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Street Sediment Build-up Rates In Anchorage, Alaska

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INTRODUCTION

Sediment represents the largest pollutant mass on urban North American streets (EPA, 1993). As such, it can have a significant physical and chemical impact on local environmental systems. When discharged to natural waterbodies, sediments can impede prey capture, impair respiration, reduce aquatic plant productivity, degrade spawning gravels, and bury substrate (MacDonald, 199 1). Heavy metals and pathogens commonly adsorbed to street sediment (Kobriger, 1984; Platin and Derry 1996; Sartor and Boyd, 1972) can also affect uses of receiving waters. Finally, street dirt is considered a basic source of dust emissions (EPA, 1995) and, in Anchorage, is suspected as a primary source of air-suspended particulate (MOA, 1995).

In 1994, in recognition of the scope of these potential problems for the city's 27 watersheds, the Municipality of Anchorage (MOA) identified source control of sediment generated from urban streets as a top water resources management priority. The MOA is developing a set of pollutant build-up and washoff models to guide selection, design and maintenance of these controls. To meet modeling data needs, the MOA characterized the nature and distribution of street sediment in urban Anchorage in 1996 and normalized the data to establish design-year street sediment build-up rates.

ANCHORAGE SAMPLING METHODOLOGY

Investigators collected data in three rounds to reflect the significant differences in sources, build-up rates and abstraction processes between the summer and winter seasons. Round 1 sampling in March/April reflected late-winter accumulated loads, and Round 3 performed in July/August measured build-up from summer sources. Field crews completed an additional sampling round (Round 2 in April/May) to set baseline conditions for the summer period and to assess the total sediment removal efficiency of the city's spring street sweeping program.

Field crews sampled a total of 34 "Intersection" and "Trackout" sites over three sampling rounds. Intersection Sites represent total street surfaces (gutter and trafficking areas) within 61 meters of an intersection. Trackout Sites represent street surfaces on sampled roadways within a nine meter zone centered about intersecting unpaved alleyways. Each site was also categorized by road type: 1) Local, 2) Collector, 3) Minor Arterial, and 4) Major Arterial (defined by average daily traffic counts (ADTs) of <2,000, 2,000-10,000, 1O,OOO-2O,OOO, and >20,000, respectively).

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Field crews composite street sediment samples from multiple transects at each sampling site using a modified shop vacuum. Samples were collected separately for gutter and trafficking surfaces to allow assessment of sources for air entrainment or storm water washoff. Total washoff loads (from snowmelt and rainfall runoff) were also measured at two sites. All composite samples were tested for mass and grain size distribution using ASTM method C-136.

ANCHORAGE BUILD-UP RATES

1996 Street Sediment Loads

Seasonal median street sediment loads summed over gutter and traffic surfaces for each project road type are shown in Figure 1 for Anchorage and selected North American cities. Anchorage's relatively high winter loads reflect both a regional climate having relatively few mid-winter thaw (and washoff) events and the city's dependence on sanding as the principle means of road traction enhancement. In fact, remnant winter sand (street sediment remaining after the city's spring sweep) may form as much as half of Anchorage's total summer street sediment loading.

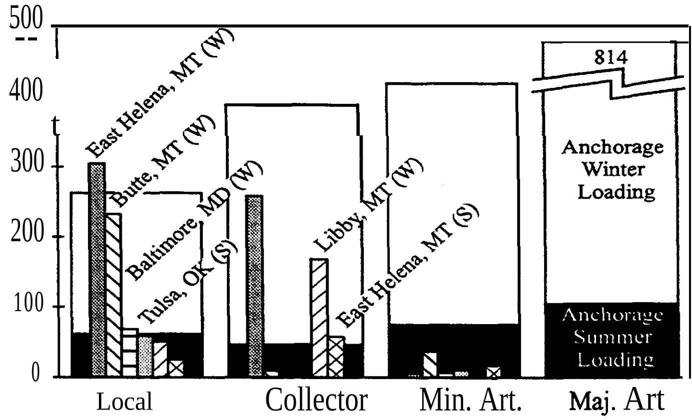

Figure 1: Street Sediment Loads (g/m^2)

Track-out from unpaved alleyways adjoining Anchorage streets was separately assessed as a potential source of summer street sediment loading. Unit loads observed at these sources in 1996 were nearly double that of other sampling sites. However, because of their localized effect, the total mass contributed by track-out areas may actually represent less than 20°/0 of the total overall summer load.

