Chapter 3

Milwaukee's Snow and Ice Control Service

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Effective and efficient snow and ice removal is a challenge to many northern cities, and Milwaukee is no exception. The city is responsible for providing snow and ice removal services for its citizens at a reasonable cost. Quality snow and ice control service is critical to preserving traffic safety, maintaining city commerce, and allowing residents access to schools and medical facilities. Quality service, however, can be expensive. Equipment maintenance, employee wages, and salt and other chemicals are among the many costs associated with effective snow and ice removal. The amount of money a city spends each year varies with the severity of the winter, which makes budgeting accurately for this service very difficult.

The National Weather Service estimates that in an average winter Milwaukee receives 47.5 inches of snow (National Weather Service, 2001). Seventy percent of that snow typically falls between December and March (see Appendix A). In December 2000, the City of Milwaukee experienced one of the snowiest months in its history. During this month alone, Milwaukee received 49.5 inches of snow, four times the December average of twelve inches. It snowed 27 out of 31 days that month (National Weather Service). Because of this heavy snowfall, the city constantly dispatched snow removal crews throughout December.

As a result of this heavy snowfall, by the end of December the City of Milwaukee exceeded its annual snow and ice operations budget by $4,303,819, or 67 percent (see Appendix B). This is not uncommon, as the city has overspent its snow and ice control budget three of the last four years. Although the city cannot control the weather, it can control the level of snow and ice control service it provides. It can also control how the service is funded and administered.

This analysis examines the efficiency and effectiveness of Milwaukee's snow and ice control program, the appropriate level of service in light of budgetary constraints, and the challenges to the cost-effectiveness of the program. This analysis is divided into four sections. The first section describes the current snow and ice removal policy in Milwaukee. The second section outlines the methodological approach we used for our analysis. The third part identifies policy alternatives for more efficient and effective service. The final section contains recommendations based on these alternatives.

Background

The Milwaukee Department of Public Works (DPW) is charged with the responsibility of plowing all city streets. Of the $7.5 million budgeted for snow removal in 2001, $4.3 million comes from the Solid Waste Fund, $3.1 million from the Buildings and Fleet Division, $159,000 from the Administrative Service budget. Under the current snow and ice policy, DPW plows from curb to curb and operates under a "bare pavement" policy. The goal of this policy, as the name suggests, is to plow the whole street in a reasonable time frame to prevent ice from bonding to the pavement. Although DPW does not plow alleyways, it does plow all arterial and residential streets (Lorbeske et al, February 2001). DPW estimates that in 2000, city streets were plowed within 12.32 hours on average. Times varied, of course, depending on the severity of the storm and the type of snow (Milwaukee 2001 Plan and Budget Summary).

To accomplish its plowing, DPW relies heavily on multipurpose vehicles. Garbage trucks are equipped with snowplows when plowing is needed, and dump trucks used in summer construction projects are fitted with rear-attached electronic salt-spreaders. By relying almost exclusively on multipurpose vehicles, DPW reduces the number of vehicles not in use during any one time. By having fewer single-purpose vehicles, Milwaukee reduces the need for storage. Because DPW uses garbage trucks to plow the streets, however, sanitation services may be delayed by a snowstorm (Lorbeske et al., February 2001).

The current snow and ice control policies have evolved into their current form over the last few decades. Technological improvements, political and social pressures, and the improved knowledge of DPW officials has led to steady improvement in the delivery of the snow and ice control services. One of the biggest changes in snow and ice removal has been the emphasis on plowing and salting early and often during a winter storm. Prior to the winter storm of 1978–79, it was common for the snow removal crews to wait for significant accumulation before plowing the streets in order to reduce the number of times trucks had to plow individual streets. While this strategy was more cost effective in the short run, streets that received several inches of wet snow before getting plowed often became glazed with ice which remained for most of the winter. This led to safety hazards and more expensive cleanup costs. Now, with greater emphasis on public safety, Milwaukee's snow and ice strategy involves pre-storm salting and early plowing of streets during the beginning of storms to prevent the packing and bonding of snow and ice to road surfaces (Lorbeske et al., March 2001).

With improved technology, Milwaukee's snow and ice removal operations have become more efficient in several areas. Weather forecasting equipment, GIS routing systems, multipurpose equipment, and recognition of best practices have modernized snow and ice control service. Despite these improvements, snow and ice removal remains a costly operation. Even in winters when snowfall is light and funds are not fully used, the majority of the budget is required to cover base costs for readiness, including staffing and procurement of equipment and materials. (Lorbeske et al., February 2001)

Budgeting for the cost of snow removal requires DPW to estimate what will be needed in the way of snow removal for the next winter. Budgets are created for an average winter; however, above-average snowfall has caused the city to go over budget in three of the last four years (Lorbeske et al., February 2001). The city cannot stop plowing just because the plowing budget is depleted. Thus, in years with above-average snowfalls, DPW will overspend its snow and ice control budget.

According to the City of Milwaukee Snow and Ice Control Policy, "the goal is to restore safe motorist and pedestrian travel to minimize economic losses to the community and the industry when workers are unable to get to or perform their jobs, and to facilitate Fire and Police Department responses to emergencies" (City of Milwaukee Snow and Ice Control Policy, 2001).

According to Dave Lorbeske, Superintendent of Sanitation Division and coordinator for snow and ice control operations for Milwaukee, the emphasis on a high level of snow and ice removal service in Milwaukee began after World War II. Today, DPW perceives a public mandate for high service level because of the benefits of clean streets. As a result, even at times when the budget is tight, DPW will still plow all city streets to the pavement in order to maintain public safety and commerce (Lorbeske et al., March 2001).

The economy of Milwaukee and the surrounding region requires the mobility of people and goods. Every day, hundreds of thousands of people depend on the city being open to them, as individuals commute to jobs in and out of the city. While one cannot assume that without a high level of service nobody would be able to get to work, there have been storms that have temporarily paralyzed other major midwestern cities.

Milwaukee's snow and ice control program has proven effective even in the worst of storms. While comparisons between cities and their services are imprecise for several reasons, examining a storm that hit much of the Midwest in 1999 can be useful. Detroit and Milwaukee receive similar annual snowfall, yet the snow removal policies and the money spent on them differ greatly between the cities. Detroit's snow and ice removal budget for 1999 was only $1.5 million, compared to the $8.6 million spent by Milwaukee (Stingl, 1999). Part of this difference can be explained by the fact that Milwaukee clears all arterial and residential streets, while Detroit clears only its major thoroughfares.

On January 2 and 3, 1999, more than a foot of snow fell on both Detroit and Milwaukee. With substantial effort, Milwaukee kept its streets open for operation, and schools were open by January 4. Detroit residents experienced a different situation. Schools were closed more than five days in the following two weeks, keeping 180,000 students out of school; delivery trucks were unable to get to small neighborhood food stores; Detroit Metropolitan Airport was crippled not only by the weather, but because workers were unable to get to work due to the conditions of the roads; and more than 15,000 addresses did not receive mail for more than two weeks (Stingl, 1999). While storms like these may be uncommon, Detroit did not have the resources to address these problems, and the storm's impact on safety and the economy was severe. By comparison, Milwaukee's more costly service benefited citizens and saved the city millions of dollars by staying open. This example demonstrates the costs of lower service levels.

The Milwaukee DPW believes its service level affects many people. In addition to businesses relying on Milwaukee's roads, thousands of schoolchildren also depend on clear roads. The decision for schools to remain open is often based on the condition of the streets and the ability of buses and cars to transfer students safely. If children are unable to attend class, some community benefit associated with the education is lost, and if parents stay at home with a child, some Milwaukee businesses may lose productivity (Lorbeske et al., February 2001).

