STORMWATER TREATMENT NORTHWEST©

HIGH-EFFICIENCY SWEEPING or *CLEAN A STREET, SAVE A SALMON!*

Could the answer to the ultimate survival of our northwest salmon be *high-efficiency sweeping?* Could it be this simple? Of course not, since the solution to this complicated problem involves more than just water quality. However, for our urban waterways that receive a large dose of pollutant runoff, this may be the most effective pollution reduction technique ever conceived. And it could become an extremely important element of any successful salmon recovery plan. Stop and consider the following reality. So much discussion and regulatory effort is devoted to controlling pollution from new developments. But even in a rapidly growing area new development represents only a small portion of the area that drains to our streams. What do we do about improving the situation in areas already extensively developed? High-efficiency sweeping may be one important part of the solution. Hence, this issue is devoted to new developments in sweeping, which professionals who are involved in this subject are calling high-efficiency sweeping. This issue has been written by Roger Sutherland who is very active in the subject and is considered the national expert on the subject. Any comments or questions you have about this edition you may direct to Roger at Roger.Sutherland@pacificwr.com.

Using a street sweeper to clean a street is the preferred over flushing. However, from the perspective of the salmon, only one type of street sweeper will actually get the street clean. That type of sweeper has been referred to as a "high-efficiency sweeper" since by definition it is highly efficient in picking up a large portion of the very fine particulate material found accumulated on street surfaces.

This material commonly referred to as "street dirt" is highly contaminated with all of the pollutants found in stormwater runoff. As such, the street dirt that accumulates on impervious areas such as streets, driveways and parking lots that are directly connected to the urban waterways via a storm sewer system, have been identified over and over again as the primary source of urban nonpoint pollutants entering the waterways of the nation.

WHAT ARE THE CHARACTERISTICS OF A HIGH-EFFICIENCY SWEEPER?

High-efficiency street sweepers utilize strong vacuums and the mechanical action of uniquely designed main and gutter brooms combined with an air filtration system that only returns clean air to the atmosphere (i.e. filters particulate to 2.9 microns). These machines sweep dry and no water is used since they do not emit dust. Schwarze Industries, Inc.'s EV series, which includes the EV1 and the EV2, are currently the only documented high-efficiency sweepers. The Tennant Company has a Model 830-II power sweeper which is actually a mechanical machine with a slight vacuum and an air filtration system. However, the machine has not been properly tested using the long established dry testing protocol so it cannot be identified as a high-efficiency sweeper at this time.

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HOW DOES THE PICKUP PERFORMANCE OF A HIGH-EFFICIENCY SWEEPER COMPARE TO A TRADITIONAL SWEEPER?

The pick up performance testing of street sweepers dates back to Dr Robert Pitt's street sweeping study conducted for USEPA in San Jose, California (Pitt, 1979). Similar studies were conducted in Alameda County, California (Pitt and Shawley, 1982) and in Washoe County, Nevada (Pitt and Sutherland, 1982). In each of these efforts, the pickup testing involved a sampling of the accumulated street dirt at a site immediately adjacent to the site of the test. This was done to establish the initial conditions. The sweeper then sweeps the test site at a specified speed of 4 or 5 miles per hour. Then, the sweeping test site is sampled to establish the residual condition. The difference between initial and residual loadings by specific particle size defines the pickup performance of a street sweeping operation.

The studies noted above found that sweeping removes little, if any, material below a certain base residual which was found to vary by particle size range. Above that base residual, the street sweeper's pick up effectiveness was described as a straight-line percentage that also varied by particle size range. Dr. Robert Pitt developed a series of mathematical equations that describe the pick up performance of a street sweeper (i.e. Pitt, 1979). Sutherland and Jelen (1997) used those equations to evaluate the pickup performance of numerous street sweepers and street sweeping operations on average accumulation conditions.

The Schwarze EV1 (formerly the Enviro Whirl I) was tested along with the Elgin Crosswind regenerative air sweeper, a Mobile mechanical sweeper, and a tandem sweeping operation that involved a single pass by a Mobil mechanical followed immediately by a single pass of a TYMCO vacuum sweeper. These test results were then compared to those obtained for the NURP-era mechanical sweepers used in Bellevue, Washington.

The EV1 clearly outperformed the field with average total pick up efficiencies of 70% for the less than 63 micron range to 96% for the greater than 6370 micron particle size range. In fact, the base residuals discussed earlier were all zero so there was no base residual load below which the EV1 would not remove some material. The regenerative air sweeper was a distant second with overall pick up efficiencies that ranged from 32% for the less than 63 micron range to 94% for the greater than 6370 micron range with times when pickup in the 250 to 2000 micron range could actually be zero. That will occur because base residual loads were found to exist for the regenerative air sweeper throughout the 250 to 2000 micron range.

