Snow and Ice Control

Report #95-06

May 1995

A Best Practices Review

Office of the Legislative Auditor
State of Minnesota

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Preface

This report is a *best practices review* — a new kind of report from the Legislative Auditor. The report identifies some of the best techniques for snow and ice control in Minnesota. It is based on a statewide survey of the current practices of counties, cities, and townships, as well as the latest research findings of scientists and road maintenance engineers.

The purpose of the report is to catalog effective methods of snow and ice control, demonstrate the conditions under which they may be successful, and encourage their adoption wherever appropriate throughout the state.

- **This report is not intended to create a new standard of conduct which local governments must meet, nor does it assume that any particular practice can or should be adopted everywhere.**

Instead, this report should be used as a source of ideas — both old and new — that may be helpful to jurisdictions facing the perennial challenge of keeping roads safe and passable. We hope that Minnesota's local governments will actively use this report to examine their own practices and consider alternative ways of getting the job done as cost effectively as possible.

This best practices review was recommended for study by the Local Government Advisory Council, including representatives from the Association of Minnesota Counties, the League of Minnesota Cities, and the Association of Metropolitan Municipalities. It was authorized by the Legislative Audit Commission in September 1994.

We appreciate the assistance of many local public works directors, road engineers, street superintendents, and snowplow operators, including members of our technical advisory panel, who provided us with information through surveys, focus groups, interviews and conversations. The report was researched and written by Jody Hauer (best practices coordinator), Gary Berger, Jennifer Moenck Feige, Don Feige, and Connie Reimer, with assistance from Rich Romness.

Saint Paul, Minnesota
May 11, 1995

Snow and Ice Control

A Best Practices Review

Executive Summary

In some years, keeping roads clear of ice and snow in Minnesota is a six-month long effort. It involves multiple decisions made by hundreds of individual agencies around the state. And because the roads can be very different — some carry tens of thousands of vehicles a day while others carry a couple of hundred, some are paved while others are gravel — how local governments maintain them during the winter can vary as well.

This is a review of local governments' snow and ice control practices in Minnesota. It highlights some of the practices that counties, cities, and townships have found to be effective or efficient. We hope that the information may be useful to local governments that are interested in how others similar to them control snow and ice on the roads.

DIFFERENT ROADS REQUIRE DIFFERENT SNOW AND ICE CONTROL

Counties, cities, townships, and the state are involved in controlling snow and ice on roads. Each level of government has roads under its jurisdiction and has discretion over how to maintain them in the winter months. The state does not govern how local jurisdictions maintain roads.

Counties, cities, and townships have road systems quite different from one another, requiring different snow and ice control services. Generally speaking, cities spend more time and resources on plowing because their plow operators have to drive at slower speeds to contend with driveways, cul-de-sacs, intersections, alleys, and traffic. In contrast, operators plowing long stretches of uninterrupted county or township roads usually cover miles more quickly. Cities' costs per lane mile tend to be higher as a result. (See the following figure.) Cities typically have more operators per lane mile and spend more snowplow personnel hours on snow and ice control per lane mile than counties or townships.

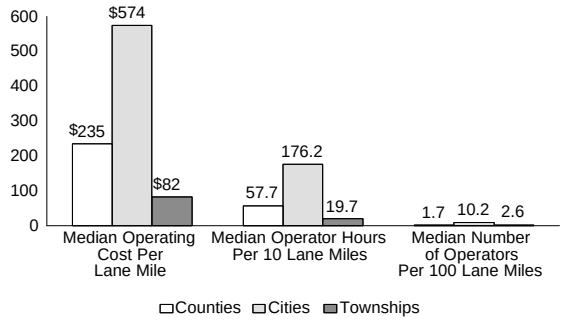
Many cities plow cul-de-sacs, deadends, alleys, and sidewalks while counties and townships usually have fewer or none of these features in their road systems. Many cities also have areas such as business districts where they must not only plow snow but also load and remove it. In contrast, fewer counties and townships load and haul snow. Further, cities have fewer miles of gravel roads than counties or townships. Compared with paved roads, gravel roads generally require lower levels of winter maintenance. These differences among the types of road systems and their required levels of service lead to higher costs for cities than counties or towns.

This review highlights snow and ice control practices that some Minnesota counties, cities, and townships have found effective or efficient.

Minnesota
Office of the
Legislative Auditor

May 11, 1995

Costs, Hours, and Number of Operators for Snow and Ice Control



Source: Office of the Legislative Auditor snow and ice control survey.

What is a best practices review?

This report identifies some of the best techniques for snow and ice control in Minnesota. It is based on a statewide study of the current practices of counties, cities, and townships, as well as the latest research findings of scientists and road maintenance engineers.

The purpose of this report is to catalog effective methods of snow and ice control, demonstrate the conditions under which they may be successful, and encourage their adoption wherever appropriate throughout the state. Unlike a regular audit or evaluation, this report does not focus on deficiencies, but highlights successful practices.

We hope that Minnesota's local governments will actively use this report to examine their own practices and consider a range of ideas for ensuring safe and passable winter roads.

This best practices review is part of a program created by the Minnesota Legislature in 1994 to identify best practices in local government service delivery.

EFFECTIVE SNOW AND ICE CONTROL

What makes for effective snow and ice control? Although many factors are involved, timing is critical. Once ice and snow bond to roads, the time and effort required to plow or clear them dramatically increases. In addition, traffic traveling over the road compacts the snow, making plowing even more difficult. Consequently, the sooner an agency initiates action, the more likely it will succeed. To make a timely response to snow and ice, agencies have to prepare in advance with trained staff, fully functioning and well-maintained equipment, adequate supplies of sand, salt, or other materials, and methods for communicating with the traveling public.

We have identified 12 actions for effective snow and ice control. The actions represent items that agencies typically consider in planning their system of snow and ice control. They affect an agency's ability to respond to snow and ice on the roads in a timely and effective manner. Some of the 12 actions deal with how agencies organize, administer, and manage their snow and ice control. Others deal with the agencies' day-to-day operations.

Many local governments already take, or have considered, these actions in their snow and ice control programs. They use a variety of practices and styles to implement the actions, some of which we list in this review. The practices included here are those that local governments have found help them save time, reduce labor, cut costs, increase their level of service, or otherwise improve their ability to get the job done.

Not every practice listed, however, can apply to every local jurisdiction. Areas with high levels of vehicle-miles traveled, for instance, will likely require different practices than areas with low traffic levels. Jurisdictions will have to come to their own decisions on what practices make sense for them given the characteristics of their road systems.

We first discuss the five actions dealing with administering and managing effective snow and ice control. Then we discuss seven actions which can help with day-to-day operations.

ADMINISTRATION AND MANAGEMENT

We identified five actions relating to administration and management which contribute to effective and efficient snow and ice control operations. These are: adopt written snow policies; encourage cooperative or coordinated snowplowing services or fa -

Actions for Effective Snow and Ice Control

ADMINISTRATION AND MANAGEMENT

- Adopt written snow policies
- Encourage cooperative snowplowing services and facilities
- Contract for services, when appropriate
- Measure performance and maintain records
- Plan for equipment replacement

OPERATIONS

- Foster a quality work force
- Prepare plans for routing, scheduling, and obtaining weather forecasts
- Select, store, and apply materials appropriately
- Communicate with the public
- Apply appropriate snowplowing techniques
- Use passive snow control measures
- Employ equipment improvements and preventive maintenance

cilities; contract for service when appropriate; measure performance; and plan for equipment replacement. We briefly discuss each of them and some of the practices local governments are using that illustrate the value of these actions.

Adopt Written Snow Policies

Writing and adopting policies to guide snow and ice control programs can protect the jurisdiction, help employees, and instruct the public. A written snow policy might address the timing of plowing or sanding, priorities in routes and procedures, general guidelines for the use of materials, and flexibility to change procedures in response to weather and road conditions. We surveyed 520 local governments in Minnesota and found that slightly more than one-half of counties and cities, and a smaller share of townships, have written policies that guide their snow and ice control.

If adopted by a jurisdiction's legislative body, policies that balance the competing needs of road safety, employee safety, and fiscal constraints, can offer some protection to communities against liability for accidents. An agency can also use written policies to familiarize employees with the jurisdiction's standards and expectations. Finally, written policies can help educate residents about what to expect from the jurisdiction's program of snow and ice control.

Owatonna's snow removal policy explains the typical circumstances under which the street department will commence plowing, sanding, and hauling snow. Owatonna plows all streets after two inches have fallen; plowing begins at midnight unless snow is still falling. The policy also states that plowing will be done at the discretion of the lead street personnel when fewer than two inches of snow falls. The policy sets priorities among its snow and ice control activities, specifying that the street department will plow and sand all arterial streets first. Sanding priorities are also listed. The policy states that the department hauls snow out of the downtown area the night after plowing is completed; it also lists the order of priority for clean-up activities.

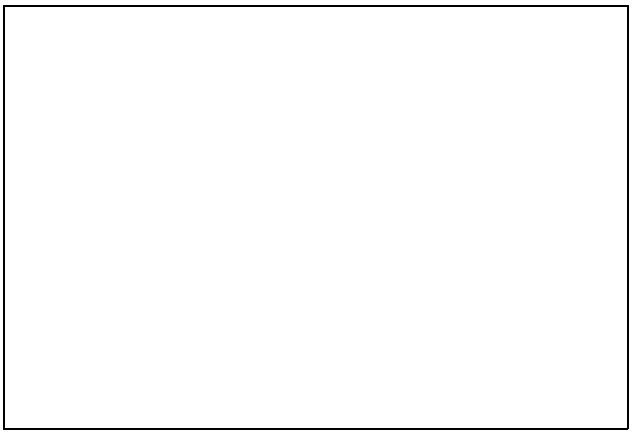
Agencies may want to state in their policies that they reserve the flexibility to change their procedures depending upon the type of snow, wind, and times of day the snow falls. For flexibility in adapting to variable weather and road conditions, an agency may want to specify details on specific techniques and practices in a document other than the policy adopted by the governing body. To make the policy workable, agencies can involve operators in developing the policy, as well as in reviewing and updating it as needs dictate.

Encourage Cooperative Services and Facilities

Local governments that coordinate services or share resources may be able to curtail expenditures, avoid duplication of services, eliminate unnecessary purchases of equipment and facilities, and use employees more

The townships of ***Hawk Creek, Ericson, Wang, Sacred Heart, and Crooks*** in Renville County share the costs of a road maintenance association. Controlled by a board of the participating township supervisors, the association hires two employees who provide snow and ice control services as well as summer maintenance on township roads. The participating townships pay an hourly rate for snowplowing plus a charge per mile of road each year for the depreciation of the association's three motor graders, plows, and wings.

effectively. Salt storage sheds or refueling stations are examples of facilities that jurisdictions could share. For smaller communities, jointly providing snow and ice control may be more cost effective than providing the service individually. According to our survey, many local jurisdictions already share snowplowing equipment, duties, or personnel.



Waseca County uses one of the bins in a state-owned salt storage facility.

Contract for Service, or Parts of Service, When Appropriate

When a service requires special types of vehicles, additional equipment, or additional staff, a jurisdiction can consider contracts with other local governments or private providers. In these situations, contracting for some or all snow and ice control services may be more cost effective than having an agency provide the service itself. About 74 percent of the townships responding to our survey contract with other local governments or private contractors for all of their snow and ice control. No counties and less than 10 percent of cities contract for all of their snowplowing routes.

White Bear Lake contracts with private companies to plow the city's 78 cul-de-sacs, as well as its alleys and parking lots. White Bear Lake does not have the equipment it needs to plow cul-de-sacs efficiently, and the city believes it is more cost effective to contract for this service than to provide the service with its own employees and equipment. White Bear Lake's public works department plows city streets while contractors plow cul-de-sacs, allowing them to usually finish all plowing on the day following a snowfall.

Measure Performance and Maintain Records

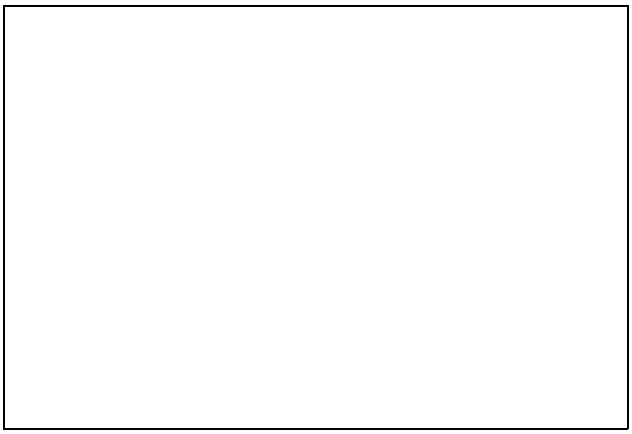
Local jurisdictions may be able to improve their snow and ice control services by measuring the effectiveness of services they provide. Measuring performance, or the results of services, provides several benefits. The results can demonstrate value to taxpayers. Knowing the results of the service allows an agency to tell whether it has accomplished its intended objectives, and, if necessary, adjust its procedures or practices. Concentrating on results also helps agencies to be more responsive to the needs of their customers, and may help agencies to communicate more effectively with taxpayers. To measure meaningful results, local governments may have to improve the records that they keep.

The street department in ***Woodbury*** sets objectives for its performance in snow and ice control. To see how closely it meets the objectives, the department collects information to assess equipment and labor costs per plowing or sanding event as well as timeliness. The department uses the data to justify requests for funds and make changes in procedures when necessary.

Plan for Equipment Replacement

Local governments can use equipment replacement funds to help them prepare for replacing equipment that wears out or becomes obsolete. This usually involves systematically determining how long equipment can be expected to last, and setting aside funds each year to replace the equipment at the end of its useful life. Equipment replacement funds prepare local governments to finance capital purchases without the need for a large influx of dollars in any single year. According to our survey, most counties and cities, and a smaller share of townships, already use equipment replacement plans.

Hoyt Lakes purchases all equipment through its capital-equipment improvement program. By accumulating money in a fund for capital purchases over several years, the city avoids the need for large increases in property taxes in a given year. The capital improvement program also helps city officials set clear priorities each year for major expenditures.



Capital equipment is an essential part of snow and ice control.

OPERATIONS

In the area of day-to-day operations, we identified seven actions for effective snow and ice control. These are: foster a quality work force; prepare plans for routing, scheduling, and obtaining weather forecasts; select, store, and apply materials appropriately; communicate with the public; apply appropriate snowplowing techniques; use passive snow control measures; and employ equipment improvements and preventive maintenance. We briefly discuss each of them and some of the practices local governments are using that illustrate the value of these actions.

Foster a Quality Work Force

Good employees are key to any operation's success, and they are crucial to successful snow and ice control. Building and retaining a quality work force comes from a long-term, ongoing commitment to an agency's staff. The day-to-day operations in an agency, including effective recruitment of employees, training, treating employees fairly, recognizing employees for a job well done, and taking care of disciplinary problems, contribute to a quality work force.

Snowplow operators new to the job in ***Polk County*** receive 16 hours of required safety training and experienced operators receive 8 hours of refresher training every year. Operators receive training on all department equipment, giving them the skills to knowledgeably and safely use any piece of equipment. Prior to the snow season, operators drive their equipment on "dry runs" of their snowplow routes to become familiar with the route, identify hazardous areas, and note turn-around areas.

One of these elements, regular training for employees, is particularly important for ongoing improvements in snow and ice control. About 84 percent of counties responding to our survey indicated that they either provide operator training themselves or require operators to attend other training. Sixty-nine percent of cities and 31 percent of townships with their own operators provide or require training.

Prepare Plans for Routing, Scheduling, and Obtaining Weather Forecasts

For effective snow and ice control, local government agencies prepare for winter operations with advance planning. Part of the planning includes designating the routes along which snowplows will travel. Effective routing establishes priorities among routes, minimizes "deadhead" trips (e.g., those trips with the sole purpose of returning to refill sand or other materials), and ensures that service is provided as expediently as possible. Over 90 percent of counties and cities with their own operators establish priority routes, according to our survey. Of the 32 townships that indicated they provide their own service, 56 percent set priority routes.

Mankato schedules on-call teams of operators who deice slippery intersections and other dangerous road sections. The operators respond quickly to treat the problem roads at night, on weekends, or whenever winter weather creates hazardous driving conditions outside of normal working hours. Each team has three operators who serve the on-call duty for a week at a time and who deice three assigned zones in the city.

Effective scheduling ensures that operators are on the job when needed — in time to make roads accessible, or to prevent precipitation from bonding to the surface of the road in the first place. Scheduling plowing or sanding prior to heavy traffic levels or rush hours helps prevent snow compaction. Assigning the same operator to the same route and to the same equipment for each storm increases operator efficiency. Most local governments already do this, according to our survey: All counties, 94 per-

cent of cities with their own operators, and 78 per - cent of townships with their own service have their operators use the same vehicle with each snowfall.

For snowplowing agencies, accurate weather re - ports are very important but not consistently easy to obtain. Knowing current and predicted weather conditions helps an agency decide what type of re - sponse is needed and when to call out operators. For example, agencies need reliable weather infor - mation to practice anti-icing, which requires spread - ing materials just as a snowstorm begins. Most counties (93 percent), cities with their own opera - tors (91 percent), and townships providing their own service (59 percent) rely on television or radio weather reports, including the National Weather Service reports via telephone, for weather informa - tion. Some agencies supplement this information with privately-provided weather forecasts specific to their geographic areas.

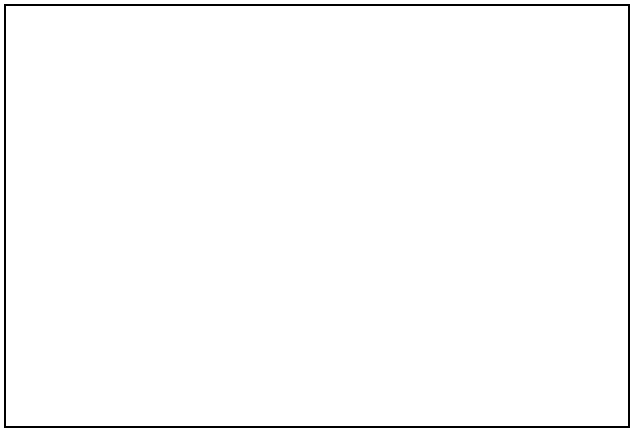
Select, Store, and Apply Materials Appropriately

The benefits of abrasives, salt, and chemicals for controlling snow and ice vary under differing condi - tions. The volume of traffic, type of weather (in - cluding temperature, wind, and form of precipitation), and type and lo - cation of the road all affect the tim - ing and quantity of spreading salt, sand, or chemi - cals. Most local governments spread a mix of sand and salt, al - though some alter the ratio of salt to sand according to weather and ice conditions.

Anoka County produces its own salt brine to prewet salt before spreading salt on roads. Four- teen of the county's snowplow trucks have 100-gallon tanks mounted on the tailgates. From inside the cab, operators control the salt brine flow from the tanks onto the salt and spread the salt onto the road surface. Prewet salt keeps more salt on the road and activates melting sooner than dry salt.

Recycling sand can be an effective way to lower the costs of purchasing and disposing of sand. Al - though recycling sand shows promise, the environ - mental impacts and costs and benefits of recycling require additional monitoring due to the relative newness of the practice.

Another relatively new practice is prewetting road salt before applying it to the paved road. Prewetted salt accelerates the melting of snow and ice. Prewetted salt quickly penetrates the snow or ice layers and breaks the bond between the snow/ice and the pavement. Prewetting also reduces salt loss that occurs when dry salt bounces off of the road. Although the practice is growing in acceptance, more research is needed to determine the circum - stances under which prewetting is most effective. Currently, about 11 percent of counties responding to our survey routinely prewet their salt. Approxi - mately 8 percent of cities with their own operators prewet salt. Only one township reported prewet - ting.



An electric pump moves salt brine from a tailgate tank onto the salt and sand mix.

Proper storage facilities are necessary to keep road salt workable and free flowing as well as to protect the environment from excessive concentrations of salt. According to our survey, about 73 percent of counties own or share an enclosed or semi-enclosed salt storage facility. Of the cities providing their own service, 39 percent own an enclosed or semi- enclosed salt storage facility. No towns reported having enclosed facilities.

Communicate With the Public

Snowplowing is a very visible service and it affects everyone who travels during winter months. Com - munication between local governments and citizens is important for the safety of the traveling public and for effective plowing and ice control. Cities

and townships have to let their residents know about parking regulations so that trucks can plow unimpeded by "snowbirds." Agencies also need to remind the public about appropriate actions during snow emergencies and ways to avoid accidents with snowplows, such as not crowding the plow.

Bloomington uses a variety of means to communicate snowplowing information to its residents. The public works department has mailed a snow and ice control brochure to all residents, describing parking regulations and other pertinent information. When a snow emergency is pending, residents can find out when the plows start by phoning the department at any hour of the day to receive the information via voice mail. The city also uses interactive cable television to inform people about plowing activities.

Apply Appropriate Snowplowing Techniques

Equipment that is effective for plowing main streets may not be as effective in other areas, such as cul-de-sacs. Effective plowing and sanding procedures can also vary depending upon traffic levels, type of road, and weather conditions.

Albert Lea's street department uses a four-way, articulated plow on a front-end loader to plow cul-de-sacs and alleys. The four-way plow angles to the right and left, converts to a v-plow for large loads of snow, and also inverts, controlled by the operator from inside the cab. Operators plowing narrow alleys can pull the blade into a tight "v" shape and then simply widen the "v" to plow the full width of a wider alley.

Use Passive Snow Control Measures

The design of a roadway can improve snow and ice control. Particularly in open areas, raising the road surface above the surrounding snow cover is one way to control blowing snow and deter drifting.

When ***Kittson County*** upgrades or rebuilds its roads, it elevates the surface of the road approximately five to six feet above the surrounding area. The heightened elevation is somewhat higher than usual to expose road surfaces to the wind and prevent the buildup of snow. With less snow drifting over the roads, the county reduces the time it spends plowing and scraping roads. Each year the county elevates segments of roads as part of its ongoing road improvement program.

Properly designed, tall snow fences and living shelter belts of trees and shrubs can also effectively control drifts. Keeping blown snow off the roads improves driver safety and reduces the need for snowplowing.

Employ Equipment Improvements and Preventive Maintenance

Minnesota's harsh winters and heavy snows mean that local governments need the proper equipment if they are to effectively control snow and ice. Not all local governments need or can afford state-of-the-art equipment, but they do need information about equipment improvements if they are to make informed decisions on purchasing and using equipment.

Chisholm uses polyurethane blades instead of steel or carbide blades on its snowplow trucks. Operators find that the polyurethane blades float over road obstructions, and ride smoothly on road surfaces, thus saving wear and tear on equipment. The blade is less likely to cause damage to curbs and can last longer than steel or carbide blades. Although not practical for high-speed plowing or for cutting hard-packed snow and ice, the polyurethane blades work well in other applications on low-traffic and low-speed roads.

With preventive maintenance programs, agencies systematically schedule regular maintenance for all their equipment. Preventive maintenance helps to ensure that equipment is available when needed most and protects agencies' capital investments. Of the counties responding to our survey, 96 percent said they have a routine maintenance program. Ninety-eight percent of cities and 72 percent of townships with their own snow control service have a routine maintenance program.

CONCLUSIONS

Effective snow and ice control practices and equipment continue to evolve. We observed local governments' road agencies trying new ways of doing things, experimenting with equipment designs to better meet their needs, and working to improve their services. Agencies expressed interest in how others similar to them are working, as well as in the latest developments in snow and ice control research and equipment. We learned about ongoing

research by the Minnesota Department of Transportation and others pertaining to winter road maintenance and about the professional networks that help disseminate that information. Yet, many questions remain about what are the best winter maintenance strategies, and under what circumstances they are best applied. In our view:

- **Local jurisdictions would benefit from additional winter maintenance research that focuses on experiences at the local government level.**

We found that local government practitioners were interested in objective information that will allow them to make decisions about the cost effectiveness of winter maintenance practices and equipment in their own jurisdictions. With any given practice they want to know for local applications: how is it done, when is it effective, how much does it cost, what are its drawbacks, and what road or weather conditions make the practice most effective.

No single practice works effectively in every jurisdiction. Differences in road types and conditions, traffic levels and speeds, and community expectations dispel the notion that there is only one right way of controlling snow and ice. At the same time, we realize that local governments need objective information about winter maintenance practices if they are to make informed decisions for themselves.

- **Service providers want ongoing exchanges of snow and ice control information among themselves.**

Some opportunities for sharing transportation information already exist. Organizations such as the Technology Transfer (T^2) Program at the University of Minnesota's Center for Transportation Studies and the Minnesota Local Road Research Board currently help local governments with research results, training, and other information. Several professional organizations in the public works field also serve their members by fostering the exchange of information.

Yet, not all jurisdictions have as much current, comprehensive information on effective snow and ice control practices as they would like. As technology continues to change and improve and as additional field applications of innovations are tested, local governments will need ongoing sources of comprehensive research and ways to share that information.

Introduction

In 1994 the Legislature gave the Office of the Legislative Auditor responsibility to conduct best practices reviews of local government services in Minnesota. [1] Minnesota's approach is similar to one used by the British Audit Commission in England and Wales to determine the "state of the art" in the delivery of local services. The Minnesota Legislature created this new tool to identify practices for delivering local government services more efficiently or more effectively.

While traditional auditing often results in reports that identify organizational and performance deficiencies, best practices reviews identify successes in the design and delivery of services. Success is defined as achieving the highest level of desired efficiency and effectiveness at the lowest cost. The Legislature hoped that communities could improve their service delivery by learning about the effective methods used by other jurisdictions similar to them. The intent of this report is to provide information to counties, cities, and townships on snow and ice control methods that improve this service's efficiency and cost effectiveness.

REVIEW OF SNOW AND ICE CONTROL PRACTICES

The 1994 Legislature created a Local Government Advisory Council to help the Legislative Audit Commission select topics for best practices reviews. By law, the advisory council consists of three members appointed by the League of Minnesota Cities, three appointed by the Association of Minnesota Counties, and two by the Association of Metropolitan Municipalities.

A best practices review looks at service delivery techniques across local governments to identify the most efficient or effective methods.

In the summer of 1994 the advisory council set criteria for selecting topics, and chose the first two topics for best practices reviews. In September, the Legislative Audit Commission approved the advisory council's recommendation and authorized the reviews of (1) snow and ice control and (2) property assessments.

The topic of snow and ice control — the subject of this first best practices review — was selected because quick and effective snowplowing is key to safe transportation and ongoing commercial activity in Minnesota. Small improvements in efficiency could lead to significant cost savings because of the large amounts of public dollars spent on snow and ice control.

METHODS OF CONDUCTING THE REVIEW

To conduct this review we collected information in a variety of ways, including:

1 *Minn. Stat.* §3.971, subd. 4.

- **Roundtable Discussion —** In October 1994, we convened a meeting of policy makers and practitioners to discuss the key issues involved with snow and ice control. Participants included legislators, public works directors, city and county engineers, and street superintendents from around the state. The group identified the major issues that define snow and ice control services in Minnesota and helped set the parameters of this review.

- **Focus groups —** We sponsored smaller group meetings, or "focus groups," in six locations around Minnesota. The purpose was twofold: to obtain feedback on our conceptual model of effective snow and ice control practices and to identify sites where our review could explore potential best practices in more depth. Focus group participants included snowplow operators, street superintendents, maintenance supervisors, and public works directors, from cities and counties of all sizes around the state.

- **Survey —** We mailed surveys to 520 local governments, including all 87 counties, all 186 cities with more than 2,500 population, and a random sample of 72 smaller cities and 175 townships. The survey's purpose was to develop a data base on snow and ice control information and further identify best practices for review.

- **Site visits —** We visited select counties, cities, and townships to observe their snow and ice control practices and learn whether their innovations and effective methods could be duplicated elsewhere.

- **Technical Panel —** A panel of eight public works directors, street superintendents, and engineers reviewed different stages of our snow and ice control review and provided technical guidance and professional advice. The panel represented varied types and sizes of jurisdictions around the state.

- **Consultant —** We enlisted a consultant to assist us in understanding the technical strengths and weaknesses of various snow and ice control practices. The consultant came with a background in snow and ice control at the city level as well as in teaching snow and ice control practices to local governments.

HOW THIS REPORT IS ORGANIZED

This report has four chapters. Chapter 1 provides background information about the kinds of snow and ice control practices in the state, who is responsible for winter road maintenance, and how it is financed. Chapter 2 presents 12 actions for effective snow and ice control. It also lists some of the practices local governments currently use that illustrate the value of these 12 actions. Chapter 3 details examples of effective practices in use around Minnesota and describes how they might be duplicated by other local governments. Chapter 4 discusses trends, observations, and conclusions about snow and ice control resulting from our review.

Background

CHAPTER 1

In Minnesota, several levels of government provide snow and ice control because they share responsibility for the road systems. Both the state and multiple local governments are involved, with the work of one frequently affecting the work of the others.

This chapter provides background information on the responsibility for snow and ice control, including what the service encompasses and how it is financed. In it we ask:

- **What are the roles of the various local governments in snow and ice control? What role does the Minnesota Department of Transportation (Mn/DOT) play?**
- **What kinds of snow and ice control services do the various units of government provide and how do they differ?**
- **How are snow and ice control services financed and how much do local governments spend on them?**

To answer some of these questions we rely on information gathered in a survey of local governments in the winter of 1994-1995. We surveyed all Minnesota counties and large cities (those above 2,500 population), and a random sample of smaller cities and townships. Because the level of snowplowing service varies for different types of roads, we present most survey data by jurisdiction instead of for all local governments in total. (Appendix A contains more information about the survey results and methodology.)

Counties, cities, and townships use different snow and ice control practices because their road systems are different.

ROLE OF LOCAL GOVERNMENTS AND THE STATE IN SNOW AND ICE CONTROL

In Minnesota, each level of government — the state, counties, cities, and townships — has roads under its jurisdiction. Local governments maintain their own systems of local roads, maintained primarily with property tax revenues. In addition, counties and cities above 5,000 population also maintain systems of state-aid roads, for which they receive financial assistance from the state.

As set out in Article XIV of Minnesota's State Constitution, the state maintains the trunk highway system, counties are responsible for the county state-aid highway system (including streets in municipalities of under 5,000 population where necessary for an integrated system), and municipalities of 5,000 or more population are to maintain highways in a municipal state-aid street system.