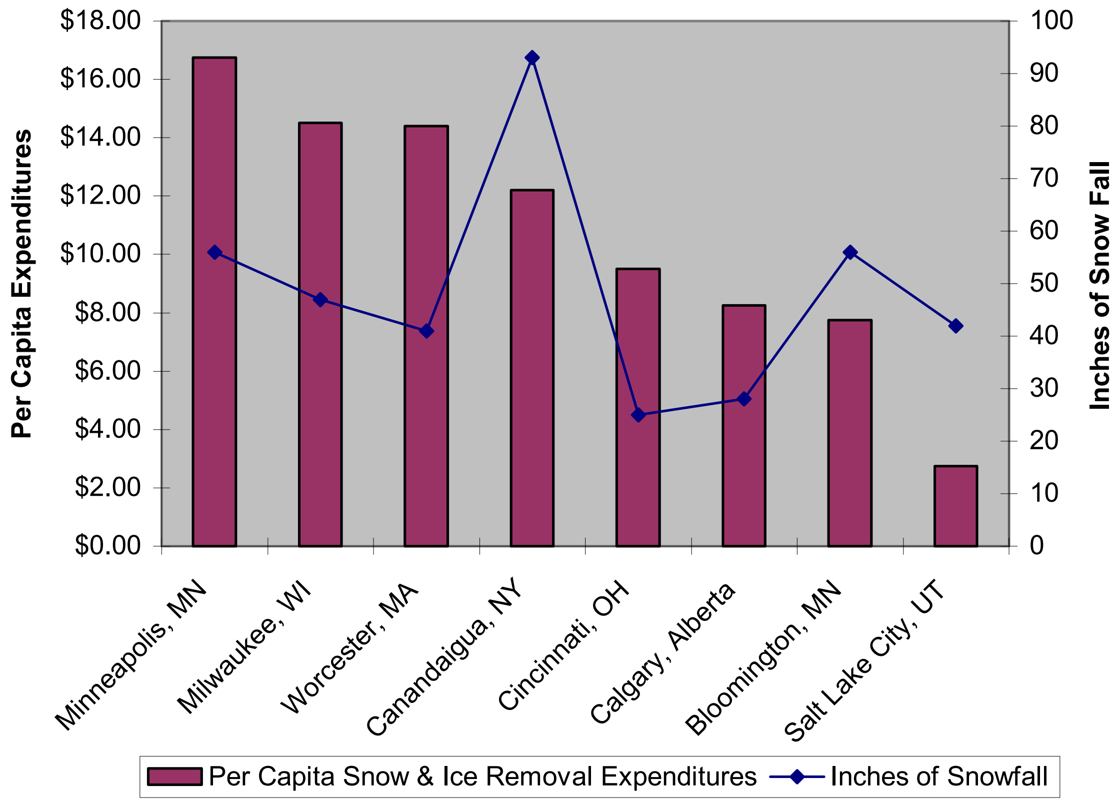
Administrative Issues

DPW faces many administrative challenges to effective and efficient snow and ice removal. The difficulties of measuring service level, of comparing service across cities, and of making accurate budgets are challenges that exist for DPW.

Comparison with Other Cities

To evaluate Milwaukee's snow and ice operations, it is important to examine other cities' policies. Every city that receives heavy snowfall has its own unique characteristics, including climate, street layout, and geography. Every city also chooses to provide a unique level of service based on historical, cultural, political, and operational factors that have evolved over time. Because of the unique factors surrounding every individual city's snow and ice operation, comparing costs or service of two or more cities can be a significant challenge. To demonstrate how Milwaukee compares to other cities, we have selected several cities that receive different levels of snow and ice each year (see Figure 1).

Figure 1
1999 Snow and Ice Control Expenditures Per Capita Compared to Number of Inches of Snowfall



Adapted from ICMA Comparative Performance Measurement FY 1999 Data Report

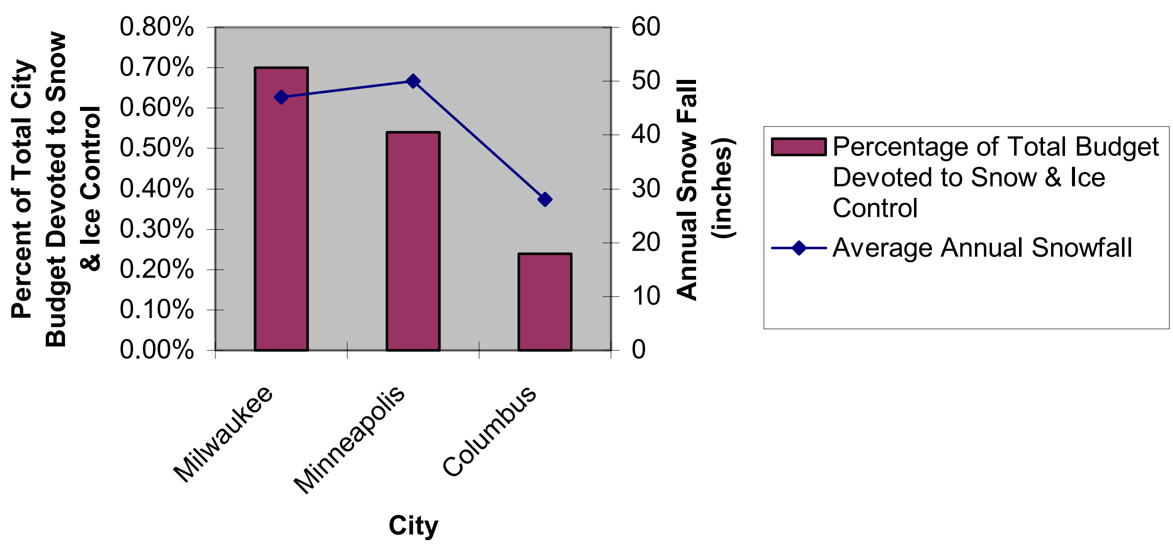
From the above chart, based on International City/County Management Association (ICMA) data, it is evident that Milwaukee has some of the highest per capita expenditures for snow and ice control among other cities with heavy amounts of snow, with each resident paying over $14 in 1999 (see Appendix C). The data include only two explanatory variables for this high cost of service—snowfall and lane miles in the city.

Regression analysis of thirteen cities shows that only snowfall is a statistically significant variable.[1] Lane miles are probably not statistically significant because they are

[1] This regression analyzes a small sample size. Accuracy would increase with a larger sample size.

likely correlated with population. In the regression, population is controlled for because we look for per-capita cost estimates. Forty-five percent of the variation in per-capita costs can be attributed to snowfall and lane miles. Since Milwaukee had high snowfall (59 inches in 1999) and many lane miles to plow (7,112), it is reasonable to expect high per-capita costs (see Appendix B) (Lorbeske et al. 2001). Yet Milwaukee still spends slightly more than what would be expected. However, using the regression model, Milwaukee's actual snow and ice control expenditures exceed the predicted per-capita expenditures by approximately 50¢ per person. In a city of 596,974, that amounts to approximately $300,000 more than predicted for a city with as much snowfall and as many lane miles. For full regression results, see Appendix C. Figure 2 below shows that Milwaukee spends a higher proportion of its budget on snow and ice control than Minneapolis or Columbus, even though its snowfall is not inordinately high.

Figure 2
Relative Size of Milwaukee's Snow and Ice Control Program



Budget Challenge

There is no precise method of budgeting for snow and ice removal. Estimating costs a year in advance involves uncertainty. Milwaukee, like other cities, has seen the cost of its snow and ice removal operations vary greatly over the past several years. Besides average annual snowfall, several other factors affect the actual cost of snow and ice removal operations. The amount of snow, temperature, rate of snowfall, time of day and week, and the overall severity of winter weather all impact the cost of operations (Milwaukee 2001 Plan and Budget Summary).

While four inches of snow is used as the theoretical standard for when the city will plow, it actually serves as more of a budgetary tool. When to plow and salt is a reactive and subjective decision that DPW makes "to provide the highest level of public safety" (Lorbeske et al., February 2001). No two snow events or circumstances are the same, so each decision requires careful consideration. For instance, a three-inch snowfall in January may require plowing and anti-icing on the roads, while a six-inch snowfall in late March followed by warmer weather may require little action ("Snow and Ice Control in Minneapolis," 2001). Timing also influences plowing and de-icing decisions. When snowfall occurs on a weeknight, there will be a strong effort to clear the streets for the following morning rush hour. On a weekend, when there is less public safety risk, DPW will take more time to clear the streets. Personnel costs vary depending on whether plowing occurs during the normal workday or on a holiday or weekend when employees must receive overtime pay (Lorbeske et al., February 2001).

Operational Issues

In contrast to administrative concerns, many issues surround the actual tasks of plowing and salting the streets. Vehicles parked on the street obstruct plowing. DPW's dependence on multi-purpose vehicles and crews means that heavy snows can delay garbage collection.

