



STREET SWEEPING PILOT STUDIES

Bringing program improvements to San Diego

BY CLEM BROWN AND BRYN EVANS

The city of San Diego, CA, Transportation and Storm Water Department has been aggressively testing assumptions regarding street sweeping and its role as a best management practice (BMP) for stormwater pollution prevention. The city has gathered significant data regarding how to best optimize the use of street sweeping equipment and routes. This article summarizes the city's findings and makes a strong case for street sweeping improvements nationwide.

Background

The city manages a large municipal separate storm sewer system (MS4) that discharges stormwater and urban runoff to creek, bay, and ocean receiving waters throughout the city limits. The San Diego Regional Water Quality Control Board regulates the discharge of urban runoff through the city's MS4 under the National Pollutant Discharge Elimination System permit program. Under the MS4 permit, the city must reduce the discharge of pollutants in urban runoff to the maximum extent

practicable through a combination of pollution prevention, source control, and treatment control BMPs. In addition to MS4 permit drivers, several watersheds within the city's jurisdiction have approved or impending total maximum daily loads (TMDLs) for various pollutants. Common pollutants in the city's receiving waters include sediment, heavy metals, pesticides, and bacteria.

Stormwater runoff, which can convey particulates and other pollutants from roadways and various impervious surfaces in urban areas, is a known contributor to water-quality problems throughout the United States. Street sweeping is a common source control BMP used by municipalities nationwide

to remove potential water pollutants from roadways. It is generally acknowledged that street sweeping can effectively reduce sediment, metals, and bacteria in stormwater runoff. Accordingly, the development of optimization techniques that improve the efficiency of the city's street sweeping program in removing roadway pollutants with potential water-quality impacts may assist city managers in meeting existing and future water-quality regulatory standards and TMDLs.

The city invests a significant amount of equipment, personnel, and fiscal resources in its street sweeping program. On an annual basis, approximately 2,500 miles of streets are swept. This translates to approximately

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Phases of the Targeted Aggressive Street Sweeping Pilot Program

Phase	Pilot Program Optimization Technique	Description
I	Sweeping Frequency Study	Assess the pollutant-removal efficiency of weekly and biweekly sweeping frequencies using both mechanical and vacuum sweepers
II	Machine Technology Study	Assess the pollutant-removal efficiency of mechanical, vacuum-assisted and regenerative-air sweeper machines
III	Median Sweeping Study	Assess the pollutant-removal efficiency of sweeping median roadway areas compared to the shoulder edge curb and gutter
IV	Speed Efficiency Study	Assess the pollutant-removal efficiency of mechanical sweepers at normal and reduced operational speeds

36,000 and 45,000 curb miles of residential and commercial street sweeping, respectively, at the city's current street sweeping frequencies. Over 20,000 cubic yards of material, weighing more than 5,000 tons, is removed annually from municipal streets as part of this program. To accomplish this work, the city has a fleet of sweepers that includes 24 mechanical, four vacuum-assisted, and one regenerative air sweeper that are operated and serviced by a team of 24 personnel.

Street Sweeping Pilot Studies

Given the amount of resources involved, the city's pollutant-reduction obligations under the MS4 permit, the TMDLs, and other regulatory drivers, the city has developed a phased series of pilot projects designed to evaluate potential water-quality benefits of various optimization techniques (See table). Phase I involves sweeping frequency, Phase II machine technology, Phase III median sweeping, and Phase IV speed efficiency. Each phase of this pilot program was designed either to assess specific modifications to current street sweeping practices or to determine the relative pollutant-removal efficiency of specific sweeper technologies and/or techniques. The overall goal in conducting the pilot studies is to identify and implement the most cost-efficient combination of optimized street sweeping practices and technologies that will maximize pollutant load reductions for the resources expended.

Pilot Study Methods

The pilot program was designed to address the project goals and was based on a review of available national, regional, and local street sweeping literature. The routes were selected based on a number of criteria, including land use, safety for sweeper and field team personnel, route representativeness, and the presence of impaired downstream receiving waters. (The geography, surrounding land use, and traffic volume of current street sweeping routes vary across the city. Pilot program routes were selected to be generally representative of typical conditions found throughout the city's jurisdiction.)

The sample process included estimating the volume of collected debris, measuring debris weight, and collecting debris samples for chemical analysis. In addition, Phase III methods included analysis of debris samples collected by hand on raised median areas where the mechanical sweepers could not reach because of logistical constraints. The Phase IV methods included collection of debris samples from the roadway before and after the sweeper passed at each of the two speeds studied. Representative samples of