In addition to these road systems described in the state's Constitution, counties and cities maintain local roads. In fact, most cities with both local roads and municipal state-aid

streets have far more miles of local roads than of state-aid roads. On the average, 80 percent of these cities' total mileage are local roads and just 20 per - cent belong to the state-aid system. Regardless of whether the roads are in the local or state-aid sys - tems, each local government has discretion over set - ting a level of snow and ice control for its roads depending upon individual needs, preferences, and resources.

Local governments generally make their own deci - sions about winter road maintenance; the state is not involved. Few state laws affect how local gov - ernments control snow and ice on their roads. One Minnesota statute re - stricts the use of salt and chemicals by road authorities but leaves to the discretion of the road authorities decisions about when to use these materials and in what quantities. Because of concern over the corrosive and other negative side effects of salt and chemi - cals, this law states that road authorities should use "salt or other chemicals only at such places as upon hills, at intersections, or upon high speed or arterial roadways where vehicle traction is particularly criti - cal, and only if in the opinion of the road authori - ties, removal of snow and ice or reduction of hazardous conditions by blading, plowing, sand - ing,...or natural elements cannot be accomplished within a reasonable time." [1] With or without the statute, most local governments control their use of road salt as a practical matter, because of the initial cost of purchasing salt and the potential negative en - vironmental consequences associated with exces - sive salt use.

Local governments set their own levels of service.

Although Mn/DOT has snow and ice control re - sponsibility for state trunk highways and interstate highways, its goals and winter maintenance philoso - phy are different from that of many local govern - ments. For instance, while Mn/DOT guidelines call for substantially bare pavements for roads with rela - tively high traffic levels, and 24-hour plowing and sanding after a snowfall to achieve these bare pave - ments, this level of service may not be necessary or cost-effective for local governments. Conse - quently, the maintenance practices Mn/DOT uses are not necessarily ones most effective or efficient for local governments.

Mn/DOT'S RESEARCH ROLE

Even though Mn/DOT's winter maintenance prac - tices may be different from those of local govern - ments, Mn/DOT plays another role: road research. Local governments, which must deal with winter maintenance problems similar to what Mn/DOT faces, are generally interested in the outcomes of that research.

Mn/DOT employees conduct field research that has potential benefits for local governments. The de - partment's Office of Maintenance has a Mainte - nance Research Unit that administers field research suggested, and often conducted, by the area mainte - nance engineers and other maintenance personnel in eight Mn/DOT districts around the state. Since 1990, a small percentage of the budget for maintain - ing state roads has been set aside for research in a maintenance operations research fund. Mn/DOT engineers and operators in the districts suggest ideas for research projects financed through the fund. Although the projects encompass all areas of road maintenance, winter maintenance projects comprised 73 percent of the research funding in fis - cal year 1994. [2]

Separate from this field research, Mn/DOT's Office of Research Administration coordinates other re - search proposed and performed by researchers in - side and outside the department. In contrast to the Maintenance Research Unit, this office does not it - self conduct research, nor is its focus exclusively on applied research. Instead, it oversees a variety of re - search projects, involving many different Mn/DOT divisions and offices, ongoing within the depart -

1 *Minn. Stat.* §160.215.

2 Minnesota Department of Transportation, Maintenance Operations Research Unit, *Statewide Maintenance Operations Research Report 1994,* December 1994, p. 5.

ment.[3] The Office of Research Administration also serves as the liaison to the University of Minnesota's Center for Transportation Studies, and administers the Local Road Research Board. [4]

DIFFERENT LEVELS OF SNOW AND ICE CONTROL SERVICE

As mentioned earlier, local governments largely decide themselves how to control snow and ice on their roads. Many jurisdictions have their own personnel and equipment for this purpose. In some cases, particularly in smaller jurisdictions, local governments contract with either another local government or a private provider for winter road maintenance.

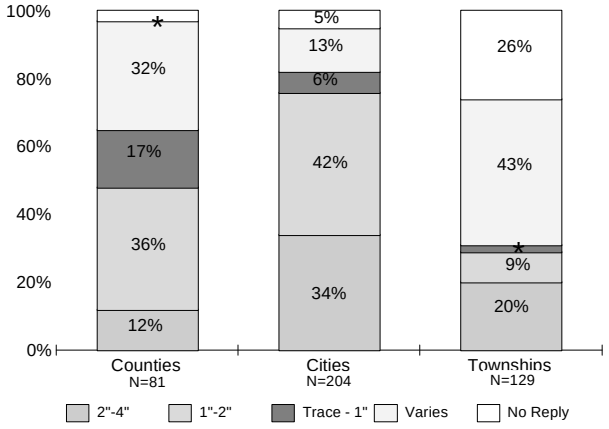
As a result of differing practices and different expectations among road users, the level of service provided varies across the state. Higher levels of service typically require more resources than lower service levels. A few indicators of the level of service are: the time when a jurisdiction typically begins plowing, whether the local government has a policy of maintaining bare pavements throughout the winter, and whether the jurisdiction plows alleys or sidewalks in addition to roads.

Timing of Plowing

One indication of the differences in level of service relates to the decision about when to activate the snowplows following a snowfall. Many local governments determine in advance that they will start plowing after a given amount of snow has fallen. This does not mean that they fail to respond for less snow when conditions, such as wind or icy rain, warrant. It is simply a benchmark that agencies use to signal when their plowing efforts typically begin. Other winter maintenance, such as sanding, may begin earlier than plowing or as road conditions dictate (even when plowing is unnecessary).

We found that the largest numbers of Minnesota counties and cities responding to our survey begin plowing snow after 1 to 2 inches have fallen. (See Figure 1.1.) The survey did not measure when local governments begin other operations such as sanding. Another large group of cities typically begins plowing only after 2 to 4 inches have fallen. About a third of the counties and 13 percent of the cities have no set policy for when to call out the plows; they make a judgment based, among other factors, on current and forecast weather conditions. Most townships have no set policy for when to begin. This is, in part, because many of them contract for their winter maintenance and, as a consequence, do not set snowplowing policies.

Figure 1.1: Timing of Plowing after Various Snowfall Amounts



Source: Office of the Legislative Auditor snow and ice control survey.

Note: * denotes less than five percent.

Bare Pavements

Another indicator of the level of snow and ice control service provided is whether a jurisdiction strives to maintain bare pavements on its paved surface roads. In areas where traffic levels are heavy and speeds are generally high, road authorities may decide that they will try to keep pavements bare. They plow and clear snow until road surfaces are

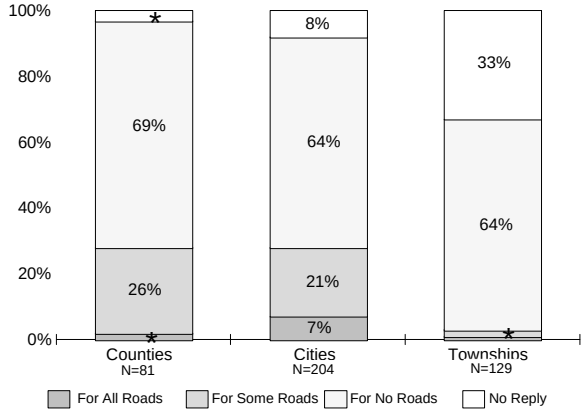
3 Some examples of the Mn/DOT offices involved with research are: the Office of Environmental Services, the Office of Materials Research and Engineering, and the Office of Bridges and Structures.

4 The Minnesota Local Road Research Board (LRRB), financed through municipal and county state-aid dollars, administers research in the design, construction, and maintenance of county and city state-aid roads. Information on the types and results of research conducted on behalf of the LRRB is available through Mn/DOT's Office of Research Administration at (612)282-2267. The Center for Transportation Studies at the University of Minnesota includes a Technology Transfer (T^2) Center for the exchange of transportation-related information among local governments; reach the T^2 Center at (612)626-1077.

visible. On the other hand, in areas with less traffic and low speeds, maintaining a bare paved surface is not necessary and may be impractical because of the expense and time involved.

We found that the majority of Minnesota local gov - ernments do not have bare pavement policies. (See Figure 1.2.) However, about 28 percent of all coun - ties and cities responding to the survey try for bare pavements on some or all of their roads. A slightly higher share of cities than counties tries to maintain bare pavements on all of their roads. Only a hand - ful of townships try to maintain bare pavements on any of their roads because many township roads ac - commodate relatively low traffic levels.

Figure 1.2: Local Governments with Bare Pavement Policies



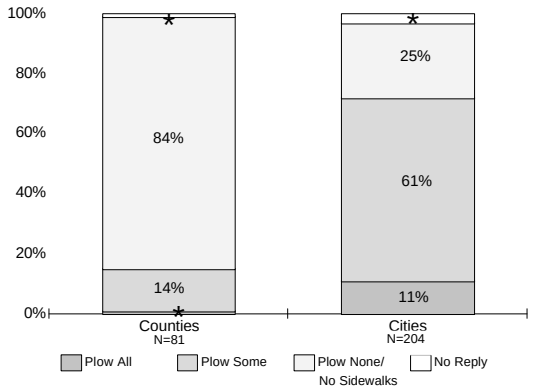
Source: Office of the Legislative Auditor snow and ice control survey.

Note: * denotes less than five percent.

Plowing Alleys and Sidewalks

Whether an agency plows sidewalks and alleys in addition to roads is another indication of the level of service provided. In general, cities are more likely to plow snow from sidewalks and alleys than counties and townships. The vast majority of coun - ties either do not plow any sidewalks or alleys, or they have none to plow. (See Figure 1.3 and Figure 1.4.) By contrast, only 25 percent of the cities do not clear any sidewalks and alleys. About 72 per - cent of the surveyed cities plow some or all side - walks and alleys in their jurisdictions. For these cities, alleys are typically a higher priority than side - walks. That is, about 58 percent of the cities plow all alleys whereas only 11 percent plow all side - walks. Of the surveyed townships, only three re - ported plowing alleys and none reported plowing sidewalks.

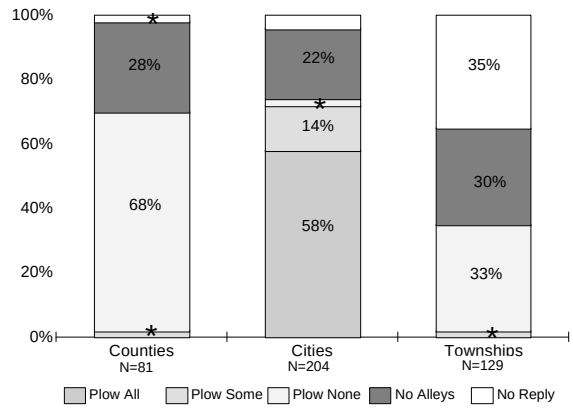
Figure 1.3: Local Governments that Plow Sidewalks



Source: Office of the Legislative Auditor snow and ice control survey.

Notes: All townships that replied either do not plow sidewalks or do not have any.

Figure 1.4: Local Governments that Plow Alleys



Source: Office of the Legislative Auditor snow and ice control survey.

Note: * denotes less than five percent.

FINANCING SNOW AND ICE CONTROL SERVICE

Revenues

Revenues for snow and ice control on roads come largely from two sources. Local property taxes fi - nance local road systems. The state distributes aid to counties and to cities above 5,000 population for roads in the county and municipal state-aid sys - tems.

For cities, however, the local road systems comprise an average 80 percent of their total road mileage and the state-aid roads average 20 percent. Cities under 5,000 population have only local streets; they have no municipal state-aid streets. All but one of Minnesota's 87 counties maintain local county roads. Their local county roads comprise an average 32 percent of total county mileage. But the ratio of local county highways to county state-aid highways varies considerably, from a high of 59 percent of local roads in Pennington County to a low of less than one percent in Brown and Houston counties.[5]

Spending varies by the level of service provided.

Counties and cities receive state aid only for those roads that are part of the county and municipal state-aid systems. County state-aid highways and municipal state-aid streets receive 29 and 9 percent, respectively, of Minnesota's highway-user tax distribution fund (made up of revenues generated by the gasoline tax and vehicle registration fees) for road construction and maintenance.[6]

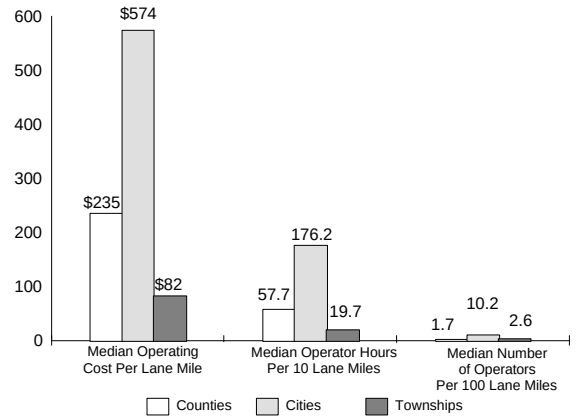
Townships do not have roads on the state-aid system. Although townships do not receive any money directly from the highway-user tax distribution fund, the county state-aid fund funnels money through counties to townships for township roads and bridges. Each county determines its own formula for this distribution to townships. Five percent of the highway-user tax distribution fund is set aside as the source of this money for townships.

Expenditures

We found that expenditures for snow and ice control vary, in part, by the level of service provided, as mentioned earlier. Townships typically provide a lower level of winter maintenance than cities because they have roads with lower traffic volumes. Cities generally have to plow alleys and clear at least some sidewalks; counties typically do not. Consequently, we would expect the costs of these jurisdictions' services to vary significantly.

Local governments reported their estimated costs for their 1993-1994 snow and ice operations, excluding capital outlay, in our survey.[7] In counties, the median cost of snow and ice operations was $235 per lane mile. (See Figure 1.5.) For cities the median cost was $574 per lane mile and for townships the median cost was $82 per lane mile.[8]

Figure 1.5: Costs, Hours, and Number of Operators for Snow and Ice Control



Source: Office of the Legislative Auditor snow and ice control survey.

5 Source: Office of Transportation Data Analysis, Mn/DOT, *Transportation Information System.*

6 Minnesota Constitution, art. XIV, sec. 5.

7 Because of varied interpretations of what should be included in the cost of operations, this analysis uses the median value to exclude data with extreme values. By using the median response, whereby one-half of the responses fall above the value and the other half falls below, extreme responses will be less likely to affect the measure.

8 For townships, we calculated lane miles by doubling the centerline miles data provided by Mn/DOT. Lane miles data for counties and cities came directly from Mn/DOT. Because of data reporting problems, in those instances where a government plows roads belonging to other jurisdictions (such as when a county plows roads for several of its municipalities), the costs per lane mile include only the mileage of the local government responding to the survey (the county, in this case) and not the mileage of the other jurisdictions served (the municipalities, in this case). This tends to inflate the expenditures per lane mile of local governments that plow other jurisdictions.

Differences in snow and ice control costs between counties, cities, and townships reflect differences in the requirements of their plowing. Cities spend more time, and therefore more resources, because their plowing personnel have to operate at slower speeds to contend with driveways, cul-de-sacs, intersections, alleys, and traffic. On the other hand, operators plowing long stretches of uninterrupted county or township roads can cover miles more quickly.

Cities' higher median lane mile costs illustrate the larger amounts of time spent per mile of road than by counties and townships. For cities, the median snowplow-employee hours spent on snow and ice control operations in 1993-1994 was 18 employee hours per lane mile. This is about three times greater than the counties' median of 6 employee hours per lane mile. Townships' median was about 2 employee hours per lane mile.

Higher lane mile costs can also be attributed to roads with larger service requirements. For instance, jurisdictions usually spend more time plowing road systems with cul-de-sacs, alleys, and dead ends than road systems of similar size without these features. Cities have far more cul-de-sacs, dead ends, and alleys than either counties or townships. (See Table 1.1.) As mentioned earlier, far more cities than counties or townships plow alleys and sidewalks. This additional service contributes to higher costs per lane mile in cities.

Table 1.1: Cul-de-sacs and Dead Ends in Counties, Cities, and Townships

	Percent of Respondents with Cul-de-sacs and Dead Ends	Median Number of Cul-de-sacs and Dead Ends
Counties	44%	3
Cities	90	24
Townships	53	5

Source: Office of the Legislative Auditor snow and ice control survey.

Higher costs per lane mile also can be expected for jurisdictions with large systems of paved roads than for those with large shares of gravel roads. Gravel roads typically require less winter maintenance than paved roads. Cities tended to have fewer gravel roads than counties or townships. (See Table 1.2.)

Table 1.2: Gravel Roads in Counties, Cities, and Townships

	Percent of Respondents with Gravel Roads	Median Number of Gravel Road Miles
Counties	93%	194
Cities	66	3
Townships	77	30

Source: Office of the Legislative Auditor snow and ice control survey.

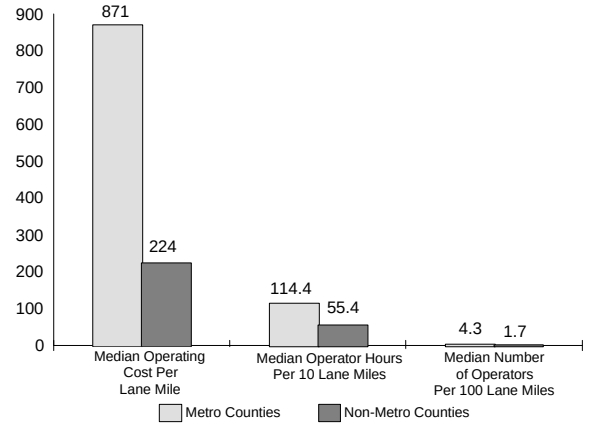
To handle the higher service levels, we found that cities also had more operators per lane mile than counties or townships. Cities reported having a median 10.2 operators per 100 lane miles for snow and ice control. This is six times more than the counties' median of 1.7 operators per 100 lane miles. Townships had a median 2.6 operators per 100 lane miles.

Differences Between Metropolitan and Non-metropolitan Areas

To compare expenditures among similar local governments, we grouped together for each level of government those agencies in the seven-county metropolitan area and those outside the metro area. [9] Metropolitan counties tended to spend more snowplow-employee hours per lane mile, have larger employee levels per 100 lane miles, and, therefore, usually spent more per lane mile than those outside the metro area. (See Figure 1.6.) As might be expected, the metropolitan area also had higher service requirements. More roads in the metropolitan area have much higher average daily traffic, requiring higher levels of service to safely accommodate

9 Too few townships in the metropolitan area responded to the survey to provide a comparison with townships outside the metropolitan area.

Figure 1.6: Metro/Non-Metro Comparison of County Costs, Hours, and Number of Operators

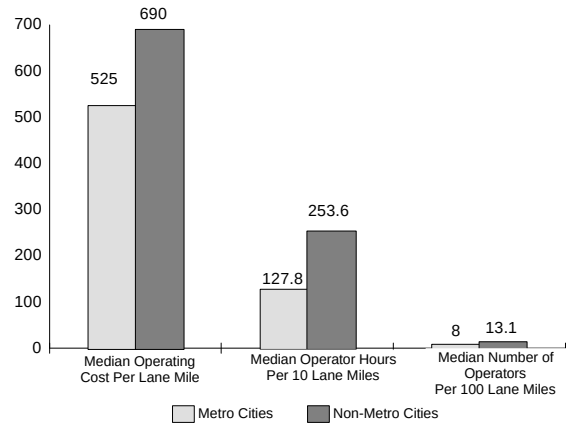


Source: Office of the Legislative Auditor snow and ice control survey.

traffic flows. (See Figure 1.7.) A larger share of the metro counties strive for bare pavement on some or all roads which also requires higher service levels. Six of the seven metro counties (86 percent) strive for bare pavement on at least some roads, while 23 percent of the non-metropolitan counties have bare pavement policies. In addition, the metro - politan counties have fewer gravel roads, which generally require a lower level of service, than other counties in the state. (See Figure 1.7.)

In contrast, cities in the metropolitan area had a lower median expenditure per lane mile than those outside the metro area. They also had a lower me - dian number of snowplow-employee hours in snow control operations per lane mile in 1993-1994 and reported a lower median number of operators per 100 lane miles than cities outside the metropolitan area. (See Figure 1.8.)

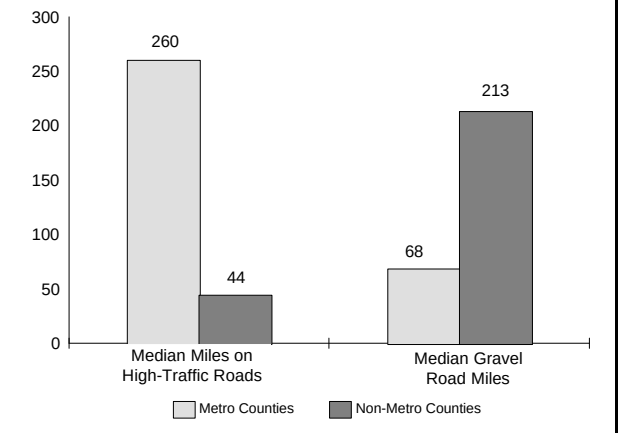
Figure 1.8: Metro/Non-Metro Comparison of City Costs, Hours, and Number of Operators



Source: Office of the Legislative Auditor snow and ice control survey.

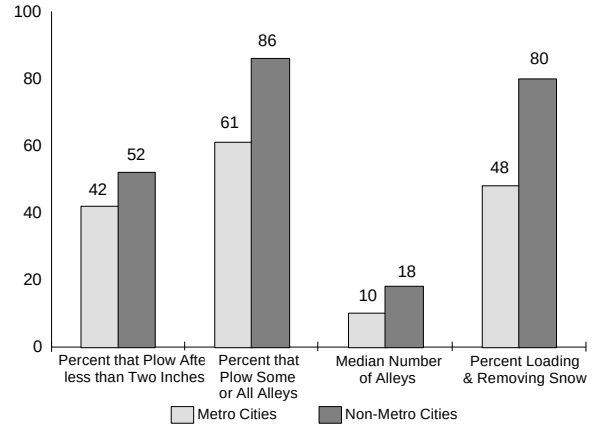
Even though the measures of expenditure, employ - ees, and time spent on snow and ice control for cit - ies in the metro area were lower than those outside the metro area, the level of service requirements did not consistently match. Some factors indicated higher service requirements for non-metropolitan cities. (See Figure 1.9.) More non-metropolitan cit - ies tended to plow alleys than cities in the metro area, and they had more alleys to plow. Further, more of the non-metropolitan cities than metropoli - tan ones made it their practice to start plowing when two inches or less of snow had fallen. (This

Figure 1.7: Metro/Non-Metro Comparison of High-Traffic Roads and Gravel Roads



Source: Office of the Legislative Auditor snow and ice control survey and Mn/DOT.

Figure 1.9: Metro/Non-Metro Comparison of City Level of Service Indicators

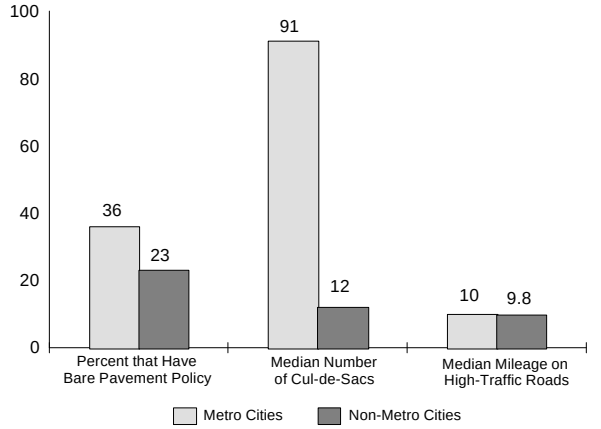


Source: Office of the Legislative Auditor snow and ice control survey.

does not measure when cities started other operations, such as sanding.) A much larger share of the non-metropolitan cities reported removing snow (that is, loading and hauling the snow away) from downtown business districts or other areas than did metropolitan cities. All of these factors (plowing alleys, plowing after a two inch snowfall, and removing snow) tend to require higher expenditures per lane mile than others.

On the other hand, some measures indicated lower service requirements in the non-metropolitan cities compared to metropolitan cities. (See Figure 1.10.) Non-metropolitan cities had fewer cul-de-sacs and dead ends to plow than in the metro area. In addition, a somewhat smaller share of the non-metropolitan cities tried for bare pavements compared to cities in the metropolitan area. The median lane mileage of high-traffic roads was approximately equivalent in all surveyed cities, both metropolitan and non-metropolitan.

Figure 1.10: Metro/Non-Metro Comparison of City Level of Service Indicators



Source: Office of the Legislative Auditor snow and ice control survey and Mn/DOT.

The rest of the differences between the metropolitan and non-metropolitan cities are probably explained by factors other than those measured by our survey. For instance, one factor may be the availability of off-street parking. Whether car owners have alternatives to the street for parking their vehicles while plows are operating affects the speed and quality of the plowing.

SUMMARY

Different levels of government maintain the various pieces of Minnesota's street and highway network, making snow and ice control a decentralized service. Different types of roads require different levels of maintenance. Some roads need to be kept as snow free as possible because of high speeds and heavy traffic use; others will remain passable and relatively safe with far less maintenance. Each local government has discretion to set the levels of service that its roads need and that its citizens demand. This is one reason that we found variations in the expenditures, time, and staffing levels devoted to winter maintenance in various localities.

Actions for Effective Snow and Ice Control

CHAPTER 2

This chapter describes actions for effective snow and ice control in Minnesota. The actions, and the steps to enact them, are intended to provide local governments with information about snow and ice control that could save money or provide more effective service delivery.

In this chapter we ask:

- **What are the important actions to consider for effective snow and ice control in Minnesota?**
- **What are some examples of practices that reflect these important actions for effective snow and ice control?**

We identified 12 actions for effective snow and ice control. (See Figure 2.1.) We based the actions on information gathered from practitioners in the field of snow and ice control, literature published about this field, and local government staff whom we surveyed or visited or who participated in a series of focus groups held around the state.

Each of the 12 actions represents an item that departments have generally considered in planning their system of snow and ice control. Because of the importance of immediate response to snow and ice, we included the 12 actions based on whether they affect a department's ability to control snow in a timely and effective manner. Timing is critical for effective snow and ice control. Once snow and ice bond to the road, the amount of time and effort required to plow them dramatically increases. Further, plowing before traffic volumes increase, such as before a rush hour, allows relatively unimpeded plowing as well as the opportunity to plow prior to snow compaction from vehicle travel.

This review includes practices that local governments have found save time, reduce labor, cut costs, or increase their level of service.

We divided the 12 actions into two main areas: Administration and Management, and Operations.

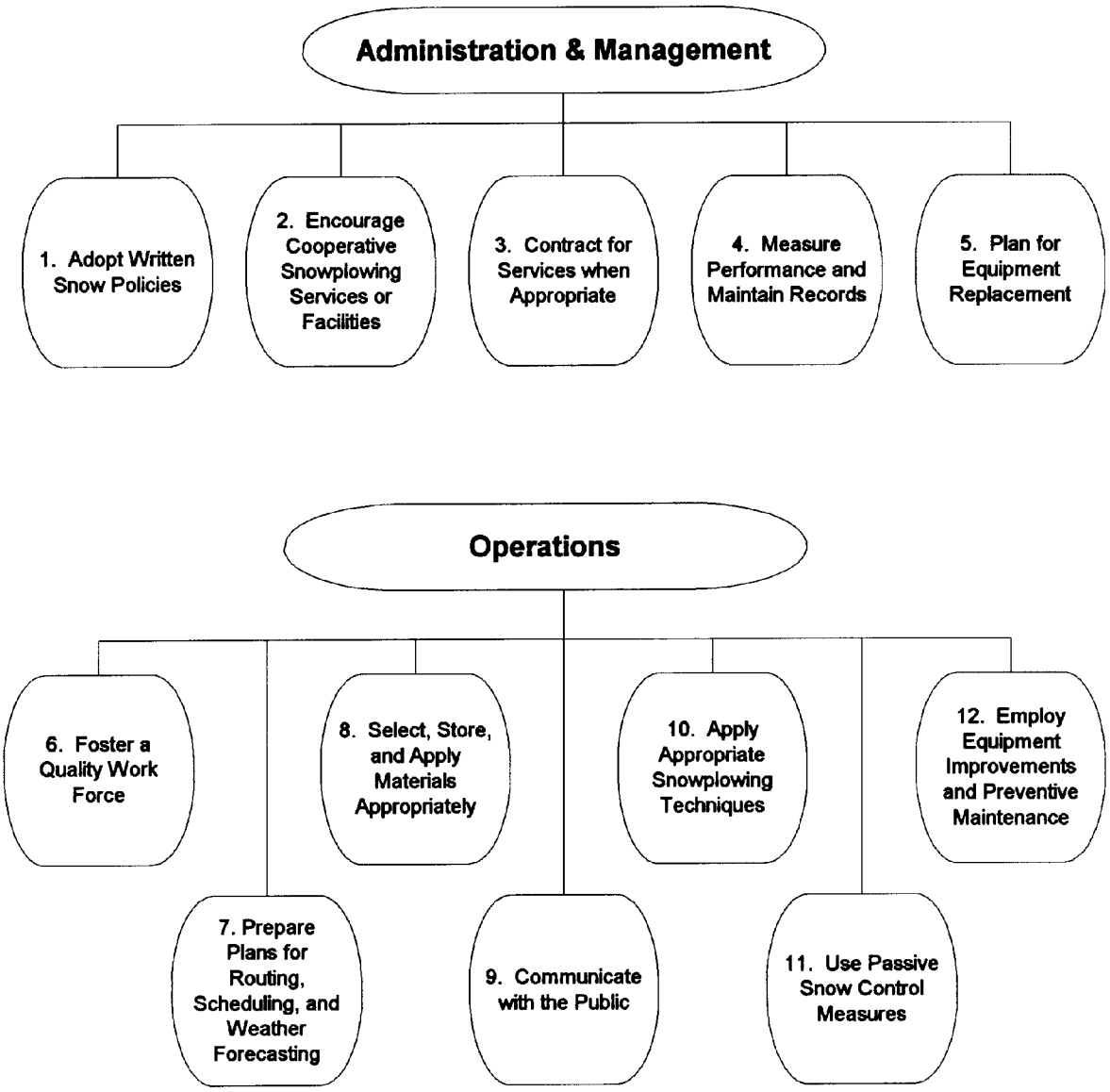
In the area of administration and management, we recommend the following five actions:

1. Adopt written snow policies,
2. Encourage cooperative snowplowing services and facilities,
3. Contract for services, or parts of service, when appropriate,
4. Measure performance and maintain records, and
5. Plan for equipment replacement.