Parking Issues

DPW attempts to plow all city streets from curb to curb; however, this can be difficult when cars are parked along the sides of roads. Because of illegally parked and abandoned vehicles, the city must plow some streets multiple times (Lorbeske et al., February 2001). One consistent comment from all of our interviews with other cities was the high cost associated with illegally parked cars in the winter. While no exact data are available on the additional expense associated with these multiple plowings, DPW managers estimate that this is a substantial portion of the snow and ice removal budget (Lorbeske et al., February 2001). Collecting data on the number of times plows return to streets because of parked cars would be extremely helpful in measuring service and costs.

On most nights, parking is typically allowed on only one side of a street. When snowfall is heavy and the city declares a snow emergency, vehicles cannot be legally parked on either side of certain streets. DPW is responsible for enforcing this policy by ticketing and towing offending vehicles.

The parking problem is the most severe on Milwaukee's East Side. In this area, parking is normally allowed on both sides of the street, but only on one side of the street during snow emergencies. However, due to a lack of parking lots and garages, residents often ignore snow emergency rules and remain parked on both sides of the streets. After a snowfall, the problem is most severe. Cars become covered with snow, and when the owner of a car then moves the car, this snow typically gets piled into the road. Often when the drivers return to park on the street, they typically park farther from the curb, leaving room for passenger doors to open. Parked cars continue to move toward the center of the road until the street is no longer wide enough for two-way traffic. This is especially dangerous if emergency vehicles need access to the street. To preserve access for emergency vehicles, plow operators return to streets multiple times after parked cars have moved (Lorbeske et al., February 2001). While tow trucks remove illegally parked cars, there are usually more cars than the current tow truck allotment can keep up with, and DPW expressed an unwillingness to tow cars in the area aggressively. Without adequate off-street parking they believe that extensive towing in this area would be unfair. The department is currently looking to renew old agreements with public schools to allow residents to park in public school lots during snow emergencies (Floyd, 2001).

Throughout the rest of the city, DPW parking checkers have struggled to keep pace with parking offenders. The city had previously employed 40 parking checkers but recently has added an additional 20 checkers in an effort to enforce existing parking regulations. DPW officials also note that limited space in tow lots in December hindered towing efforts. The towing that was done may have assisted the plowing efforts considerably. A February 14, 2001, article from the *Milwaukee Journal-Sentinel* reports that after parking checking responsibilities moved from the police department to DPW, the number of parking tickets written fell by 5 percent (Borowski, 2001). The intention of moving the parking checkers from the police department to the DPW was to increase the enforcement of parking regulations and to increase revenue for the city. An unintended consequence of the move has been the reduction in tickets issued by the police department's regular patrol officers. While it may be too early to evaluate this move, the initial result is that Milwaukee has brought in less revenue than originally projected (Sanders, 2001).

Disruption to Garbage Collection

Milwaukee uses multipurpose vehicles to remove snow and ice. Because garbage trucks fitted with plows are used for snow and ice removal, garbage collection crews sometimes must plow in lieu of collecting garbage after snowstorms. In the winter, residents are not required to put their garbage on the curb, since collection on specific days is not guaranteed due to the use of the garbage crews to plow and salt roads. Rather, residents place their garbage cans in an accessible location not on the curb, and when garbage collection is possible, workers must walk around houses to find trash receptacles before unloading them into trucks (Lorbeske et al., February 2001). This clearly reduces the efficiency of trash collection and delays trash pickup. According to John Brown, director of office operations for the Sherman Park Community Organization, garbage collection is a major issue. During times of heavy snow, garbage is not always collected. Even when garbage was being collected, some trash receptacles that were embedded in the snow were not always being emptied. These unemptied receptacles became a major sanitation issue in the winter of 2001. According to Brown, as refuse spilled over into the streets, rats were common, especially after the holidays when was more trash (Brown, 2001).

Methodology: Approaches and Issues

To conduct this analysis of Milwaukee's snow and ice removal program we used the following approach. First, we attempted to measure Milwaukee's service level by interviewing members of Milwaukee DPW to learn how they define and measure service level. We considered both the possibilities and limitations of more comprehensive measures. Next, we compiled as much data as possible for Milwaukee's snow and ice operations. We then selected several comparable-sized cities that receive significant snowfall and examined how they defined and measured their snow removal operations. We tried to gain some comparative data on different approaches that other cities used to determine if these approaches would benefit Milwaukee's operations. Finally, we generated recommendations.

A major focus of our analysis was on measuring service levels. The question of how much service the program should provide is complex. A more fundamental question asks what level of snow and ice control service DPW currently provides. The answer is surprisingly elusive, since measuring service benefits quantitatively is difficult. Although the cost of the program can be easily measured, the benefits of snow and ice control cannot. Therefore, a proper cost-benefit analysis of the snow and ice control program may not be possible.

The two major objectives of the program are to minimize the number of snow- and ice-related traffic accidents and disruptions to everyday life and to economic activity caused by winter storms (City of Milwaukee Snow and Ice Control Policy, 2001). Selecting criteria to measure these outcomes is difficult. A possible criterion for measuring public safety is the number of traffic accidents the snow removal program reduces. For instance, we could measure accidents on a plowed street or accidents on an unplowed street compared to accidents on those same streets during good weather. This measure is not necessarily practical, because it is difficult to prove how many accidents were caused strictly by poor street conditions. Furthermore, if unplowed streets prevent cars from moving at all, then poor service might actually reduce accidents by keeping drivers off the road. Measuring public safety is therefore beyond the scope of this analysis.

Keeping the city "open for business" after a snowstorm is another possible outcome by which to evaluate service level. "Open for business" means that businesses, schools, hospitals, government agencies, and other institutions are open to the public. To measure this, one could examine sales of businesses, delays and cancellations in public transportation, school closings, and emergency vehicle response times. The time and cost required to collect this data outweighs its benefits. The bigger conceptual problem is determining whether people stayed home for reasons unrelated to the quality of the roads or because of unplowed roads.

Because outcomes are difficult to quantify, a growing practice within city governments across the country is to evaluate service using performance measures. Performance measures quantify the relationship of the inputs and outputs of a service. Inputs primarily include costs, but can also include man-hours, and number of trucks used. Outputs include number of lane miles plowed, amount of snow plowed, and the quality of that plowing. DPW currently has no system of performance measures to evaluate the cost-effectiveness of the service they provide.

DPW does measure some outputs associated with snow and ice removal. The department knows the average time it takes to do a first-run plow, how much salt is used, its total expenditures for recent years, and other figures. However, more figures could be recorded after each plowing or salting, and entered in a data management system. There is currently room for drastic improvement in DPW's data management practices. Without better data collection and management, the department will be unable to measure cost-effectiveness satisfactorily.

Policy Alternatives

This section offers several policy alternatives. They include (1) continuing current service levels and operations practices, (2) reducing service levels and spending, (3) continuing current service levels with increased charges for off-street parking and parking violations, and (4) continuing current service levels with changes in operations practices. Changes in operations practices include developing performance measures, enhancing car removal and off-street parking, improving staff scheduling to reduce labor costs, managing data better, and modifying budgeting approaches.

Continuing Current Service Levels and Operations Practices

Politically, there is support for the current level of service. Aldermen D'Amato, Donovan, and Nardelli state that they receive few complaints regarding snow and ice removal (D'Amato, Donovan, Nardelli, 2001). They state that their constituents seem satisfied with the level of service Milwaukee provides. In fact, they believe that many citizens expect the current level of service and that reductions would be politically unpopular. In a written statement, Nardelli explained his view of Milwaukee's service level:

> I don't think Milwaukee provides too much snow and ice removal service. This is a service taxpayers expect and for all they pay in taxes, they should receive the current level of service. I see no reason for changing the current methods we employ to deal with snow and ice removal (Nardelli).

Reduction in Service Level

Though Milwaukee residents seem to appreciate the current service level, it may be desirable to reduce service. A cut in service will obviously save money, though the exact amount is uncertain. There is a variety of methods used to reduce service. First, plow trucks could be sent to clear the major artery roads only during smaller storms. Under the current system, crews are typically sent out on a full plow when snowfall reaches four inches, or earlier if the snow is wet and heavy. The policy could be changed so the plowing standard is six inches rather than four. The fewer plow runs that occur, the more money the city will save.