The tandem sweeping operation finished third. Although the straight line percentages above the base residual loading varied by particle size from 84% to 98%, the base residual loadings for all particle sizes less than 6370 microns totaled to 8.2 lbs. per paved acre. This means that during lower accumulation periods, when accumulations are less than 8.2 lbs. per paved acre, the tandem sweeping operation would essentially pick up nothing.

The stand-alone operation of a Mobil mechanical finished fourth and was similar to the tandem operation. However, the base residual loadings totaled 20.6 lbs. per paved acre for all particles less than 6370 microns. So, if the accumulation were less than 20.6 lbs. per paved acre, which is a very common occurrence throughout the Pacific Northwest, the mechanical sweeper would pick up nothing. Pick up efficiencies above the base residual loading varied greatly for the mechanical sweeper with a range of 48% to 100% depending on particle size.

The NURP-era sweepers performed very poorly. If the accumulation on the paved area were less than 80 lbs. per paved acre (which is probably close to an average loading throughout western Oregon and Washington), these sweepers would not remove any material. The actual removals above this residual loading of 80 lbs. per paved acre only range from 44% to 79%.

SPEAKING OF NURP, DIDN'T THEY CONCLUDE THAT SWEEPING WAS INEFFECTIVE?

The Nationwide Urban Runoff Program (NURP) studies of street sweeping effects on stormwater quality (USEPA, 1983) concluded that street sweeping proved to be largely ineffective in its ability to reduce the event mean concentration of pollutants found in urban runoff. This conclusion is largely based on the fact that the street sweepers used and tested were not able to effectively pick up very fine accumulated sediments that have been found to be highly contaminated with most of the pollutants observed in urban runoff. The reason? Broom sweepers of this era were effective at picking up litter and large dirt particles, but harmful contaminants are concentrated primarily in the finer particles, the particles less than 250 microns. Not only were these finer particles left behind in the pavement after broom sweeping, but once the heavy covering of sediment was gone, the finer particles and their contaminants were even more likely to wash into storm drains during the next rain.

It was the phenomena of exposed fine particle washoff that led the NURP researchers to the conclusion that the sweeping was ineffective. The actual NURP analyses showed that water quality benefits appeared to have occurred in three-fifths of the cases where sweeping was investigated. In fact, all five of the pollutants monitored at the two Bellevue, Washington NURP sites were believed to be reduced as a result of street sweeping. However, it was the dramatic increases of pollutant concentrations observed in the two Winston- Salem, North Carolina sites that led researchers to the overall conclusion of sweeping ineffectiveness. The exposed fine particle washoff phenomena, which the researchers did not understand, can now explain the elevated concentrations of pollutants observed during intense sweeping periods.

HOW WAS STREET SWEEPING EVALUATED IN THE NURP STUDY?

NURP sponsored the investigation of street sweeping as a potential control measure for urban stormwater pollution abatement at ten sites located throughout four U.S. cities. The cities were Bellevue, Washington; Champaign-Urbana, Illinois; Milwaukee, Wisconsin; and Winston-Salem, North Carolina. Champaign-Urbana had four sites and the other three cities had two each.

The studies used either a paired basin or serial basin approach with continuous sampling of end-of-pipe urban runoff quantity and quality occurring under either periods of rather intense sweeping or no sweeping at all. The resulting runoff quality data was analyzed statistically rather than explicitly since the computer models of that era were not considered to be reliable or accurate.

The statistical analysis first involved the classification of observed runoff events based on whether a sweeping period was underway (i.e., swept condition) or whether no sweeping was being undertaken (i.e., unswept condition) when the data was obtained. Using each of the two separate data sets (i.e., swept conditions or unswept conditions) the site's median event mean concentration (EMC) was determined for five pollutants. The pollutants were total suspended solids (TSS); chemical oxygen demand (COD); total phosphorus (TP); total Kjeldahl; nitrogen (TKN); and total lead (TPb). The swept condition median pollutant concentration was then compared to the unswept condition to see if any reductions occurred.

