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Street Cleaner Pick-Up Performance Tests For the Elgin Sweeper Company

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INTRODUCTION

A great deal of controversy surrounds the question of how effective street cleaning is in removing pollutants generally found in urban stormwater runoff. Modeling studies using road dirt accumulation data and stormwater quality data have concluded that street cleaning can be a very effective best management practice (BMP) (Sutherland, Minton, Marinov, 2006: Sutherland and Jelen, 1997). However, others believe that this isn't the case and cite several pilot studies in which the analyses of the collected data seem to support their conclusion that street cleaning is ineffective in its ability to reduce the concentrations of pollutants found in urban runoff (Geosyntec Consultants, 2008). Unfortunately, the suspended sediment data that has been collected and the analyses that have been conducted as part of these studies are flawed since they have failed to measure all of the particulate material in transport and have failed to use analytical methods and modeling tools that can actually simulate these behaviors and the appropriate interaction with cleaning practices (Sutherland and Minton, document in press).

Flawed how can that be? First, the withdrawal water velocities of automatic samplers used to collect the water quality samples limits pickup capabilities with regard to particle size. Silt and sand particles larger than 100 to 200 microns have been rarely sampled. Somewhat larger sizes of organic particles and clays having lower specific gravities have likely been collected. Second, the standard laboratory procedures for total suspended solids (TSS) testing does not measure the effect of these larger particles assuming they were captured at all. Protocols for water quality sampling specify the use of a pipette for splitting a sample into smaller aliquots for analysis. Rapid hand mixing and pouring fails to properly move larger material that may have been captured. And, lab test sub-sampling procedures failed to pick up these particles. Newer procedures (e.g. churn splitters, separate analysis of larger material by prescreening, full sample rather than sub-sample analysis, etc.) have likely reduced but not eliminated these laboratory procedures biases.

How do we know this is a problem? A 1998 study of runoff from an interstate highway in Cincinnati, Ohio used gravimetric-based sampling techniques that relied on gravity for the sample collection not automatic samplers. The study also filtered and analyzed the entire volumes of discrete samples obtained throughout each sampled runoff event. The study concluded that 20% by mass of the particulate material transported in the runoff ranged from 600 to 1000 microns and 30% from 1000 to 10,000 microns (Sansalone, et al., 1998). Recent discrete runoff sampling of eight storms captured from an elevated section of I-10 in Baton Rouge, Louisiana used both gravimetric sampling techniques and whole effluent analyses. The study found particles in transport that ranged from 1 to 24,500 microns in size (Kim and Sansalone, 2008).

If we are to believe the results of Sansalone's research, then one must conclude that the concentrations of sediments and their associated pollutants found in runoff from highway pavements have been routinely understated. Metals, phosphorus, petroleum and related hydrocarbons, and pesticides, are all hydrophobic and, therefore, sorb to these larger particles. Sansalone and Cristina (2004) found that more than 60% of the particulate-bound metal mass (i.e. Cd, Cu, Pb, and Zn) was associated with particles greater than 250 microns.

Those that have been critical of street cleaning as an effective BMP generally lack a good understanding of the complicated processes that relate to both the accumulation and transport by runoff of contaminated particulate material on urban streets and how the effective removal of this material by cleaning practices will essentially deplete the supply available to stormwater. Those pilot studies that have concluded that street cleaning is not very effective have not used models whose washoff component is based on sediment transport equations which can accurately simulate the complex processes and their interactions (Selbig and Bannerman, 2007; Center for Watershed Protection, 2008).

PWR has developed and used sediment transport based models (Sutherland and Jelen, 1996) that can accurately reproduce these complicated processes and their interactions including the contribution of contaminated material from other urban source areas whose runoff flows onto these street and parking lot surfaces (i.e. wet weather washon). Through these modeling studies PWR seems to be the only researchers in the country that understand the importance of a street cleaner's ability to pick-up and contain the entire range of accumulated particulate material. PWR studies using a calibrated sediment transport based washoff model called SIMPTM (Sutherland and Jelen, 1998) concluded that optimum sweeping using a regenerative air cleaner available at that time would likely remove 66% of the TSS annual mass found in stormwater from single family residential sites (Sutherland, et. al., 2001).