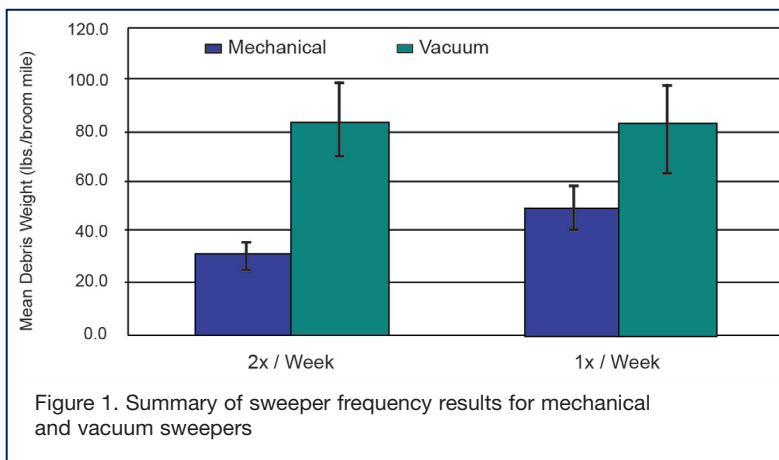


Figure 1. Summary of sweeper frequency results for mechanical and vacuum sweepers

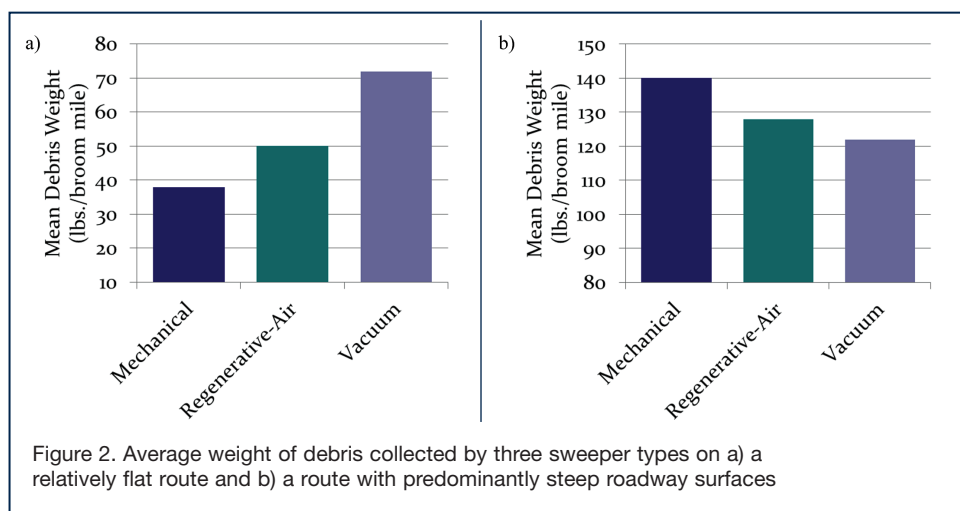


Figure 2. Average weight of debris collected by three sweeper types on a) a relatively flat route and b) a route with predominantly steep roadway surfaces

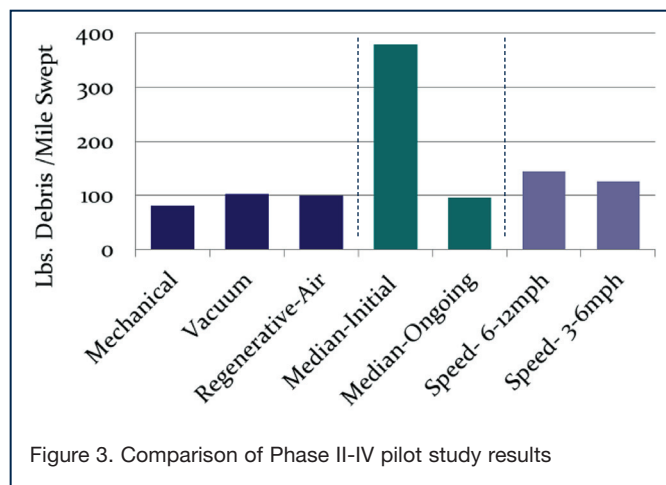


Figure 3. Comparison of Phase II-IV pilot study results

the collected debris were analyzed for common roadway constituents including metals, general chemistry, pesticides, and hydrocarbons. These methods allowed the city to balance its operational resource needs with those of the pilot study.

Summary of Pilot Study Results

Generally, the Phase I frequency study results indicate that increased sweeping frequency using vacuum-assisted sweepers provided a linear increase in debris removal ben-

efit. That is, additional sweeping with the vacuum-assisted sweeper resulted in similar debris removal rates at both the once-per-week and twice-per-week sweeping frequencies. In contrast, the results indicate that the mechanical sweepers were somewhat less effective at debris removal on a weight-of-debris-removed-per-mile-swept basis when sweeping was conducted twice per week as opposed to the standard once-per-week frequency (Figure 1).

The Phase II machine type results indicate that the vacuum-assisted sweepers are generally more effective than the regenerative air and mechanical sweepers at removing debris and especially fine particulates. However, the study results also indicate that site-specific variations in roadway surface condition, roadway grade, and presence of a curb and gutter may have limiting impacts on vacuum-assisted machine performance (Figure 2).