In the area of operations, we recommend the following seven actions:

6. Foster a quality work force,
7. Prepare plans for routing, scheduling, and obtaining weather forecasting,
8. Select, store, and apply materials appropriately,
9. Communicate with the public,
10. Apply appropriate snowplowing techniques,
11. Use passive snow control measures, and

Figure 2.1: Actions for Effective Snow and Ice Control



12. Employ equipment improvements and preven - tive maintenance.

Local governments can implement these actions in a variety of ways. In this chapter we list for each action some practices that local governments around Minnesota have tried. Local governments found that these practices help them save time, re - duce labor, cut costs, increase their level of service, or otherwise improve their ability to get the job done. Not every practice listed, however, can apply to every local jurisdiction. Areas with high levels of vehicle-miles traveled, for instance, will likely re - quire different treatment than areas with low traffic levels. On the other hand, some practices appear to be potentially useful in any setting. Practices lim - ited to specific areas or conditions are so noted.

Although we did not independently test any of the practices described, we present only those practices that others have found useful. Each practice either has produced demonstrable savings of resources for

a department or was considered vital to a department's effective snow and ice control. The practices generally appear to be transferable to other jurisdictions. In some cases, however, the practice may appear appropriate for some, but not all, jurisdictions. In those cases, the examples of the practices (described in Chapter 3) contain considerations that local governments should be aware of when assessing whether to use the practice within their own jurisdictions.

These practices may save resources or improve the management of the service.

This chapter describes actions that will result in effective snow and ice control. First, we briefly describe the 12 actions outlined above. The description includes relevant information from a survey we conducted of all Minnesota counties and large cities (those above 2,500 population), and a random sample of smaller cities and townships. Unless indicated otherwise, we present the responses from only those local governments that provide some or all of their own service; that is, they have their own operators and do not rely on other local governments or contractors for all of their snow and ice control. (Appendix A contains more information about the survey results and methodology.)

Second, we list a number of effective practices that illustrate each of the 12 actions. We include practices that some local governments have found valuable. However, we do not profess to include all effective practices. Some of the practices, such as prewetting a salt/sand mixture before applying it to a paved surface, although effective in early tests, remain under examination. More experience and complete information will be needed to detail the exact circumstances under which these practices make most sense for local governments. Nonetheless, we include them because of their early successes.

In Chapter 3 we provide examples of local governments, based on 34 counties, cities, and townships we visited or called during the review, that use the practices described here. We also include Mn/DOT in these examples where appropriate. Chapter 3 also lists names and phone numbers of contact persons in the local governments associated with each practice.

ADMINISTRATION AND MANAGEMENT

1. Adopt Written Snow Policies

A written snow policy clearly states the scope of snow and ice control within a jurisdiction. It is the central policy document that guides the department's winter operations. (See Appendix E for the ingredients of a typical snow policy.) Written policies describe the level of service that can be expected on jurisdictions' roads following snowfalls, other precipitation, or blowing snow. Departments that modify their typical operations for extreme snowstorms can also use the policy to distinguish between services for the most severe conditions and services provided at other times.

A written snow policy, adopted by the local governing body, can serve multiple purposes. It can help reduce a jurisdiction's exposure to liability for tort litigation. To be useful, the document should reflect the balance between the competing needs of reasonably accessible roads and limited resources. The document can illustrate the public policy considerations made in a jurisdiction over what winter maintenance activities have priority. While a written policy does not guarantee protection against lawsuits, it can help minimize the department's liability.

A written snow policy can also instruct maintenance employees about the expectations and procedures of the department. A department can use the written document to help employees know about and follow the policies. Particularly for new employees, the written policy can be a training tool that explicitly states the jurisdiction's intents and priorities for plowing, sanding, and other winter road maintenance. Department personnel can be helpful in developing new snow policies or review -

ing existing ones. Their input can ensure that the policies are workable.

Further, written snow policies serve as a form of communication with the public. The policy helps the public understand the operations of the depart - ment. It can also instruct residents about any perti - nent ordinances, such as parking restrictions, relevant to snowplowing or ice control operations. The policy tells residents what they can expect from the winter maintenance activities by describ - ing the typical mode of operation following a snow - fall. Residents can also learn that weather and road conditions may force changes in operations from the norm. In addition, the policy can indicate to the public the limitations facing the department that pre - vent it from doing certain operations, such as haul - ing snow away.

Survey Results

About half of the counties (52 percent) and cities (50 percent) responding to our survey have written snow policies. Most of those respondents with writ - ten policies (81 percent of counties and 86 percent of cities), had their elected boards or councils ap - prove the policies. By contrast, only 17 percent of townships responding to the survey had written snow policies, but all of these were approved by boards. Fewer townships than counties or cities have written snow policies. This may be in part be - cause a large percentage of townships do not pro - vide their own plowing services but instead contract for them.

Only five counties have parking restrictions in place during plowing, probably because few county roads allow or need parking. However, 74 percent of cities responding to the survey have parking re - strictions. Of these cities, 75 percent consider their parking plans either highly or moderately effective. Of the 32 townships providing their own service, only 9 percent have parking regulations.

Effective Practices for Written Snow Policies

A. Departments should put their policies in writing. To develop the policy, departments can solicit reactions and input from department managers and operators and, if possible, seek legal ad - vice.

   Departments should communicate snow poli - cies to employees. Familiarize operators with the department's policies on snow and ice con - trol. Involve operators in reviewing those poli - cies following the snow season.

   Departments can keep the policies flexible to reflect different circumstances within a juris - diction (such as paved versus gravel roads) and to allow exceptions to established policies when weather and road conditions dictate.

   Distinguish between policies and procedures. Policies are the guiding principles for a depart - ment's actions in snow and ice control. In con - trast, operating procedures are specific actions or ways of doing things; they need not be a part of a department's written policy approved by its governing body.

   Departments can establish public parking poli - cies when they are needed for effective plow - ing. Communication and enforcement are key to a workable parking policy.

B. The department's governing body can adopt the written policy. This helps establish that the policies resulted from planning-level decisions regarding the competing needs of accessible roads, constraints on equipment and personnel, and employee safety.

C. The department can communicate relevant poli - cies to the public who will be affected by win - ter operations. This is particularly important in jurisdictions with parking restrictions.

2. Encourage Cooperative Services and Facilities

To the extent feasible, coordination of snowplowing services or cooperative use of materials or equip - ment offers efficient and effective use of resources. Local governments that coordinate services or dis - cover ways to share resources may be able to curtail

expenditures, avoid duplication of services, elimi - nate unnecessary purchases of equipment and facili - ties, and more effectively use employees. Cooperation can free resources for other activities.

Survey Results

About 56 percent of counties and 45 percent of cit - ies providing their own service share snowplowing equipment, duties, or personnel. Of the townships that provided their own service, 9 percent share equipment, duties, or personnel. Although some of the sharing is with other departments within the same jurisdiction, most of it is with other local gov - ernments or the state.

Effective Practices for Cooperatively Provided Services and Equipment

A. Facilities common to most jurisdictions for snow and ice control operations, such as salt storage sheds or refueling stations, may be readily shared. Such facilities can serve several juris - dictions in proximity with each other without the expense of each jurisdiction building its own.

   Action by the local government's governing body encouraging cooperative ventures vali - dates those arrangements already in place and encourages employees to pursue additional co - operative activities. Involve all levels of de - partment personnel in identifying services that can be delivered cooperatively or resources that can be shared.

B. For smaller communities, jointly providing snow and ice control may be more cost effective than providing it alone.

C. Opportunities for joint use of facilities or materi - als are most practical for jurisdictions in close proximity to each other. One sand pile avail - able to several nearby jurisdictions, for exam - ple, can save storage costs.

D. Joint purchasing can provide materials at lower costs than individual purchases by a single ju - risdiction.

E. Cooperative activities between jurisdictions in picking up and hauling snow can accomplish the job efficiently.

3. Contract for Services, or Parts of Services, When Appropriate

In some situations, contracting for snow and ice control services, through another government unit or a private provider, can be more cost effective than having a department provide the service itself. Jurisdictions lacking the proper equipment or ade - quate personnel to provide winter maintenance by themselves may find it advantageous to contract. Some may find it cost effective to contract for one segment of service, or one route, instead of all snow and ice control services.

Survey Results

Forty-eight percent of the counties and 35 percent of cities responding to our survey contract for some or all of their snowplow - ing routes. However, most contract for less than a quarter of all their routes. No counties and only 10 percent of cities contract for all of their snowplowing service.

Most townships but few cities or counties contract for all their snowplowing service.

On the other hand, 74 percent of townships respond - ing to the survey contract with other local govern - ments or private contractors for all of their snowplowing.

Effective Practices for Contracting

A. When a service requires special vehicles, or more equipment or employees than a department has, the department may be able to contract with other local governments or private provid - ers for the service.

   Contracts based on providing a specific level of service avoid the problem of paying by the

hour without receiving the desired results. This requires the contractee to clearly specify the expected performance and to also measure the results of the work so that payment to the contractor is based on the results or outcome of the job.

B. Contracting can be practical for plowing specific routes or special areas, such as cul-de-sacs, enabling a department to devote its staff to mainline routes. This can allow the depart - ment to complete its snow and ice control in less time overall.

Contracted services can provide part-time help when needed to supplement existing public personnel and/or equipment.

Contracting one or two routes (in areas with multiple routes) provides an additional means of measuring efficiency by comparing public and private costs and service levels.

Including contractors in the training sessions set up for the department's own employees ac - quaints the contractor with the department's procedures and expectations.

Contracting can, however, have political rami - fications. Departments considering contract - ing for services should be aware of the possibility that they may encounter resistance from employees or others if the contract is viewed as competition with existing jobs.

4. Measure Performance and Maintain Records

4.1 Measure Performance

Departments can improve their snow and ice con - trol services by measuring the effectiveness of serv - ices they provide. Measuring performance can show what value a department is getting for the dol - lars it spends. By measuring the results of its serv - ices, a department can track its achievements and tell whether it has accomplished its intended objec - tives. This helps a department know when it needs to adjust its procedures and practices. Performance evaluation can also demonstrate the real winter maintenance needs of a road system, thereby help - ing to justify requests for expenditures. Informa - tion gathered from performance evaluation can also assist a department in its communications with elected officials and the public. (See Appendix F for examples of performance evaluation and meas - urement.)

Survey Results

Many local governments evaluate their perform - ance in some form. Most reported that they track customer requests for service and complaints as a way of measuring performance. That is, a rela - tively low number of complaints would indicate sat - isfaction with the service, whereas many complaints would indicate dissatisfaction. About 75 percent of counties and 82 percent of cities pro - viding their own service evaluate their effectiveness by monitoring and responding to customer requests or complaints. Two-thirds of townships providing their own service evaluate their effectiveness by re - sponding to customer requests or complaints. In ad - dition, smaller shares of local governments use various other means to evaluate their performance. (See Table 2.1.)

Effective Practices for Measuring Performance

A. Departments can systematically track the effec - tiveness of their snow and ice control practices through a variety of measures. Measures might include:

- public satisfaction;
- the time it takes to plow snow compared to the time intended to plow;
- comparisons of the level of service achieved with earlier snowfalls or previous years (adjusting for snowfall differences);
- comparisons of actual results with in - tended results set out in the department's snow policy;

Table 2.1: How Local Governments Evaluate Snowplowing Effectiveness

	Counties (n = 81)	Cities* (n = 182)	Townships* (n = 32)
Monitor and respond to customer complaints	75%	82%	66%
Compare work with other jurisdictions	63	59	31
Compare with previous snow events	47	48	25
Compare against guidelines in snow policy	25	24	9
Use statistical measures (e.g., miles plowed per operator)	17	6	0
No routine evaluation	12	18	34

*Jurisdictions providing their own snow and ice control services.

- comparisons of inputs (such as personnel and number of vehicles used) with outputs (such as miles plowed per hour or per plow) that attain the specified level of service; and

- timeliness of response to correcting slippery areas or trouble spots prone to accidents (using accident records from the local police or sheriff's department if necessary).

Although departments can measure effectiveness of their snow and ice control operations against their own past performance, departments can also measure themselves against similar departments in other jurisdictions. Measuring effectiveness in this way could be done with any of the examples of performance measures discussed above, but it is important for the department to compare itself to others with similar characteristics, such as those with comparable levels of service.

B. Departments can track public satisfaction with their service by using formal, written surveys or phone interviews with residents or other customers of the service. Departments can also monitor customer requests or complaints over time as well as the department's type and timeliness of response to those requests. However, this latter measure is limited because it assesses the satisfaction of only those persons who contact the department. The satisfaction levels, positive or negative, of other residents or customers who do not take the time to call remain unknown.

4.2 Maintain Records

By maintaining adequate records on vehicles, equipment, and staff, departments can make informed decisions regarding operations, equipment needs, and personnel assignments. For instance, vehicle records can indicate when routine maintenance is necessary and can help by providing specific information at the time of resale if the department intends to sell the equipment to other users. To evaluate the effectiveness or efficiency of the department's performance, departments can maintain records on use of equipment and materials, labor hours, responses to storms, and costs. (See Appendix F for additional information.)

Survey Results

Ninety-six percent of counties and 76 percent of cities providing their own service keep ongoing records for their vehicles and equipment. Of townships providing their own service, 50 percent keep ongoing records for snowplow equipment.

Effective Practices for Maintaining Records

A. Effective records maintenance requires ongoing, thorough record keeping on snow operations, equipment, and personnel. Although computerized records are efficient, computerization is not necessary for developing a record system.

Departments can regularly record information on vehicles and equipment such as: type, number of hours of use, maintenance schedule,

service and parts availability, and the condi - tions under which the equipment is found to be most or least useful. Such records allow in - formed decisions on replacing equipment with the same or modified specifications.

Departments can regularly record staff infor - mation such as: external and in-service train - ing received, familiarity with equipment and licensure (when applicable), and productivity measures.

Departments can maintain records on their service that will allow them to monitor their performance over time and document compli - ance with their own levels of service. Records on the average time to plow or sand routes, for instance, will help departments measure their effectiveness.

5. Plan for Equipment Replacement

Systematically financing large capital purchases over a period of several years prevents undue finan - cial stress for the department. Planned equipment replacement programs also help ensure that equip - ment purchases occur in a timely manner. Purchas - ing versatile equipment with year-round uses can be cost-effective if the equipment performs multiple functions well.

Survey Results

About 90 percent of counties, 81 percent of cities providing their own service, and 38 percent of town - ships providing their own service have capital equipment replacement plans. Most of these coun - ties, cities, and townships (84, 63, and 83 percent, respectively) finance their capital replacement funds through their annual budget.

Effective Practices for Planning Equipment Replacement

A. Departments can plan in advance for replacing obsolete equipment by regularly setting aside funds through the budget process. Depart - ments of all sizes can benefit from planned equipment replacement funds.

B. With the use of a vehicle/equipment maintenance fund, departments can set aside an allowance for the known and expected losses in value (de - preciation) of vehicles and equipment. In one arrangement, all departments in the jurisdic - tion that use this equipment pay rental fees to a central account. Revenues from the rent are used to replace equipment as needed.

C. To the extent possible, departments can purchase equipment for year-round uses. Using attach - ments, such as a snow blower, can provide ad - ditional flexibility in the use of equipment.

D. In making equipment purchases, departments can solicit operators' and mechanics' input and par - ticipation. This ensures that the equipment purchased will meet the employees' needs.

The low bid on equipment is not necessarily the best option. Consider other indirect eco - nomic factors such as: versatility of equip - ment, availability of service and parts, delivery schedule, potential value upon re-sale, and other specifications as determined by the op - erators and mechanics. These factors can influ - ence the long-term costs and usefulness of equipment. For instance, equipment awaiting parts from distant suppliers may be out of use for longer periods of time than others. Be - cause snowstorms can occur at any time dur - ing the winter, the need for working equipment is ongoing. Equipment that is unusable while waiting for parts may limit a department's abil - ity to plow or sand roads when needed.

OPERATIONS

6. Foster a Quality Work Force

A quality work force with dedicated employees is crucial to a successful snow and ice control opera - tion and results, in part, from a long-term, ongoing commitment to a department's staff. The day-to-day operations in a department, including effective recruitment of employees, employee training, treat - ing employees fairly, seeking and incorporating em - ployee input into department planning, recognizing

employees for a job well done, and taking care of disciplinary problems, contribute to a quality work force.

Although some of these components are more difficult to control than others, they all play a role in creating the environment in which employees work. Combined with the work ethic of the employees themselves, the operations of the department on these matters can strengthen the quality of its work force. We discuss below only some of the many practices that reflect a commitment to a quality work force.

A quality work force comes, in part, from a department's commitment to its staff.

Survey Results

Our survey measured one of the components, employee training, necessary for building a quality work force. Of the counties responding to the survey, 84 percent indicated that they either provide operator training themselves or require operators to attend other training. About 90 percent of these require in-house training on procedures and safety; 43 percent have trial runs prior to a snowfall.

Of cities and townships with their own snowplow operators, 68 percent and 31 percent, respectively, provide or require training. About 94 percent of these cities and 30 percent of these townships provide in-house training on procedures and safety.

Effective Practices for Fostering a Quality Work Force

A. Training can promote departmental goals, increase employee efficiency and effectiveness, contribute to safety, and improve overall morale. For employee training, departments can hold a meeting of operators prior to and after the snow season. They can train operators on: safety, equipment operation, routes, materials application, environmental issues, and department policies, plans, and procedures.

   Departments can link training directly to their own goals. Doing so ensures that the training will help employees fulfill the department's overall mission. Departments can also relate training to the needs of the employee. Because the needs and skills of employees will likely vary from person to person, departments can make training most relevant by periodically assessing its employees' training needs.

   Training employees from other appropriate departments within a jurisdiction creates a larger pool of available operators and may be an efficient way to prepare sufficient numbers of employees to provide services at peak times.

   Hands-on training is important in learning different aspects of snow and ice control. Beyond that, to be effective, training should recognize that learning styles differ among individuals. For instance, some people learn best by working with other people, while others learn better independently. The department can tailor training programs accordingly.

B. Recognizing and acknowledging employees' needs can contribute to the operators' safety as well as assist in getting the job done correctly and efficiently. For instance, because operators spend long hours in their snowplow vehicles, they are acquainted with what does and does not work well and what improvements could enhance operations. Operators are usually in a good position to identify additions or modifications to equipment that could improve how well or how easily the equipment works. Departments that have installed features such as power right-hand windows or heated mirrors in snowplow trucks at the suggestion of operators have found that these additions can improve the safety and comfort of the operator, as well as increase productivity.

C. Departments that provide ongoing feedback to operators help to acknowledge employees' good performance and address performance problems. Recognizing and providing incentives for good performance, effectiveness, and

professionalism among employees reinforces the importance of these desired characteristics. When departments reward good performance they help instill the value of that performance among their employees. Likewise, feedback on performance problems is also important. Departments that monitor and remedy performance problems as they occur can resolve difficulties before they escalate into difficult or intractable issues. In addition, confronting the problem immediately reinforces to all employees that such performance is unacceptable.

7. Prepare Plans for Routing, Scheduling, and Weather Forecasting

7.1 Advance Planning

Effective snow and ice control requires advance planning. Planning should encompass: equipment operation, safety, environmental issues, training, scheduling, routing, weather forecasting and storm notification procedures, material purchasing and usage, recommended procedures for snowplowing and ice control, and clean-up activities.

Departments should communicate winter operations plans to employees and seek their input when updating plans.

Advance planning is tied to each of the other 11 actions listed in this review for effective snow and ice control. For instance, budgeting for replacing equipment requires estimating the expected life cycle for equipment and setting aside amounts of money each year to purchase future equipment when existing equipment malfunctions or becomes obsolete. We mention advance planning here to emphasize its importance, while stressing that all facets of winter maintenance require such planning to be effective.

Effective Practices for Planning

A. Departments can develop a plan that documents pre-winter preparation, winter operations, procedures the department believes necessary for dealing with special areas (such as bridge decks or business districts), and post-winter activities. They can include the materials, equipment, and labor needed to perform winter operations.

   Departments can communicate the plan to employees so all are familiar with the objectives, procedures, and expectations of the department. Departments can review the plan at least annually with input from operators, and update it as needed.

   The plan can also:

   - Document assistance available from other departments and notification procedures for communicating with these other personnel.
   - Include a list of contacts for police and fire departments, and document procedures if the department relies on emergency personnel at night and on weekends for notification of ice or snow problems.
   - Establish procedures for receiving and responding to customer requests and complaints.
   - Identify key contacts from outside the government, such as a school district or a large private company, that are major road users, and with whom the department may need to communicate.
   - Describe assistance provided to, or received from, other jurisdictions when such assistance is part of a department's standard operating procedure.

7.2 Route Planning

Effective route planning ensures that departments provide service as rapidly as possible and plow the highest priority routes first. It also means that the majority of time operators spend on their routes is time spent plowing or sanding. In other words, the routes minimize "deadhead" trips (those trips whose sole purpose is returning to refill sand or other materials, to refuel, etc.).

Survey Results

Most counties and cities providing their own service (90 percent of counties and 91 percent of cities) establish priority routes. Many also reevaluate their routes yearly (62 percent of both counties and cities) to make route changes as needed.

Of the 32 townships that provide their own service, 56 percent set priority routes. About 38 percent of townships with their own service reevaluate their routes annually; about one-half do not reevaluate their routes at all.

Effective Practices for Route Planning

A. Departments can identify areas to be plowed or sanded first, including areas with high accident rates, areas commonly used by emergency vehicles, or high-traffic areas. In larger jurisdictions, priority routing may change from one snow event to another depending on traffic levels and weather conditions.

   Effective routing may include the following elements:

   - Establish routes that minimize vehicle "deadhead" trips.

   - Prior to the start of the snow season, discuss any changes in routes from the past year with the operators. As part of operator training, conduct a dry run so operators drive their routes, become familiar with them, and identify potential trouble areas or hazards. This is particularly useful for new operators.

   - In residential areas, design routes that allow snowplow operators to make repeated right-hand turns to avoid leaving windrows at intersections.

   - Build new facilities for storing materials or equipment in central locations that minimize deadhead trips.

   - Jurisdictions with multiple or complex routes or several remote stations may benefit from using computerized routing software.[1] Computerized routing packages are fairly recent developments and, thus far, not widely used here. Computerized routing software attempts to improve routing effectiveness by controlling the efficiency of each pass by a snowplow. Further, the software can assess efficiencies for types of vehicles, the location of facilities, and the use of materials along priority routes.

7.3 Operator Scheduling

Effective scheduling ensures that snowplow operators are on the job when needed, in time to make roads accessible through plowing and scraping or to prevent precipitation from bonding to the road surface. Successful scheduling involves assigning personnel effectively, using equipment productively, holding down labor costs by minimizing overtime, and letting operators know what to expect in advance of plowing or sanding operations.

With effective scheduling, departments recognize the needs of snowplow operators, such as their familiarity and skills with certain equipment, the need to balance family responsibilities with plowing during odd hours, and the limitations of their endurance during heavy snowfalls. In this way, successful scheduling can contribute to productivity and safety for operators, leading to greater job satisfaction for employees.

1 Bill Waddell, "Snow and Ice Control Excellence with Routing Software," *Public Works,* September 1994, 72.

Survey Results

All counties, 94 percent of cities providing their own service, and 78 percent of townships with their own service have their operators use the same vehicle with each snowfall. Virtually all counties, 89 percent of cities, and 63 percent of townships assign their operators to the same route each snow event. All but two counties, 84 percent of cities, and 50 percent of townships with their own service have a set procedure to notify their personnel for snow events.

Effective Practices for Operator Scheduling

A. Departments can schedule plowing or sanding prior to heavy traffic levels or rush hours to prevent snow compaction and avoid the increased difficulty of plowing hard-packed snow.

B. Departments can assign the same operator to the same route and to the same equipment for each storm to improve operator efficiency. However, some jurisdictions with residential areas have the operator start the route at different points with each snow event so that different residences are plowed first along the route.

C. Departments with sufficient manpower or back-up staff from other departments can provide more complete coverage after a storm by scheduling operators for rotating, or dual, shifts. This means that about half of the crew works one shift and is replaced by the second half of the crew working a second shift, providing ongoing coverage. Departments can use rotating or dual shifts for short durations such as during the portion of the season when the most severe storms are likely to occur. Using dual shifts, or changing shifts to accommodate major storms, may not be practical or necessary in jurisdictions requiring lesser levels of service. One study shows that dual shifts can be more cost-effective than a single shift in situations when overtime hours accumulated by a single-shift are excessive. [2] The point at which the overtime hours of a single shift become excessive will vary by jurisdiction.

D. To provide snow and ice control responses at night or on weekends, departments can develop a communication plan with other departments in their jurisdiction, particularly the police or sheriff or those likely to see icy spots or detect other problems during the course of their jobs.

E. In larger jurisdictions, night patrols can provide quick responses to slippery areas and continual monitoring of weather and road conditions.

F. Departments may enhance safety by allowing operators to decide when it is necessary to stop plowing during a long (e.g., 12-hour) shift.

7.4 Weather Forecasting

Adequate weather reports and updates provide a department with one of the tools to decide what type of winter road maintenance is needed and when to call out operators.

Survey Results

Most counties (93 percent), cities providing their own service (91 percent), and townships providing their own service (59 percent) rely on television or radio weather reports, including the National Weather Service reports via telephone, for weather information. Radio scanners are less common, but 35 percent of counties, 41 percent of cities, and 3 percent of townships use radio scanners to receive weather information. About 17 percent of counties, 12 percent of cities providing their own service, and 6 percent of townships with their own service supplement weather information with private weather forecasting services.

Effective Practices for Weather Forecasting

A. Relying on multiple weather information sources can give departments a better chance of predicting what equipment and personnel are

2 Martin C. Rissel, "Cost-Effective Staffing of Crews During Winter," *Public Works,* August 1985, 91.

needed for a particular storm. However, be - cause of the variability of weather systems and the demands of local conditions, these weather resources should be recognized as tools to sup - plement departments' own experience and common sense regarding calling out operators.

Localized weather forecasting provides addi - tional information specific to a given locale.

B. Although not practical for a single local govern - ment, Road Weather Information Systems use pavement temperature sensors, meteorological sensors, and pavement condition systems to de - termine which materials and call-out times (call outs refer to mobilizing operators to be - gin plowing, sanding, or other operations) are most appropriate for particular conditions.

Mn/DOT is currently in the early stages of a three-phase project to implement a statewide road weather information system. Inde - pendent from the road weather information sys - tem, Mn/DOT is also testing portable monitors that measure road surface temperatures.

8. Select, Store, and Apply Materials Appropriately

8.1 Selecting Materials

Abrasives, salt, and chemicals are useful in control - ling snow and ice, but their benefits vary under dif - fering conditions. Effective departments take into account the volume of traffic, type of weather condi - tions (including temperature, wind, and form of pre - cipitation), and the type and location of the road when applying salt, sand, or chemicals.

Survey Results

Of counties and cities responding to our survey and providing their own service, 20 percent and 23 per - cent, respectively, use only sand (with no salt mixed in) for some or all applications. Only two of 32 townships providing their own service responded that they use only sand. About 27 percent of coun - ties, 31 percent of cities, and only one township re - ported using only salt for some applications.

About 84 percent of counties, 75 percent of cities, and 19 percent of townships reported using a sand and salt mix. In those jurisdictions using a mix, the ratio of sand to salt in the mix varied, as indicated in Table 2.2.

Table 2.2: Percent of Local Governments Using Various Ratios of Sand to Salt in Mix

Percent of Sand in Mix	Counties (n = 68)	Cities (n = 137)	Townships (n = 6)
99 to 90%	47%	28%	50%
89 to 80%	29	39	17
79 to 70%	15	10	0
Less than 70%	3	9	16
No Reply	6	14	17

A small number of local governments (less than 7 percent) use dry or liquid calcium chloride or other chemicals.

Less than 5 percent of counties and 28 percent of cities providing their own service said they recycle some or all of their road sand. One township re - ported recycling road sand.

Effective Practices for Selecting and Applying Materials

A. Materials that create friction (like sand) provide immediate traction, work at all temperatures, and are visible to the driving public. Alterna - tives to sand, such as blue chip rock and red chip rock, can also work well by providing su - perior traction. However, sand is not effec - tively applied to hard ice because it does not tend to remain there.

B. To keep sand workable in low temperatures, de - partments can mix salt in a ratio of up to 10 percent salt to sand (this adds a corrosive ele -

ment to the use of the sand). Higher concentrations of salt are used for deicing purposes. Other reasons for higher ratios of salt include: reducing sand for spring sweeping (and thus reducing air quality problems from sand dust); reducing problems with sand filling drains; and reducing potential environmental impacts with controlled, higher-salt applications that lower the total number of applications needed over the course of a winter.

On paved surfaces, controlled application of salt is effective in melting snow and ice, but salt's effectiveness drops off in the 20 °F to 25°F range. Salt stops working when temperatures reach minus 6 °F. Research shows that salt or calcium chloride reduces the number and severity of traffic accidents and lowers travel time costs when comparing roads before and after applying the deicer. [3] Spread salt early in the storm, unless on open roads where wind might blow the salt from the surface or where the wind might blow drifting snow over wet areas that will refreeze. Plow salted roads only after sufficient time has elapsed to make the snow/ice slushy. Avoid salt on gravel roads, as it can make those roads soft or mushy in the spring and can create frost boils.

C. Calcium chloride has the capability of melting ice at lower temperatures than salt. However as a chloride-based deicer, it poses the same corrosion problems as salt. Also, it is usually more expensive than salt.

D. Magnesium chloride, or chemicals such as calcium magnesium acetate (CMA), can also melt ice at lower temperatures than straight salt. Products with magnesium chloride, CMA, or other chloride-based products with corrosion inhibitors may be justified for special areas, such as bridge decks, to counter the long-term and costly corrosive effects of salt. Because of these chemicals' expense, they are more commonly used in environmentally sensitive areas or to avoid corrosion and rebuilding of major bridges.