For years the focus has been on the finest fraction of these accumulated particulates largely due to the toxic pollutants. But based on Sansalone's work regarding metals and the work of others regarding nutrients, it should be now clear to public works and stormwater management staff concerned about water quality that the focus should be on a much larger range of particulate material (i.e. up to 2000 microns).

Pacific Water Resources, Inc. (PWR) was contracted to design and implement a series of controlled street dirt pick-up performance tests for four different sweeper models. The purpose of these tests was to measure the street dirt pick-up efficiency of these various machines operating under conditions that are typically found throughout the country. The purpose of this memorandum is to document the test protocols that were used and the results that were obtained from these pick-up performance tests conducted in University Park, Illinois on July 28-30, 2008.

EXECUTIVE SUMMARY

Five controlled pick-up performance tests on four different sweepers were conducted over a three day period at a curbed test track under a tent that was erected on a parking lot located in University Park, Illinois. Each test was based on an initial street dirt accumulation of approximately 792 lbs per curb mile (i.e. 7.5 lbs or 3405 grams spread evenly over a 50 foot by 2 foot track). The street dirt loadings used for these tests were realistic and well within the range of both accumulated mass and particle size distributions (PSDs) observed some 25 years ago in Winston-Salem, North Carolina and Bellevue, Washington as part of the Nationwide Urban Runoff Program (NURP). PWR is not aware of any significant street dirt accumulation or PSD data for the Chicago IL metropolitan area.

The controlled street dirt accumulations were created with the use of a simulant which is a mixture of various silica based products that result in the specific gravities and PSDs that have been observed in actual street dirt. The PSD of the street dirt simulant created for these tests is close to the overall average found in some 600 samples of actual street dirt taken from streets located throughout five different land use areas monitored in the Bellevue Washington NURP. PSD's are based on dry mass sieve analyses of 8 pre-established particle size (PS) groups that range from less than 63 microns to greater than 6370 microns.

Average forward sweeping speeds for these tests were specified at 5 miles per hour and were actually measured from 4.7 to 5.1 miles per hour. The use of water spray for dust suppression was not used in five of the six tests. One of the tests of the Elgin Eagle FW model was conducted with the use of the water spray. The same machine was also tested without the use of water. Fugitive dust losses were not measured. However, each of the sweepers was photographed several times during each test.

Overall pick-up efficiency for each sweeper test was computed as a percentage of the initial weight removed and was based on the weight of remaining material collected following the sweeping operation compared to the known weight of simulant spread evenly along the test track. A sieve analysis was conducted by a certified third party soils lab on each of the six remaining material samples collected after each test and a single sample of the simulant itself. The results of these analyses allowed PWR to estimate the overall pick-up efficiency of each sweeper test and the pick-up efficiencies for each of the eight PS groups used in the sieve analysis.

The overall pick-up efficiencies for the six tests ranged from 97.5% to 81.0% with the regenerative air based Elgin Crosswind NX model with dust control performing the best. The second best performer was the standard Elgin Crosswind, followed by the Elgin Whirlwind and then the Elgin Eagle FW without any water spray. The Eagle test that used water spray for fugitive dust control had the lowest overall pick-up which was some 10.5 % lower than the 91.5 % pick-up of the Eagle without water. Generally speaking, the pick-up efficiencies increased for increasing size particles which is typical for street cleaner tests. Pick-up efficiencies for the finest two fractions of particles measured (i.e. less than 125 microns) during waterless sweeping ranged from 83.4% to 94.9% depending on the machine used.

Most sweepers generated dust when they operate, which creates fugitive dust losses. This means that dust from the simulant that was entrained during the test and eventually settled off of the test track would be assumed to be captured by the sweeper which is clearly not the case. Fugitive dust losses will only effect the pick-up performance calculations for the two smallest particle sizes fractions (i.e. less than 125 microns). Photographs taken during each sweeper test provides some qualitative evidence of the relative amount of fugitive dust loss generated by each machine. It should be noted that the Crosswind NX with fugitive dust control appeared to generate no visible fugitive dust losses. Plus the fugitive dust losses observed when the Eagle FW was being tested (both with and without the use of the water spray) were very low. This is due to the shrouded gutter broom design with the vacuum assist that transport fugitive dust generated by the gutter brooms directly to the hopper.