Another option would be to increase the time used to clear streets of snow. Currently, the city attempts to clear major roads within 12 to 18 hours after a snowstorm (Lorbeske et al., February 2001). Cleaning side streets takes longer, but drivers plow continually until all roads are clear. This results in significant overtime costs. By lengthening "service runs," overtime costs may decrease dramatically. Overtime is one of the largest components of the snow and ice operations budget (Lorbeske et al., February 2001). Because the decisions to remove snow and ice are subjective and reactive, it would be difficult to estimate cost savings and to establish levels of reduced service to measure the savings. No monetary cost figures are available, however, to separate how much savings would occur under a scenario such as the delaying of residential street snow and ice removal.

One area where service could be reduced is salt use on residential streets. Cost savings could be estimated for this service reduction. Milwaukee currently uses an average of 50,000 tons of salt annually with roughly 33 percent of that salt being used on residential streets (McDonnell, 2001). The issue is more complicated than simple numbers can determine. According to DPW's salting policy,

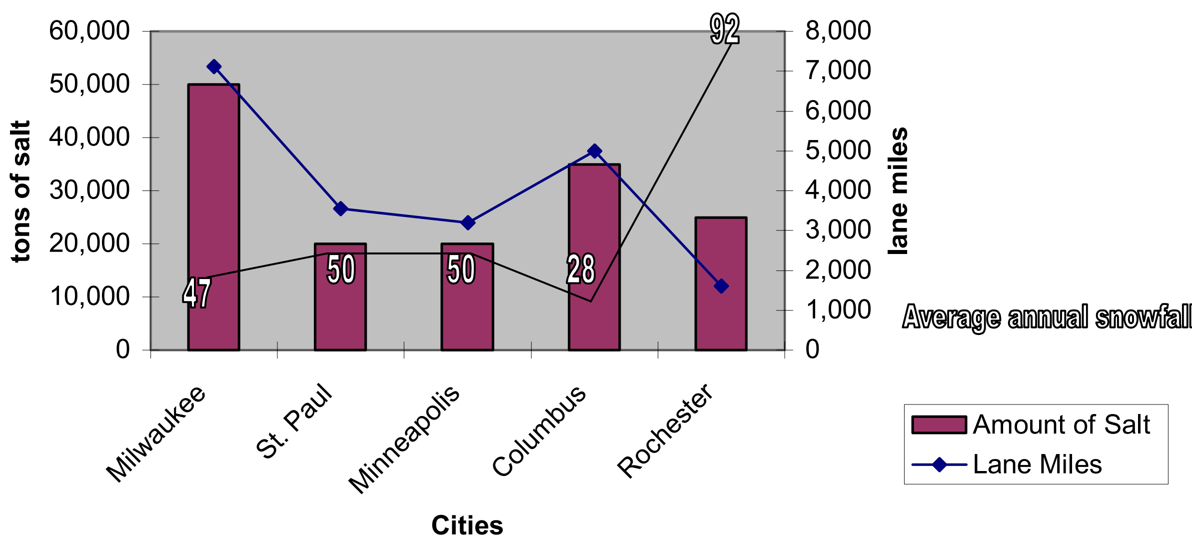
> Streets are prioritized for salting and snow plowing operations based on traffic volume, public transportation routes, access to emergency services and schools. The Sanitation Division does not automatically apply a uniform amount of salt throughout the city; salt is only applied where it is needed and

in an amount appropriate for conditions. Salt may be applied only to the main streets, or to bridges, hill stops, major intersections or slippery areas. Salt application rates are reduced on side streets (Milwaukee's Salting Policy).

Salting policy, like other snow and ice operations, differs among cities. St. Paul and Minneapolis both use less salt (20,000 tons each), although they have fewer lane miles than Milwaukee (Scaramuzzo, Kennedy, 2001). W e know that lane miles, area of the city, bridges, and terrain affect the amount of salt used. The Twin Cities also use a salt and sand mixture, something that Milwaukee's DPW feels is ineffective and costly to clean in the spring (Lorbeske, March 2001). Figure 3 shows a comparison of cities.

It is difficult to determine the benefit of salting on residential streets. Most cities use salt primarily on main arteries and at intersections. It is reasonable to suggest that streets would be passable after they are plowed, even if they are not salted. Milwaukee currently purchases salt for $27.13 a ton including delivery charges. Using the 2000 cost for salt, reducing residential salt service by one-half would save the city roughly $223,823 (McDonnell). A reduction in salt use in residential streets would lower labor costs also.

Figure 3
Comparison of Salt Usage



While these three reductions in service would increase savings for the city, safety could diminish. There would be political obstacles to a reduction in service as well. Alderman Thomas Nardelli from the 15th District added, "It is expensive to do full plowing operation. I think the Sanitation Department decisions are based on safety rather than budget, but I do know they do all in their power to minimize costs whenever and wherever they can" (Nardelli).

Maintaining Current Service Level with Changes in Parking

"The single biggest problem to efficient snow plowing is parked and abandoned cars" ("Snow and Ice Control in the City of Milwaukee"). These cars present obstacles to snowplows and do not allow for true curb-to-curb plowing. The snow buildup causes the street to narrow making it difficult for cars or emergency vehicles to travel through these streets. Often, plows must return to streets after cars have been towed. This is expensive and an inefficient allocation of resources. Towing is time consuming, challenging to coordinate, and hinders the effort to plow effectively. In a perfect world, people would comply with the parking regulations that are designed to have the streets clear to allow for effective plowing. Unfortunately, too many people do not pay attention, or choose to ignore the parking rules. To address this problem, we offer four alternatives.

Increased Off-Street Parking

One option for dealing with illegally parked cars is to increase the availability of off-street parking. We recognize the department's concern about being "heavy handed" by increasing ticketing and towing in dense urban areas without adequate off-street parking (Floyd). The city has made some progress in this area by opening Milwaukee Public School lots and playgrounds as well as other city owned lots to the public. If the city is going to make further progress in clearing the streets, it is important they continue to explore other off-street parking solutions. The city could work more with area businesses or churches with parking lots not being used at night. As an incentive, businesses can charge people to park in their lots. Alderman D'Amato stated that some businesses currently rent their lots to citizens (D'Amato). The city could encourage businesses to take advantage of this possibility.

Increased Ticketing

Increased ticket prices and enforcement could lead to behavioral changes in the parking patterns of Milwaukee residents. Higher fines and a greater probability of getting a ticket may induce drivers not to park illegally. If this occurs, the costs of additional plowing because of illegally parked and abandoned cars on the streets could decrease. Fewer cars on the road could also ease the problem of impassable streets that emergency vehicles could encounter.

During the December 2000 storm, the city did not have enough parking checkers to enforce snow emergency and alternate-side parking regulations. At various points during 2000, 20 of 45 parking checker positions were vacant (Borowski, 2001). DPW has tried to address this situation by hiring additional parking checkers and increasing the overall number of positions to 64. By the end of March 2001, only two of the sixty-four slots remained vacant (Sanders). This increase in parking checkers should lead to increased enforcement.

Another way to increase compliance with the current parking regulations is to raise the ticket fees for illegally parked vehicles. If the current $33 ticket (Floyd) for snow emergency parking violations does not deter illegal parking, a higher ticket price may be sufficient to induce compliance.

Increased Towing

During the winter storms in December 2000, thousands of cars were illegally parked which blocked plowing. Milwaukee's towing contractor, CHI, despite towing 1,000 cars per week, did not have the capacity to keep up with the high demand for towing (Borowski, 2001). The current towing contract requires that a certain amount of equipment be available for towing and that standards be met. For instance, contractors must respond within an hour to a police-reported citation and within 24 hours for abandoned vehicles. When the contractor is unable to meet these standards, they are required to subcontract the business to other towing companies (Sanders).

DPW has contracts for20 towing vehicles during the winter and has had as many as 30, but is reluctant to increase the amount. One challenge to increased towing is the limited space available in the impound lot. During the December 2000 storm, Milwaukee's impound lot was near capacity. Although the Summerfest grounds provide the city with a spillover lot, DPW would be responsible for staffing the lot, and there is no transportation that would bring people to the lot conveniently (Sanders).

One of the obstacles to increasing towing is that towing contracts are for annual services, and the biggest time of demand for the city is during the harshest months of winter. Most towing companies make their money during this time, and it is difficult to increase capacity without paying market price. Currently the city pays between $55 and $60 per tow, and up to $100 during heavy snowfall periods (Sanders).