E. Recycling sand can be an effective way to lower the costs of purchasing and disposing of sand. The gradation of sand or ice control rock is one factor in the economics of sand recycling. Because of the relative newness of recycling road sand, the environmental impacts of wash water disposal and the comparative costs of aggregates require ongoing analysis.

F. Anti-icing road treatments, whereby departments apply materials to pavement before snow and ice bond to the road surface, have been shown to be cost effective in some situations. [4] Tests of anti-icing in the early 1990s, using either liquid chemicals or prewetted salt, indicated that departments use less material because anti-icing reduces the number of passes needed over a given road segment. Anti-icing operations also reduced the costs of accidents on roads with high levels of traffic (20,000 average vehicle daily traffic). These tests involved using weather forecasts specific to the tested areas and included remote atmospheric sensors and pavement temperature sensors. However, additional testing of anti-icing practices on local government roads is needed to show the road, traffic, and weather conditions where anti-icing is most effective.

8.2 Storing Salt

Adequate storage facilities are essential to protect salt from wind and precipitation, protect the environment, and make salt loading easier. Wet salt becomes lumpy and caked, making it difficult to load and spread, and can dissolve altogether.

Uncontained runoff from salt piles can contaminate streams, ground water supplies, and underground wells.

3 David A. Kuemmel and Rashad M. Hanbali, "Accident Analysis of Ice Control Operations," *Public Works,* July 1993, 48-50.

4 Robert R. Blackburn and others, *Development of Anti-Icing Technology* (Washington D.C.: Strategic Highway Research Program, National Research Council, 1994) 140 -148, 173-187.

Survey Results

Of the counties responding to our survey, 73 per - cent use an enclosed or semi-enclosed salt storage facility. Of the cities providing their own service, 39 percent use an enclosed or semi-enclosed salt storage facility. No townships reported having en - closed salt storage facili - ties. Some counties and cities also have enclosed storage for salt/sand mixes or straight sand.

73 percent of counties and 39 percent of cities reported using an enclosed or semi-enclosed salt storage facility.

About 52 percent of the counties and the cities pro - viding their own service reported that they control runoff from around salt storage facilities. They control runoff by recy - cling it, running it to a storm sewer system, or otherwise treating it be - fore discharging it. About 6 percent of townships providing their own service reported that they con - trol runoff.

Effective Practices for Storing Salt

A. Optimally, departments can store salt or salt mixes on an impermeable pad in a ground-level storage building. For ease of loading and unloading, the building should have sufficient capacity to accommodate a loader or other ve - hicle. In smaller facilities, conveyors can load the materials, although some conveyors have more success than others. Enclosed conveyors with chutes at the top can prevent salt spillage and have an additional advantage of covered bearings. Exposed bearings are susceptible to corrosion and can require additional repairs.

   When indoor facilities are impractical or unaf - fordable, departments can store salt on an im - permeable pad and covered with a waterproof tarpaulin. Weight the covers to prevent them from being blown away.

B. Departments can collect and recycle runoff, as in using the runoff to prewet salt before spreading it on the road. In areas with munici - pal or sanitary district wastewater treatment fa - cilities, departments can collect runoff for treatment at the facility.

   Minnesota's Pollution Control Agency (MPCA) recommends practices to manage run - off from stockpiles because it estimates that most environmental damage related to deicing chemicals comes from inadequate storage fa - cilities.[5] To prevent chloride from entering surface or ground water, MPCA recommends covering salt piles with polyethylene if they are not stored in a shed. It recommends mov - ing salt/sand mixes to sheds or covering them during the spring and summer. Further, it rec - ommends containing runoff from stockpiles.

C. Departments can minimize the formation and ef - fects of salt brine. Mn/DOT recommends a number of measures to minimize the formation of salt brine in the first place at stockpiles and truck washing stations, and minimize the ef - fects of salt brine once it has been created. (Chapter 3 includes a summary of these recom - mendations.)

8.3 Prewetting Salt

Prewetting road salt before applying to the road sur - face accelerates the melting action of snow and ice. Prewetted salt particles instantly penetrate the snow or ice layers and break the bond between the snow/ice and the pavement. Salt prewetting also permits more accurate placement on the roadway by reducing the amount of salt that bounces off of the road.

Prewetting salt generally means less overall use of salt, resulting in fewer potentially negative environ - mental effects, as well as cost savings. Some for -

5 John Brach, *Protecting Water Quality in Urban Areas: Best Management Practices for Minnesota* (St. Paul: Minnesota Pollution Control Agency, Water Quality Division, July 1991) 5.5-1.

eign countries, state highway departments, and a small number of local jurisdictions in Minnesota have used prewetting extensively. Additional re - search on local roads in Minnesota would help de - termine the best temperatures, timing, and road and traffic conditions for prewetting salt.

Applying prewetted salt can melt snow and ice, al - lowing operators to plow the slushy areas relatively easily. However, if left to refreeze, the slush may be more difficult to remove.

Survey Results

Of the counties responding to our survey, 11 per - cent reported routinely prewetting salt or salt mix. Of the surveyed cities providing their own service, only eight percent routinely prewet their salt or mix. Only one township reported routine prewet - ting of its salt or mix.

Effective Practices for Prewetting Salt

A. Salt brine is the least expensive and most com - monly used prewetting agent in Minnesota. Departments can prewet salt and sand/salt mix with salt brine to increase the effectiveness of spreading salt, particularly in warmer temperatures (about 15°F and above). At very low temperatures the brine is less effective because of the potential of freezing hoses and valves. A 23.3 percent salt brine solution lowers the brine's freezing point to -6 °F.

Salt brine is the least expensive and most commonly used prewetting agent.

Salt brine offers the possibility of recycling water already containing salt (from salt pile runoff and truck wash water, for example) to prewet road salt.

Spreading salt brine alone immediately before a storm (when temperatures are from 0 ° to 32°F) as an anti-icer can prevent ice from bonding to the pavement. Additional field ex - perience with salt brine as an anti-icer is neces - sary to determine the road and weather conditions under which it is most effective.

Brine production tanks allow departments to produce at their own shop the salt brine needed for prewetting salt or mix. Some brine-produc - tion systems made with materials at hand are relatively inexpensive (about $400) yet may not meet environmental requirements for above-ground storage tanks. State Rules (Chapter 7100) require a secondary contain - ment system around storage tanks, such as a double-walled tank or a dike adequate to con - tain 110 percent of the tank's volume. Prefab - ricated kits for producing brine are more expensive initially (at about $4,000) but can be expected to last longer and provide better sec - ondary containment.

B. Departments can prewet salt with calcium chlo - ride for use through colder winter tempera - tures. Calcium chloride's benefits — reducing the amount of salt and the number of re-appli - cations — can often justify its higher costs in controlled applications. Some tests have indi - cated that eight to ten gallons of calcium chlo - ride per ton of salt provides good melting down to 0°F.[6] Magnesium chloride and CMA have also been used as prewetting agents. Al - though some departments have had success with a variety of prewetting agents, additional field testing on local government roads is nec - essary to assess their benefits as well as their costs or negative effects (such as corrosion).

C. Departments can use truck-mounted tanks to prewet salt as they spread it. These tanks have been found to be more effective than prewet - ting salt in the stockpile or during truck load - ing with either hand-held sprayers or

6 Robert R. Blackburn and others, *Development of Anti-Icing Technology* (Washington D.C.: Strategic Highway Research Program, National Research Council, 1994) 312. Alan L. Gesford, "Prewetting Rock Salt with Calcium Chl oride for Safer Winter Roads and Economic Savings," *Pennsylvanian,* September 1994, 4.

drive-under racks. Advantages to the truck-mounted tanks are a more even distribution of the prewetting solu - tion throughout the salt and no leak - age from the truck box.

9. Communicate with the Public

To garner cooperation from the public, de - partments can identify what residents and commuters need to know about the snow policies and then communicate that infor - mation through a variety of means. In ad - dition, learning about the level and type of service demanded by the public is impor - tant in understanding how to best meet the community's needs.

Table 2.3: How Local Governments Publicize Snow and Ice Control Operations

	Counties (n = 26)	Cities (n = 97)	Townships (n = 5)
Newspaper articles/ press releases	73%	63%	80%
Radio or T.V. announce- ments	42	46	0
Newsletters or brochures	4	59	20
Public school workshops	4	4	0
Telephone hotlines	4	12	20
Other activities	8	6	20

Survey Results

Approximately 56 percent of counties and 68 per - cent of cities with a written snow policy, a parking plan, or other relevant policy, use community news - paper articles to communicate their policies to the public. They also use flyers, radio, broadcast and cable T.V., posted signs, local newsletters, notices in utility billings, and ads on bus shelters. Only 22 of the surveyed townships have written policies; most of these communicate the policy at their an - nual meetings, and about 40 percent write articles in the local newspaper, or post notices at commu - nity buildings.

Some local governments publicize their snow and ice control operations. About 32 percent of coun - ties, 53 percent of cities providing their own serv - ice, and 16 percent of townships providing their own service publicize their services. They use a va - riety of methods, as Table 2.3 indicates.

Effective Practices for Communicating with the Public

A. Departments can use a variety of forms of com - munication to familiarize residents with snow emergency procedures and with pertinent snow policies , such as parking restrictions, prior to the snow season. Possibilities include: local radio and T.V. stations, posted signs, fly - ers distributed to property owners along with utility bills, recorded phone messages, pub - licly-posted notices, newsletters, or other pub - lic relations strategies.

Prior to the snowfall season, departments can provide information that describes snow emer - gency procedures and reviews basic winter driving precautions for the use of local media to announce over the airwaves when needed.

Departments can engage in public relations ac - tivities to educate members of the public about safety and snowplowing activities. Such activi - ties also elevate the department's visibility to the citizenry.

10. Apply Appropriate Snowplowing Techniques

Effective procedures vary for plowing roads and special areas such as bridges, cul-de-sacs, alleys, and parking lots. Factors such as type of road, traf - fic levels, weather conditions, and operator experi - ence can determine what techniques are most practical.

Effective Practices for Snowplowing Techniques

A. Departments can plow priority routes with a lead plow vehicle followed by a second plow to open routes quickly and avoid double passes by the same vehicle. Although the use of two plows requires twice the number of vehicles and employees, the technique can cut the time needed to plow a given route and may there - fore be particularly cost effective on roads that require immediate response. These are roads where the gains provided by a fast plowing re - sponse are crucial and outweigh the costs of the additional labor per route.

B. Departments can use a wing to push back snow onto boulevards, as applicable, to provide stor - age space for future snow.

C. Departments with large numbers of cul-de-sacs, alleys, or dead ends can create routes to deal specifically with those areas and assign appro - priate equipment to plow them. For instance, front-end loaders may work better in some cul-de-sacs than a standard truck and plow. A 4 x 4 with an adjustable-width plow may be effec - tive in narrow alleys or sets of alleys with mul - tiple widths. Reversible plows provide versatility that may be useful to plow cul-de-sacs.

D. For cul-de-sacs large enough to accommodate snow piles, or those with center islands, depart - ments may find it more cost effective to plow cul-de-sacs to the middle and remove snow only when it impedes visibility or travel.

E. For some cul-de-sacs, particularly smaller ones, departments can plow snow to the perimeter in - stead of to the center. Some smaller cul-de-sacs may require the removal of snow after multiple snowfalls.

F. In plowing dead ends, departments can save time by not removing the piled snow unless it ex - ceeds a pre-determined unsafe height.

G. Departments can plow snow in priority areas, such as a business district, to the middle of the street, then load and haul it away. In smaller jurisdictions' business districts, departments can blow sidewalk snow into the street before plowing roads.

H. Departments can use snow stakes as hazard mark - ers to alert operators to potentially treacherous areas or obstructions hidden by snow.

I. Departments can use graders or trucks with under - body plows instead of one-way plows on gravel roads in the spring and fall. One-way plows have the potential to dig in to the unfro - zen road surface and ride up, possibly damag - ing either the plow, truck, or road. Because the underbody plow can ride slightly above the gravel surface, it may allow faster vehicle speeds without displacing as much gravel from the road.

11. Use Passive Snow Control Measures

Passive snow control includes snow fences, shelter belts, and roadway design. Where appropriate, properly installed snow fences can provide a solu - tion to the problems of blowing and drifting snow. Keeping snow off the road enhances safety by improving visibility and reducing slippery con - ditions. It also reduces maintenance costs by minimizing snowplowing and by preventing runoff from either seeping under and damaging the pavement or blocking drainage. Effective use of snow fences takes into account the height, placement, capacity, and design of the fence.

Road design can help control blowing and drifting snow.

Properly designed living snow fences of trees and shrubs can also effectively control drifts. Use of snow hedges and snow storage ditches can prevent drifting snow from reaching a roadway.

The design of a roadway can improve snow and ice control. Roads designed to accommodate blowing snow and deter drifting are easier to maintain than others.

Survey Results

Of those counties responding to the survey, 33 percent use snow fences to control blowing snow. Of the cities that provide their own snow and ice control, 21 percent use snow fences. Only 6 percent of the townships providing their own service use snow fences.

One-quarter of the counties responding to the survey said they use natural plantings to control blowing and drifting snow. Of the cities providing their own service, 16 percent use natural plantings. About 6 percent of the townships providing their own service use natural plantings.

Effective Practices for Passive Snow Control Measures

A. Snow fences should be a minimum of eight feet in height.[7] The actual height of the fence depends on the fence's porosity (surface area of the fence pores) and the needed snow-storage capacity of the fence. A single row of tall fence is preferable to several rows of shorter fence.

   Departments can build snow fences to accommodate the quantity of blowing snow expected over an average winter. They can calculate adequate capacity for a fence by measuring the distance the wind can pick up snow and deposit it on the road (the fetch) and the mass of snow moved by the wind over a given amount of time (the snow transport).

   Because solid fences do not collect snow efficiently, departments can design snow fences with about 40 to 50 percent of the fence surface area open for improved effectiveness. In addition, the gap between the bottom of the fence and the ground should be approximately 10 to 15 percent of the fence height. Horizontal rails are better than vertical rails because they prevent the bottom gap from becoming plugged, which can bury the fence. The length of the fence should cover the stretch of roadway to be protected, plus a length on either side that is approximately 20 times the height of the fence.

   Departments can place fences at a distance from the road that is at least 35 times the height of the fence on flat terrain. Hilly terrain or ditches may require placement farther back. The fence should be placed perpendicular to prevailing winds but the orientation can be within 25 degrees without loss of performance.

   Where there is insufficient right-of-way on public land, departments need permission and may need easements before placing fences on private property.

B. Jurisdictions can use shelter belts to reduce the need for snow fences. Because the height and porosity of the natural fence will change as the plantings mature, the setback distance for such fences is shorter than that for the structural snow fence and is based on the expected mature height of the plants.

   Local zoning ordinances, setback allowances, the amount of storage space for accumulated snow, and the expected height of the plantings can affect the effectiveness of a shelter belt.

   Some studies found that three rows of spruce or two-to-three rows of cedar were effective snow protection when set back 15 times the mature height of the hedge on level ground.[8] Departments can use a computer modeling sys-

7 Much of the information pertaining to snow fences comes from: Ronald D. Tabler, *Design Guidelines for the Control of Blowing and Drifting Snow* (Washington D.C.: Strategic Highway and Research Program, 1994) and Mn/DOT.

8 Max S. Perchanok, Dan G. McGillivray, and James D. Smith, *An Approach to the Design of Treatments to Prevent Snow Drifting on Highways*, prepared for the Third International Symposium on Snow Removal and Ice Control Technology conducted by the Transportation Research Board, Minneapolis, Minnesota, September 14-18, 1992.

tem to test the effectiveness of untried snow hedge treatments.

C. Departments can use a wide snow storage ditch, with a steep backslope between the edge and the road, to store the drifting snow and fallen snow plowed from the road. A shallow side slope with vegetation cut close to the ground allows plowed snow to fall into the ditch and allows wind to clear the shoulder and pave - ment.

D. Departments can cut down vegetation on backslopes to reduce snow traps.

E. Departments can use road design options for con - trol of drifting snow including: raising the road surface above the surrounding snow cover, widening ditches on both sides of the road, making embankments drift-free with shallow leeward fill slopes, and removing guard rail that tends to act as an unintended snow fence depositing snow downwind and collecting snow plowed from the road.

   On gravel roads with little traffic, re-grading the roads so that the driving surface is higher than the adjacent fields can help departments control snow traps caused by blowing snow.

12. Employ Equipment Improvements and Preventive Maintenance

12.1 Equipment Improvements

Equipment improvements and technological ad - vances can increase snowplowing and sanding per - formance and lower cost.

For instance, a ground-oriented sander, which pre - cisely controls the amount of sand or mix placed on the road, has considerable advantages over tradi - tional spreaders. Departments can have much bet - ter control over the use and quantity of the materials they spread with ground-oriented sanders. Although the initial cost of ground-oriented sanders is higher than the cost of sanders with manual or automatic controls, the department can save signifi - cant time and materials with these sander controls.

Although not all departments need or can afford state-of-the-art equipment, they do need informa - tion about available improvements if they are to make practical equipment decisions.

Survey Results

Of the counties responding to our survey, 7 percent have ground-oriented sanders. Only about 4 per - cent of the cities providing their own service and one township providing its own service have these sanders.

Effective Practices for Employing Equipment Improvements

A. Departments can use uniform, quick-release hitches for fast, labor-saving changes of plows or other attachments. In addition, a depart - ment that uses uniform engines, transmissions, axles, etc., can improve the efficiency of equip - ment use and repairs. For each brand of equip - ment, departments can write uniform specifications for bidding purposes when pur - chasing equipment.

B. Departments can use ground-oriented sanders to apply a precise amount of sand or mix to the road surface. Operators in the cab can alter the pounds per mile of material spread on the road. Departments face larger front-end costs for ground-oriented sanders but save time and have greatly improved control over the rate of spreading sand and salt as well as lower mate - rial costs from controlled sand and salt applica - tions.

   Regardless of the type of sander controls, depart - ments can gain efficiencies by periodically cali - brating their sanders.

C. For departments that use plow shoes on their plows, snow wheels can replace plow shoes, reducing wear on the plow and saving labor and time to change plow shoes.

D. Although still in a developmental stage, zero-velocity spreaders dispense liquid or dry deicers in controlled patterns and precise amounts using air flow. Initial tests show a 30 to 40 percent reduction in sand and salt at speeds up to 35 mph. Some local government use of the zero-velocity spreader shows that it worked less effectively in situations where plow speeds were slow and intersections were frequent.

E. Departments can use two-way radios to allow drivers to communicate problems that arise while plowing or sanding. Two-way radios can increase the efficiency of a department's response during a snow storm and reduce downtime.

F. Departments using graders on gravel roads can use certain radial tires that last longer than traditional tires and can replace the need for tire chains. Although the initial cost of the radials is somewhat higher, their improved traction, durability, and time savings can make them cost effective.

G. Departments can use truck features such as power right-hand windows, heated mirrors, comfortable seats, and plexi-glass passenger doors to contribute to driver safety and productivity.

H. Departments can use polyurethane mold boards on plows which are lighter and more fuel efficient than steel. Departments with road systems that have protrusions, such as manhole covers, can use polyurethane cutting edges. Some local governments have found polyurethane cutting edges to last longer than other types and minimize deterioration of equipment because they ride more smoothly over obstructions. However, they are less effective than other edges in cutting through ice or hardened snow.

I. Departments that use sidewalk plows can use rubber edges that allow operators to plow snow as effectively as other edges while avoiding the hazard of catching the edge on protrusions.

J. To increase the visibility of snowplow vehicles, departments can add truck lighting, such as a six-strobe light package.

K. Departments that plow paved surfaces can use carbide blades for increased efficiencies. For plowing, carbide blades can last longer and require less maintenance than traditional blades.

L. While still considered experimental, coating the snowplow truck's undersections and box with coal tar epoxy has inhibited corrosion.

M. Extendible plows, while still being field tested, can replace a plow and wing combination. In lower traffic and lower-speed areas, the extendible plow can reduce the weight and unwieldy nature of the plow/wing arrangement, while allowing the driver to hydraulically adjust the width of the plow to fit different road widths.

12.2 Preventive Maintenance

A preventive maintenance program systematically schedules regular maintenance for all of the department's equipment to ensure that the equipment reaches its full life expectancy. Such a program also maximizes the availability of the equipment when it is most needed and promotes cost-effectiveness by protecting capital investments.

Virtually all local governments have a routine maintenance program to care for their snowplowing vehicles.

Survey Results

Virtually all local governments with their own snowplowing equipment have a routine maintenance program to prepare their snowplowing vehicles. Of the counties responding to our survey, 96 percent said they have a routine maintenance program. Of cities and townships with their own snow control service, 98 percent and 72 percent, respectively, have a routine maintenance program.

Effective Practices for Preventive Maintenance

A. Departments that use preventive maintenance can stagger the maintenance schedule to ensure that not all equipment is serviced at the same time. The department can maintain adequate records to indicate when routine maintenance is required, and schedule the maintenance for down times between snow storms. Departments can prepare equipment for the snow season before the first snowfall and use spring and summer months for maintenance as needed. Maintenance can be scheduled by type of vehicle, odometer miles, or number of hours of use.

B. Operators can routinely check the equipment they use and report any special maintenance requirements after each operation. Daily equipment inspections required for a Minnesota commercial drivers license offer a method for routinely checking equipment to detect maintenance problems. Departments can use these inspections as a basis for their own checks.

Examples of Best Practices

CHAPTER 3

This chapter describes examples of Minnesota local governments that are using the effective snow and ice control practices summarized in Chapter 2.

For each action identified for effective snow and ice control, we present examples from Minnesota counties, cities, and townships. These examples come from the 34 local governments we visited or called for in-depth interviews. Many other local governments may also employ best practices even though they are not specifically listed here. Where appropriate, we also include examples from Mn/DOT.

The following list contains the 12 actions for effective snow and ice control, divided into 2 main areas of Administration/Management and Operations, and the alphabetized names of local governments we use as examples.

This chapter describes 80 examples of best practices used by local governments around Minnesota for snow and ice control planning and operations.

ADMINISTRATION AND MANAGEMENT

Adopt written snow policies: Mankato, Owatonna, Paynesville, Pine City Township, St. Peter

Encourage cooperative snowplowing services and facilities: Alden, Douglas County, Hawk Creek Township, Madison, Paynesville

Contract for services, or parts of services, when appropriate: Moorhead, Paynesville, White Bear Lake

Measure performance and maintain records: Chisholm, Hennepin County, Hoyt Lakes, New Hope, Washington County, Woodbury

Plan for equipment replacement: Edina, Hoyt Lakes

OPERATIONS

Foster a quality work force: New Hope, Polk County, Washington County, White Bear Lake, Woodbury

Prepare plans for routing, scheduling, and obtaining weather forecasting: Albert Lea, Anoka County, Bloomington, Mankato, Mn/DOT, Mounds View, Owatonna, Ramsey County

Select, store, and apply materials appropriately: Albert Lea, Anoka County, Bloomington, Forest Lake Township, Jordan, Little Canada, Mankato, Mounds View, Mn/DOT, Otter Tail County, Owatonna, Pine City Township, Ramsey County, Rochester, St. Peter, Woodbury

Communicate with the public: Bloomington

Apply appropriate snowplowing techniques: Albert Lea, Woodbury

Use passive snow control measures: Alden, Kittson County, Madison, Polk County

Employ equipment improvements and preventive maintenance: Anoka County, Chisholm, Douglas County, Jordan, Little Canada, Martin County, McLeod County, Mn/DOT, New Hope, Otter Tail County, Owatonna, Waseca County, Woodbury

This chapter describes these jurisdictions' practices in detail. In each example, we describe why the local governments adopted the practices they have, the advantages they gained, and any problems in implementing the practices that might impede some other jurisdiction from adopting the practice. Along with the descriptions of the practices themselves, we include the names and telephone numbers of contacts who can provide more information to readers with further questions.

1. ADOPT WRITTEN SNOW POLICIES

Written Snow and Ice Control Policy

City of Mankato

Mankato's public works department has used a written snow and ice control policy for approximately 25 years. The policy covers key elements such as procedures for varying weather conditions, operator shifts, public information, chemicals and abrasives, snowplow routes, parking ordinances, and sidewalk plowing. Department officials emphasize that input from a variety of community organizations is one of the most important factors in a successful policy. Mankato is located in Blue Earth County, has a population of 31,000, and maintains 260 lane miles of road.

In September of each year the public works department sends a memorandum to all concerned organizations regarding snow and ice control, including the Mankato Public Safety Department, Mn/DOT, the State Highway Patrol, and members of the business community. The purpose of the memorandum is to solicit input on the city's snow and ice control policy. The city invites concerned organizations to an annual session in October where participants reach consensus on additions or deletions to the policy. The public works department sends policy changes to the city council for approval.

Throughout the snowplowing season the department records and reviews citizen requests for service. However, only at the annual October meeting during the review of the snow policy does the department entertain major policy changes. The department evaluates new requests for service to determine if the need for service justifies additional expenditures and the potential impact on property taxes. Emergency services to hospitals, schools, or the fire department are mandatory.

Mankato's public works department has made the following considerations in developing and updating a policy on snow and ice control:

- Social needs, such as rental housing or a college campus, and physical characteristics, such as hills or cul-de-sacs, affect the policy. Plowing priorities and parking ordinances are usually tailored to reflect these needs and characteristics.

- Flexible policies adapt to changing community needs. Review the policy annually and keep an open mind.

- Plan logical snowplow routes and adhere to them. This promotes efficiency and prevents outspoken citizens from influencing how and when streets are plowed.

- Develop an interdepartmental team to stay current with new technology.

- Remember that a community cannot simply duplicate the policies and equipment of another. Each community is unique and its policies should reflect its own individual needs and characteristics.

- Ongoing operator training is important for an effective snowplowing operation.

An advantage of a written policy is that it facilitates citizen understanding of what services the city provides and an awareness of citizen responsibilities. This promotes safety and efficiency by encouraging citizen cooperation.

For more information contact:

Gerald B. Eken
Public Works Superintendent
City of Mankato
(507)387-8644

City of Owatonna

Since February 1991, Owatonna has had a written snow control policy approved by its city council. Located in Steele County, Owatonna is a city with 20,100 residents and 184 lane miles of road. The policy explains the typical circumstances under which the street department will commence plowing, sanding, and hauling snow. In addition to the policy, the city's parks, recreation, and streets department developed a written plan detailing procedures, routes, and equipment for the city's snow and ice plowing and removal. Details on Owatonna's written plowing and snow removal plans are in the section of this chapter dealing with Preparing Plans for Routing, Scheduling, and Weather Forecasting.

In its snow policy, Owatonna's street department explains that it will plow streets after a snowfall of at least two inches. It specifies that the city will plow arterials first and that plowing will begin at midnight, unless snow is still falling, in which case the lead personnel will set a start time. Further, it states that plowing may be done at the discretion of lead personnel when fewer than two inches have fallen. In this situation, authorized personnel may isolate plowing to identified trouble spots.

The policy indicates when sanding will commence and specifies that the on-call personnel will determine whether conditions warrant additional response. It sets priorities for areas requiring sanding and indicates that the city does not normally sand the full length of all streets. Regarding the removal of snow, the policy makes clear that removing snow is a secondary priority done only after plowing is completed. It also describes the areas from which the city will remove snow and the priorities among those areas.

The department developed the policy, and the corresponding snow and ice plowing and removal plans, with deliberate involvement from workers in the street department. It wanted the input of those workers who are expected to keep the streets plowed, sanded, and passable. Together they determined reasonable guidelines that established parameters for their work without unnecessarily binding them to strict and inflexible operations. They wanted policies that would allow them to provide an acceptable level of travel in the city. Each fall prior to the snow season, the department reviews the policy (along with the snow and ice control plans) with its operators to assess the need for changes. It does this as part of its training for snowplow operators.

Owatonna developed its written policy for a number of reasons. It believes that the policy affords the city some protection against liability by documenting what is and is not its standard way of operating. With a written policy, citizens know what to expect from city snowplowing and sanding operations. The department has taken it upon itself to inform the public about its snow policy by using newspaper articles, handouts, and television and radio announcements. In addition, the policy provides the city administrator and elected officials with snowplowing information they can use to answer questions from the public. When calls come in for service of an extraordinary nature, the department refers to its policy to explain its snowplowing priorities. An additional advantage is that the written policy allows the department to reevaluate its plowing and ice control system on a regular basis in an ongoing attempt to improve its operations.

For more information contact:

Leo Rudolph
Director of Parks, Recreation, and Streets
(507)455-0800

or
Mark Arett
Street Foreman
City of Owatonna
(507)451-0370

Pine City Township

Pine City Township, with a population of 950 and 42 lane miles of road in Pine County, maintains and annually reviews a written snowplowing policy. Township officials emphasize flexibility in working together to keep the policy current according to the changing conditions. After an annual review, township officials publish the policy every fall in the township newspaper so that all residents are aware of it.

Plowing begins under specific conditions delineated in the policy. The policy addresses emergency plowing, parking, plowing of driveways, hazardous conditions, salting, and sanding. It also covers liability and property damage, and it indicates that the township does not ensure bare pavement. In its written policy, Pine City Township chose to combine policy statements that guide its operation along with specific snowplowing procedures; it does not distinguish policies from procedures in separate documents as some local governments have.

The snow policy is intended to ensure fair treatment of all township residents. It provides officials with an answer to residents' questions regarding methods used to plow roads. It enhances efficiency by laying out logical, cost-effective plowing routes. The policy specifies that the township has the right to refuse to provide service under dangerous conditions, such as when damages could occur to township equipment or personal property, or residents or township employees could be endangered. The township officials' intent is to limit service under these conditions without incurring liability.

It is the township's policy to channel all emergency calls for service through the sheriff's department. This arrangement, specified in its written policy, eliminated a problem the township had been experiencing with false emergency calls from residents who simply wanted their road plowed first.

For more information contact:

Dennis Gottschalk
Operator
Pine City Township
(612)629-2806

Effective Parking Policy

City of Edina

For the past 22 years, Edina has had a parking ban that prohibits overnight parking on all city streets from November through March. Edina is located in Hennepin County and has 47,000 residents and 413 lane miles of road. To provide effective service and meet residents' expectations, Edina's public works department stresses planning ahead as much as possible for each element of snow and ice control, including efforts to reduce parked cars on the streets during snow emergencies.