Fugitive dust is an important issue that can affect the pick-up performance of the sweeper but it also affects the public's perception of how effective the sweeper's pick-up performance may actually be. When someone sees a sweeper going down the street generating a cloud of dust, one usually questions the overall effectiveness of the machines pick-up performance. Plus the dust from real street dirt contains toxic pollutants that can have a negative effect on the respiratory health of many people.

METHODOLOGY

Test Site Selection

Since the testing was expected to occur over a number of days it was important that PWR design a test that could be repeated under dry weather and low wind conditions at the same location on any given day. Dry weather conditions are needed since the test involves the use of a street dirt stimulant whose remaining amount after the sweeping operation has to be removed using an industrial vacuum cleaner (i.e. Shop Vac) powered by an electric generator. It was also important to select a site that had essentially had no traffic or could be closed to traffic. And most importantly the test site needed to be a curbed street with at least fair pavement conditions similar to the conditions generally encountered by the street sweepers on their route.

Given these requirements, it was decided to conduct the tests at a parking lot located in University Park, Illinois under a large tent. Below are photographs of the tent and the 50 foot long curbed test track that was used.

Testing Protocol

The test procedure was quite simple. A known quantity of the street dirt simulant was spread evenly along the test track curb line using a fertilizer spreader whose spreading width is approximately two feet. (The actual street dirt simulant mixture used will be fully discussed later in this memorandum)

A street sweeper then performs a single pass at a specified forward speed. However, the actual time that the machine spends cleaning the test length is recorded using a stopwatch so the average sweeping speed can be computed. Several digital photographs are taken before and during the sweeping operation. Before the test material is actually applied, the street sweeper operator is given the opportunity to practice several sweeping passes that are timed. This ensures that the operator will successfully execute the desired sweeping speed when the actual test is performed. For example, a street sweeper traveling at exactly 5 miles per hour will only be on the test track for 6.8 seconds. Plus, these practices runs ensure the track is very clean before the stimulant is applied.

Following the sweeping, an industrial vacuum cleaner with a smooth stainless steel canister is used to vacuum up by hand all of the simulant that remained on the test track including any simulant moved further away from the original application area by the gutter broom action. After the hand cleaning the vacuum hose is elevated and shaken several times to ensure that all of the pebbles have traveled to the canister, the vacuum is turned off and the canister is carefully opened in a working area protected from any wind. The small micron Dacron filter cloth (that is covering the canister to separate the machine's built in air filter from the captured material) is tapped several times by a clean brand new paintbrush before it is very carefully removed and brushed to dislodge material trapped on the canister side of the filter cloth, which then carefully transfers it to the canister. A new Dacron filter was used after each test and a new paper filter was used for each day of testing.

The captured material is then slowly transferred from the vacuum canister to a plastic zip lock bag using the paintbrush and a wire holder needed to keep the zip lock bag open. This delicate operation requires two people to ensure that none of the captured material is spilled. Some loss of dust will occur and should be expected but its mass weight is generally very small and not significant enough to meaningfully influence the results. The bag is sealed and labeled. The material is weighed in the field using a kitchen scale (after zeroing out the weight of a empty zip lock bag) and that weight is recorded along with other test information on a sampling log. The material is then taken to a soils lab where it is weighed, dried, weighed again and sieved into eight pre-selected particle size groups. A single representative sample of the simulant is also sieved so the particle size distribution of the initial material is known. The sieve results have been tabulated and can be found in Appendix A.

Before the application of the test material for the first test, the test track and its approach section is swept several times by the sweeper waiting to be tested as noted earlier and then hand vacuumed as described earlier. However this sample is not retained but discarded instead. Between tests, the test track and approach section are only swept several times and not hand cleaned again. If water is used in these pre-test sweepings able time is needed for the track to completely dry before the next test material is applied. On cloudy or cool days, the water spray between testing is not recommended. If water is used during a test as was the case for one of these tests, then able time is needed for the track to completely dry before the sample collection using the vacuum starts. Several photos of the loading and sampling protocol now follow.