Another obstacle to increased towing is DPW's view that increased towing would not help with plowing on the front end of storms. With limited towing capabilities, DPW believes that it is not possible to tow illegally parked cars in front of plowing crews. They also cite the fact that most violations typically occur 24 hours after the initial plowing operation, when vehicles can only be towed for not moving in 24 hours. As a result, the city has typically not towed cars for these violations (Floyd).

Milwaukee residents previously complained only about ticketing and towing, but more recently, they have expressed concern about illegally parked cars. Minneapolis officials have noticed the same trend and in the mid-1990s, they confronted the problem. Minneapolis Public Works increased its towing capability from 30 tow trucks to 80 tow trucks. Prior to 1997, Minneapolis typically wrote between 3,500 and 5,500 citations and towed between 600 and 900 vehicles in each snow emergency. Since increasing enforcement capabilities in 1997, Minneapolis has issued 7,000 to 10,000 citations per snow emergency; and 1,300 to 2,000 vehicles per snow emergency are towed by 65 to 80 tow trucks, depending on available personnel (Kennedy).

Minneapolis's decision to increase towing was part of a broader reorganization of the contracting and bidding processes, impound lot operations, and financial management. Logistical and contract issues for the towing operations had to be updated. Creative ways to increase ticket writing were found. Impound Lot operations and financial issues required adjustment, including storage issues that required expansion of the facilities (Kennedy).

A large reason for their program's success is the coordination between the towing contractors and snow and ice removal teams. Towing crews clear the arterial streets and dense neighborhoods prior to plowing. Streets and routes are prioritized, and towing contractors are equipped with route books.

Milwaukee DPW has already taken the first step toward better enforcement of winter parking regulations by increasing the parking checkers in the hope of encouraging people to move their cars thus making it easier and more efficient when plowing. It also has begun updating its parking enforcement protocol for snow emergencies, in coordination with the Milwaukee Police Department. Much of this updating includes prioritizing routes and allocating parking checkers more efficiently (Floyd). Increased towing could be included in this process. Removing cars from major thoroughfares and dense neighborhoods will increase public safety and reduce the amount of additional plows by snow removal crews.

Increase Cost of Parking Permits

The increased parking enforcement alternatives will be more politically acceptable if more off-street parking is available. Another way to capture the costs associated with parked cars is to increase the price of the city's on-street, night parking permits.

Currently, the charge for a quarterly parking permit is $10. The city sold 130,430 quarterly permits in 2000, raising $1,304,300 (Floyd). In the absence of significant off-street parking options, we assume the demand for these permits is fairly inelastic, and the number of permits sold would not decline significantly. A possible alternative is to raise the price of the quarterly permit by $3. Assuming the number of permits purchased does not change, revenue would increase by approximately $390,000. The revenue from this increase, however, goes to the City's General Fund, not to snow and ice removal policies.

One benefit of increasing this fee is that it imposes costs on those parking their cars on the streets. By charging those parking on the streets, the city captures some of the cost of re-plowing the streets.

Other Administrative and Operational Changes

In addition to changes proposed in the previous section, several other changes could be considered that would still maintain current service levels.

Restructuring Staff Scheduling

One of the greatest expenses of snow and ice removal operations is overtime pay. The timing of a particular storm can greatly affect the cost of the snow and ice removal. A storm requiring plowing and salting during the normal workday costs less than a storm in the evening when overtime must be paid. Three divisions of DPW—Sanitation, Building and Fleet, and Forestry—provide staffing for snow and ice removal. This means that during storms, workers leave their assignments to participate in snow and ice removal. Their normal work schedule is the standard Monday through Friday eight-hour shift from 7:30 a.m. to 4:00 p.m. or 7:00 a.m. to 3:30 p.m. (McDonnell). When snow and ice operation requires labor after these normal work hours, workers receive overtime pay and higher costs for the city. For example, the overtime incurred on December 11 and 12, 2000, for the Buildings and Fleet Division was $89,061 for 3,163 hours of overtime, and for the Sanitation Division it was $97,844 for 3,799 hours of overtime (Floyd), These numbers do not include the additional overtime associated with this storm for the delayed garbage and recycling collection.

One way to reduce overtime costs and have a ready workforce for snow and ice operations is to schedule workers using rotational shifts that cover more than an eight-hour day. For example, Milwaukee County DPW Highway Maintenance adds a second shift starting in mid-November and ending in the beginning of April so that they can promptly respond to snow and ice on highways and reduce overtime costs. The first shift, with 50 workers, is from 7:30 a.m. to 4:00 p.m., and the second shift, with another 50 workers, goes from 11:00 p.m. until 7:30 a.m. These two eight-hour shifts allow for a maximum of four hours of overtime each shift. The first overtime shift occurs immediately after the first shift, and the second shift has overtime for four hours before their scheduled shift, filling the middle eight hours between normal shifts. These workers can complete their normal tasks besides plowing during these later hours. Street repair, trash collections, and guardrail and fence maintenance, are tasks that accomplished during the later hours (Ponath, 2001).

Less overtime is needed, and the county is better staffed as workers are on duty, unlike Milwaukee DPW workers who need to be called in. Another major benefit is that these operators work no more than 12 hours consecutively, preventing burnout by plow operators. City of Milwaukee plow operators were plowing more than eighteen hours straight during December 2000, which could be considered a safety hazard (Lorbeske, et al., February 2001).

While managers at the city's DPW acknowledge the benefits of such a scheduling system and recognize the savings, they are limited by the current labor contract, among other things (McDonnell). There are questions regarding whether some of the residential jobs that involve working outdoors could be conducted during second and third shifts. These concerns would have to be considered, but even if a small portion of the staff worked a second or third shift, overtime pay could be reduced, and snow and ice teams could be better rested and more prepared. DPW acknowledges that during winter months when storms are not occurring there is not enough work for all staff. Consequently, they attempted to lay off as many as 54 employees in previous years during the winter months (McDonnell). The Milwaukee Common Council reversed this decision after strong union opposition. These workers are now limited to work such as sweeping the garages, washing trucks, and, according to one observer, "standing around" (Jagman). To quote one DPW official, "They don't do a whole lot." These jobs also do not depend on daylight or warmer weather and could easily be moved to a second shift. Switching to a rotational schedule would require reorganization within DPW; the cost savings and the potential improved operations response nonetheless make rotational shifts a viable option.

Performance Measures

Currently, DPW has no means of objectively measuring the efficiency and effectiveness of its snow and ice removal program. Although the department keeps a few output measures, such as average plow time, it lacks a systematic means of relating costs to performance. A system of performance measures could give DPW managers information they need to make effective operational decisions. For example, the department could allow managers to diagnose where the snow and ice control program is efficient and effective and where it is not, so managers could more accurately apply corrective measures to problem areas. Performance measures could also make the department more accountable to city executives and the public, and may allow the city to budget more accurately for snow removal.

ICMA developed pseudo-performance measures for snow and ice removal in *Comparative Performance Measurement*. ICMA's measure is simply per capita snow and ice removal expenditures. Per capita expenditures are plotted against the number of days with freezing or snow conditions (ICMA, 2000). Although Milwaukee did not participate in the ICMA study, we calculated its performance using the same criteria. These figures are represented in Table 1.

Performance measures are not widely used by U.S. cities for snow and ice control, and the few measures we encountered did not account for different types of snow or the quality of roads after a plow. Therefore, if Milwaukee adopted the performance measures developed below, they would need to compare cost and quality changes. The measures should be taken after each plowing, and the total should be aggregated to provide citywide performance measures. For more accurate measures, DPW analysts could measure the cost and quality of service in various city precincts, so they can determine which areas of the city are not being plowed effectively. Managers could combine measures annually from different precincts to provide annual weighted averages.

The ICMA performance measure does not measure quality of service, account for differing population densities within cities, or provide unit costs of service. A better performance measure relates costs to lane miles rather than population, since lane miles plowed is the product DPW provides.

Performance measures provide unit costs of providing a service. A unit cost is calculated by dividing the cost of the inputs of a good by the amount of output (input/output). The simplest measures examine only product and cost. *Performance Measure 1* is a ratio of the actual expenditures of snow and ice control to the number of streets plowed and the amount of freezing precipitation. The resulting unit measure is dollars per lane mile per inch of freezing precipitation. However, a better performance measurement system not only measures the cost efficiency of a service, but also its effectiveness. *Performance Measure 2* measures quality of service. To calculate *Performance Measure 2,* trained observers within DPW would examine the quality of roads after DPW has done a first-run plow or salting after a precipitation event. The trained observers would have a standard set of photographs depicting roads in varying degrees of maintenance with which to compare the observed street condition. They would then rate the quality on a scale from zero to one. Observers must be trained so two observers rate the same conditions equally and so individual observers are consistent in their ratings. To contain the costs of this analysis, the trained observers would monitor only a sample of roads rather than all roads.