Edina's public works department has found that an all-night parking ban is necessary for effective plowing. Although Edina snowplow operators typically begin plowing after one and a half inches of snowfall, they sometimes go out before that amount has fallen, depending upon weather conditions and predictions. To eliminate any uncertainty about when vehicles should be off the street, the ordinance bans overnight parking at any time in the winter months. Without the ban, ice would build up in spots where plows are forced to plow around parked vehicles. Edina residents seem willing to sacrifice parking on streets in exchange for thoroughly plowed streets, and most of the neighborhoods have off-street parking available.

Success of the parking policy is also due to the department's communications with city residents. The department reminds residents of the parking policy each fall in the city's quarterly newsletter that is mailed to each residence. In addition, after the first of November but usually prior to the first snowfall, the department's night shift will place

warning tags on vehicles parked in the street. The tags explain the parking prohibition and the reasons behind it.

Furthermore, if more than a few inches of snow falls, the snowplow operators will call the police dispatcher when they see illegally parked cars. The police call the vehicles' owners at home and remind them to remove the vehicles or risk being tagged and towed. Operators come back to the residence later to plow the area where the car had been parked. The success of the city's parking policies is evident in the fact that, typically, the department faces only a half dozen or so illegally parked cars during each storm.

Communities lacking off-street parking may have difficulty implementing a similar parking ban unless they are able to provide alternative parking arrangements for residents who usually park on the street. Enforcement of the parking ban requires an ongoing working relationship between the street department and the police.

For more information contact:

Francis Hoffman
Director of Public Works
or
Steve Johnson
Public Works Coordinator
City of Edina
(612)927-8861

City of Paynesville

Paynesville is a small city (2,300 residents) in central Minnesota with parking regulations that have worked well for its plowing operations. In 1992 Paynesville instituted a parking ban from November 1 through March 31 during the hours of 1:00 a.m. to 6:00 a.m. following a snowfall. The ban is in effect only after a snowfall; during other times of the winter residents park freely. The downtown area has a parking ban between 2:00 a.m. and 6:00 a.m. If more than one inch of snow falls, the police tag and tow vehicles parked on the streets.

In the first year of the parking ban, the city had problems because the high number of tagged and towed vehicles created poor public relations. Because the city had not banned parking prior to this time, residents were reluctant to accept it and were unaware of the consequences. However, vehicles left on the street (snowbirds) slowed down plowing operations and left snow mounds on the streets which the city had to clean up at a later date.

The city used flyers, newspaper articles, and a local cable television channel to publicize information on the parking ban. It posted signs describing the ban at the entrances to the city. The city also tried to convey the message about the advantages of keeping cars off the streets during plowing. Once members of the public realized they could get towed and after they saw that the parking ban resulted in quicker plowing — reducing up to an hour of the plowing time — they started taking the parking ban more seriously.

In the second and third years of implementation, the parking ban has worked well. Police have towed only a handful of cars each year. The city does very little of the cleanup operations that had consumed a lot of time prior to the parking ban.

For more information contact:

Ronald Mergen
Public Works Director
City of Paynesville
(612)243-3714

City of St. Peter

Since 1992 St. Peter in Nicollet County has followed a parking policy that prohibits parking on certain priority streets during a declared snow emergency and restricts parking elsewhere. The policy, now in its third year, has worked well for St. Peter, which has a population of approximately 10,000, about 55 lane miles of roads, and 43 cul-de-sacs and dead ends. In part because of the ordinance, St. Peter's public works department can usually complete all city plowing between midnight

and 8:00 a.m. following a snowfall, and all clean-up activities by the following day.

St. Peter's streets foreman has the authority to de - clare a snow emergency in the city. The streets fore - man always declares a snow emergency before 5:00 p.m. and has it announced over two local radio sta - tions and public access television. Once the fore - man declares an emergency, the parking ordinance prohibits parking for two days on the city's snow emergency routes. St. Peter includes portions of eight streets as emergency routes, with signs posted along the routes to clearly mark where they begin and end. In addition, the ordinance bans parking on residential streets between the hours of midnight and 7:00 a.m. and prohibits parking on downtown streets from 2:00 a.m. until 6:00 a.m.

Crews plow from midnight to 8:00 a.m. following a snowfall and come back the following night at mid - night to clean up and haul out snow. During the sec - ond night, one of the trucks has the duty of cleaning up areas where cars had been illegally parked.

Residents without parking facilities may park in any of eight designated lots during snow emergencies.

Although the city requires all rental properties to pro - vide off-street parking, some do not. To assist those who have no off-street parking, the public works department desig - nated eight municipal parking lots around the city for free public parking during snow emergencies. The department does not plow these lots until after first giving advance warning. Street department workers post signs at the lots stating when no parking goes into effect.

To inform the public about the parking ordinance, the public works department sends out information about the parking regulations in the fall when the city mails out its utility bills. The costs of commu - nicating the information are incidental because the department produces the notices in-house and in - curs no additional mailing costs. Once reminded prior to each snow season, citizens generally accept and obey the ordinance.

St. Peter adopted this parking policy three years ago because compliance was poor with its former park - ing regulations, which some thought were too com - plicated. Although the police were responsible for enforcing the parking regulations and tagging cars, the number of violations was so great under the for - mer system that the police had a hard time keeping up. In addition, the volume of tickets created poor public relations for the city. Since implementation of the new parking regulations, compliance has im - proved and the police department has written fewer citations. The police and the city council support the current parking policy because the street depart - ment is generally able to plow all streets by 8:00 a.m. and the city tags fewer vehicles than in the past.

For more information contact:

Greg Kozitza
Streets Foreman
City of St. Peter
(507)931-4840

2. ENCOURAGE COOPERATIVE SNOWPLOWING SERVICES AND FACILITIES

Township Maintenance Association

Hawk Creek, Ericson, Wang, Sacred Heart, and Crooks Townships

The Renville County townships of Hawk Creek, Ericson, Wang, Sacred Heart, and Crooks success - fully participate in a township maintenance associa - tion. The association provides snow and ice control services as well as year-round maintenance for township roads. It has been in existence since 1945.

A township maintenance board governs the associa - tion. The four townships' supervisors comprise the maintenance board, with a total of 20 board mem - bers (Crooks Township is not a full member). The township maintenance board elects a president,

vice-president, treasurer, and secretary. The asso - ciation's total revenues are about $125,000 annually with expenditures of about $105,000 annually. The township maintenance board president serves as the chief administrator of the maintenance association.

The township maintenance association employs two full-time operators. Their primary duties are snow and ice control, blading gravel roads, and mowing grass. The association owns three motor graders with front "V" plows, underbody plows, and wings. The two operators keep track of the hours they work and charge the townships as follows:

- Snowplowing and gravel blading at the rate of $27 per hour (Crooks Township pays $36 per hour as a non-member);
- Shop time at the rate of $20 per hour for the four members;
- Mowing three times a year at $10 per mile for all the member townships, a total of $4,620.

Depreciation on the three motor graders is calcu - lated at $100 per mile of township road. For the four member townships, this amounts to a total of $15,400 per year. (Hawk Creek Township has 28 miles of road, Ericson has 37 miles, Wang has 34 miles and Sacred Heart has 55 miles.) To pay for the service, the four townships use special assess - ments that residents pay along with their property tax bills.

Township officials and residents are positive about the level of service provided by the township main - tenance association. Officials indicate that they would not use a less expensive contractor because they would not receive the same high level of serv - ice. They also believe that it would not be cost ef - fective for all of the townships to have their own separate contracts. Officials believe that sharing the purchase costs of large equipment was a signifi - cant advantage to townships that would not have been able to afford the equipment on their own.

Township officials enjoy a high degree of local con - trol over when work gets done, which is important to them. Officials believe that the amount of con - trol is much higher with the association than it would be with a contractor or the county.

For more information contact:

Brad Froland
Supervisor
Hawk Creek Township
(612)564-2415
or
Myron D. Peterson
Supervisor
Hawk Creek Township
(612)765-2676

Shared Salt Storage and Other Cooperative Approaches

City of Alden

Alden is a city of 623 residents in southern Minne - sota that shares the use of an enclosed salt and sand storage facility owned by the state. Mn/DOT has owned a storage facility in Alden for many years. Alden has shared in the use of the facility since it was first built.

Alden buys its own sand and salt materials and hauls them to the Mn/DOT facility. As the city uses the mix, it keeps track of the number of loads taken from the storage facility. Without the use of Mn/DOT's salt storage, Alden would have to con - struct its own storage shed at a cost the small city would find prohibitively expensive.

Alden's public works superintendent has forged a cooperative relationship with the state for a variety of services in addition to the shared use of the salt shed. For instance, the city provides all the sweep - ing services in the spring to sweep sand off the roads, including the state highway, and dumps the sand in vacant lots or uses it in other city projects. Although Alden formerly contracted with a vendor to haul snow out of the downtown streets, the city and state now work together to load and haul this snow. The cooperative relationship has proven beneficial to both the city and the state as it devel -

oped over the years. Alden's public works superin - tendent believes that the cooperative arrangements work because of a mutual "give and take" attitude shared by the participants. One helps out others knowing that they will return the assistance in the future.

For more information contact:

Dan Reindal
Public Works Superintendent
City of Alden
(507)874-3620

Douglas County

Douglas County's public works department pro - vides salt, sand, and an enclosed storage facility in a shared arrangement with eight townships and the city of Alexandria. No formal written agreements exist among the jurisdictions, but the county has successfully provided this service for 15 years. Douglas County has 1,083 lane miles of road and about 29,000 residents.

In the last ten years, the local governments using Douglas County's facility increased their salt and sand orders by 35 percent due to public demand for safe intersections during the winter. Annually, the 8 townships use about 1,100 cubic yards of salt and sand, Alexandria uses about 1,200 cubic yards, and the county uses 1,000 cubic yards.

Douglas County stores salt and sand for nine other local governments.

The department buys salt and sand in bulk, mixes it, and sells it to the cities and towns at cost plus a 10 percent administrative fee. It purchases salt for $35 per ton; sand costs about $3 per cubic yard in central Minnesota. The department mixes the materials at a 10 percent salt to sand ratio and sells it for $11 per cubic yard, in - cluding a $1 administrative fee. Record keeping is simple: operators sign a slip indicating how many cubic yards they loaded and the county bills the ju - risdictions later.

Douglas County's cooperative arrangements for salt, sand, and storage have benefited all local gov - ernments involved. They can have a positive im - pact on the environment since each of the participating local governments does not maintain separate salt storage facilities. The storage facility is designed to handle peak demands for salt and sand because all local governments need their mate - rials simultaneously (preceding a major snow fall). The department facility is centrally located so that all of the local governments can efficiently use it. All townships using the Douglas County storage fa - cility are within 30 miles of the facility.

The savings for all of the jurisdictions involved are substantial. Without the bulk purchasing of materi - als and without shared storage, county officials esti - mate costs would double per cubic yard of material. The department benefits because administrative fees collected from all of the jurisdictions subsidize the cost of the department's purchases.

For more information contact:

Jim Nohre
Public Works Superintendent
Douglas County
(612)763-6001

City of Madison

In the fall of 1995 the street division in the city of Madison, a city of 1,900 residents in west-central Minnesota near the South Dakota border, will begin sharing a salt storage facility currently under con - struction by Mn/DOT. Because Mn/DOT is build - ing its storage facility right in the city, the location allows Madison to receive all the benefits of en - closed salt storage without adding to its travel time and costs for salt and sand mix.

Up to this point, Madison's street division has stored its salt and sand in outside piles. The divi - sion will switch over to using the state-owned facil - ity once construction is completed (anticipated for

the 1995-1996 snow season). It will pay the state for its use of the facility based on the amount of mix that it uses. Because the salt and sand mix under this arrangement will be stored in a covered facility, Madison will receive better quality mix that has not been exposed to the elements. Additional advantages accrue from avoiding possible environmental degradation caused by exposed salt piles. Although it would be difficult for Madison to afford such a facility by itself, the shared arrangement gives the city the advantages of covered salt storage without bearing the capital costs of a facility.

Madison's proximity to the Mn/DOT facility allows this cooperative venture to occur. For other areas considering shared salt facilities, distance to the facility could be an issue; they would have to estimate travel times and costs to determine the actual benefits and costs of such an arrangement.

Currently, Madison and Lac Qui Parle County join forces to bid for their road salt purchases. Together the city and county are able to buy road salt at a better rate than if they bought their salt supplies individually. They compare their bid prices to what they could receive by buying through the state contract. Using a nearby supplier, they have received lower bids to provide salt than what they would have paid by using the state contract.

For more information contact:

Harold Hodge
Utilities Superintendent
City of Madison
(612)598-7373

City of Paynesville

Paynesville is a small city (2,300 residents) in central Minnesota that shares the use of a salt storage facility with the state. Mn/DOT owns a salt storage facility that is located within the city's boundaries.

The city buys salt at the price the state receives on its contract for road salt. Paynesville buys its own sand from a local vendor. It transports the sand to the Mn/DOT storage facility in Paynesville where it is mixed and stored in the same bin with Mn/DOT's materials. The state mixes at a ratio of about 93 percent sand and 7 percent salt. Paynesville uses this mix unless it has particularly icy conditions or freezing rain. Under those weather conditions the city will add more salt, sometimes up to a ratio of two-thirds sand to one-third salt. Typically, Paynesville uses the mix only in specific areas such as in the downtown, at intersections, or around schools.

Paynesville avoids the cost of building its own storage facility by storing its materials with Mn/DOT's.

In this arrangement, the city avoids the cost of building its own facility by storing its materials with Mn/DOT's. This saves the city both the capital expenditure that would be required to build the facility as well as ongoing facility maintenance expenses. Because the city purchases its own salt and sand, Mn/DOT is not at risk of running out of its supply. The advantage to Paynesville is possible because of the location of Mn/DOT's storage facility. If the city had to travel to use the salt/sand storage bin, it would have to weigh the costs of transporting the mix against building its own facility.

For more information contact:

Ronald Mergen
Public Works Director
City of Paynesville
(612)243-3714

3. CONTRACT FOR SERVICE, OR PARTS OF SERVICE, WHEN APPROPRIATE

Contracting for Snow Hauling

City of Moorhead

Moorhead's public works department contracts with private providers for the removal of snow from the city's downtown business district. Moor -

head has about 33,000 residents, 258 lane miles of road, and is located in Clay County. Contracting for snow removal has been particularly effective during snow emergencies when there is the greatest demand on employees and equipment to plow the entire city. Responsive snow and ice removal has been welcomed by the business community.

Moorhead's downtown business district presents a challenge in terms of winter maintenance. The district's lack of boulevards makes plowing difficult and the shortage of snow storage makes snow hauling mandatory. Because the district is a retail shopping area, it requires immediate snow removal to accommodate downtown shoppers and the needs of the businesses.

The city began contracting for snow hauling services in 1985. Owners of semi-truck trailers were interested in contracting during the winter months when their equipment was typically not in use. The city owns a snow blower that can fill a semi-truck trailer in approximately 90 seconds. Due to the high speed of loading and readily available haulers, contracting became an efficient solution to the city's snow hauling problem.

Contracting for snow hauling in the downtown business district has made the job of plowing the entire city during a snow emergency much easier. Department officials use their equipment and employees to plow streets instead of remove snow from the downtown area. Also the department has lowered its overall labor costs by contracting with outside firms to meet peak demands. It has avoided the administration of insurance-related issues such as workers compensation and health care. Finally, the city has had a pool of readily available experienced truck drivers at its disposal.

For more information contact:

David Weidner
Street Supervisor
City of Moorhead
(218)299-5422

Contracting for Mainline Service

City of Paynesville

Paynesville, with 34 lane miles of streets, contracts both its street plowing and snow hauling services. It has always relied on contracted plowing and uses city workers only for snowblowing and sanding as needed.

The city has continued to use contract snowplowing over the years because of its high level of satisfaction with the service provided by the contractor. Further, the expense to the city of adding the equipment and labor it would need to plow its own streets is prohibitive.

Even though the contractor plows the streets, the city's public works director controls the decision about when to plow. As in several other cities, during the night and on weekends the local police department notifies Paynesville's public works director when conditions appear to warrant plowing or sanding. If the public works director decides plowing should begin, he contacts the contractor.

Snowplowing operations usually begin between 2:00 and 4:00 a.m., depending upon when snow stops falling. While the contractor plows the city's residential streets, city employees clear the sidewalks in the downtown business district using tractors with blower attachments. (Paynesville charges downtown businesses $1 per linear foot of sidewalk once a year for this service.) City workers blow the snow into the street. When they finish, they contact the contractor via radio. Typically, the contractor is finishing the residential streets as the city workers finish blowing snow from the sidewalks downtown. The contractor then plows the downtown streets, including the snow blown from the sidewalks, using two motor graders. Between the contractor and the city workers, all plowing is usually done before 6:00 a.m.

The city holds a second, separate contract with a different vendor for hauling snow out of the downtown area. Using a front-end loader and tandem dump trucks, the contractor will usually finish the hauling before 8:00 a.m. Thus, following a typical

snowfall, Paynesville has its 34 lane-miles of street plowed, its sidewalks cleared, and the snow hauled away by 8:00 a.m.

Although it is not always possible, the city's goal is to try to maintain bare pavements on the downtown roads, which are the ones most heavily used. It does not try to keep bare pavement on residential streets. Because Paynesville has a few cul-de-sacs that will not accommodate the large graders used by the contractor, city workers clear the cul-de-sacs with tractors and blowers. In addition to the tractors and blowers, the city owns a single-axle dump truck with a rear-mounted tailgate sander for ice control.

Paynesville uses a negotiated contract with its vendors. In its contract the city specifies who is responsible for what operations and when the contractor will be expected to provide the service. It pays a straight dollar amount per hour per unit. The contractor plows the city before any other jobs and has proven reliable. Paynesville officials believe the arrangement provides the city with a high quality of service at minimal cost.

Other communities with less established contractor relationships or those beginning a contract relationship would likely have to: specify in a written proposal the level of service expected from the contractor, solicit bids from more than one vendor, and explicitly measure the quality of the service to determine whether the intended results have been achieved.

For more information contact:

Ronald Mergen
Public Works Director
City of Paynesville
(612)243-3714

Contracting for Cul-de-Sac Plowing

City of White Bear Lake

White Bear Lake's public works department plows mainline streets but contracts with private plowing companies to plow the city's 78 cul-de-sacs, as well as alleys and parking lots. For White Bear Lake, a city with 120 lane miles of road and 25,000 residents on the border of Ramsey and Washington counties, contracting cul-de-sac and alley plowing saves capital and operating expenditures while allowing the city to maintain a high level of snow and ice control service.

White Bear Lake has successfully contracted for its cul-de-sac plowing for the past 21 years; in 1994 it began contracting for alley plowing. The public works department began contracting because it did not have the necessary personnel or equipment to plow cul-de-sacs in a timely manner. Before the department contracted for this plowing, it took two days to plow all of its cul-de-sacs. The department lacked the proper equipment to plow cul-de-sacs efficiently, owning neither front-end loaders with reversible plows nor 4 X 4 pickup trucks. With contractors plowing cul-de-sacs, both cul-de-sac and street plowing are finished at approximately the same time on the day following the snowfall.

White Bear Lake contracts for the plowing of its 78 cul-de-sacs and uses its own equipment and employees for street plowing.

White Bear Lake accepts bids each year for its three contracts (two contracts for two groups of cul-de-sacs and parking lots, and a third for alleys) and has multiple vendors competing for the contracts. City officials require contractors to show certificates of insurance for workers' compensation and for liability. Contractors are responsible for any damage they cause to mail boxes, curb, or other property while plowing. Before signing a contract, the public works department performs background checks on the contractors. The public works department requires contractors to begin plowing at the same time the city begins. The department pays its contractors on a straight hourly basis. In the contract to plow parking lots, though, the city includes a snow -

fall variable that increases the hourly rate after a snowfall of six inches or more. In 1994 White Bear Lake paid $500 for alley plowing and about $8,400 for cul-de-sac plowing.

In two decades of contracting for cul-de-sac plowing, the department has not had to sever a contract for poor service. To avoid potential problems with contractors, such as differences between the city and the contractor in the quality or level of service, public works officials meet with contractors before the snow season to present the city's expectations. If the department receives a complaint about service provided by the contractor, it notifies the contractor who is then responsible to respond to the complaint. To maintain communications during plowing operations, the department and the contractors use telephones in their trucks. Contractors that experience a mechanical problem while plowing can use the city shop to repair the problem and complete the job.

White Bear Lake's public works department estimates that snowplowing contracts save an average 40 percent of the operational cost of plowing cul-de-sacs. Besides avoiding the cost of hiring additional staff, the department avoids the costs of maintaining the trucks, equipment, and insurance needed for cul-de-sac plowing. In addition, the city has not had to make capital purchases for equipment to plow cul-de-sacs.

When the department first considered contracting its cul-de-sacs, it faced some resistance from its workers. The city administrator at the time had to convince employees that a unified effort with an outside crew could result in streets and cul-de-sacs plowed faster than city employees working alone. One reason the department was able to make the change was that it had an open-shop clause in the union contract. Cities where unions have a closed-shop policy may encounter more difficulty making a similar change. The department has not had to lay off people because of the contracted services, however, nor has it had to add personnel as its workload increased over time.

For more information contact:

Gene Smith
Public Works Coordinator
City of White Bear Lake
(612)429-8566

4. MEASURE PERFORMANCE AND MAINTAIN RECORDS

Computerized Complaint System

City of Chisholm

Chisholm's public works department is computerizing its system of recording complaints. What initially began as a manual log-in system with pen and paper is developing into an automated information system. Located in St. Louis County, Chisholm has a population of 5,200 and 62 lane miles of road. Although the whole city is using the system, the public works department is the primary focus at this time.

The initial impetus for automating the complaint system was the public works department's desire to distinguish complaints voicing personal preferences from those with substantive service problems. Many times the department received complaints from residents that, though well intentioned, merely stated the residents' own preferences, such as where operators piled snow, as opposed to complaints about the actual quality of service. The department wanted to focus on issues related to the quality of service.

Searching and sorting data by computer have accelerated the department's ability to manage information. The computerized complaint system has helped the department distinguish and set priorities among various kinds of complaints, such as:

- calls from chronically complaining residents,
- problem areas on city streets, and
- problems with operators or equipment.

The department wanted to learn whether the com - plaints were related to equipment, personnel, or safety. The department also wanted feedback to de - termine if it was satisfying residents' needs.

The system is beginning to provide information about service delivery. It allows the department to quantify its snowplowing service. For example, the department uses the computerized system to log the number of complaints on a particular route. More importantly, the system allows the department to ap - ply resources where needed and to focus on the highest priority work. Additionally, the system tracks complaints through to their resolution and clears a complaint from the system only after appro - priate follow up.

The system's biggest drawback has been its time-consuming data entry. The city is refining the sys - tem to generate useful reports and to centralize the beginning and ending points of the complaint proc - ess.

For more information contact:

James Kosluchar
City Engineer
City of Chisholm
(218)254-3257

Computerized Records

Hennepin County

Hennepin County's public works department main - tains computerized records of snow and ice control data. The department began actively tracking mate - rial usage in 1988 and snow emergency response in 1992. Prior to the computerized record system, the department had no systematic, relatively immediate information source other than a manually assem - bled season-end summary report detailing specific snow and ice control operational data for the county. Hennepin County has over one million resi - dents and 1,510 lane miles of road. The public works department has found that systematically tracking material usage and storm response via com - puter provides an effective means of assembling data for observation, analysis, and retrieval.

Material usage records allow the department to track the quantity and type of material used for plowing and sanding. Operators manually com - plete a daily activity log on which they report the date the shift starts, route number, unit (truck or other equipment) number, operator name, stockpile location, type of material, and quantity of material. Operators turn in the activity log with their time cards to the district supervisor, who ensures that all logs are returned and complete.

Snow emergency response records summarize Hen - nepin County's snow and ice control activities. The district supervisors or foremen report measures rele - vant to storm response, including the weather condi - tions of the snow or ice event, the time the event started and ended, the shifts and operators called out, and the response taken. An operations plan - ning analyst then consolidates this information into a summary report. Information contained in the re - port includes:

- date of snow or ice event and start time of re - sponse,
- shift called (first, second, or third shift),
- callout (full or partial),
- number of regularly assigned and fill-in em - ployees used in routes,
- total routes filled and not filled,
- total plowing units,
- ability to fill all routes needed for callout, and
- amount of precipitation and weather condi - tion.

In addition, each report includes a summary capsule and corresponding graph that indicates the amount of snowfall, number of day shift responses, and number of night shift responses.

The computerized data permit the department to analyze particular snow and ice control practices. Tracking materials proves especially beneficial to the county, which uses five equipment and mainte - nance shops (one main and four outlying). The out -

lying shops do not have scales for their stockpiles and, therefore, operators have to estimate material usage based on the number of buckets loaded. Al - though the operators are fairly accurate with their estimations, the material usage reports allow offi - cials to compare estimates with the actual material used, as measured with scales at the end of the sea - son. Both actual and estimated reports facilitate the county's goal of increasing operator awareness and controlling material usage. The weekly and monthly records, reporting total daily quantity of material used and monthly quantity of material used per lane mile, allows officials to identify and cor - rect potential problems in material application.

Because the department records how much and what type of material was used by operator and equipment piece, it can determine if a piece of equipment is not operating properly and needs atten - tion, if an operator needs additional training, or if a particular route requires more or less attention be - cause of trouble intersections, hills, curves, or traf - fic. The intent of the tracking is not to monitor individual operators, but to maximize efficiency with accurate inventories of ma - terials and their use.

Hennepin County's record keeping helps the department estimate its needs for personnel, equipment, and materials.

Snow response records pro - vide information to im - prove performance. The department can determine if it had enough operators to cover routes, whether conditions and call outs varied from district to dis - trict, which shifts (first or second) were affected, and which conditions were most labor and time inten - sive. The information also aids in estimating the county's needs in terms of snow and ice control per - sonnel, equipment, and materials. For example, the department is constructing a new main building and will use the computerized information to assist in making design estimates for material storage based on the actual needs of its snow and ice control op - eration.

In addition, the public works department finds that the computerized records facilitate responses to re - quests from commissioners, county administrators, and the general public. If the department receives a question or complaint, officials can easily retrieve the necessary data to support the department's ac - tions. This systematic and comprehensive attention to requests builds credibility for the department and its employees.

Hennepin County's public works deparment uses a computer spreadsheet to record both material usage and snow emergency response. The principal capi - tal expense of computerized record keeping is the cost of the computer and corresponding spreadsheet software. Because the public works department al - ready had the computer and software, the only cost it incurred was that of labor. Ongoing, accurate re - cords require time. Officials estimate that for each snow or ice event, operators spend approximately five minutes completing activity sheets, supervisors spend 15 to 20 minutes compiling and verifying the activity sheets, and a public works clerk spends two to three hours entering the activity sheet data onto the computer. The planning analyst spends approxi - mately four to eight hours preparing forms and com - posing weekly and monthly summary reports.

Despite the labor involved, the public works depart - ment believes computerized records generate multi - ple benefits for Hennepin County. The system provides the county with accurate data to assist in managing snow and ice control operations, from material usage to the personnel and equipment in - volved with snow emergency response. The depart - ment believes that this systems management approach increases its efficiency and effectiveness in snow and ice control, which optimizes resources in the delivery of service provided by the county.

For more information contact:

Marc Simcox
Public Works Planning Analyst
Hennepin County
(612)930-2629

City of Hoyt Lakes

Hoyt Lakes' public works department is in the proc - ess of implementing its first computerized record keeping and preventive maintenance system. The department has two primary objectives. One is to operate a cost-effective fleet, and the second is to implement an aggressive preventive-maintenance program for its equipment. Activities include devel - oping a thorough history on each piece of equip - ment to evaluate and determine what work needs to be done and, most importantly, anticipate mainte - nance needs. Hoyt Lakes has 2,300 people, 30 lane miles of road, and is located in St. Louis County.

The initial impetus for computerizing department re - cords was to provide a more uniform way of keep - ing records and to end confusion about whether work was completed or not. The department used the services of a local consultant to develop a sys - tem. They designed a "work history" report to de - scribe what work has been done, a parts list and prices, hours worked on equipment, hours since last service, dates of service, model and year of equip - ment, and mileage.

The department will use the computerized reports to aid its preventive-maintenance program for equipment. A routine oil and filter change on a mo - tor grader costs about $60, but if internal engine parts are damaged due to a lack of scheduled main - tenance, the city would face substantially higher costs. A computer makes it easy to list what main - tenance needs to be done and when. While perform - ing routine maintenance, such as oil changes, the mechanic inspects other systems like fluids or brakes, notes their condition, makes necessary re - pairs, and records the information.

The department's next step is designing a report that anticipates future needs and helps mechanics schedule routine maintenance in advance. Cur - rently, equipment operators notify the mechanic when service is needed. In the future, the computer system will operate like a "tickler file," enabling the mechanic to call in the equipment for routine serv - ice and identify any additional preventive mainte - nance needed.

Department officials hope that the combination of computerization and preventive maintenance will enable them to operate better, safer equipment over a longer period of time. Their goal is getting the most value out of every piece of equipment by maximizing its useful life. Department managers expect the computerized system will help them to use historical records to make better decisions about which equipment and parts to buy and which vendor services to use.

For more information contact:

Mark Novsel
Foreman
City of Hoyt Lakes
(218)225-2832

Maintaining Records of Customer Contacts

City of New Hope

New Hope's public works department instituted a system of tracking calls regarding snowplowing and sanding operations, as well as other department activities. New Hope is a city in Hennepin County with 21,700 residents and 130 lane miles of road. Tracking requests and complaints is one component of a larger effort in the department focused on pro - viding quality service and fulfilling the needs of customers.

Although the department has always responded to calls received from residents, in 1994 it developed a one-page form to systematically monitor calls from the public and the department's response to them. On the form, staff provide pertinent information about the type of customer contact, when it was made, and by whom. The form also allows staff to document the action taken in response to the con - tact, the date of the response, and the staff person re - sponsible. Responses may include a return phone call, a letter, or other actions, such as sending a crew to the site of an icy intersection.

The customer-contact form is simple and easy for staff to fill out, yet allows the department to track the nature and timeliness of its responses to cus -

tomer calls. With this monitoring system, the department can systematically assess whether a problem is recurring and determine whether changing procedures could alleviate it. Although the number of customer contacts regarding snow and ice control have been few (approximately a half dozen after a major snowfall), the department's system of tracking contacts ensures that each caller requesting a response receives a timely one. The costs of this tracking system are minimal and are related to the time involved with completing the form and following up the contact.