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Logic Associated with Testing Protocol

Pavement conditions are known to significantly affect the pick-up performance of street cleaners (Sartor and Boyd, 1972). Street sweepers have considerable difficulty effectively picking up particulate material from streets whose pavements are classified as poor since this usually means lots of surface cracks and deep depressions where dirt can accumulate. The uneven surfaces that accompany poor pavement conditions make it difficult for the sweepers to operate effectively. Research has shown that when sweeping poor pavement condition streets a large portion of the material removed could be the street pavement itself. The selected test track should be representative of the average pavement conditions that are likely found within a given City or County which would most likely be classified as fair to good. The condition of the pavement for these tests conducted in University Park, Illinois would be fair however the pavement cracks where sealed which is a common practice throughout the country and essentially in area that experience a lot of freeze and thaw.

Barriers such as street curbs or New Jersey barriers are known to have a significant effect on both the accumulation of "street dirt" and the ability of street cleaners to effectively pick up the accumulated material. A study in San Jose, California found on monitored residential asphalt streets in fair to good conditions with medium to light parking densities, approximately 58 to 73% of the street dirt accumulation was located within 2 feet of the curb (Pitt, 1979). Street dirt monitoring throughout six cities at bus stops where no parking was allowed found that 90% of the solids were located within one foot of the curb (Sartor and Boyd, 1972). To be representative, the selected site should include a curb gutter and the street dirt simultant used should be applied within a few feet of the curb. This was the protocol used in the University Park tests.

Safety is perhaps the most important consideration when conducting a street cleaning performance test. It takes a considerable amount of time to initially clean the test track, place the material on the track, sweep the track and hand vacuum the remaining material for each machine and initial mass tested. Working at a location that is open to traffic would be dangerous and highly undesirable. So one has to select a test site where no traffic exists or where traffic can be totally closed to traffic. There was no traffic at the University Park testing site.

The length of the test track is also very important. The longer the length of the test track the longer it takes to prepare the test and hand vacuum the remaining amount. If the test track is too short, the mass of the remaining material could be too little to effectively measure its particle size distribution. The 50 foot test track length used in University Park provided plenty of length needed to balance these competing factors.

The forward speed of a street cleaner will also affect its ability to pick up particulate material. Everything else considered equal, the pick-up effectiveness increases as the forward speed decreases (Sartor and Boyd, 1972). The machine operators were instructed to clean at approximately 5 miles per hour which is generally considered the optimum operating speed given the trade off between pick-up performance effectiveness and the need to sweep a certain number of miles a day. Operating at 5 miles per hour, it only takes about 7 seconds to sweep the 50-foot long test track. Since the testing protocol called for measuring the actual time it took the cleaner to sweep the test track, one always knows exactly how fast each machine was going during each test.

Fugitive dust losses were not measured. This means that dust from the simulant that was entrained during the test and eventually settled off of the test track would be assumed to be captured by the sweeper which is clearly not the case. Keep in mind that fugitive dust losses will only effect the pick-up performance calculations for the two smallest particle sizes fraction of less than 125 microns. Because of dust concerns, mild wind conditions are desired during testing and each of the sweepers were photographed during testing. One can then observe the photographs and make a qualitative assessment of the relative difference in fugitive dust losses that may have occurred. It should be noted that several of the sweepers tested were equipped with fugitive dust collection technologies.