As stated earlier, EMC reductions actually occurred in 30 of the 50 cases evaluated! However, the NURP researchers decided that the reductions of less than 50% would not be considered significant! All of the 30 reductions found in the analysis were under 50%. EMC increases were observed for 16 of the cases evaluated and no change occurred in the remaining 4 cases. Nine of these EMC increases occurred in the two North Carolina sites where the intensity of rainfall was greater than any of the other three cities involved. Ten of the reported thirty EMC reductions occurred in the two Bellevue, Washington sites where the intensity of rainfall was less than any of the other three cities studied. Once again, the phenomena of exposed particle washoff can explain why EMC increases occurred in the North Carolina sites and other sites as well.

CAN YOU ESTIMATE THE POLLUTANT REDUCTION BY HIGH-EFFICIENCY SWEEPING?

The ability of a street sweeping operation to reduce the overall pollutant washoff loads depends on several things. First is the street sweeper's innate ability, when operated properly, to remove accumulated sediment. Another is the environmental dynamics of sediment accumulation and resuspension, and of sediment washoff during storm events plus suspended sediment removal by downstream water quality controls.

The Simplified Particulate Transport Model (SIMPTM) can accurately simulate this complicated interaction of accumulation, washoff, catchbasin trapping and street sweeper pick up that occurs over a period of time (Sutherland, and Jelen, 1993). Working with a calibrated version of the SIMPTM program, the average annual expected reduction in total suspended solids (TSS) washoff from two of Portland's NPDES stormwater sites were projected for varying sweeping operations. The sweepers used in these simulations were the same as those described earlier: the NURP era sweepers, the Mobil mechanical sweeper, the tandem operation, the Elgin regenerative air sweeper and the Enviro Whirl I (Schwarze Industries EV1). (For a more detailed description of the SIMPTM program and its calibration to the City of Portland's NPDES monitoring sites, the reader is referred to Sutherland and Jelen, 1996.)

Table 1 shows the simulated results of the expected annual washoff reductions for varied intensity of street sweeping in residential areas by each of the alternative technologies. It clearly shows that all of the newer street sweeping technologies would be significantly more effective than the NURP-era sweepers in reducing TSS washoff from single family residential areas with curb and gutter drainage in Portland, Oregon. Note that the Schwarze EV1 is the best, followed by the Elgin regenerative air and the tandem operation. Even the 1988 Mobil mechanical sweeper will provide reductions in the 20% to 30 % range. Also note that weekly or twice monthly sweeping appears to be optimum for this type of land use in Portland, Oregon.

Table 1. Simulated Annual TSS Washoff Reduction (%) Single Family Residential

Sweeping Operation	Frequency of Sweeping			
	Monthly	Twice Monthly	Sweeping Weekly	Twice Weekly
Schwarze EV	51	63	79	87
Elgin Regenerative	43	53	65	71
Tandem (M+V)	33	41	49	53
Mobil Mechanical	17	23	29	33
NURP Era	0	0	0	0

Table 2 shows how the results change significantly when sweeping a highly loaded major arterials instead. It even more clearly demonstrates the superiority of the Schwarze EV1 sweeper in reducing TSS washoff from highly impervious, ultra-urban drainages in Portland, Oregon. The Elgin regenerative air provides some TSS reduction, whereas the other technologies appear to be largely ineffective on this type of land use. This same land use was found to provide the highest pollutant washoffs on a pound per paved acre basis of the six Portland area homogenous land uses studied (Sutherland and Jelen, 1996).

Table 2. Simulated Annual TSS Washoff Reduction (%) Major Arterial

Sweeping Operation	Frequency of Sweeping			
	Monthly	Twice Monthly	Sweeping Weekly	Twice Weekly
Schwarze EV	49	62	76	85
Elgin Regenerative	15	17	22	24
Tandem (M+V)	4	5	6	8
Mobil Mechanical	3	4	5	7
NURP Era	0	0	0	0

Clearly, though, both tables show that the NURP-era sweepers were totally ineffective in their ability to reduce TSS washoffs from either of the basins simulated. So this confirms the earlier conclusions of the NURP in regard to sweeper performance, while suggesting that significant benefits could now be expected from high-efficiency sweeping.

WHAT ABOUT OTHER POLLUTANTS?

SIMPTM has also been used to simulate the potential reductions in other pollutant loadings by high-efficiency sweeping. These simulations have primarily dealt with the particulate phases of the pollutants. For example, if the TSS annual reduction was estimated by the model to be 60%, total metals annual reductions are estimated to vary from 45 to 55%; nutrient reductions such as total phosphorus would vary from 25 to 35% annually; and oxygen demand annual reductions are projected to vary from 35 to 45 %.