Performance Measure 3 measures cost-effectiveness of service. It is calculated by dividing the unit costs found in *Performance Measure 1* by the quality rating found in *Performance Measure 2*. It does not show actual dollar expenditures, but is simply an analytic tool showing dollars weighted for quality. Cost saving measures that do not reduce the quality of service will show reduced unit costs in *Performance Measure 3*. However, cost saving measures that substantially lower quality could yield higher unit costs in this measure. For examples of the performance measures with generated numbers, see Appendix D.

Performance Measure 1: Efficiency. This ratio measures the efficiency of the snow removal program. It weights the various types of snow differently, since it is more costly to control wetter, heavier substances. The numbers in the weighting system below are illustrative only. DPW managers could weight the different types of freezing precipitation as they see appropriate. However, once a weighting system is established, it should remain constant.

$$\frac{\textit{expenditures}}{\textit{(lane miles) x (inches of freezing precipitation)}}$$

where:

- *Expenditures* are measured in dollars

- *Lane miles* are 5280 feet, but width can vary. *Lane miles* equal the number of miles plowed after each precipitation event. If the city must plow or salt the same stretch of road more than once for a single snowfall event, the lane miles will only be counted once, but the cost of multiple plowings should be added to the total.
- 1 inch of dry snow equals 1 inch of *freezing precipitation*
- 1 inch of wet snow equals 1.5 inches of *freezing precipitation*
- 1 inch of freezing rain equals 2 inches of *freezing precipitation*

Performance Measure 2: Effectiveness. This equation measures the quality of snow and ice control service. The measure can be taken for individual precincts or for the entire city. The final figure will be a quality rating, from zero to one, with one meaning that all streets are plowed to bare pavement. City managers can also adjust the weighting system before initially using the measure. The measure would be taken after each freezing precipitation event. If no plowing or salting is done after it precipitates and if the storm was equally spread over the precinct or city, a quality rating from a very small sample can be applied to the whole area or city.

$$\frac{\Sigma(\textit{precinct lane miles x quality rating})}{\textit{total precinct lane miles}} \quad \text{Or} \quad \frac{\Sigma(\textit{city lane miles x quality rating})}{\textit{total city lane miles}}$$

where:

- The *quality rating* should be measured by the trained observers after the worst of the precipitation event has passed. If plows or salt trucks are deployed, measures should be taken after they have made at least one pass.
  - Ice ratings are as follows: 1 for bare pavement, normal traction; 0.9 for wet but not frozen; 0.75 for heavy slush; 0.50 for navigable but caution required; 0.20 for treacherous.
  - Snow ratings are as follows: 1 for bare pavement; 0.75 for navigable packed snow; 0.6 for navigable for most cars but caution required; 0.2 streets not navigable for most cars.
- Milwaukee has 7,112 *Total City Lane Miles.* The sum of *City Lane Miles*, when not multiplied by a *Quality Rating*, would equal exactly 7,112.

Performance Measure 3: Cost -Effectiveness. Cost-effectiveness is measured by dividing *Performance Measure 1* by *Performance Measure 2.* DPW managers can use this equation to make budgeting decisions and diagnose problems. Because *Performance Measure 2* is a percent in the denominator, lower quality ratings will yield higher unit costs. Where the cost of providing better service exceeds the benefit, the performance measure will show higher unit costs. The measure should be taken after each precipitation event, and then aggregated to obtain annual figures.

$$\frac{\textit{expenditures}}{(\textit{lane miles}) \text{ x } (\textit{inches of freezing precipitation})} \div \textit{Quality Percent}$$

where:

- Expenditures, lane miles, quality percent, and inches of freezing precipitation are figured the same as Performance Measures 1 and 2.

To determine whether performance is acceptable, the annual performance must be compared to a relevant standard. Under this alternative, a standard benchmark or goal by which to measure its performance must be developed. The benchmark is a number, based on the above equations, toward which the snow removal program should strive. Because to our knowledge no other cities are using the same performance measures, the city would have to arbitrarily set its own benchmark at a level that is challenging yet attainable. After current performance measures are taken, DPW managers should cooperate with budget office personnel to establish a benchmark performance level that is slightly more stringent than what is currently being attained.

Each precipitation event presents unique challenges. Snow and ice control managers should exercise caution in interpreting the measures for each snowfall. It is reasonable to expect that some plowing efforts will fall short of the benchmark, and others will exceed it. The goal is to have the yearly performance measure meet or exceed the benchmark. DPW managers can establish control charts that define the acceptable limits of performance. If performance measures consistently fall outside the acceptable limits, managers will know there is a problem that needs to be addressed.

These performance measures attempt to provide a detailed and fair means of evaluating snow and ice removal service. They should not be used solely to evaluate performance. Rather, they are meant to bring problems to light so that they can be solved, and to keep decision makers more informed.

Budgeting Alternatives

The purpose of a budget is to control and predict costs. Budgeting is rarely accurate for snow and ice control because of the unpredictability of snowfall and related weather conditions. DPW budgets according to the "average" winter, where the average response is four plowings and 26 saltings. However, Appendix B reveals the inadequacy of the system. Not only do the actual number of plowings and saltings vary from year to year, but the costs of those plowings also differ, due to a variety of weather factors. In 1997 and 1999, DPW plowed the entire city four times each year. In 1997 the city salted 38 times, whereas in 1999 it salted only 26 times. In 1999, however, the city used almost seven more tons of salt and spent approximately $2.4 million dollars more than it did in 1997. These figures show that average numbers of saltings and plowings are not an accurate means of predicting snow and ice control costs. A better alternative bases the costs on a performance measure benchmark, as suggested earlier. It could then budget according to the formula:

$$\left(\frac{\textit{Benchmark Expenditures}}{\textit{(lane miles) x (in. of freezing precip.)}}\right) \times \textit{(average annual lane miles plowed) x (avg. annual weighted in. of freezing precipitation)}$$

Although there will still be great variation in the amount of snowfall from year to year, budgeting with benchmarks could provide more accurate budget predictions.

To reduce the impact on the city budget from remaining unpredictability, at least two strategies could be employed for distributing the snow removal expenditures more evenly from year to year. The strategies could be implemented alone or in tandem. The first strategy is to purchase snow insurance. The city could purchase an insurance policy from a private vendor, paying yearly premiums. The policy would pay the city for every inch of snow that fell above a critical amount. The critical amount could be determined by adding 15 or 20 inches to the annual weighted snowfall average. Because snow insurance is a relatively new phenomenon among U.S. cities, there is currently not enough data to assess its cost-effectiveness. Because insurance companies must make a profit, we can assume that over the long run, the city will pay more in premiums than it will collect from the company. Therefore, the city policymakers must decide how much reducing the financial impact of a winter like 2000–01 is worth.

The second strategy is to create a Snow Contingency Fund. The city would establish the fund, and DPW would be responsible for building the fund in years when snow and ice spending is under budget. The Snow Contingency Fund could include enough money each year to assist snow and ice operations during harsher winters. Rather than withdrawing from the general city contingency fund, DPW would have their own fund. The fund should be capped, after which additional surpluses would be returned to the general fund. This option would be advantageous, especially when a budget deficit is possible. In 2000, Milwaukee's $12 million shortfall forced the city to borrow money; a major component of this shortfall was snow and ice control for the December storms (Borowski, 2001).

Criteria for Selecting Alternatives

When considering alternative policies for snow and ice control, policy analysts need a set of criteria to select alternatives that are most appropriate. Our criteria include economic efficiency, political feasibility, democratic accountability, and egalitarian treatment of individuals.

First, when selecting an alternative, it is important that city dollars are used efficiently and effectively. Since it is beyond the scope of this paper to evaluate the city's other budgetary needs, we assume that snow and ice control spending is placing a burden on the budget, and measures ought to be taken to ease this burden.