The Phase III median sweeping results indicate that the initial median sweeping event collected three to five times more debris than subsequent three-week-interval sweeping events (Figure 3). This suggests that a significant buildup of roadway debris occurs within and adjacent to median areas. The results also indicate that debris collected from median areas is similar in pollutant concentrations to the curb and gutter areas on the shoulder edge of the roadway surface. Preliminary raised median hand sweeping results

unable to reach.

Results from the Phase IV speed efficiency study indicate that the operational speed of mechanical street sweepers has little impact on the weight of debris collected in the field. The weight of material collected by the sweepers on the portions of the routes that were swept at the study operation speed (3 to 6 miles per hour) and the control operational speed (6 to 12 miles per hour) was highly variable. In some cases the treatment operational speed collected a higher weight of material, and in other cases the control operational speed collected a higher weight of material.

Implementing Optimization Techniques

The pilot studies were conducted over a three-year period, during which many operational and budgetary changes occurred at the city. In late 2011, the city's street sweeping program went through managed competition, and the potential for outsourcing the sweeping activities was evaluated. City staff developed a scope of work detailing current and future sweeping needs. The pilot study results were used in the scope of work to identify potential sweeping program component adjustments to improve compliance with current and future water-quality regulations. Ultimately, the city's employee proposal was selected as the most cost-efficient approach to meeting the city's long-term operational and water-quality improvement sweeping needs.

It is likely that the city staffs' familiarity and experience with the goals, processes, and results of the pilot studies performed over the past three years contributed to the selection.

The city has begun implementation of several program optimization techniques as an outcome of the pilot study results. For example, the city is in the planning stages of increasing sweeping frequencies in certain high-priority areas where there are known water-quality problems in adjacent or downstream receiving waters. Phases I and II of the pilot program not only provided the necessary data to justify this change but also allowed city staff to identify economic and social constraints for large-scale implementation of increased sweeping frequencies. Given the current economic climate, the city is unable to significantly expand its street sweeping program to accommodate additional sweeping in all the high-priority areas. Accordingly, city planning staff are working to identify routes where factors such as traffic volume, surrounding land use, and estimated trash loads indicate that an increased street sweeping frequency will most benefit water quality. In addition, city staff learned during Phase I that communities may oppose the signage and "no parking" restrictions on residential routes subject to increased frequency. As a result of the Phase I study, the city has developed an extended education and outreach program to inform and collaborate with potentially affected communities.

Phase II results indicate that the performance of the vacuum-assisted sweepers declined on pilot study routes with steep hills and poor roadway conditions, so a second sweeping optimization technique the city is actively working to implement is assigning vacuum-assisted sweepers to flatter routes



Studies show pollutant concentrations in debris from curb and gutter areas are similar to those from raised medians.

indicate there are potentially significant concentrations of common roadway constituents present on the raised median surfaces, where traditional sweeping machines are



Sweepers' operational speed had relatively little effect on the weight of material collected.

with better surfaces.

As a result of the Phase III study, the city is considering developing dedicated median routes in high-priority areas, as medians are currently only swept on an as-needed basis. An advantage of median sweeping is that there are very few signage and parking impacts to residents adjacent to those routes. The potential addition of median or other supplementary routes will require careful planning to make sure the city continues to meet its current level of service. As such, the city is currently working to evaluate areas where long, contiguous sections of median roadways coincide with high-priority water-quality areas. These areas will be studied for potential median route implementation in future years.

Phase IV results indicate that mechanical sweeper debris and pollutant removal was not significantly increased with slower speeds. This work provides justification to continue current operational speeds. In the current climate of limited municipal agency resources, this allows the current level of service to be maintained without the addition of staff or equipment resources.

Several long-term modifications to the city's overall street sweeping program are also being considered. The city is looking to potentially transition its fleet of sweepers to a more equitable mix of vacuum and mechanical machines. The better performance of vacuum sweepers in certain geographic locations justifies a long-term strategy to invest in the higher-cap-

ital-cost technology as the fleet ages and mechanical machines are retired. The city has also recognized that operator training and machine-type driver consistency are key components in decreasing repair and maintenance costs for the vacuum machines. In addition, the city is actively engaged in identifying and working with communities that may request more sweeping and/or new routes. Those communities are more likely to support changes to city operations (such as increased sweeping frequencies) that have tangible impacts, such as increased parking restrictions, to residents adjacent to those routes.

Finally, the city is working to improve its data collection and management functions to provide robust machine-specific debris and pollutant removal data citywide. The envisioned monitoring strategy would utilize existing equipment (such as machine-specific GPS units) to compile route-specific and/or a geography-based debris data. It is anticipated that the data could, in a relatively short implementation period, allow long-term, route-specific debris accumulation to be tracked over time. The analysis of route-specific debris accumulation may provide a unique, low-cost, and comprehensive dataset that will allow focused implementation of targeted street sweeping and/or other pollution prevention and source control activities to improve water quality within the city. ♦

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