

## **Brake Pad Partnership Technical Studies**

### **Estimates of Air Deposition Rates of Copper in the San Francisco Bay Watershed**

#### **Summary of Findings**

The Brake Pad Partnership commissioned an air deposition modeling study to obtain estimates of the amounts of copper from brake pad wear debris and other airborne sources of copper that are deposited to surfaces and water bodies in the San Francisco Bay watershed. Atmospheric and Environmental Research, Inc. (AER) conducted the modeling. AER modeled the dispersion and deposition of copper in the Castro Valley sub-watershed using a detailed source-based dispersion model to simulate local impacts, and a regional-scale box model to account for regional-scale effects. The deposition estimates in the Castro Valley sub-watershed were scaled using modeled information along with estimates of copper releases in order to create estimates of the rate of wet and dry deposition in the remaining 22 sub-watersheds in the greater San Francisco Bay Area watershed.

The copper source estimates used in the air deposition modeling were developed for the Brake Pad Partnership by Process Profiles and are described elsewhere. The brake wear debris particle size distributions used were based on additional research conducted for the Brake Pad Partnership at Clemson University, which is described elsewhere. Key modeling assumptions include:

- Copper emissions were treated as uniform over time.
- Estimated copper releases from vehicles on surface streets were treated as a uniform source over the watershed.
- Estimated releases from Interstate 580 (I-580), which bisects the southern portion of the sub-watershed, were treated as a line source.
- Based on anecdotal information and assumptions about differences in brake wear debris emissions under surface street and freeway driving conditions, source loading estimates for surface streets in Castro Valley were adjusted upwards by a factor of five and emissions from I-580 were adjusted downwards by a corresponding amount.

AER modeled wet and dry deposition fluxes of copper in the watershed for a five year period from March 2000 to February 2005). The modeling produced the following key findings:

- Dry deposition is the dominant source of depositional copper, even during the rainy season.
- Local emissions (emissions occurring within the sub-watershed) account for most of the dry deposition. Regional emissions (emissions occurring outside the sub-watershed) account for less than 5% of the total dry deposition.
- Due to differences in traffic densities, estimated average dry deposition rates of copper vary by more than a factor of ten among the Bay Area sub-watersheds.
- Regional emissions are the dominant source of copper in wet deposition, and therefore do not vary significantly among the sub-watersheds.
- Copper deposition to Bay waters is due to regional emissions because there are no air emission sources for copper from the Bay itself.
- The dominant source of uncertainty in the modeled deposition results is the uncertainty in the release estimate of copper in brake pad wear debris.

- There is no local component of copper emissions to San Francisco Bay waters, and the estimated average dry deposition rate direct to Bay waters is  $0.8 \mu\text{g Cu/m}^2/\text{day}$ , while the estimated average wet deposition rate direct to Bay waters is  $0.9 \mu\text{g Cu/m}^2/\text{day}$ . Note that the modeled estimate for wet deposition represents wet deposition for an average calendar day and not wet deposition for days with rain.
- The estimated average rate of dry deposition in the Castro Valley sub-watershed is  $20 \mu\text{g Cu/m}^2/\text{day}$ , and the estimated average rate of wet deposition in the Castro Valley sub-watershed is  $1.2 \mu\text{g Cu/m}^2/\text{day}$ .
- Modeled results indicate that of the estimated 47,000 kg Cu/y of copper released to air in the Bay Area in 2003, 17,000 kg Cu/y is dry deposited in the sub-watersheds, 3,200 kg Cu/y is wet deposited in the sub-watersheds, 1,200 kg Cu/y is dry deposited directly to Bay waters, and 1,300 kg Cu/y is wet deposited directly to Bay waters. The remaining 24,000 kg Cu/y remains airborne until it leaves the Bay Area.