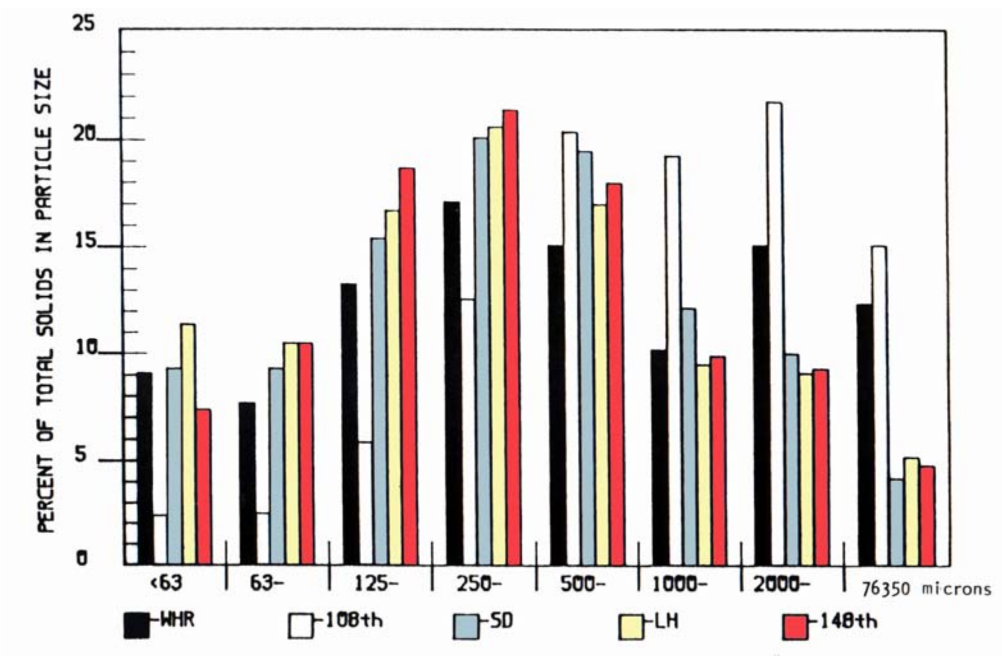
Street Dirt Simulant

One of the most important aspects of a street cleaner pick-up performance test is the amount and particle size distribution of the street dirt that is used. The magnitude and particle size distribution of accumulated street dirt has been investigated in the United States starting in 1969 when the historic APWA Chicago study of urban runoff pollution sources was conducted (APWA, 1969). PWR is unaware of any significant street dirt accumulation or particle size data set for the Chicago metropolitan area.

The **test quantities** used for these University Park tests were based on the range of street dirt accumulations that had been observed in Winston-Salem, North Carolina (North Carolina DNR, 1983) as part of the Nationwide Urban Runoff Program (NURP) conducted in the early 1980's (USEPA, 1983). That study found that street dirt accumulations generally ranged from 300 to 1000 pounds per curb mile. The test for each machine used 7.5 lbs (3405 grams) of simultant applied along the 50-foot test track which is equivalent to 792 lbs per curb mile (225 grams per curb meter). Thus, the initial accumulation used in these tests is well within the range observed in the Winston-Salem data set.

One of the largest street dirt data sets ever collected in the country occurred in Bellevue Washington in the early 1980's also as part of the NURP. Street dirt was monitored throughout five small urban watersheds and approximately 600 samples were collected over a two-year period. Each of these 600 street surface samples was separated into eight different particle sizes. Figure 1 (reproduced from Pitt and Bissonnette, 1984) shows the average particle size distribution (PSD) for each of these five areas observed during the two dry seasons that were monitored. These size distributions show that the smallest particle sizes account for a relatively small fraction of the total particulate material. This was especially true during the wet season when the rains were most effective in removing the smallest particles. The larger particle sizes also accounted for relatively small fractions of the total sediment weight. Most of the street surface particulates were associated with particles in the size range of 125 to 1000 microns.

Figure 1 – Dry Season Particle Size Distributions in Bellevue, Washington



The underlying objective was to create a street dirt simulant that was as close as possible to the overall particle size distributions found in Bellevue during dry season conditions. The materials needed to create the simulant mixture had to: (1) be available in relatively small quantities; (2) have a known particle size distribution so the proper recipe could be designed; and (3) has the same specific gravity of real street dirt, which is approximately 2.6.

A street dirt mixture was created using six different silica products whose particles ranged from 1 to 3360 microns. The exact nature of the mixture will remain proprietary since it is an important piece of knowledge that PWR has gained from multiple attempts at stimulant mixtures from other sweeper testing projects. The particle size distribution (PSD) of the resulting street dirt simulant is presented below in Table 1 along with a comparison to the average PSD from the Bellevue NURP data.