1996 MOA Street Sweeping Efficiencies

Total sediment mass removal achieved by MOA street sweeping practices during the 1996 spring street sweeping event is estimated at 60 to 90 percent. Total removal efficiency improved significantly as ADT increased. Investigators believe these higher efficiencies are the result of differences in street sweeping practices and the presence of larger accumulated winter loads on high ADT streets.

Street sweeping removal efficiencies by particle size show much more complex patterns than those for total mass removal (Figure 2). For all road types, removal efficiency decreased with decreasing particle size. This pattern was most pronounced for low ADT roads. For these road types, street sediment loading for fine fractions actually showed a net increase after completion of spring street sweeping.

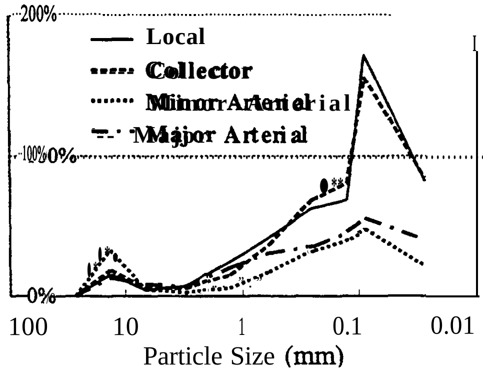

Figure 2: % Remaining After Sweep

Anchorage Street Sediment Build-up Rates

Investigators estimated winter and summer street sediment build-up rates for urban Anchorage using mass balance equations calibrated to 1996 data (Figure 3).

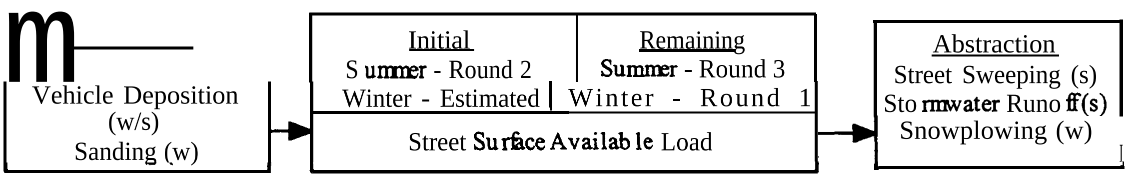

Figure 3: Street Sediment Loads Mass Balance

The simpler summer model was calibrated first. Total street sediment build-up occurring between Rounds 2 and 3 was approximated by summing initial summer loads (Round 2 data) with vehicle deposition and stud wear loads [calculated based on adjusted national and local loading estimates (Barter et. al., 1996; Kobriger, 1984)]. Abstractions were estimated using 1996 baseline street sweeping efficiencies and 1996 washoff data. Using these frost estimates of loading and abstraction, an initial mass balance error was calculated. The entire process was iterated, calibrating by adjusting the vehicle deposition rate, to optimize the mass balance error for all four road types.

In the winter model, the calibrated vehicle deposition rate was first adjusted for increased studded tire use. The 1996 MOA winter street sanding inventory was then apportioned to each road type, weighted by total intersection area. A remnant summer load was also estimated for the beginning of the 1995 winter season (using the calibrated summer mass balance model) and added to the total winter build-up mass. Because the mass lost to snowmelt runoff as measured at two project sites in 1996 was less than 3% of the total load, snowmelt washoff was not considered in the winter mass balance equation. The final equation was completed by adding a snowplowing abstraction load to the 1996 remnant winter load (Round 1 data) sufficient to balance the estimated total seasonal build-up. The resultant snowplow mass removal rates reasonably matched that estimated using national snow dump total solids data (Droste and Johnston, 1993) and mass balance calculations made for local annual sanding and street sweeping inventories.

Finally, proposed design-year street sediment build-up rates were estimated by normalizing calibrated 1996 mass balances to the median Anchorage climatic year. Because sanding for traffic traction enhancement is highly weather dependent, 1996 winter build-up rates were normalized using a climate-based algorithm. This algorithm reflects the MOA sanding practices and is driven by snowfall amount, storm length, and occurrence of freeze-thaw events. Summer build-up sources (vehicle deposition and trackout) are independent of weather, and the unaltered 1996 summer build-up rates are proposed for use as design values. Table 1 summarizes calibrated and normalized sediment build-up rates proposed as standards for urban Anchorage.

Table 1: MOA Street Sediment Build-up Rates

	Sediment Build-up Rate, $g/m^2 \cdot day$	
Road Type	Summer	Winter (normalized)
Local	0.03	11
Collector	0.19	23
Minor Arterial	0.53	35
Major Arterial	1.3	47

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