There is one final aspect of high-efficiency street sweeping that make its potential even more promising. It appears that both the concentration and mass of dissolved pollutants such as metals and phosphorus that are associated with the 63 to 250 micron range of street dirt is much greater than that found in the very fine <63 micron faction (Sutherland and Jelen, 1998). The Schwarze EV sweepers can easily pick up 80 to 90% of the particulates in this range. Therefore, high-efficiency sweeping may have the ability to remove dissolved pollutants before they become dissolved from rainwater! No other control technology with the exception of filtration systems can remove dissolved pollutants such as dissolved metals and phosphorus.

IF HIGH-EFFICIENCY STREET SWEEPING IS THIS GOOD WHY ISN'T ANYONE USING IT IN THE PACIFIC NORTHWEST?

This is a good question and I believe there are several different answers to it. First, not everyone is aware of this technology. The original EnviroWhirl I was only invented in late 1993. EnviroWhirl Technologies was sold to Schwarze Industries in May 1997 and Schwarze has not invested much effort in marketing the machines, especially in the Northwest. Second, the Schwarze EV's are considerably more expensive than traditional sweepers with prices ranging from $190,000 to $250,000 depending on the machine. However, it should be noted that this higher capital cost is offset by the ability of the machine to sweep a greater percentage of its operating hours because there is no time wasted on dumping dirty water and picking up clean water as this sweeper sweeps dry. Third, the maximum forward speed of approximately 20 to 25 mph has been viewed as a problem by many large cities and counties. Schwarze needs to be encouraged to mount its technology onto a truck chassis. Fourth, the technology does not appear to have a competitor. Based on pickup performance the Schwarze EV series is essentially superior in fine sediment removal and containment. Unfortunately, lack of competition makes public works officials nervous and they are generally reluctant to act as a result.

But most importantly, the projected water quality benefits of this technology are based on modeling and many people feel that models cannot accurately simulate this behavior. The modeling results are unbelievable so many professionals have chosen not to believe them! The naysayers will point out that this technology has not been field verified and there is no end-of-the-pipe water quality data that can currently verify the modeling results.

ARE THERE ANY PROJECTS ENVISIONED FOR THE NORTHWEST?

There is a NURP-like project starting in Wisconsin that will monitor the pollutant reduction benefits of EV sweeping of interstate highways in Milwaukee. Unfortunately, as of this date, no field verification project has been proposed or funded for any urban area in Oregon or Washington. Given the actual results of the NURP that implied the old sweepers may have been doing some good here in the Pacific Northwest, how can we continue to ignore the potential pollutant reduction benefits of this high-efficiency technology? It could simply be the most practical and cost-effective management practice ever conceived for the ultra-urban environment.

While this argument continues amongst those that should care about water quality, street dirt continues to accumulate and rainfall continues to transport it to the urban waterways. Salmon and other aquatic life continue to be affected with declining numbers. So until further notice, this researcher will continue to believe that salmon can be saved if we simply find the resources needed to keep our streets clean!

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NEXT EDITION

The primary topic of our last edition of the year will be the treatment of stormwater from construction sites; that's right, treatment. The City of Redmond has pioneered the use of polymers to treat stormwater from construction sites. Under a contract with the city, Gary Minton recently documented the experience with this system and will present a summary of findings in our last issue of the year.

SHORT COURSES AT THE UNIVERSITY OF WASHINGTON

A reminder that the short course New Technologies and Concepts in Stormwater Treatment will be February 10th and 11th. Offered by the University of Washington Professional Development Program, the two-day short course will focus on the new, manufactured technologies that have recently appeared on the market like Stormceptor, StormFilter, BaySaver, etc. About 10 of these technologies will be covered; no doubt several that you have not even heard of as they are not yet being marketed on the west coast. Vendor representatives will make presentations of their particular technologies. This is a singular opportunity for attendees to see all technologies at once; to compare and contrast. Roger Sutherland will also discuss high-efficiency sweeping, the topic of this newsletter. If you are interested in this course or other courses on the subject of stormwater management call Stephanie Strom of the University of Washington at 206-543-5539 to get on the mailing list for course brochures.

DO YOU KNOW OF AN ON-GOING STUDY ON A TREATMENT BMP? IF SO, PLEASE FILL OUT THE FOLLOWING AND SEND TO GARY

Your name _____ Your phone # _____.

Location of facility _____ Type of facility _____ .

Owner _____ .

Contact name _____ Their phone # _____ .
(if you know) (if you know)

Mail to Gary Minton, RPA, 311 W. McGraw, Seattle, WA 98119

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