Table 1 – Particle Size Distribution (PSD) of Street Dirt Simulant

PS No.	Sieve No.	Size Range (microns)	Bellevue NURP Average Incremental Mass (%)	Incremental Mass (%)	Percent Retained	Percent Passing
8	1/4	>6370	8.2	0.0	0.0	100.0
7	10	2000-6370	13.0	16.9	16.9	83.1
6	18	1000-2000	11.8	10.8	27.7	72.3
5	30	600-1000	17.8	7.1	34.8	65.2
4	60	250-600	19.1	19.4	54.2	45.8
3	120	125-250	14.2	30.1	84.3	15.7
2	230	63-125	8.0	7.1	91.4	8.6
1	Pan	<63	7.9	8.6	100	0.0

A comparison of the PSD's presented earlier in Figure 1 to that of the simulant clearly shows that the simulant was somewhat finer than the average street dirt observed in Bellevue. For example, approximately 57% of the simulant was in the 125 to 1000 micron range compared to only 51% in the actual Bellevue street dirt. Only 17% of the simulant was greater than 2000 microns compared to approximately 21% for the Bellevue street dirt. However, the amount of material in the finest two fractions matched very well with 16.9% of the simulant was less than 125 microns and the average observed in the Bellevue street dirt was essentially the same at 16.7%. Even though the PSD of the simulant didn't match exactly as planned, the use of a simulant is still preferred since the initial quantities and PSD are known. As a result, both total pick-up performance and pick-up performance by particle size (PS) group can be computed.

The Bellevue street dirt data also showed that the average dry season accumulations ranged from 160 to 920 lbs per curb mile (i.e. 45 to 259 grams per curb meter), depending on several factors like land use and traffic (Pitt, 1985). One of the most common mistakes made during most street cleaning pick-up tests or demonstrations is that an excessive amount of material is used, which does not represent day-to-day realistic conditions (Sutherland, 1997). As stated previously, the University Park tests were designed to simulate initial accumulations of 792 1bs per curb mile (225 grams per curb meter) which is well within the range of the average accumulations observed in Bellevue.

RESULTS

Sweeper Models Tested

Five controlled pick-up performance tests on four different sweeper models were conducted over a three day period at a curbed test track under a tent that was erected on a parking lot located in University Park, Illinois. Two different regenerative air based Elgin Crosswind models where tested. The standard Crosswind and the Crosswind NX with dry systems dust control. The waterless Elgin Eagle FW designed with shrouded gutter brooms and vacuum assist that transports dust to the hopper was tested both without and with water. The Eagle is a mechanical machine with main broom action and a conveyor used to entrain and transport sweepings to its hopper. A truck mounted vacuum based Elgin Whirlwind MV was also tested.

Overall Pick-Up Performance

The overall pick-up performance results from the five tests conducted on July 28-30, 2008 are presented in Table 2.

Table 2 – Overall Pick-Up Performance Test Results

Sweeper Model	Type	Remaining Mass (gms)	Initial Mass (gms)	Pick-up Mass (gms)	Pick-Up %	Forward Sweeping Speed (mph)
Crosswind (NX)	Regenerative	85.6	3405	3319.4	97.5	4.7
Crosswind	Regenerative	121.1	3405	3283.9	96.4	4.9
Eagle (FW)	Mechanical	288.3	3405	3116.7	91.5	4.9
Eagle (FW) with water	Mechanical	646.0	3405	2759.0	81.0	4.7
Whirlwind (MV)	Vacuum	221.1	3405	3183.9	93.5	5.1

Remaining Material by Particle Size (PS) Range

The remaining material in each particle size (PS) range that was measured through the use of sieve analyses is presented below in Table 3.