The second criterion is political feasibility. Policymakers should be able to implement the alternative within the current political constraints. The alternative must be acceptable to the controlling councils and elected executives, who are accountable to the public. The policy must accord with the public mandate, communicated through the voting process. Managers who hope to implement the alternative must be able to garner support from the Public Works operators, who may resist a change in policy. If the alternative involves a change in labor policy, the Public Works labor union should at least be willing to negotiate on the terms. We have assumed that constituents prefer the current level of service, and any that cuts in service could have political implications.

The third criterion for selecting the proper snow and ice control alternative is democratic accountability. The alternative should make DPW transparent to public scrutiny in operational and budgetary areas, so voters can make informed decisions regarding snow and ice control service.

Finally, the alternative should not disproportionately harm any population within the city, especially low-income residents. This does not, however, preclude the use of user fees or other measures that correct for residents whose actions directly add cost to the snow and ice control program. For example, more forceful measures could be adopted to address the amount of illegally parked cars, while still treating populations in an egalitarian manner.

Recommendations

We recommend that Milwaukee continue its current level of snow and ice removal service. Our investigation did not reveal substantial inefficiencies in the way DPW provides service. Cuts in service would likely cause a public outcry, because snow and ice removal is visible to residents and businesses. Additionally, without prior implementation of defined performance measures, it is unclear how much money the city would save by reducing service. We recommend the following alternatives to reduce costs while maintaining the current service level:

- ✓ **Implement rotational scheduling during winter months.**
- ✓ **Increase off-street parking through a cooperative effort with the private sector.**
- ✓ **Increase towing during snow emergencies.**

We recommend that DPW create a rotational scheduling system for snow and ice control employees during the winter months. The system would distribute employees over two shifts rather than one, and would cap the amount of overtime a plow operator could work at four hours per day. This system would reduce overtime expenditures and increase public safety by allowing plow operators to drive no more than twelve hours at a time.

Cars parked on streets during snow emergencies create obstacles to plow operators and can reduce the efficiency and effectiveness of snow and ice control efforts. One solution is to increase the availability of off-street parking, especially in dense areas such as Milwaukee's East Side. In the 2000–01 winter, DPW encouraged local public schools to open their lots to the public during snow emergencies. We recommend the city continue to expand cooperative partnerships with private businesses and churches. These private organizations can charge people to park in their lots during snow emergencies.

If the city can increase the availability off-street parking, DPW would be justified in more aggressively enforcing current parking laws. More enforcement could lead to more ticket revenue for the city and would give residents incentives to park elsewhere. Increased towing of automobiles would reduce obstacles to plows and increase their efficiency and effectiveness.

To increase accountability at DPW, more accurately budget for snow and ice control operations, and measure the cost-effectiveness of the previous recommendations, we also advise that DPW:

- ✓ **Adopt performance measures for the Snow and Ice Control Program.**

Using these performance measures, managers could make informed decisions to correct inefficiencies and potentially save the city money. Prior or simultaneous to creating performance measures, DPW managers would need to improve data collection and data management. We recommend DPW record:

- The amount of freezing precipitation weighted for type,
- Lane miles plowed,
- Observations of street quality after plows,
- Number of plow passes on the same street after a single snowfall, and
- A detailed record of expenditures, including overtime paid during snow and ice control operations.

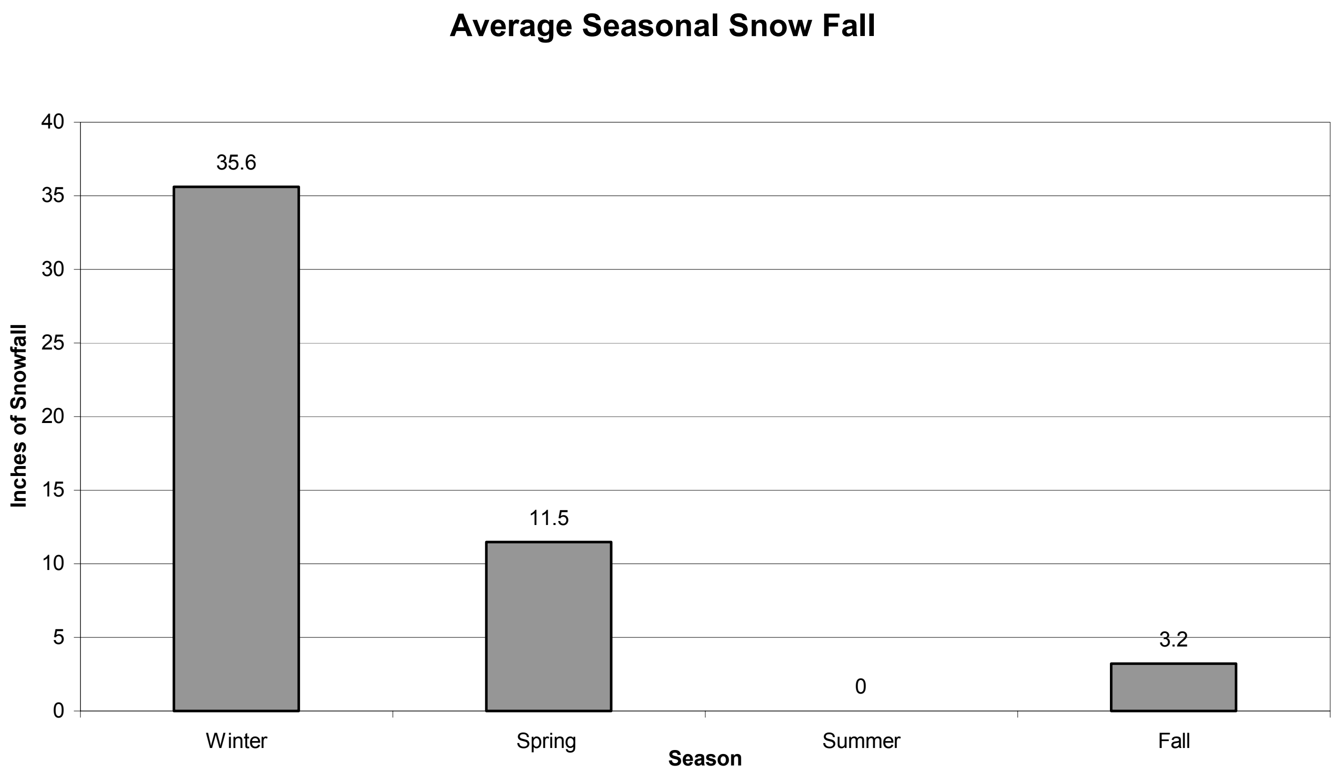
Although the creation and maintenance of snow and ice control performance measures requires an investment of time and money, this investment could yield long-term savings. If the city adopts performance measures, then it should use benchmark performance measures to budget more accurately for snow and ice control services.

To reduce the variation in costs for snow removal operations from year to year, we recommend that Milwaukee

✓ **Create a Snow Contingency Fund within DPW.**

The Department of Public Works provides excellent snow and ice control service to residents of Milwaukee. Implementing the above recommendations would allow DPW to maintain its tradition of excellent service but at a lower and more consistent price.

Appendix A



Average Seasonal Snow Fall
Inches of Snowfall
40
35
30
25
20
15
10
5
0
35.6
11.5
0
3.2
Winter
Spring
Summer
Fall
Season

Appendix B
Snow and Ice Removal in Milwaukee: Budgets and Actual Operations

			Number of Operations						
	Funding		*Plowing*		*Ice Control*		*Tons of Salt*		*Inches*
Year	*Budget*	*Actual*	*Budget*	*Actual*	*Budget*	*Actual*	*Budget*	*Actual*	*of Snow*
1997	$6,004,424	$6,233,087	4	4	26	38	32,700	56,859	51.9
1998	$6,011,324	$4,149,443	4	2	26	28	42,000	33,092	43.3
1999	$6,562,888	$8,681,087	4	4	26	26	42,000	63,807	59.3
2000	$6,423,219	$10,727,038	4	11	26	49	42,000	102,098	89.9
2001	$7,267,392	NA	4	NA	26	NA	50,000	NA	NA

Source: Milwaukee Department of Public Works

Appendix C
Comparison of Per Capita Expenditures, Snow Fall, and Lane Miles Across Selected Cities