New Hope's public works department is in the process of computerizing its system of monitoring customer contacts. The department expects computerization will increase efficiency in both monitoring responses to each phone call and determining when changes in procedures are necessary to correct a problem.

For more information contact:

Don Larson
Public Works Superintendent
or
Paul Coone
Street Lead Worker
City of New Hope
(612)533-4823

Measuring Service Satisfaction

Washington County

Washington County's public works department uses written surveys to measure public satisfaction with its services. Washington County has a population of 163,500 and 314 centerline miles (609 lane miles) of county road. Eight cities and townships in the county, with a total of 194 centerline miles of road, also contract with the public works department for road maintenance and construction.

In 1994 the public works department developed a one-page survey to ask its major users of roads their opinions of the department's services. To encourage potential respondents to fill out the survey, the department designed the brochure as a postage-paid self mailer; respondents needed only to drop their comments in the mail. The brief survey asked respondents to check off the type of service they received (whether it was snowplowing, park maintenance, etc.), whether they were pleased or dissatisfied with the department's initial response and the final results of its work, and how courteous, knowledgeable, and timely the employees were. Respondents could indicate they wanted a public works representative to contact them about particular concerns. The survey included space for comments or suggestions. The county was unable to provide an estimate on the cost of developing and printing the brochure.

The department sent out the survey to all surrounding cities, townships, school districts, and major businesses. Residents could pick up a survey in any county building. Respondents could provide their name, address, and phone number on the survey, but this was optional.

The survey is a tool to inform the department of the public's level of satisfaction with its service. The ratings and comments allow the department to evaluate its service and determine what changes it could make to improve service. Department officials intend to also use the results during the budgeting process to make spending decisions that can improve the satisfaction of customers.

The department is developing another survey that will specifically measure satisfaction of the cities and townships that contract with the department for road maintenance. Contract cities and townships will receive the written survey periodically to rate the level of service they receive from the department and indicate what changes they would like to see. The department will use feedback from this survey to assess whether it needs to change its service to those jurisdictions that rely on the county for road maintenance.

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Evaluating Performance

City of Woodbury

While Woodbury officials have always monitored the city's snow and ice control efforts, they did not implement formal performance measures until 1993. The city administrator encouraged depart - ment heads to define their department's mission, the level of service the department hopes to pro - vide, and how to evaluate the service achieved. Woodbury, a city in Washington County with 30,000 residents and 305 lane miles of roads, evalu - ates performance as a public service to citizens and as a means to track costs and corresponding service.

The Woodbury street department set its own goals for snow and ice control performance. Although the department was not formally required to de - velop any performance measures, the city council and the city administrator promoted the adoption of these measures. The philosophy behind setting measures internally is that departments know best how to measure their own performance.

Employees were initially concerned with the amount of documentation time performance meas - ures might require. Woodbury's street supervisor, however, was determined to make the performance measures as simple and user-friendly as possible. To counter employees' concern, the department adopted a worksheet that takes two minutes to com - plete, in addition to the daily time-sheet log. As ex - plained to street department employees, tracking performance is necessary to justify the department's existence.

Performance measures used by the street depart - ment include the following units of output, effi - ciency measures, and productivity measures:

Units of Output

- miles of primary and secondary streets plowed and sanded, and
- number of cul-de-sacs cleaned;

Efficiency Measures (cost per unit of output)

- equipment cost per event,
- material (salt and sand) cost per event, and
- annual mailbox and sod damage cost analysis;

Productivity Measures (personnel costs per unit of output)

- labor cost per event, and
- annual labor cost in relation to mailbox and sod damage.

The street department also assesses the combined annual cost for its entire program. The department measures its effectiveness in terms of quality, timeli - ness, and process. These entail annually evaluating routes and equipment, monitoring equipment readi - ness, monitoring and recording precipitation accu - mulation relative to output activity, monitoring and recording winter parking violations, annually evalu - ating the parking ordinance, and semi-annually comparing Woodbury's program to other communi - ties.

The department uses the information to produce an annual summary of snow and ice control perform - ance. Measures include:

- number of snowfalls and ice events,
- salt and sand tonnage consumption,
- average pieces of equipment used,
- salt and sand mix rate,
- average miles per route,
- average mixed tons per route,
- average task hours per event,
- average mixed tons per event,
- miles of street,
- material costs per ton delivered,

- number of cul-de-sacs,
- average cul-de-sacs per route,
- average salt and sand mix ton cost,
- average time per cul-de-sacs,
- average annual cost per mile,
- repair hours per unit,
- average annual cost per hour,
- repair cost per unit,
- average annual cost per route,
- repair cost per route,
- average annual cost per event,
- average hours per event,
- average crew response times per street condition,
- average snow event start times,
- number of street-related citizen contacts, and
- number of complaints on plow and mailbox damage.

The only cost of measuring performance is the time required to compile the information. Woodbury's street department supervisor performs this task and views it as a necessary part of his daily responsibility for managing his workforce. Although the data compilation takes a significant amount of time, the supervisor believes that the time is well spent. He believes that it has helped the street department justify requests for funds, and changes in procedure or courses of action when necessary.

For more information contact:

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City of Woodbury
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5. PLAN FOR EQUIPMENT REPLACEMENT

Equipment-Replacement Fund

City of Edina

Edina's public works department uses an equipment-replacement fund to financially prepare for replacing equipment that wears out or becomes obsolete. The combination of an equipment-replacement fund and a preventive maintenance program to keep equipment well maintained helps to ensure the availability of fully functioning equipment for effective winter maintenance. Edina is located in Hennepin County and has 47,000 residents and 413 lane miles of road.

To be useful, an equipment-replacement fund requires advance planning. The Edina public works department first estimates the expected life cycle of each piece of motorized equipment, from snowplow trucks to chain saws. After compiling an inventory of the current pieces of equipment and their expected life cycles, the department then determines what amount of money it is likely to need in the future to replace the equipment.

Each year the department sets aside an amount of money that it will use to replace equipment.

Each year the department sets aside in the equipment-replacement fund an amount needed to replace the equipment by the end of its life cycle. For instance, the department typically plans for a 12-year replacement cycle on its snowplow trucks. For the first year following the purchase of a truck, the department divides the truck's cost by the expected 12 years of life and puts this amount into the equipment-replacement fund.

Each year the department updates its list of expected life cycles. If a piece of equipment lasts longer or wears our sooner than expected, the de-

partment adjusts its calculations accordingly and changes the amount of dollars set aside. The depart - ment also includes in its account the value of equip - ment that can be traded in at the end of its useful life in Edina.

With the replacement fund, the department is pre - pared to finance large and small capital purchases without the need for a large revenue increase in any single year. Edina's public works department is able to anticipate its equipment needs and make pur - chases on a timely basis instead of suddenly and un - expectedly.

The department uses the replacement fund to fi - nance both new and used equipment. By looking for good values in the market of equipment, the de - partment has purchased three- to five-year old equipment that meets its specifications and offers savings of 15 percent or more over new equipment. If the purchase price is less than the amount set aside in the equipment-replacement fund, the money either goes back to the general fund or the department may use it to finance other needed pur - chases.

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City of Edina
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Capital Improvement Program for Equipment

City of Hoyt Lakes

For the past ten years, the Hoyt Lakes public works department has used a capital improvement pro - gram to acquire a cost-effective equipment fleet. Hoyt Lakes is a city in St. Louis County with a population of 2,300 and 30 lane miles of road. The city purchases all of its equipment, not only its snow and ice control equipment, through the capital improvement program.

Hoyt Lakes experienced several problems that served as the impetus for developing its capital-equipment improvement program. First, the city's budget process had become confusing and exces - sively time consuming. Personnel did not set priori - ties for capital purchases and had no systematic approach to budgeting equipment expenditures. Second, there was considerable competition for re - sources. Arguments and disagreements over budget expenditures occurred frequently, taking a toll on staff camaraderie. Finally, staff used a wish-list ap - proach to budgeting: they brought in a multitude of budget requests hoping to get at least some of what they wanted. This approach made it difficult for de - cision makers to sort out priorities for decision mak - ing.

The capital-equipment improvement program relies on department heads who systematically plan for the life of their equipment. Department heads deter - mine when equipment typically wears out and annu - ally budget an amount to finance its eventual replacement. While the concept is simple, the im - pact on the department has been significant. De - partment heads have indicated that they have successfully planned for and purchased their equip - ment with this approach 80 percent of the time. The city's finance department coordinates the pro - gram for all of the city's departments.

The capital-equipment replacement program has had positive effects. Overall it has taken much of the combativeness out of the budget process and shortened the budget sessions. Because city offi - cials budget funds several years in advance of large expenditures and accumulate the money annually in the fund, the city avoids large, short-term impacts on the budget. In this way, the city prevents huge increases in property taxes for capital purchases in any given year. All city departments contribute funds to the program so that all who use the equip - ment bear the financial burden. As importantly, the program has helped the city council in its decision-making process because it makes priorities clear and indicates the funding needed to maintain cur - rent equipment levels.

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6. FOSTER A QUALITY WORK FORCE

Strategic Use of Labor Pool

City of New Hope

New Hope's public works department attempts to keep its main streets plowed to bare pavement in the winter. To achieve this objective, the department starts its plowing and sanding early (typically 2:00 a.m.), applies a mix of one-third salt and two-thirds sand to intersections and icy spots, taps into a department labor pool, and provides its operators with the right equipment. This example focuses on the department's cross-training and use of its labor. New Hope, located in northern Hennepin County has 21,700 residents and 130 lane miles of road.

The city's public works department has 14 maintenance workers in its streets, sewer and water, and parks divisions. Typically, seven workers plow and sand city streets and cul-de-sacs using five plow trucks and two front-end loaders; two workers from the water and sewer division plow sidewalks. However, after a large snowstorm the department is also able to use the other maintenance workers as necessary to get the job done.

In preparation for a full call out of personnel in response to a severe storm, all workers in the department, not just the streets employees, receive training. Training familiarizes all the maintenance workers with the snowplowing and sanding equipment and procedures. The department also requires all workers to have the proper commercial driver licenses in case they are called upon in a snowstorm. This labor pool adds flexibility to the department's efforts because it is able to use additional trained workers when a snow emergency becomes the number one priority. With this staffing flexibility the department can meet service needs during peak times without having all of its workers devoted solely to snow and ice control.

To aid in snowplowing operations, the department will call in at least one of its two mechanics during a snowstorm. The mechanic can communicate from the shop with the operators and can immediately respond to mechanical problems that operators experience while plowing their routes. Although this practice may result in overtime hours for the mechanic, the department believes the ability to minimize downtime of plowing vehicles during a snowstorm is worth the additional cost. Moreover, during this time, the mechanics clear snow at the public works facility and perform their other daily duties.

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Operator Training and Recognition

Polk County

Polk County's public works department has developed a systematic approach to training snowplow operators. Ongoing training is a significant part of the department's snow and ice control policy. New operators take 16 hours of required safety training and existing operators take 8 hours of refresher training. Training covers every facet of the operation, from complaints to the chain of command. Located in northwestern Minnesota, Polk County has 1,870 lane miles of road and 32,600 residents.

Fall marks the beginning of the department's operator training program. The season starts with operators mounting attachments to their equipment and conducting a general inspection. The purpose is to reacquaint operators with their equipment and to

identify any potential problems before the snow season starts.

In mid-October operators meet with foremen and supervisors to talk about winter operations and review snowplowing techniques. For example, they discuss pulling off the road to let cars pass the plow, as a way to prevent accidents with anxious motorists who pass in dangerous situations. Supervisors emphasize defensive and safe driving as part of setting a good example for the motoring public.

Each snowplowing season the public works department sends questionnaires to the school districts and emergency systems to obtain data and evaluate their needs. On the basis of the survey data, the department draws colored route maps for each of eight snowplowing districts. It assigns a truck with front and underbody plows and a motor grader to each district. The department also develops sanding control maps that illustrate priority roads for applying salt and sand. Operators are expected to be familiar with these routes.

The department trains new drivers by pairing them with an experienced foreman at the beginning of the plowing season. Cross training of operators on all department equipment is mandatory. Because the training requires operators to understand the needs of the total county, operators can assist drivers in other districts, thus adding flexibility to the department's operations.

As part of Polk County's ongoing training program, operators view operational training videos from Mn/DOT, the University of Minnesota's Technology Transfer Program, and Polk County. Operators discuss winter survival and safety techniques and familiarize themselves with survival and safety kits. They also review the use of radio equipment. Operators talk about snowplowing policies to: 1) make one pass on every road in eight hours and have all county roads passable, and 2) salt and sand within 24 hours of the snowfall. Training emphasizes getting started early and plowing the snow right away to prevent compacted snow and ice. The payoff is controlled use of salt and sand and fewer returns for replowing and scraping of roads.

Dry runs are a critical part of the ongoing training program. Prior to the snow season, operators drive their equipment on their route and identify hazardous areas, such as drop-offs or low shoulders, mail boxes, and potential turn-around areas. New drivers typically do this with an experienced foreman who points out the hazards.

Throughout the snow season, supervisors and the superintendent monitor the condition of the routes to provide ongoing feedback to operators about their snowplowing techniques. The emphasis is on identifying problems and correcting them as soon as possible.

For more information contact:

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City of Woodbury

The Woodbury street department has formally trained its plowing and sanding operators since 1988. The department believes that training is both needed and appreciated. It further believes that the city, located in Washington County with 30,000 residents, 305 lane miles of roads, and 15 full-time snowplow operators, needs to give operators the tools to do what is expected and required for snow and ice control.

The street department hosts an annual "snowplow preparedness day" each fall, as well as monthly safety meetings. The snowplow preparedness day is a two-day seminar consisting of discussions on:

- route maps,
- route inspections,
- safety procedures,
- plowing procedures,
- sanding procedures,
- cul-de-sac maintenance,
- material application,
- role and importance of snow tasks and events,

- equipment inspection,
- truck washing,
- performance measures,
- task sheets,
- communication, and
- overtime (including daycare arrangements).

Woodbury's street supervisor teaches the workshop and uses guest lecturers, videos, and workbooks to keep employees interested. At the end of snow - plow preparedness day, operators participate in an obstacle course designed to test snowplowing skills and compete for a trophy awarded for the best ob - stacle course score. Street department operators, back-up operators from the public works depart - ment, and general department staff (from mainte - nance personnel to department secretaries) are welcome and encouraged to attend the event. The city recently budgeted coffee and rolls for breaks and a complete lunch for the workshop, hosted by the street department, to reward employees for their efforts.

Woodbury's officials incorporate employee recogni - tion into other aspects of the city's snow and ice control efforts. For example, the street department provides:

- hats and mugs to promote the snowplowing program,
- gift certificates to show employee apprecia - tion,
- cots to allow operators to rest when needed (*i.e.*, when they cannot make it home during a continuing storm),
- meals during emergency call outs that last over eleven hours,
- letters of commendation, and
- employee awards, such as the "Snowfighting Team Annual Performance Commendation" (recognizing the operator team with the few - est complaints).

Woodbury officials have noticed an improvement in employee job performance since implementing the formal training and employees have appreciated the service. Formal training (a) lets employees know what is expected from managers, council members, and citizens, (b) allows multiple departments to work together on a common activity, and (c) in - creases employee morale. Precise cost estimates are unavailable because the street department has one training budget for all of its activities. The street department estimates that a total of approxi - mately $950 is spent annually for snow and ice con - trol training, with nearly $750 going toward the Snow Preparedness Day. The department has re - fined its training over the years, using the newest and most current information whenever possible to maintain continued employee interest. Training in - stills a sense of pride in the snow and ice control program and generates among employees a commit - ment to effective service.

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Equipment Enhancements and Employee Safety and Comfort

Washington County

Washington County's public works department be - lieves that the quality of its workers and equipment allows it to meet its objective of plowing the county's main roads to bare pavements. It has used the suggestions of its workers to make equipment changes that have improved the operators' safety and comfort as well as the efficiency of the county's snow and ice control operations. Washing - ton County has 314 centerline miles (609 lane miles) of county road, but actually provides more road services because it also maintains roads for 8 cities and townships with an additional 194 center - line miles. Many of the county roads are major col - lectors carrying an average daily traffic level of 25,000 vehicles. However, the city and township roads require different service levels because they serve less traffic (an average daily traffic level of about 300) and are gravel.

The department is committed to improving the ride and safety for its operators while advancing its snowplowing operations. The department believes that the truck enhancements in which it has invested aid the operators, give them greater job satisfaction, and, in turn, lead to greater productivity and more efficiently plowed roads. Many of the ideas for improvements came from the operators themselves. During the department's annual fall meeting and a spring wrap-up meeting, operators discuss what worked and did not work and what they would like to see done differently. The following list includes steps the department has taken to assist drivers and improve snowplowing and sanding operations.

Over the past five fall seasons, the department has marked all areas that could pose a potential hazard while snowplowing. It uses fiberglass stakes at $16 each to mark curbs and problem manholes that could interfere with plowing. It also uses hazard markers near cable guard rail to indicate when the snowplow operator should lift the wing. The department uses metal sign posts to mark grass medians, enabling operators to use the posts as a guide while plowing.

Washington County's snowplow trucks have two heated mirrors, one on either side of the cab, to improve the drivers' visibility. The heated mirrors cost $110 a pair. The trucks also have power windows on the driver and passenger sides, costing about $300, which allow the operator to easily see out while still operating the truck and the plowing and sanding controls. To keep the cab windows clear, the department purchased high-output window defoggers and heater systems. Some trucks have extra fans, costing $44, as a backup to the defoggers.

The department equipped the trucks with high-quality seats to provide a comfortable ride and reduce fatigue for drivers who sometimes drive 10 and 12 hour shifts. The seats cost about $40 more than conventional seats.

To make the trucks easier for other motorists to see, the department has increased the number of strobe lights on the snowplow trucks from four to six. The six-strobe light arrangement has been in use since 1992. The additional lights cost $285 per truck. The department has also placed extra reflective markings on the full length of the truck boxes, at a cost of about $30.

Instead of levers for controlling the plow and wing, the department has installed joy sticks that increase the ease and maneuverability of the controls. Although operators usually drive the same truck for each snowstorm, the department has located the controls in all trucks in the same place so that drivers can easily operate a different vehicle if their usual vehicle is down for repair.

The department painted all truck engine hoods with a flat black paint to deaden the glare caused by a combination of snow and sun. This cost about $100 per truck.

In 1991 the department installed heated fuel tanks to eliminate the problem of fluids thickening to gels during very cold temperatures. This option cost about $350 more than the standard arrangement.

Employees made extended steps for safer and easier entrances and exits to and from the truck cabs. The trucks are also equipped with first-aid kits and safety gloves.

The department installed rear fenders on all of its trucks. The fenders cost about $100 per truck and help prevent the salt and sand from getting onto the truck frames, thereby slowing corrosion.

Trucks have fender-mounted mirrors on their right and left sides. These mirrors, which cost $64 for a set, help the operator see the whole length of the wing. They also help operators see how close they are to mailboxes and the side of the road.

Trucks are equipped with two-way radios for communication among drivers and FM radios for weather updates. The two-way radios cost a total of $2,100. The FM feature cost about $100 more than a radio with AM only.

Each plow has a curb bumper to help the driver feel the curb line. The bumpers cost $42 each and can prevent curb damage caused by the force of plows

running into them. Some of the county's trucks have curb bumpers on both the plow and wing.

The county's snowplow trucks all have automatic transmissions, 275 horsepower engines (compared to 225 hp in the past), and bigger, heavier plows. The additional power provided by these features accommodates heavier snows and generates less downtime for vehicle repairs during snowstorms. Increasing the horsepower and moving to an automatic transmission cost about $3,000 per unit.

To extend the life of the trucks' body and equipment, the employees wash the trucks after every storm. In addition, the department has an arrangement whereby persons who are sentenced to perform community service wash and clean the entire fleet inside and out on a regular basis.

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City of White Bear Lake

To enhance the safety and comfort of its truck operators, the public works department in White Bear Lake has invested in numerous snowplow truck features and has adopted a general philosophy supporting the safety and well being of its employees. The department believes its philosophy and actions contribute to employee job satisfaction, which increases worker productivity. White Bear Lake is a city with 25,000 residents and 120 lane miles of road on the eastern border of Ramsey County.

White Bear Lake's public works department has equipped its seven single-axle snowplow trucks with a variety of features. These include:

- AM/FM radios, both for access to updated weather reports and for operators' enjoyment;
- roomy, adjustable, custom-fit seats to make the operator as comfortable as possible for long plowing shifts;
- two-way radios to maintain ongoing communications with supervisors, the dispatcher, and others in the department;
- the placement of plowing and sanding controls in the cab so that they are located within an easy arm's-length reach;
- the location of the controls according to the wishes of the operator, who typically uses the same vehicle for each plowing event;
- soundproofed cabs with large windows for added visibility as well as extended roofs for extra head room;
- automatic transmissions for driving ease while operating plows, wings, and sanding controls;
- power-assisted steering and braking for driving ease and quick response; and
- top-of-the-line lighting packages to make the truck more visible to other drivers and enhance the operators' ability to see outside the vehicle.

Although the department does not have precise costs for each of the individual amenities on the trucks, it estimates that overall the features represent no more than 1 or 2 percent of the outlay for a truck purchase.

In addition to these truck features, other department efforts focus on the operators' comfort and safety. For instance, workers have a comfortable cafeteria to use during break times. Although the department occasionally asks operators to work up to 12 hours following a snowstorm, workers use their own discretion to determine if they are too tired to work beyond an eight-hour shift. If an operator believes that continuing to work after eight hours would jeopardize his safety, the department calls in backup personnel from the city's engineering division or the building inspection division to replace that operator.

As part of its emphasis on safety, the department uses an inspection program with an outside inspec-

tor who regularly assesses potential hazards and safety problems. To control risks and minimize dangers to its employees, the department always complies with the recommendations of the inspector, even if they require expenditures that carry through more than one budget cycle.

The department believes that treating its employees well is conducive to a productive work force that will generate returns for the city in terms of quality work. Though difficult to measure empirically, the benefits to the city come from a positive attitude on the part of city workers. For instance, even though drivers have the option to work fewer than 12 hours after a snowfall, they rarely use that option. Over the years the department has had very few workers' days lost to injuries or unplanned absences. The department believes that high-quality equipment and a philosophy that respects its workers have reduced absenteeism and lowered insurance costs for the city. In addition, the department's emphasis on safety lowers the potential for accidents and subsequent lawsuits.

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7. PREPARE PLANS FOR ROUTING, SCHEDULING, AND OBTAINING WEATHER FORECASTING

Planning for Regular and Heavy Snowfalls

Owatonna

When Owatonna developed a written snow policy in 1991, it also developed a snow plan that details the steps it follows to implement its snow policy. In the plan, the parks, recreation, and streets department specifies that the outlined procedures represent a "normal" sequence of events to give itself flexibility should weather or road conditions require altering its plan. Owatonna has 20,100 residents and 184 lane miles of road.

Within the description of its operations, the department lists its plowing and sanding priorities from the point of its start time (typically midnight) until the point when it completes the job. Completion of the job includes all clean-up operations, such as hauling snow from the downtown area and alley plowing, and usually occurs over a period of days. The plan delineates and includes maps for: the four plow zones in the city plus the downtown motor patrol zone; the arterials that are plowed first within each zone; and locations of cul-de-sacs, sidewalk areas to be cleared, and priority sanding areas. It also briefly describes the type of equipment and human resources used in each area.

Owatonna's heavy snowfall plan identifies the personnel, equipment, and operations that will be used with a snowfall of 18 inches or more over 36 hours.

Since first developing the plan, the department has amended it by adding a separate "heavy snowfall removal plan." In this plan, the department describes how it will use other appropriate city personnel not typically involved in snowplowing operations to assist when confronted with a snowfall of 18 inches or more in 36 hours. It identifies the affected city workers and lists the equipment operators will use, the zones of operation, the stages of the operation, and what is expected of the operators, such as the work shift (employees are not required to work beyond eight hours but may volunteer to do so). The plan includes a description and map of the zones and priority streets for plowing during a heavy snowfall.

The department relied heavily on input from workers in its streets division to develop its snow plan. It met with those workers who are expected to keep the streets plowed and sanded to solicit their contri -

butions and reactions to the plan. Becoming famil - iar with the plan is now a part of the employee train - ing process. All workers are well acquainted with the procedures set out in the plan. Because the heavy snowfall plan includes using employees not usually involved with the snowplowing process, those employees participate in annual orientations and training operations in the field during the late fall and early winter. Together, the operators and supervisors review the snow plan each fall to look for areas that need updating or changing. Operators will, for instance, suggest changes to routes based on their familiarity with a particular route.

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Condition Blue, Yellow, Green, Red Routing; Pull Routes; and Computerized Routing Software

Ramsey County

Ramsey County, with 485,000 residents and 652 lane miles of road, began using a "condition blue, yellow, green, red" routing system over 10 years ago. The county's maintenance department had not previously used a formal routing system based on specific snow and ice conditions and they hoped that the new system would establish more consis - tent responses to storms among the county's four districts. The condition blue, yellow, green, red routing system has made plowing more systematic and organized, saving the county time and increas - ing the level of service provided. This ultimately helps Ramsey County achieve its bare-pavement policy on all roads, where the goal is to get county highways as clean as possible in the shortest amount of time possible.

The maintenance department divides snow and ice conditions into four categories for sanding and plowing, with different responses for each condi - tion:

Condition BLUE

condition:	light snow or light ice
action:	sanding
trucks:	8 - 16 trucks
goal:	sand only to improve traction

Condition YELLOW

condition:	light to medium snow (expected to continue for a while)
action:	plowing
trucks:	16 - 20 plows
goal:	plowing enough to keep roads open (no curb to curb plowing)

Condition GREEN

condition:	heavy snow
action:	full plowing and sanding
trucks:	30 plows
goal:	plow all lanes and shoulders

Condition RED

condition:	ice storm
action:	sanding
trucks:	25 trucks
goal:	all roads sanded within one hour

Each of the county's four districts has instructions for all four conditions, specifying the number of ve - hicles, type of equipment, and routing priorities for every route. The system has cleared much of the confusion regarding what course of action needs to be taken for a particular condition. All operators are familiar with the routing system so they immedi - ately understand their roles and responsibilities for each color condition. This saves significant time in mobilizing operators and responding to snow and ice conditions, since the department does not need to explain to each operator what the exact snow or ice event is, what plowing or sanding action each will be taking, and what each needs to accomplish.

When operators are alerted to a "condition yellow," for example, all understand that they are contending with a lighter snowfall and will be plowing just enough to keep county roads clear.

The department has observed multiple benefits from the condition blue, yellow, green, red routing system. First, response time has improved. The department makes a decision (blue, yellow, green or red condition), communicates it to the operators, and the operators respond. Second, routing flexibility has increased. Operators can easily change the degree of their response (plowing activities and material application) as conditions change. The routing system allows officials to continually upgrade or downgrade plowing and sanding actions as conditions change over time. Third, public complaints have decreased. The savings in time and confusion have increased the level of service Ramsey County is able to provide, resulting in faster and more efficient plowing of county roads and increased attainment of the county's bare pavement policy. The primary cost of the routing system was the administrative time spent devising the routes and responses for each given condition.

Ramsey County also uses one "pull route" in each district. The department sends out an extra truck on main routes, which can be pulled off the route if needed elsewhere (such as for a mechanical problem, breakdown, or unusual road condition on another route). The public works department believes that its pull routes allow priority routes to be plowed faster, assisting the department in meeting its bare pavement policy and increasing the level of service provided in the county.

Additionally, the department has ordered a computerized routing software package, hoping to increase their routing efficiency. The cost of the system is $3,500, which includes the computerized routing software and the installation costs of incorporating Ramsey County's road system into the program. The software company estimates that installation will take one to two days and claims that the software package should increase efficiency. According to the company, jurisdictions typically decrease their number of routes by 20 to 30 percent, which subsequently decreases the number of trucks sent out for plowing and sanding operations.

For more information contact:

Dan Schacht
Maintenance Engineer
Ramsey County
(612)482-5220

Scheduling Night Patrols

City of Bloomington

Since 1993 Bloomington, a city in Hennepin County with 87,000 residents and over 1,800 lane miles of roads, has used night patrols to monitor weather conditions, handle emergencies, and plow or sand icy areas as needed during off hours. This provides the city with a better level of service because the public works department takes care of trouble spots (such as an icy intersection) immediately and monitors road conditions 24 hours a day.

Night patrols handle emergencies and plow or sand during off hours.

Night crews consist of two operators from the street maintenance division who are on duty from 11:00 p.m. to 7:00 a.m. from November through March. The same two operators will work a night crew shift for a two-week period. Although all street maintenance personnel are expected to participate in the night crews, they may switch with other operators. Some operators particularly enjoy the night shift because they receive 25 cents more per hour.

Operators on the night crew follow two pre-determined routes along city streets, ensuring that roads are clear along these routes. Night shift operators check with the police dispatch each night to monitor trouble spots where traffic accidents may have occurred; they may also receive calls from water plant personnel. The operators will notify the street maintenance manager if conditions warrant addi -

tional plowing personnel. Night shift crews have been particularly helpful for nuisance snows, that is, those times when the precipitation is light but just enough to cause slippery roads. They are also particularly useful during the early and late parts of the season when the roads go through thaw and freeze cycles over a 24-hour period.

In the first year of the night shift crews, the street maintenance division set the schedule and made it mandatory for all personnel. Because of some em - ployee reluctance about this, the department altered its procedure by allowing the operators to set their own schedule for the night shifts. When operators cannot work a shift, they are responsible to find oth - ers to cover for them. Operators often trade with one another to accommodate their own personal schedules.

When a snowfall occurs that requires a full shift call-out during the day, the operators that had worked the night shift are available until their eight-hour shift is up. They are available on a voluntary basis for an additional 4 hours for a maximum 12-hour shift. When this occurs, the department may recruit personnel from either utilities or park main - tenance to fill the two night crew spots when those workers go home. This reduces the capabilities of the utilities or park maintenance sections for that day, but the department puts first priority on plow - ing and sanding its streets. Maintenance personnel from all sections within the public works depart - ment receive training in the fall to prepare them for snowplowing duties should they be needed.