Table 3 – Remaining Material by Particle Size Range (grams)

PS No.	Size Range (microns)	Crosswind NX	Crosswind Std.	Eagle FW waterless	Eagle FW with water	Whirlwind MV
7	2000-6370	3.8	3.5	23.6	24.6	4.4
6	1000-2000	5.6	4.6	24.6	32.3	6.8
5	600-1000	5.2	4.7	16.7	28.4	8.9
4	250-600	13.6	15.9	43.5	104.7	43.1
3	125-250	23.4	44.3	91.4	287.3	106.1
2	63-125	7.2	17.0	24.5	75.6	32.7
1	<63	26.8	31.1	64.0	93.1	19.1

Fugitive dust losses will only affect the remaining material measured in the two smallest PS ranges (i.e. less than 125 microns). Qualitative analysis of the photographs taken during sweeping indicated that no visible fugitive dust losses occurred during the Crosswind NX equipped with fugitive dust control. The fugitive dust losses observed when the Eagle was being tested (both with and without the use of the water spray) were very low. In the case of the test without water, this is due to the shrouded gutter broom design with the vacuum assist that transport fugitive dust generated by the gutter brooms directly to the hopper.

Keep in mind that some fugitive dust losses always occur in the process of transferring the collected material from the stainless steel vacuum canister to the plastic container bags. However, it is largely believed that these losses are small in comparison to those from the sweeping process itself and the losses through material transfer are essentially the same or each sample obtained.

Pick-Up Performance Results by PS Range

The pick-up efficiencies computed for each of the particle size ranges is presented in Table 4. The results of the sieve analyses and the initial mass loading in each particle size range needed to compute the pick-up performance efficiencies shown in Table 4 can be found in Appendix A.

Table 4 – Pick-Up Performance Efficiencies by Particle Size Range (Percent of Initial Mass)

PS No.	Size Range (microns)	Crosswind NX	Crosswind Std.	Eagle FW waterless	Eagle FW with water	Whirlwind MV
7	2000-6370	99.4	99.4	95.9	95.8	99.3
6	1000-2000	98.5	98.7	93.3	91.2	98.2
5	600-1000	97.8	98.1	93.1	88.3	96.3
4	250-600	97.9	97.6	93.4	84.2	93.5
3	125-250	97.7	95.7	91.1	72.0	89.6
2	63-125	97.0	93.0	89.9	68.7	86.5
1	<63	90.8	89.4	78.1	68.2	93.5

DISSCUSSION OF THE RESULTS

Overall Pick-Up Performance

Overall the pick-up performance results were very good and they generally conformed to preconceived expectations. The regenerative air based Crosswind NX model with dust control performed the best as expected with an impressive overall efficiency of 97.5%. The second best performer was the standard regenerative air Crosswind at 96.4% overall. Regenerative air machines are generally considered the best overall performers in particulate pick-up. The Whirlwind WV vacuum machine was third with an overall pick-up efficiency of 93.5%. The Eagle FW without water spray which is a mechanical machine finished in fourth place overall with an impressive pick-up efficiency for a machine of its type measured at 91.5%. The fifth place performance with an overall pick-up efficiency measured at 81.0% was the mechanical Eagle FW operating with a water spray. This was also expected since it has been known for some time by sweeper manufacturers that water spray used to suppress fugitive dust reduces a machine's ability to pick-up particulate material. In fact, the pick-up performance of the Eagle that used water spray was some 10.5 % lower than the measured pick-up of the Eagle without water. So the preconceived expectations as it relates to overall pick-up efficiencies which were regenerative air first, followed by vacuum and then mechanical proved to be correct.

Remaining Material by Particle Size (PS) Range

When we examine the remaining material by particle size (PS) range data it becomes clear that the use of water to suppress fugitive dust results in a significant amount of additional material remaining on the street surface for particles less than 1000 microns. Notice that the use of water with the Eagle resulted in a 121% increase in the remaining mass for particles 250 to 1000 microns in size and a 153% increase in remaining material for particles less than 250 microns when compared to using the same machine with no water spray for fugitive dust control.

Pick-Up Performance by Particle Size Range

In addition to the overall pick-up performance discussed previously, there is a heighten amount of concern for the pick-up performance of the finest particles (i.e. less than 63 microns). As expected all of the regenerative air and vacuum machines outperformed the mechanical one in this regard. It is interesting to note that the vacuum machine actually out performed both Crosswinds in finest particle pick-up. However, the pick-up percentages were very close and this factor alone would not preclude the potential selection of a regenerative air machine (like the Crosswind NX with fugitive dust control) over a vacuum one.

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