City	Approximate Per Capita Expenditures	Snow Fall	Lane Miles
Minneapolis, MN	$16.75	56	3200
Milwaukee, WI	$14.50	47	7112
Worcester, MA	$14.40	41	1058
Canandaigua, NY	$12.20	93	99
Cincinnati, OH	$9.50	25	2352
Calgary, Alberta	$8.25	28	7545
Bloomington, MN	$7.75	56	1585
Salt Lake City, UT	$2.75	42	1700
Portland, OR	$0.25	0	3855
Fort Worth, TX	$0.10	1	5600
Reno, NV	$1.50	16	1686
Richmond, VA	$1.20	16	1840
Eagan, MN	$4.16	61	616

Model: **Per Capita Expenditures=β_0 + β_1Snowfall + β_2Lane Miles + ε**

Predicted: **Per Capita Expenditures=-2.35 + .181Snowfall + .001Lane Miles + ε**

Predicted Milwaukee: **Per Capita Expenditures=β_0 + β_1Snowfall + β_2Lane Miles + ε**

SUMMARY
OUTPUT

Regression Statistics	
Multiple R	0.729196759
R Square	0.531727913
Adjusted R Square	0.438073496
Standard Error	4.457239763
Observations	13

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	225.5917332	112.7958666	5.677552945	0.022516006
Residual	10	198.6698631	19.86698631		
Total	12	424.2615963			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-2.348872652	3.374952874	-0.695971985	0.502300627	-9.868737575	5.170992272
Snow Fall	0.180802687	0.053792955	3.36108488	0.007229105	0.060944494	0.300660881
Lane Miles	0.000959513	0.000586955	1.634730326	0.133151718	-0.000348304	0.00226733

Appendix D
Performance Measure Examples

Assume the Precinct A of the city has 1,789 total lane miles. Precinct B has 898 total lane miles and is heavily congested with parked cars. Precinct C has 452 lane miles. Precinct D has 765 lane miles. Precinct E has 1,209 lane miles. One evening, 0.75 inches of freezing rain falls, and then turns to three inches of heavy, wet snow. The next morning, city plows cover the three precincts. In precinct A, salt trucks make one pass, and plows make one pass, which sufficiently clears the roads. In Precinct B, city plows must make three passes to sufficiently clear the streets. Precincts C are never plowed or salted. In Precinct D, DPW experiments with a new technology that more efficiently spreads salt. Precinct D is sufficiently cleared after one salting and one plow. Precinct E is plowed once, but is not salted. After the storm has passed and the plowing effort has ended, trained observers rate a sample of the streets. Precinct A gets rated 1 for bare pavement. 200 lane miles of Precinct B gets rated 0.6 because it is navigable for most cars but caution is required, and the remaining 698 get rated 1. Precinct C is rated 0.2 since most cars cannot navigate the streets. Precinct D is rated 1. Precinct E is rated 0.75 because a layer of packed snow covers the street. The cost to salt and plow Precinct A $139,542. The cost of the three plow runs and saltings in precinct cost B costs $109,556. There are no costs in Precinct C. The department spends $55,080 to plow Precinct D and $76,167 to plow precinct E. How efficient, effective, and cost-effective is the plowing effort?

First, the inches of freezing precipitation are weighted for type. (1 inch of dry snow equals 1 inch of *freezing precipitation,* 1 inch of wet snow equals 1.5 inches of *freezing precipitation,* and

1 inch of freezing rain equals 2 inches of *freezing precipitation)*

(0.75 inches of freezing rain *x* 2) + (3 inches wet snow *x* 1.5)= 6 inches freezing precipitation.

Precinct	*Lane Miles*	*Weighted Inches of Freezing Precipitation*	*Cost*
A	1789	6	$139,542.00
B	898	6	$109,556.00
C	452	6	$0.00
D	765	6	$55,080
E	1209	6	$76,167

Performance Measure 1 is taken for each precinct to measure efficiency.

$$\frac{\textit{\textbf{expenditures}}}{\textit{\textbf{(lane miles) x (inches of freezing precipitation)}}}$$

Precinct A unit costs = $87,552/(1789 lane miles x 6 inches freezing precipitation)=
$13 per lane mile per inch of freezing precipitation.

Precinct B unit costs = $109,556/(898 lane miles x 6 inches freezing precipitation)=
$20.33 per lane mile per inch of freezing precipitation.

Precinct C unit costs = $0/(452 lane miles x 6 inches freezing precipitation)=
$0 per lane mile per inch of freezing precipitation.

Precinct D unit costs = $55,080(765 lane miles x 6 inches freezing precipitation)=
$12 per lane mile per inch of freezing precipitation.

Precinct E unit costs = $76,167(1209 lane miles x 6 inches freezing precipitation)=
$10.50 per lane mile per inch of freezing precipitation.

Performance Measure 2 is taken to measure quality of streets and effectiveness of plowing effort.

$$\frac{\boldsymbol{\Sigma}\textit{\textbf{(precinct lane miles x quality rating)}}}{\textit{\textbf{total precinct lane miles}}}$$

Precinct A quality = (1789 lane miles x 1.0)/1789 lane miles = 1.0

Precinct B quality = [(200 lane miles x 0.6) + (698 x 1)]/898 lane miles= 0.91

Precinct C quality = (452 lane miles x 0.2)/452 lane miles= 0.2

Precinct D quality = (765 lane miles x 1.0)/765 lane miles= 1.0

Precinct E quality = (1209 lane miles x 0.75)/1209 lane miles= 0.75

Performance Measure 3 is taken to measure cost effectiveness.

$$\frac{\textbf{\textit{expenditures}}}{\textbf{\textit{(lane miles) x (inches of freezing precipitation)}}} \div \textbf{\textit{Quality Percent}}$$

Precinct A cost effectiveness = \$13/lane mile, inch precip. ÷ 1.0 = \$13/lane mile, inch precip.

Precinct B cost effectiveness = \$20.33/lane mile, inch precip. ÷ .92 = \$22/lane mile, inch precip.

Precinct C cost effectiveness = \$0/lane mile, inch precip. ÷ .2 = \$0/lane mile, inch precip.

Precinct D cost effectiveness = \$12/lane mile, inch precip. ÷ 1.0 = \$12/lane mile, inch precip.

Precinct E cost effectiveness = \$10.50/lane mile, inch precip. ÷ .75 = \$14/lane mile, inch precip.

Precinct	*Actual Unit Cost (\$/lane mile x in. freezing precip.)*	*Quality Percent*	*Quality Adjusted Unit Cost (\$/lane mile x in. freezing precip.)*
A	\$13	1.0	\$13
B	\$20.33	0.92	\$22
C	\$0	0.2	\$0
D	\$12	1.0	\$12
E	\$10.50	.75	\$14

Interpretation

In this example, we presume that DPW used standard procedures to control snow and ice using one salting and one pass with city plows. If the \$13 is a common figure for DPW and is considered reasonably efficient, a benchmark unit cost would be established at \$13 or slightly lower. Because the effort yielded perfect quality, the quality-adjusted unit cost is the same as the actual unit costs. In Precinct B, illegally parked cars presented a major obstacle and required multiple plowings. The high unit costs reflect the reduced efficiency. Because the quality rating was less than perfect, the quality-adjusted unit cost is higher still. These high figures would alarm DPW managers, who would determine the problem in that precinct. In Precinct C, DPW incurred no unit costs because it did not plow in this precinct. Because *Performance Measure 3* cannot adjust for zero costs, the quality-adjusted rating also yields \$0. When the quality adjusted unit cost equals zero, it is flawed and should not be included in any aggregate performance measure for the city. In Precinct D, the city piloted a new technology that increased efficiency and did not reduce quality. Both the actual and quality adjusted unit costs are lower than the benchmark, indicating that the new technology successfully improved the cost-effectiveness of service. In Precinct E, DPW tried to save money by using less salt. Although the actual unit costs were lower than the benchmark, the quality-adjusted unit cost, which is higher than the benchmark, reveals that the measure is not cost-effective.

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Acknowledgments

We would like to thank Thomas Bell and the entire Milwaukee Budget Office for sponsoring this project. We also appreciate the assistance from the Department of Public Works, including Dorinda Floyd, David Lorbeske, Tom Sanders, Dick McDonnell, Michael Englebert, and Greg Jagman. We also thank Aldermen Mike D'Amato, Thomas Nardelli, and Bob Donavan for their unique perspective on this issue. Roger Goodwin of Madison, Mike Kennedy of Minneapolis, and Paul Nato of Rochester, NY were also very insightful and we thank them as well. Finally, we wish to thank Andrew Reschovsky, Terry Shelton, and Alice Honeywell for their encouragement and guidance.