Smaller communities or those with fewer staff may find it more difficult to implement a night shift crew. Those that do not cross train employees on snowplowing equipment would not be able to effec - tively use the night shift schedule. Scheduling night shift crews requires flexibility and coopera - tion across employee divisions or sections within an department. Labor contracts may also play a role in the organization of night patrols.

For more information call:

Don Elvrum
Street Maintenance Manager
City of Bloomington
(612)948-8772

On-Call Response Team

City of Mankato

Mankato's public works department has developed an effective practice for the immediate deicing of its streets. The department organized "on-call re - sponse teams" that specialize in deicing activities only and are a significant part of its emergency snow policy. The department has 17 operators all qualified to drive a deicing unit. Mankato is lo - cated in Blue Earth County, has a population of 31,000, and maintains 260 lane miles of road.

The department's three on-call response teams oper - ate on a volunteer basis. Each team has three opera - tors. One team is "on call" duty for a week at a time. Every team has one foreman whom dispatch - ers notify of ice emergencies. The team foreman notifies operators of an ice emergency by voice-message pager and operators are expected to be at work within one-half hour. All trucks are standing by with salt/sand material and are ready for immedi - ate response.

Each operator within the team has an assigned zone, in either the north or south part of the city, or the central business district. Each zone has priority streets determined by high-volume traffic, hills, and intersections. Operators are familiar with their routes. A typical operation takes two hours but may last longer if conditions warrant.

The public works department implemented its on-call deicing teams in 1990. Prior to this, the depart - ment had two operators responding to police calls about street icing problems. Public works officials found that the police department, in a sense, was controlling their deicing operation. The new re - sponse teams have centralized control of the deic - ing activities in the public works department.

The key to Mankato's success with on-call response teams is communications through the use of voice-message pagers. Prior to pagers the department used a radio system but found it ineffective. Voice-message pagers ensure quick, consistent response, which is critical in an ice emergency. Each year the department reevaluates the on-call deicing teams as part of a review of its snowplowing policy.

The city's labor contracts allow the public works department to organize the on-call response teams. Labor contracts in other areas may not allow the formation of such teams without additional negotiations.

For more information contact:

Gerald B. Eken
Public Works Superintendent
City of Mankato
(507)387-8644

Weather Forecasting

City of Albert Lea

Albert Lea's street department relies on several sources of weather information during the winter months, but finds the information it receives from a private weather forecasting service to be most helpful. This service provides detailed weather information specific to the city and surrounding area. Albert Lea, located in Freeborn County near the Iowa border, has 18,300 residents and 185 lane miles of road.

Albert Lea's street department uses a forecasting service that provides weather information over the telephone. Whenever the department wants the latest weather forecast it calls this service. As the forecasting service relays information, the street superintendent writes in the weather details on precipitation, wind, temperatures, clouds, fog, and probabilities for precipitation using pre-printed forms provided by the weather forecasting company. The department pays $625 a year for this weather service. The cost also includes services for early storm notifications and weekend forecasts.

Over the years the department has received dependable forecasts that are generally closer to actual weather conditions than those provided by commercial television. Although the department sometimes uses a Rochester weather radio station on the FM band for weather information, this option is unreliable because Albert Lea does not consistently receive good reception of this signal.

The department has found the weather service particularly useful before weekends and prior to every holiday. With the weather predictions, the street department can be prepared for those times when its workers are not normally on duty. According to the department, if it can prevent even one accident because of early preparation and response to weather conditions, the cost of the weather service is justifiable.

For more information contact:

Dean Williamschen
Street Superintendent
City of Albert Lea
(507)377-4378

Anoka County

Anoka County's maintenance department has used privately-provided weather forecasting since 1991, to help provide snow and ice control services to its 243,00 residents. The department believes that the forecasting service increases department autonomy and the speed of its response on the county's 893 lane miles of road.

The department receives weather forecasts by computer modem and by phone.

To help predict storms, the maintenance department currently has two contracts: one for meteorology forecasts and one for weather radar. The department contracts with a local meteorologist and receives weather forecasts four times a day, seven days a week. Supervisors access the forecasts by computer modem but can

contact a meteorologist by phone 24 hours a day. The maintenance department also contracts for weather radar. The department owns computer radar software with zoom capability, which officials use to receive radar imagery of the three-state area. The cost of the contracted meteorological forecasts is $334 per month and the cost of the contracted weather radar is $74 per month. The department paid a one-time cost of $500 for the new computer software.

The department has also enhanced communications equipment for supervisors who are responsible for a continual 24-hour weather watch. The department uses two portable cellular phones and a portable notebook computer (in addition to the central computer located at the department) which can access the contracted radar service. The supervisor on duty is responsible for monitoring changing weather conditions and taking appropriate snow and ice control actions. Using the notebook computer and portable phone allows the supervisor to respond immediately, independent of when the storm strikes or where the supervisor is at the time of storm activity. The department can respond more quickly and effectively due to this improved mobility, enabling it to consistently achieve Anoka County's bare pavement policy on all roads and increase the level of service provided to residents. The cost of the newest portable phone was approximately $200 and the cost of the notebook computer with software was approximately $2,600.

For more information contact:

Arvid Gutzwiller
Maintenance Supervisor
Anoka County
(612)754-3520

City of Mounds View

Mounds View, a city in Ramsey County with 12,500 residents and 72.5 lane miles of roads, first contracted with a private forecasting firm in 1991. Because of the forecasting service, the city was well prepared for the heavy snowfall of the Halloween storm that year. The Mounds View public works department had all necessary equipment and operators ready for plowing and sanding operations. Forecasting is now a resource the department uses to assist in snow and ice control preparedness, ultimately improving its level of service.

The weather forecasting service costs approximately $125 per month. The public works department receives a minimum of two forecasts per day, with that number increasing during storm periods. If meteorologists are predicting a storm, the department receives five forecasts a day; if a major storm is approaching, the department receives a forecast every two hours throughout the end of the storm. The forecasts are site specific, with Mounds View receiving information for the northern Twin Cities metro area. Because conditions can vary substantially from one area to the next, the department believes site-specific weather forecasting allows for greater accuracy in storm prediction and response.

For more information contact:

Michael Ulrich
Public Works Director
City of Mounds View
(612)784-3114

Road Weather Information System and Portable Pavement Temperature Sensors

Minnesota Department of Transportation

Mn/DOT is in the early phases of a process to implement a road weather information system (RWIS) around the state. The final result will allow better forecasting and improved monitoring of weather and road surface conditions. Improved weather and road information will put Mn/DOT in a better position to take preventive measures, such as anti-icing efforts, that keep the snow and ice from bonding to the pavement. Sweden has been using road weather information systems for more than 20 years.

The system will consist of several components:

- pavement sensors imbedded in the road surface to record pavement temperatures and other conditions;
- meteorological sensors for measuring wind speed and direction, humidity, air temperatures, and precipitation;
- thermal mapping, to survey patterns of road surface temperatures, wind, and humidity, and to create a map that targets problem areas by indicating what road segments are most susceptible to freezing overnight;
- a communication system to both collect and disseminate road and weather information between weather forecasters, maintenance personnel, and the public; and
- weather forecasts and advice.

Mn/DOT currently has 16 RWIS installations with site-specific pavement sensors in place. However, this limited number of sensors does not provide sufficient system-wide information to fully realize the benefits of a road weather information system. The plan is to establish an additional 60 remote sites around the state. The next round of the project would cover the southern one-half of Minnesota and the final stage would cover the northern one-half. Mn/DOT expects a working system to be in place and operating by January 1997.

The road weather information system will help move Mn/DOT from simply reacting to weather and road conditions to more accurately predicting weather in advance and detecting conditions on individual road segments. With the ability to detect pavement conditions, Mn/DOT will be able to decide to start or stop spreading salt, sand, or chemicals on an up-to-the-minute "real-time" basis as conditions change. Mn/DOT estimates that with an integrated statewide system it will be able to save between 30 and 40 percent of the winter maintenance materials it now uses.

How Mn/DOT will integrate local governments into this road weather information system is still unclear. Mn/DOT is considering ways that the system could help address the needs of counties, cities, and airports around the state.

Separate from the road weather information system, Mn/DOT is field testing portable road surface temperature-monitoring systems. Mn/DOT is using several different portable sensors that measure road surface temperatures in addition to air temperatures. Road surface temperatures where the tire hits the road can vary considerably from air temperatures. Information on road surface temperatures can help decisions about the most appropriate times to apply salt or other materials. Pavement temperatures indicate if the surface is likely to freeze.

One portable temperature sensor attaches to a car and measures road temperatures from that position. It costs about $2,000. Others are handheld models that cost between $400 and $700. The user holds the sensor near the pavement to take the reading. Between uses, the handheld models should be carried in cases to protect them from extreme temperatures that could affect their pavement temperature readings.

For more information contact:

Paul Keranen
Maintenance Operations Engineer
(612)282-2281
or
Paivi K. Martikainen
Maintenance Operations Research Engineer
Minnesota Department of Transportation
(612)282-5434

8. SELECT, STORE, AND APPLY MATERIALS APPROPRIATELY

Cooperative Test of Anti-Icing Bridges

City of Rochester, Olmsted County, and Mn/DOT

Rochester's public works department arranged a cooperative venture with Olmsted County and Mn/DOT to test bridge anti-icing in the 1994-1995 winter season. Rochester is a city with 76,000 peo -

ple and 571 lane miles of road. The test used CG-90 which is a liquid deicing chemical with an anti-corrosive additive. Using anti-corrosive material is especially important on bridges because they are ex - pensive to replace. The full results of the test are not yet available.

In the collaboration, Rochester's public works de - partment applied the CG-90 on 44 bridges, of which 21 were city bridges, 4 were county bridges, and 19 were state bridges. Rochester's public works department supplied the labor and the truck and rented the 2,000-gallon tank and spreader, Olm - sted County contributed $2,500 towards the use of the truck, and Mn/DOT supplied the liquid CG-90 and paid for half of the spreader rental. [1]

One intent of the anti-icing was to spread the mate - rial prior to heavy accumulations of snow in order to prevent the precipitation from bonding to the bridge surface. Rochester's public works depart - ment applied CG-90 as storms began, applying the material while snow accumulated up to one inch. After one inch fell, the department discontinued ap - plying the CG-90. The goal was to time the applica - tion of the material as closely as possible to when the storm began. Because covering 44 bridges took over 2 hours, the department tried to target the start of its application 2 to 3 hours before the storm hit.

Although Rochester's public works department ap - plied the CG-90 in all temperatures, it found that ap - plications in the range of 15° to 20° F worked better than others. In general, the material reduced skid - ding when drivers applied their brakes hard, but did not melt snow as salt does. Although CG-90 turned bridge decks brown, the discoloration was not per - manent and did not appear to affect the bridges in any other way.

Traffic moving along the bridges picked up the ma - terial and scattered it. According to Mn/DOT, traf - fic tended to make the CG-90 disappear on bridges with higher traffic speeds. The material seemed to hold better on bridges with lower-speed traffic. Be - cause of the concern with keeping high-speed traf - fic moving safely, state plow trucks traveling over a bridge in some cases would spread salt or salt mix after the city had already applied the CG-90, mak - ing it difficult to isolate the effects of the CG-90.

When testing began, Rochester's public works de - partment applied the CG-90 at a rate of about 50 gallons per lane mile of bridge. After observing the results, the department concluded that this rate did not supply sufficient material and, therefore, gradu - ally increased its application rate to 150 gallons per lane mile.

One reason the jurisdictions experimented with CG-90 was to test corrosiveness. The product manufac - turer mounted plates near the bridges and at some points farther away to monitor the corrosion. In early spring of 1995, the manufacturer removed the plates to test for corrosion levels. The results of the testing were not available at the time of this print - ing.

Whether the bridge testing continues in the 1995-1996 winter season remains to be seen. The three participants do not believe this one-year test was conclusive. However, it is unlikely that Mn/DOT will continue with the test on state-owned bridges because of its concern with bridges carrying high-speed traffic.

For more information contact:

Joe Fitzpatrick
Street Superintendent
City of Rochester
(507)281-6008
or
Dave Redig
Highway Maintenance Superintendent
Mn/DOT Rochester District Headquarters
(507)285-7361

1 Purchasing the spreader, which is designed specifically to spread the liquid CG-90, would cost about $25,000.

Blue Rock Chip

Forest Lake Township

Forest Lake Township, located in Washington County with 7,000 residents and 141 lane miles of roads, began using blue rock chip as an abrasive in place of sand nearly five years ago. Responding to an increased public demand for barer pavement and safer roads, Forest Lake Township's road maintenance department began looking for a more effective and less costly abrasive than county pre-mixed sand. The alternative it discovered is a blue rock chip produced as a byproduct at a nearby Wisconsin quarry.

Blue rock chip, unlike sand, works well on both paved and gravel roads. The abrasive has less tendency to freeze on the pavement than sand, due to the chip's sharper and more numerous edges. Forest Lake Township had problems with compacted snow and ice ruts freezing overnight and it found that blue rock chips are better at cutting away snow compact than sand. Additionally, the blue rock chip provides better traction, stays in place longer, can be applied at higher speeds, produces a faster melting reaction from the sun (due to the darker color of the chip), cleans up better, is easier to use, and requires less material for improved service. The department officials noted that the chip works especially well on pervious blacktop surfaces, where the sharper rock pierces the ice as cars drive on it.

Forest Lake Township found blue rock chip to work well on paved and gravel roads.

Blue rock chip gradation ranges from 1/8 inch to 7/16 inch. Forest Lake Township uses a gradation of 3/16 inch on paved and blacktop roads, and a 7/16 inch chip on gravel roads. The chip comes premixed from the quarry at a ratio of 5 percent salt to 95 percent rock chip. When the township began using the blue rock chip, it had to change the speed of the auger to accommodate the mix. Forest Lake Township has since increased its salt percentage to approximately 30 to 50 percent salt, and it plans to decrease the auger speed to accommodate this change.

The pre-mixed blue rock chip mix costs less than the pre-mixed county sand mix. The department estimates that pre-mixed sand costs approximately $15 a ton, while the blue rock chip mix costs $8.75 a ton. The additional cost of hauling the chip from the quarry is approximately $2 a ton, so the jurisdiction still saves over $4 a ton. In addition, the township uses fewer tons of rock chip during snow and ice control operations than it did with sand applications. Forest Lake Township keeps 100 tons of blue rock chip in its stockpile and prefers to pick up a load of chip when operators can directly apply the abrasive to its roads on the way back from the quarry (when weather conditions establish a need for application).

The main disadvantage of using the blue rock chip is the hauling distance necessary to transport the product from Wisconsin to Minnesota. Although the cost is manageable for Forest Lake Township due to the jurisdiction's proximity to Wisconsin, distance from the quarry is a limitation to the use of this abrasive byproduct. Another disadvantage is the limited supply of this particular quarry byproduct. The department noted, however, that the supplier watches the rock chip selling price to produce a competitive product that is less costly than sand.

Proximity to a quarry will largely indicate how feasible and cost-effective this practice might be for a jurisdiction. Even if costs per ton are slightly higher than sand, jurisdictions might still benefit from the decreased amount of product needed for application. Additionally, several jurisdictions could use blue rock chip cooperatively. Sharing the travel cost of hauling the material, as well as potential savings from purchasing larger quantities, might make this an affordable alternative for other jurisdictions across the state.

For more information contact:

Mike Tate
Maintenance Supervisor
Forest Lake Township
(612)464-4348

Red Rock Chip and Anti-Icing

City of St. Peter

St. Peter's public works department has used red rock chip to improve traction on particularly slippery sections of its city streets for two years. Over the past several years, St. Peter's public works department has practiced anti-icing by applying salt and sand mix very early in a snowfall to prevent the bonding of ice and snow to the streets. St. Peter, located in Nicollet County, contains about 10,000 residents and 55 lane miles of road.

Because of St. Peter's proximity to the Minnesota River, many of its city streets are aligned up hills of the river bluff. St. Peter's public works department uses red rock chip for traction on heavily traveled roads, primarily on the hills and other particularly slippery areas. Red rock chip is granite that is larger and coarser than most road sand. Because red rock chip is more expensive than road sand (red rock chip costs about $13.50 per ton, including hauling charges, compared to about $4.50 per ton for sand) the department uses it judiciously. Despite the higher cost of red rock chip, the city uses the chip rock because it provides superior traction. During ice storms or especially icy conditions, the department uses a mix of 90 percent red rock chip and 10 percent salt.

St. Peter has fairly easy access to a supply of red rock chip because of the city's proximity to a quarry in an adjoining county. Other communities considering the use of red rock chip would have to factor in the expense of transportation costs.

St. Peter's public works department also routinely takes anti-icing measures on heavily traveled segments of its paved surface roads. As the snow begins to fall the department begins applying its salt and sand mix to the roads. Typically the department uses a mix with one part salt to seven parts sand. St. Peter officials have found that early application of salt and sand helps prevent the snow and ice from bonding to the road pavement. Traffic moving over the salt and sand helps the material wear down the snow and keeps the road relatively free of hard-packed snow and ice. This anti-icing practice is not as helpful on lesser traveled roads.

Because of environmental concerns and the corrosive potential of salt, the department controls its road salt applications. Among the priorities for the department's application of anti-icing materials are police department call outs, areas such as the schools, and major work centers like a boat plant, the downtown business district, and a regional treatment center. The department also applies the salt and sand at regulated intersections and on hilly streets. Because the department monitors the traffic accident list generated by the city's police department, it can pinpoint potential trouble spots and, subsequently, apply the anti-icing materials in an attempt to prevent additional accidents.

When the street department first began anti-icing, it received feedback from some residents who thought that it was odd to apply sand and salt when so little snow had fallen. Nonetheless, the department has used this anti-icing strategy to help it maintain in passable condition those city streets carrying steady traffic. Without anti-icing, the department would have to spend more time plowing and scraping snow and ice than it now does. Although some areas, such as stop-sign intersections, may need just one pass by the sanding truck, other areas, including the hilly streets, may require more than one.

For more information contact:

Greg Kozitza
Streets Foreman
City of St. Peter
(507)931-4840

Dry Calcium Chloride

Pine City Township

Pine City Township, with a population of 950 and 42 lane miles of road in Pine County, has been using dry calcium chloride as part of its snow and ice control program since 1983. The township found that applying dry calcium chloride directly to the road or mixing it dry with sand has been highly effective in cutting through ice and hard packed snow. Pine City Township uses dry calcium chloride to avoid the expense of purchasing equipment to mix the chemical with water.

The township operator applies straight calcium chloride directly to the road surface by hand, or with a shovel from the back of a pickup truck, pinpointing icy and slippery spots. When road conditions demand an abrasive, the operator mixes calcium chloride with sand. The application rate is 80 to 100 pounds of calcium chloride per cubic yard of sand. Pine City Township uses calcium chloride in all temperature ranges to open some bare road so that the operator can cut and scrape the snow and ice. It uses calcium chloride instead of salt because calcium chloride is more effective at lower temperatures than salt. Also, calcium chloride is readily available in the area; it costs about $10 per 50 pound bag; the township uses only about 150 pounds over a winter season. Mixing calcium chloride with sand also prevents sand from freezing into lumps.

Pine City Township applies calcium chloride on areas with glare ice to begin the melting process. Immediately treating dangerous intersections can prevent accidents. This has been important because the township is experiencing increasing volumes of traffic. Spreading the calcium chloride from the back of a pickup truck keeps the cost low. With the combination of calcium chloride and scraping, the operator makes fewer returns for additional scraping, even after light dustings of snow.

One disadvantage of calcium chloride is that the material draws water. During the early spring or late winter, this can worsen damage to roads in the form of pot holes and frost boils, and, therefore users should exercise caution about when they apply calcium chloride.

Township officials report that residents have been positive about the use of calcium chloride on the roads and are satisfied with the level of service.

For more information contact:

Dennis Gottschalk
Operator
Pine City Township
(612)629-2806

Recycling Sand

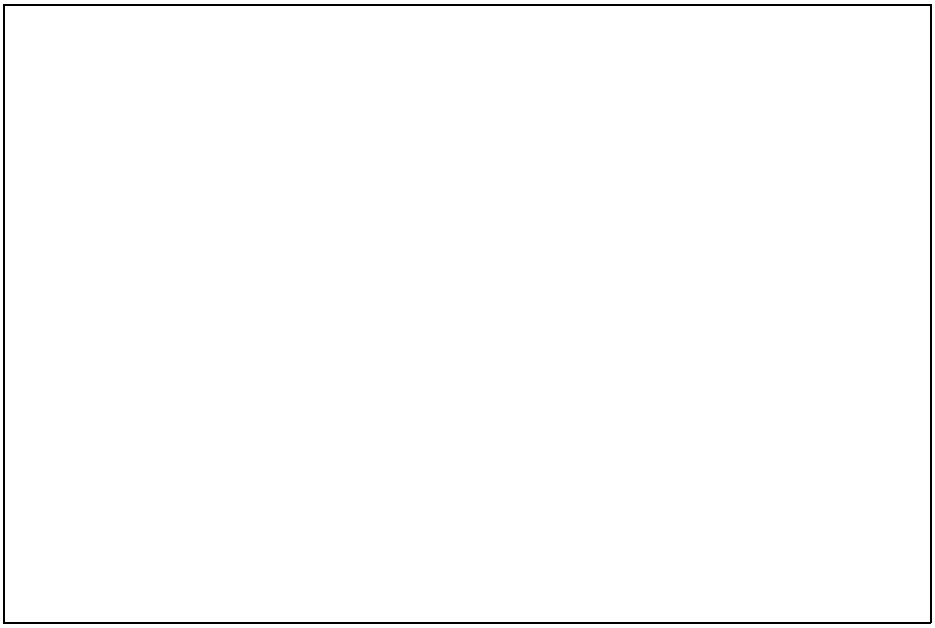
City of Bloomington

Bloomington, a city in Hennepin County with 87,000 residents and over 500 miles of roads, recycles its road sand with an aggregate screener purchased in 1993. In buying the screener/shredder, the public works department's goals were to (1) abate the need for using landfills to store street sweepings and granite seal-coat chips, and (2) reduce costs by reusing materials in its street maintenance operations. The department is accomplishing its goals and expects the screener to pay for itself over the first two years of use.

Bloomington purchased a fully portable $80,000 screener/shredder, including a washing attachment and stacking conveyor, with the assistance of a financial grant from the Metropolitan Council. In its first year of use, the equipment screened over 4,800 cubic yards of street sweepings, seal-coat chips, and soil material from street maintenance for reuse. If this amount of material had been landfilled, the department estimates it would have spent nearly $475,000 in landfill tipping fees. The department used approximately one-half of the reusable material for ice control; the rest was used to repair streets and curbs and maintain ball fields. In 1994, the department screened another 2,200 cubic yards of material, primarily street sweepings, for reuse.

In addition to avoiding landfill fees, the department saved on the costs of purchasing new materials, in-

cluding ice control aggregate, seal-coat chips, and clean soil. Purchasing new ice control rock cost about $3.87 per ton in 1993. Because the depart - ment paid $1.83 per ton (including both labor and equipment costs) to recycle the street sweepings, it saved about $2 per ton for each of the 3,100 tons it did not have to buy new. The department attained even greater per ton savings by using recycled seal coat chips over buying new chips. Bloomington also avoided the equipment and labor costs that would have been needed to pick up and haul in new supplies of these materials. Because the depart - ment uses the stacking conveyor to load salt and salt/sand mix in its salt storage facility, it saved many hours of labor that would have otherwise been needed to stack salt. With the conveyor, the department is able to stack the salt higher than in the past, making fuller use of its storage facility.



Screener/shredder equipment used to recycle road sand in Bloomington.

When the department buys sand it purchases ice control rock, a sharp, angular, less-rounded grain of sand that passes through a 3/8 inch sieve. It avoids coarser grains because they would bounce too much when spread. A finer-grained material would not be as inexpensive or screenable. Although the de - partment anticipated that the screening might round off the sand grains, making them unusable for ice control, this problem did not arise. Had rounding occurred, the department would have mixed the re - cycled grains with new ice control rock until it achieved an acceptable blend for traction. The de - partment has typically not mixed the recycled street sweepings with new sand. Although darker in color, the reusable ice-control sand is environmen - tally clean. The sand has not caused any sticking problems at the auger during spreading.

The screener/shredder works by conveying the street sweepings material from a hopper onto a large, vibrating screen of appropriate size for the material being recycled. It sifts and rinses the mate - rial, removing debris and leaving clean sand for the next snow season. When the department first began screen - ing, it sent the street sweep - ings through the equipment dry. When this produced un - satisfactory results, the depart - ment began using water to screen and clean the sweep - ings, sometimes running the sweepings through the process three times. This added to the cost of using the screening equipment. Now it is using more water and completing the screening in two steps.

Although in 1993 the depart - ment pumped water from tanker trucks for the screening process, it has since moved the screener/shredder near a storm water pond. In 1994 the department pumped water from the pond through the equipment and then directed the water through two settling ponds. By the time the flow traveled through both holding ponds, most of the sediment had fallen to the bottom. Although the de - partment has tested the sediment and found zinc and chromium present in material from the first pond, the quantities have not been above hazardous levels. The zinc and chromium levels have been equivalent to what is found in materials tested from off the street.

The department is satisfied with the mechanical performance of its screener/shredder, having had to replace only bearings. Because the screens receive the most wear, they must be monitored and replaced. The department is considering purchasing a de-watering auger unit. This may permit the department to recycle the street sweepings with less water. In addition, the department is considering using the screener equipment to clean materials taken from the inlets and outlets of storm sewers or collected from water main breaks.

Although Bloomington has found the screener/shredder productive and cost saving, the screening process may not be as useful to local governments that use all salt, very fine sand, or to communities where landfilling is readily available and inexpensive. Smaller communities that may not be able to afford the capital costs of a screener/shredder may have to join with other units of government to make the purchase. Other options include renting a screener or hiring a contractor that owns the equipment. In some cases, recycling is also possible by trading in the street sweepings to the quarry or dealer where the department purchases clean sand.

For more information call:

Glen Shirley
Maintenance Coordinator
City of Bloomington
(612)881-5811

City of Little Canada

Little Canada, a city in Ramsey County with 9,800 residents and 44 lane miles of roads, began recycling sand nearly five years ago in an effort to save money and conserve natural resources. The public works department believes the recycling process has been effective. Ramsey County, after talking with several jurisdictions which recycle sand, now plans to adopt a collaborative recycling process involving multiple cities throughout the county, including Little Canada.

The public works department began its recycling project by looking for a business to screen used sand for later use. The department approached an excavating company which mixes its own black dirt and therefore already makes use of a screening process. Little Canada initially used the screen for one year and found it worked well.

The screening process involves (1) initially stockpiling the sand gathered during clean-up operations, (2) allowing the sand to sit several weeks and dry out, (3) scheduling a day with the company to screen the sand, (4) hauling the sand to the company for recycling, and (5) hauling the recycled sand to storage. Little Canada finds no need to add chemicals to the recycling process and recycles its sand dry. The jurisdiction has also not experienced any problems with sand particle rounding in its five years of practice.

Finding a useful screen required testing several different salt/sand mixes as well as different sized screens. Once Little Canada officials identified the best screen for its material mix, the private company purchased the screen and began recycling preparations. This particular company absorbed the cost of the special screen, since the new screen still worked for its business purposes and would generate annual revenues from the city's spring sand recycling efforts.

The key to an efficient recycling operation for this jurisdiction is the timing of hauling recycled sand. Little Canada initially picked up and hauled the cleaned materials to a temporary storage location, and then needed to haul the material once again for extended storage. Because of the time and labor costs incurred with this inefficient hauling process, Little Canada now strives to move the recycled material only once, hauling the material to permanent storage on the same day it is picked up from the recycling company.

Close contact with the contractor and experimentation have also helped make this practice a success. Getting the right salt/sand mix with the recycled sand for sanding and plowing operations initially proved somewhat burdensome, but simply required a "trial and error" process. Little Canada started with approximately the same mix it used in operations without recycled sand and then gradually de-

creased the amount of sand used while increasing the amount of salt used. The city ultimately found a mix which worked effectively on its roads while accommodating the slightly finer recycled sand gra - dation.

Little Canada has experienced savings in its costs of spring cleanup and sand purchasing. The recy - cling cost is approximately $800 to $1,000 per year for Little Canada. This is approximately $3 to $5 per ton, lower than the average price the department currently pays for sand.

Sand recycling could work for most urban jurisdic - tions, where there generally are companies which possess recycling and screening capabilities. Mu - nicipalities in rural areas might be able to develop collaborative sand recycling programs. Jurisdic - tions could share either the hauling costs or the costs of purchasing screening equipment through a joint powers agreement (similar to that of the Ram - sey County recycling collaborative venture, dis - cussed next).

For more information contact:

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Public Works Superintendent
City of Little Canada
(612)484-2177

Ramsey County

Ramsey County officials expect to have a joint county-city road sand recycling project operational by mid-summer of 1995. Ramsey County will work through a joint powers agreement with ap - proximately 14 cities located throughout the county. Under this arrangement, Ramsey County will own the recycling equipment and operate the project, with costs shared among all jurisdictions choosing to recycle their sand.

The city of Roseville, located in Ramsey County, in - itiated the project. Roseville secured a $94,000 grant for the collaborative proposal from the Board of Government Innovation and Cooperation in 1994 and invited Ramsey County to participate. Because of the relatively large snow and ice control de - mands associated with its 486,000 residents and 652 lane miles of road, Ramsey County has the per - sonnel, vehicles, and equipment necessary to better absorb some of the administrative functions associ - ated with the joint recycling effort. Ramsey County is also the largest user of sand among participating jurisdictions, needing approximately 70 percent of all sand used in the county to achieve its bare pave - ment policy on all county roads.

The recycling equipment will be housed centrally in Ramsey County. The county's public works depart - ment hopes it will be able to "dry screen" the sand; if dry screening is not possible, the department will have to add water to the process. In addition to the recycling equipment, the department expects to need two front-end loaders and two to three people to run the recycling operation. Ramsey County's public works department believes that existing county equipment and per - sonnel can provide the loader and labor.

Ramsey County will begin recycling road sand for itself and 14 nearby cities.

