sites and four dry deposition sites within the watershed. There was no map showing the location of the monitoring sites so it wasn't possible to judge how representative these sites were of deposition directly to the Bay or other parts of the watershed. This map should show the monitoring sites as well as the location of major roadways and point sources. There was also no presentation of the results in terms of the spatial total deposition patterns predicted to the watershed and Bay. While it is understandable that the emphasis was on evaluation and optimization of the modeling system, it would be helpful to see the end results using the optimized system. Thus, while we can consider whether the model performs adequately at the monitoring sites, we cannot judge whether the overall spatial and temporal deposition patterns appear reasonable across the watershed and the bay. This kind of output would also help determine how representative each monitoring site is of the overall deposition pattern in the area. Further, it would also help understand the model evaluation results at each monitoring site. For example, if the model predicted steep horizontal gradients in wet or dry deposition and a monitoring site is located within this area of steep gradient, it could be expected that results for the site might be quite susceptible to small errors in wind direction or to the impact of nearby sources. On the other hand, if a monitoring site is located in an area where deposition rates are relatively uniform, then we might expect better results and less sensitivity of the results to nearby sources

In terms of the reliability of the model estimates, the comparison with the observations suggest that wet deposition is dominated by regional sources and is reasonably well predicted while dry deposition is generally underestimated and dominated by local sources. Long term average deposition rates (observed and predicted) were given, but no measure of the variability was provided. It would be useful to include a table of error statistics that includes, for example, fractional bias and fractional error. To judge whether these model results are acceptable requires some discussion of how these results will be used in a watershed model. Because uncertainties in watershed modeling may be quite large, the level of accuracy required in an air deposition model might not be as critical as for other applications. The report does not provide an overall conclusion as to the acceptability of the model performance.

2. Does the report clearly describe the uncertainties and sensitivities in the analysis?

Generally, there is considerable effort made to address uncertainties and sensitivities in the analysis related to specification of emissions and other modeling aspects. As noted above, it would be helpful to include a summary table of model performance measures that includes both bias and gross error. In addition, there should be some indication of the reliability of the observations. What are the uncertainties in measured wet and dry deposition? Generally, these are not straightforward measurements and there can be large uncertainties associated with the measurements. No error bars are provided on the measurements, but it would be useful to know how the range in model errors compares to the range of observation uncertainty. The regional box model is a significant component of the system, and it presumably is quite sensitive to specification of the mixed layer height. There was no discussion or evaluation of the uncertainties in mixed layer height as used in the box model. It would be helpful to include a brief description of the box model (perhaps as an appendix). Finally, some of the entries in Table 4, which lists the model runs, were confusing. For example, the ‘change with respect to the base run’ column contains an entry for the base run which isn’t clear. Similarly, under Run 4, Meteorology, the entry seems to suggest two runs: 1) alternate rain data used as input and 2) used to scale output

3. Based on your experience with similar fate and transport of modeling pollutants do you have any suggestions for how results could be improved using available data?

The report acknowledges the need to incorporate activity patterns on surface streets and freeways to specify the emissions and to differentiation emissions rates on this basis. This seems to be an aspect that should be explored further to improve the model. The report also recognizes that structures (sound barriers) along the roadways could affect the model results. A method for treating horizontal impaction on structures could be included. Recently, the Idaho DEQ developed a method for treating particle deposition in urban areas that accounts for horizontal impaction. While this was developed for use in an Eulerian grid model, it would be worthwhile to review this work to see if it could be included in this modeling system.

4. Are the data generated by the air deposition model appropriate inputs for the watershed model?

Based on the model evaluation and use of the sensitivity analyses, it appears that the deposition model output will be appropriate for watershed modeling. However, as indicated previously, this cannot be completely addressed without a discussion of the level of accuracy for deposition required by the watershed model and without presentation of watershed and bay deposition patterns.