Ramsey County officials expect to process 300 tons of sand per hour and hope to reclaim the recycled sand at $1 per ton, with each participating city hauling its own sand to the facility. Cities will pay 50 cents per ton to haul sand in and 50 cents per ton to haul clean sand back out. Currently, Ramsey County's public works de - partment pays $3.83 per ton for new sand. With re - cycled sand costing just $1 plus hauling expenses, participating jurisdictions should save money.

The department is developing some monitoring pro - cedures to ensure that only sand from participating cities is recycled. Since many cities contract for their sweeping services, the county public works de - partment wants to avoid recycling sand swept by contractors in non-participating jurisdictions. Recy - cled sand which is not reclaimed will increase the cost of the recycling process, ultimately increasing the recycled sand price per ton paid by Ramsey County and participating cities. The county public

works department does not expect unreclaimed sand to be a problem and believes that the benefit recycling offers the environment and the money saved through reduced sand prices will make the joint sand recycling collaboration a success.

For more information contact:

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Ramsey County
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City of Woodbury

Woodbury began recycling its road sand in 1993, largely due to concern for the environment. A portion of used sand had previously been dumped in landfills, which the street department did not believe was environmentally beneficial. Although Woodbury does not currently pay a tipping fee for landfill use, the possibility of future landfill fees was another motivation to begin recycling.

Woodbury, a city in Washington County with 30,000 residents and 305 lane miles of roads, rents a screen for sand recycling from a local asphalt company. The project has largely been trial and error, with the street department experimenting to find the best recycling process and overcome various problems. Woodbury found that regraded sand got too wet when housed outside, that recycling affected the gradation of sand granules, and that auger speed required adjustment to accommodate the newly recycled sand particles. The department tried various screens until finding one that effectively met its needs. Although one year is insufficient time to draw firm conclusions, the department believes that recycling has improved its snow and ice control operation. Benefits include a reduction in the amount of sand purchased in 1994 and a darker sand color, allowing operators to better view sand placement.

The cost for screen rental in 1993 was approximately $2,670. Screening 2,000 tons of sand took Woodbury 20 hours. Comparative cost figures show recycling lowered the cost per ton of sand for Woodbury. The cost of new sand for Woodbury in 1993 was $3.77 per ton. Calculating the labor and rental costs of screening, the cost of recycled sand in 1993 was $1.49 per ton. (Hauling costs were not included in the cost comparisons; it is assumed that the cost of hauling road sand to a landfill is about equal to the cost of hauling road sand to be screened and then stored.) Although the time required to screen is a drawback to the process, Woodbury officials believe recycling will continue to save the city money and ease stress placed on the environment from persistent sand use.

For more information contact:

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Enclosed Salt and Sand Storage Facility

City of Jordan

Jordan moved its salt and sand piles from outside covered pads to an enclosed storage facility in the fall of 1992. The public works department was dissatisfied with the difficulties involved in storing materials outside, having experienced winds which blew the covers off the piles, rains which permeated the piles, and some vandalism. The department was also uncertain about possible environmental effects resulting from outdoor salt storage. Jordan had only one sander when the jurisdiction kept piles outside, but the decision to move the materials inside became an immediate objective once the city purchased another sander.

Jordan converted a cold storage shed into salt and sand storage.

Instead of constructing a new building for storage, Jordan converted a portion of its cold storage shed to house both the salt and sand piles. Jordan, a city in Scott County with approximately 3,000 residents and 24 lane miles of roads, used 400 tons of salt/sand during the 1993-

1994 winter. Because the city does not require a large quantity of materials for its winter season, the materials occupied only about one-third of the cold storage space. Jordan easily found this space by disposing of old, unused equipment that it had housed in the shed for years.

Jordan built two three-sided bins from old lumber found in the shed, one each to hold the sand and the salt. Because the jurisdiction used no new materials for either the building or bin construction, the only cost Jordan incurred was that for labor hours used to move the materials inside and construct the bins. Jordan still covers the piles in the summer, as a safeguard against rain entering the facility through ceiling leaks.

An enclosed storage facility keeps sand and salt clean and dry, while diminishing potential pollution concerns. Jordan's public works director considers the enclosed materials virtually hassle-free. He believes that the time saved from avoiding tunneling problems (which can occur when wet sand does not flow freely from the sanders) is substantial. If a jurisdiction currently has an enclosed place where it could readily place its materials, the move should prove relatively easy. A jurisdiction thinking about erecting an enclosed facility should consider in its cost estimates the savings gained from reduced material maintenance.

For more information, contact:

Dave Bendzick
Public Works Director
City of Jordan
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City of Mounds View

Mounds View, a city in Ramsey County with 12,500 residents and 72.5 lane miles of road, built an enclosed salt storage facility in conjunction with a cold storage equipment shed in 1990. City officials decided to move salt indoors primarily for easier material handling, but also to gain the environmental benefits of indoor storage.

Mounds View officials designed the facility to hold 500 tons of salt, or approximately twice the city's annual use. The total cost of the combined building was $80,000, with the estimated share of the salt facility approximately $25,000. The base of the facility is a bituminous surface, with the salt storage measuring 30 feet by 48 feet and the cold storage measuring 48 feet by 50 feet. Mounds View officials have slightly modified the salt structure since its construction, strengthening the load bearing wall from six feet in height to eight feet to ensure safe storage of larger salt quantities if ever needed.

Enclosed salt storage yields multiple benefits. Salt is always dry, freeing maintenance personnel from fighting wet, clumpy, unclean salt. Mounds View can store a large quantity of salt, allowing the city to fill salt just once each winter season. Moreover, the city avoids salt brine runoff and its negative effects on the environment. The only disadvantage to the enclosed salt storage facility is the capital investment required for construction.

For further information, contact:

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City of Mounds View
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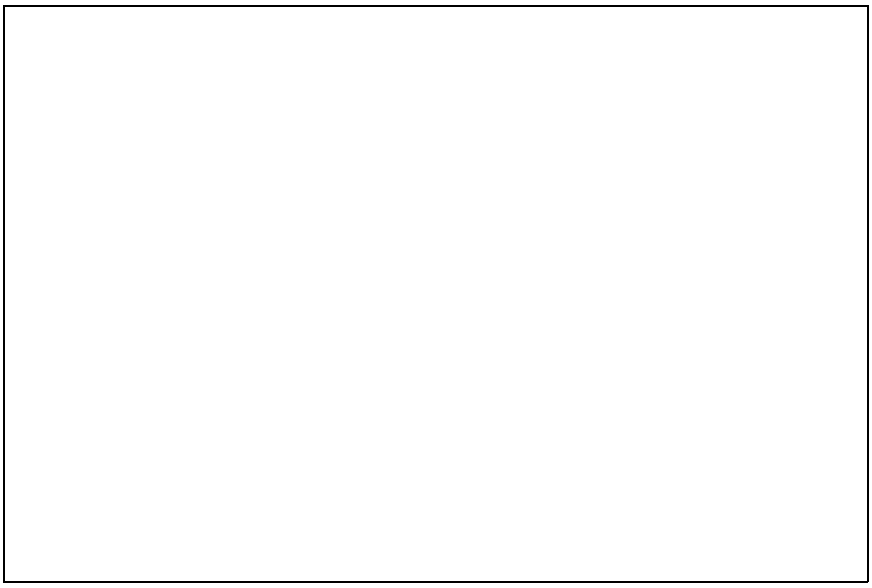
City of Owatonna

In 1994 Owatonna built a new salt and sand storage facility with capacity to hold 4,000 tons of dry material. Owatonna is a city with 20,100 residents and 184 lane miles of road. The storage facility has treated wood side walls and a bituminous base floor. It stands 20 feet high, 50 feet wide, and 100 feet deep. Its height easily accommodates a front-end loader for loading the salt and sand mix into the facility.

In planning the facility, the city's street department looked at a variety of other salt storage facilities and based its plan on the best features from six other storage facilities in the vicinity. Owatonna built the facility on land adjacent to its water treatment plant. It graded the base of the salt storage fa-

cility to a slope and runoff flows to a catch basin. To protect against possible negative environmental effects from salt brine runoff, the department in - stalled a valve that can direct the flow through to the city's nearby water treatment plant when neces - sary. Whenever the department mixes the salt and sand on the mixing pad outside the storage facility, it will turn the valve so that runoff flows through the water treatment plant.

The capital expenditure for the facility was approxi - mately $65,000, including the runoff control fea - tures. The site for salt storage was a former dump that required a liner and clay cap before building a new structure. Because the proposed site was lo - cated on the fringe of a 100-year flood plain, the structure had to be built at a level that was one foot above the 100-year flood elevation. To build the fa - cility on sufficiently high ground the department brought clay onto the site. It also built an earthen berm around the outside of the facility for addi - tional support to withstand the pressure of 4,000 tons of sand and salt.



Owatonna's salt and sand storage facility stores 4,000 tons of material and controls runoff.

The new facility offers several advantages. The street department can easily store sand and salt left over from one snow season for use in the following season. Previously, the department had mixed its salt and sand outdoors on a blacktop pad and mix left over was unusable by the next season because of water leaching through it. The department is able to purchase sand and salt in the off season at a better price and store them until they are needed with no diminution in quality. Plus, the facility eases the concern about possible negative environ - mental effects of salt runoff into the river running through the city.

In another jurisdiction, the distance needed to chan - nel the runoff to the sanitary sewer could affect the cost of building a similar facility. Areas without the capability of connecting to the sani - tary sewer would have to install a leach tank as an alternative. De - partments considering such a facil - ity could explore building a joint facility with another jurisdiction to share the expense.

For more information contact:

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or
Mark Arett
Street Foreman
City of Owatonna
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Collection and Treatment of Runoff

Ramsey County

Ramsey County's public works department began collecting and treating salt brine runoff from salt storage in 1978. Ramsey County, with 486,000 resi - dents and 652 lane miles of road, has a 10,000 gal - lon fiberglass tank to hold salt brine runoff. The brine from salt stockpiles, which rest on pavement in the maintenance yard, runs into a collection drain connected to the fiberglass tank.

The drainage pump initially corroded from the chlo - ride. The department solved this problem by flush - ing the pump after each drainage. The flushing

prevents corrosion, and is more cost effective than the stainless steel alternative pump. The depart - ment currently discharges the brine to a sanitary sewer, but plans to use the brine for prewetting dur - ing the 1995-1996 winter season. The department estimates that the cost of the tank and pump in 1978 was approximately $10,000 to $12,000, and be - lieves the collection system decreases the poten - tially harmful environmental effects which salt brine runoff can cause.

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Ramsey County
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Minimizing Salt Brine Runoff and Mitigating Its Negative Effects

Mn/DOT

Mn/DOT supports a number of measures for its maintenance areas to both limit the creation of salt brine runoff from stockpiles and truck wash opera - tions and mitigate the effects of salt brine once it is created. Even though these measures were in - tended for Mn/DOT districts around the state, local governments involved with winter road mainte - nance can also benefit from them. The focus of these measures is on salt stockpiles and truck wash operations because these are the areas of highest salt concentrations. Although Mn/DOT is also con - cerned about controlled application of salt on road - ways, it is taking other steps to control use of salt. This description deals exclusively with salt stock - piles and truck washing operations.

Mn/DOT recommends the following measures to minimize the creation of salt brine.[2] Many of these recommendations are common-sense suggestions that require little expense.

- Consider relocating or sharing a salt storage site, or even eliminating a site, to cut down on the number of sites overall.
- Rearrange the site so that stockpiles are on high ground and runoff flows away from the pile. Surface water should flow around the piles rather than into and through them to minimize contact with salt.
- Manage the inventory of salt to limit the amount on hand to what can be stored safely and to minimize leftover piles in the spring and summer.
- Haul leftover salt and mix from uncovered sites to buildings before the rains of spring and summer.
- Premix the winter sand as late as possible to avoid contact with fall rains.
- Minimize the salt to sand ratio in exposed piles.
- Cover outside bulk salt piles with a water - proof material.
- Clean up spillage during loading operations after every operation.
- Keep the bituminous pad under the stockpile in good repair.
- Using brooms, scrapers, or other tools, clean snow and salt from trucks as much as possi - ble without water. Do not rinse or wash trucks where salt brine will seep into the ground water.
- Wash trucks indoors if the rinse water goes to a sanitary sewer connected to a wastewater treatment facility. Wash outdoors if the run - off can be directed to a viable runoff han - dling system. Alternatively, wash trucks off

2 These recommendations come from Michael Herman, *Nature of the Problem and Myths About Salt Brine Runoff,* Conference on Controlling Salt Brine Runoff, November 7, 1994 (St. Paul: Minnesota Department of Transp ortation, 1994).

site at a location connected to a sanitary sewer.

- Use a self-closing nozzle or pressure washer to conserve water while washing trucks.

Mn/DOT recommends the following to minimize the effects of salt brine once it has been created at the stockpile or truck wash station.

- Recycle brine from runoff collection facili - ties. Use the brine to wet winter sand piles or in truck washing facilities. Brine could also be pumped onto the loaded trucks immedi - ately prior to salt/sanding operations.

- Allow sand to settle out before runoff leaves the property with the use of check dams or shallow basins.

- In areas with collection basins, prevent sum - mer runoff from entering the tank or basin to avoid off-season disposal of contaminated runoff.

- Dilute the salt brine with as much fresh water surface runoff from the yard as possible.

The following measures require constructing facili - ties to minimize the formation of salt brine or miti - gate its effects.

- Build covered buildings with paved floors. The pads should be designed with slopes of at least one percent and all water should drain away from the pile toward a containment sys - tem.

- Construct a collection facility to contain run - off. The facility must be sealed with an im - permeable liner to prevent percolation into the ground water.

- Connect to a municipal or sanitary sewer dis - trict wastewater treatment system to dilute and ultimately dispose of salt brine from truck washing.

- Construct a brine handling system, such as an underground storage tank, to collect the truck wash or rinse water.

For more information contact:

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Design Engineer
Mn/DOT
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Prewetting with Calcium Chloride

City of Albert Lea

Since 1992, Albert Lea's street department has been prewetting salt with calcium chloride prior to spreading it on main roads and intersections. Prewetting salt before spreading it on paved sur - faces saves the department both time and materials and provides safe travel along the city's high-traffic roads. Located in Freeborn County, Albert Lea is a community with 18,300 residents and 185 lane miles of road.

The street department mixes dry calcium chloride with water in a 30 percent solution. One of the de - partment's 9 snowplow trucks has a 100-gallon tank and sure-flow pump attached to the back of its box. As the driver spreads salt, the calcium chloride solu - tion is pumped at about 1.5 to 2 gallons per minute over the salt coming through the auger. After spreading the prewet salt, the operator returns to plow the road surface almost down to bare pave - ment. Because of the cost and corrosive tendencies of calcium chloride, the department typically limits the use of prewet salt to its main highways and in - tersections with the highest traffic levels.

Albert Lea's street department spreads the prewet salt as a snowstorm begins. This helps prevent the precipitation from bonding to the road surface. The department also uses prewet salt with extremely icy conditions. If the ice is dry and hard and tempera - tures are cold (approximately 0° to 15° F), the prewet salt breaks up the ice well because it stays where it is spread and begins working faster than dry salt. When temperatures are about 20° to 30° F

and expected to reach freezing or above, the depart - ment does not prewet salt before spreading because the salt alone will work sufficiently to melt the snow and ice.

Because the truck with the prewetting tank has a ground-oriented sander, the department is able to spread precise amounts of prewet salt according to conditions. The department can spread as many pounds per lane mile as needed to respond to road conditions and the expected weather. The ground-oriented sander also allows the department to con - trol the width of the pattern of prewet salt to cover one or two lanes. This can reduce the amount of time needed to complete the operation.

Prewetting salt saves the street department time, la - bor, and materials. Once ice or snow bonds to pave - ment, it becomes very difficult to remove. In these circumstances, street department officials estimate they would need two to three times the amount of materials than they do with prewet salt, as well as more intensive work to get through the ice and snow. When the department is able to prevent the ice from bonding in the first place, operators make fewer passes through any given intersection.

Albert Lea's street department purchased, mounted, and hooked up the prewetting tank, pump, and bracket for about $700 in 1992. Dry calcium chlo - ride costs about $295 per ton. The department be - gan prewetting on a trial basis and now uses the prewet salt routinely. Departments considering the use of prewet salt may want to approach the prac - tice gradually, recognizing that adequate training and experimentation are necessary before operators will be able to comfortably and knowledgeably spread the prewet salt.

For more information contact:

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City of Albert Lea
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Otter Tail County

Otter Tail County's public works department has had success prewetting its salt and sand mix with calcium chloride. The department began prewet - ting in 1992 in response to a severe problem with compacted snow and ice. Since implementing this practice, the department has noted a significant posi - tive improvement in the public's perception of serv - ice delivery. Otter Tail County has a population of 51,300 and 2,095 lane miles of road.

What initially began as a solution to a short-term problem, with an investment of about $20,000 for 2 6,000-gallon storage tanks and spray bar systems to prewet entire loads, developed into a long-term win - ter maintenance strategy. Prewetting has become one of the county's significant low-temperature snow and ice fighting practices.

The county prewets with calcium chloride in ex - tremely cold weather, 15° F or colder, and when compacted snow and ice are a problem. Currently, the department has fitted two trucks with tanks to apply the calcium chloride at the auger and spinner. Because these tanks function more efficiently than prewetting entire loads, the department plans to ex - pand the use of tailgate tanks and auger-spinner ap - plication to other trucks. Officials estimate that the calcium chloride costs about 75 cents per gallon and the department is still experimenting with the application rate.

One problem experienced by Otter Tail's public works department was the refreezing of some roads which it had prewet with calcium chloride. Be - cause calcium chloride attracts moisture, blowing snow can stick and refreeze to the wet areas where the calcium chloride was applied. Therefore, the de - partment attempts to avoid using calcium chloride under windy conditions. A second problem is that calcium chloride is corrosive; equipment mainte - nance, including frequent washing, becomes very important. Finally, to give a timely response to the communities' concerns about ice covered roads dur - ing a severe winter, the department began installing its prewetting equipment in the middle of the win - ter. Installation of storage tanks and pumps systems

was very difficult because of temperatures reaching -28° F.

Overall the department is satisfied with the results of prewetting with calcium chloride. The depart - ment receives fewer complaints from citizens and the county commissioners are very supportive of the department's efforts.

For more information contact:

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Prewetting with Salt Brine

Anoka County

In 1994, Anoka County's maintenance department purchased a salt brine system to produce salt brine for prewetting salt before applying it to roads. Department repre - sentatives had attended salt brine seminars hosted by Mn/DOT and wanted to experiment with prewet - ting in Anoka County, which has 243,000 residents and 893 lane miles of road. Although just in its infancy, the department's prewet - ting keeps more salt on the road sur - face and activates melting sooner than dry salt.

The maintenance department in - itially rented one brine tank to test prewetting effects in 1993 and had enough success that it purchased materials for its own operation the following year. Anoka County's salt brine operation consists of a salt brine production tank to make the salt brine, a 2,000-gallon tank for salt brine stor - age, and 14 100-gallon tanks for individual tailgates on both single-axle and tandem trucks. The tailgate tanks allow operators to adjust the brine flow with electric pumps to achieve consistent pressure. Al - though the rental tank operated with a gravity feed, officials wanted the ability to control the salt brine flow.

The salt brine system production tank produces the brine, using a hydrometer to measure the salt con - centration (the department maintains a 23 to 26 per - cent salt concentration). Once produced, the salt brine is pumped to the 2,000 gallon storage tank which the maintenance department borrows from the county parks department. Operators use a lift pump attached with a quick-coupler system to fill up the individual tailgate tanks. Once in the tanks, the salt brine flows through a nozzle to the auger, spraying the salt just before it drops to the spinner.

The maintenance department purchased the brine production tank for approximately $5,000 and the 14 100-gallon tailgate tanks for approximately $950 per tank. The department borrows the storage tank from the parks department, although it hopes to eventually purchase its own tank. The department has priced similar storage tanks at approximately $2,200. The system additionally requires some la - bor costs. Department employees installed the tanks themselves, which took two to three hours per truck. Operators spend an additional 10 minutes to load the tanks with salt brine, although the mainte -

An electric pump moves salt brine from a tailgate tank onto the salt and sand mix.

nance supervisor views that time as well spent be - cause it allows operators to do a complete check of their trucks in the heated garage.

For more information contact:

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Anoka County
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City of Mankato

Mankato's public works department has had consid - erable success prewetting its salt and sand mix with salt brine. The department developed successful prewetting practices that emphasize simplicity and low cost. Mankato is located in Blue Earth County, has a population of 31,000, and maintains 260 lane miles of road.

The public works department invested about $500 per truck or a total of about $1,500 for its prewet - ting operation. By using gravity flow on its trucks (with no pumps), and by building its own distiller tanks for making salt brine, the department has avoided the expense of commercially-manufactured systems.

Mankato's public works department utilizes "V" box trucks with conveyor belt discharge in the cen - ter of the box, which is more conducive to gravity flow of salt brine than a side discharge with auger and spinner. This design has allowed the depart - ment to avoid using electric or hydraulic pumps which are expensive and difficult to maintain due to the corrosion caused by salt on metal parts. Also, the solenoid mini-valves used in gravity flow are made of polyurethane or vinyl (PVC) and the salt brine tanks are made of plastic. The "V" box trucks hold about 8,000 pounds of material. The de - partment uses an application rate of 40 to 50 gal - lons of salt brine to four tons of salt and sand material.

The department has kept salt brine distilling simple by purchasing tanks and garden hose from local dis - tributors and assembling the distiller on site. The salt tank that it uses is 30 inches deep to percolate water through to achieve a specific gravity of 1.18. This is necessary for a brine that works to six de - grees below zero. For efficiency, the department lo - cated the salt brine distiller tanks near the area for filling the prewetting tanks.

Mankato's public works department first began prewetting with straight liquid calcium chloride in 1986-87 but switched to salt brine in the fall of 1994 due to the high cost of liquid calcium chloride ($0.52 per gallon) and its corrosiveness. The deci - sion to prewet was also influenced by increased traf - fic levels, public demand for higher levels of service (faster response time), and a desire for safer roads. With prewetting, the time needed to activate the salt has decreased from 45 minutes to about 20 minutes.

The department has reduced its use of sand and salt because of prewetting. Previously the department used 125 to 400 pounds of material per lane mile. Now the department uses 50 to 100 pounds of mate - rial per lane mile. The department estimates it saves 20 to 30 percent on the amount of deicing salt because of prewetting and expects to save $10,000 to $15,000 annually on deicing materials.

The department believes that its prewetting philoso - phy of "keep it simple" resulted in low-cost equip - ment while providing savings on materials and staffing.

For more information contact:

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Public Works Superintendent
City of Mankato
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Prewetting with Magnesium Chloride

City of Mounds View

Mounds View, a city in Ramsey County with 12,500 residents and 72 lane miles of roads, first be - gan prewetting in 1993 because of a salt shortage. Mounds View had budgeted 350 tons of salt for the

winter snow season, but its supplier ran out of salt before filling the city's entire order. Although the material was still available from another supplier, it cost $8 more per ton. Mounds View's public works department decided to try to minimize the use of its existing salt supply to avoid purchasing the more expensive salt. The department then began a prewetting trial to determine if it was possible to use less salt and still achieve the same level of service.

The trial was successful; Mounds View effectively cut back its total salt use, decreasing from an average of 400 pounds of salt per lane mile before prewetting to 300 pounds of salt per lane mile with prewetting. The department used calcium chloride, stored in a plastic watering tank, in its prewetting trial at a cost of one dollar per gallon. Mounds View applied five gallons of calcium chloride to three tons of salt, with operators spraying the chemical onto the salt in the loader bucket. The prewet material required a reduction of auger speed for effective application, but it produced a faster reaction time on city streets.

Mounds View switched from calcium chloride to magnesium chloride for its 1994-1995 snow season because it could no longer purchase the calcium chloride in the small quantities needed for prewetting operations. Although magnesium chloride costs 50 cents more per gallon, Mounds View can purchase it in small quantities.

Mounds View's prewetting system has required 350 to 500 gallons of chemical annually, at a total yearly expense of approximately $750. The public works department borrows the 300-gallon watering tank and gravity feeder from the parks department at no cost. The benefits realized from prewetting include: a faster salt reaction time, which allows for quicker and improved service; lowered brine freezing point, which slows potential solidification; and decreased salt usage, which lowers costs and negative environmental effects. Magnesium chloride, moreover, appears less corrosive than calcium chloride, according to the department's observations.

Mounds View has witnessed additional savings in labor, as a result of both prewetting and switching from a salt/sand mix to straight salt. Before changing to straight salt, the city required an average of six salt loads per storm. Straight salt has reduced that amount to two loads per storm. With proper application, Mounds View needs to plow its roads only once, saving significant labor time in second and third rounds of plowing or sanding. Although Mounds View has no formal bare pavement policy, most of its roads end up bare due to the effectiveness of its prewetting and chemical operation. These multiple benefits contribute to an overall increase in road safety. Mounds View believes that its roads are clearer and therefore safer, enhancing the city's level of snow and ice control service.

The disadvantages of the Mounds View prewetting practices rest in the method used to wet the salt. The spray system is a laborious process that requires operators to quickly spread an even layer of chemical onto salt in the loader bucket, rapidly dump the prewet material into the plow truck, and start spreading the material as soon as possible. The city plans to request a capital purchase of a large supply tank and automatic spray system, at an expected cost of $3,100.

Prewetting with magnesium chloride has worked particularly well for Mounds View, which uses straight salt in its operations. It is less clear from Mounds View's experience whether this practice would be effective for jurisdictions using a significant amount of sand in their salt/sand mix.

For more information contact:

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City of Mounds View
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Prewetting Salt and Sand

Mn/DOT

Each of Mn/DOT's districts around the state has tested prewetting salt and salt/sand mixes. While testing is expected to continue for several years, Mn/DOT reports generally successful results from

the first few seasons of prewetting. Mn/DOT's field testing in 1992-1993 and 1993-1994 showed that it could reduce salt use by a minimum of 20 percent and up to 30 percent. Mn/DOT used several different prewetting agents, such as salt brine, calcium chloride liquid, and calcium magnesium acetate, and different application systems, although virtually all were variations of tanks mounted on the rear or side of a plow truck. According to the results of our survey, 11 of the 13 districts specifically listed prewetting in answer to an open-ended question regarding innovative and effective methods of snow and ice control.

Besides prewetting salt/sand mixes, Mn/DOT is experimenting with the use of brine as an anti-icing material. Of the 13 maintenance districts and subdistricts responding to our survey, 3 indicated that they are experimenting with anti-icing measures. Mn/DOT applies the brine to paved roads about 4 hours prior to a storm in temperatures from 0° to 32° F. This prevents the ice from bonding to the road pavements. Mn/DOT typically does not use the brine alone on compacted snow and ice; for those conditions it prewets its salt/sand mix with the brine.

Although all Mn/DOT districts prewet their salt/sand mixes, they have been using different prewetting agents, according to our survey. All but one of the 13 Mn/DOT maintenance districts responding to our survey reported using salt brine for at least some prewetting purposes. Of those 12 districts using salt brine, the largest number (six) reported using only salt brine, four reported using brine and liquid calcium chloride, two reported using brine and magnesium chloride, and one reported using brine, Freezguard and CG-90. [3] The one district not using salt brine reported using liquid calcium chloride and calcium magnesium acetate as prewetting agents.

Districts using salt brine reported mixing the brine in solutions containing between 22 percent and 27 percent salt. The median concentration was 23 percent salt. Only two districts reported application rates of the salt brine; they applied between 7.4 and 8 gallons of brine to a cubic yard of salt mix. Mn/DOT representatives said that it costs between 5 and 15 cents per gallon to make the salt brine. This is inexpensive compared to other prewetting agents and can reduce expenditures for salt use overall.

Although all districts reported success with prewetting, different conditions and materials produced different results by district. The following section summarizes these results. [4] Other Mn/DOT districts not described below used prewetting but did not report outcomes of their use.

- Salt Brine

The Duluth district's Virginia maintenance area used salt brine for prewetting, with a 23 percent concentration of salt, and reported good results on the roads. Brainerd's maintenance area in District 3 used a salt brine with concentrations between 23 and 26 percent and reported faster de-icing in prewetted areas. Using the same salt brine concentrations, the St. Cloud maintenance area reported good results with prewetting salt/sand on glare ice. District 4's Morris maintenance area reported good results using a 23 percent solution of salt brine on glare ice.

District 6's Rochester maintenance area also reported good results using salt brine to prewet sand for use on glare ice. The Owatonna maintenance area has mixed liquid salt brine with calcium chloride for good results on ice and in sub-zero temperatures.

District 7's Mankato maintenance area reported success down to -2.5° F using a 22 percent concentration of salt brine. It reported good results in prewetting a half-salt and half-sand mix with 8.5 gallons of salt brine per ton and applying on glare

3 The numbers add to 13 instead of 12 because one of those using brine and liquid calcium chloride reported using magnesium chloride as well.

4 The following section presenting pre-wetting results relies primarily on results reported in: Minnesota Department of Transportation, Maintenance Operations Research, *Statewide Maintenance Operations Research Report,* December 1994.

ice. Windom's maintenance area used a 26 percent concentration of salt brine to prewet and reported reduced use of salt and sand. It also reported good results on glare ice by prewetting a sand/salt mix that contained 10 percent salt.

District 8 (Twin Cities metropolitan area) reported good results with prewet sand on glare ice using salt brine with concentrations between 10 and 20 percent. The metropolitan district reported success in tests using salt brine as a prewetting agent in temperatures beginning in the 5° to 10° F range and up through 32° F.

- Calcium Chloride Liquid

The Duluth district used a 32 percent concentration of calcium chloride liquid to prewet in the metropolitan area and concluded that prewetting melted the ice at colder temperatures and held the mix better on the road surface. In the Duluth district's Virginia maintenance area, operators reported that lack of traffic caused a roadway prewetted with calcium chloride to stay wet and subsequently become slippery. The Grand Rapids sub-area reported successfully using salt brine instead of rock salt to mix with sand before storing in a stockpile. By using salt brine and mixing via loader, the sub-area saved $1.73 per cubic yard over mixing sand with rock salt. Even greater savings resulted from mixing with a conveyor instead of a front-end loader.

District 7's Mankato maintenance area successfully mixed a 24 percent solution of liquid calcium chloride with salt brine for prewetting. However, its attempts to mix dry calcium chloride with salt brine were not successful.

- Calcium Magnesium Acetate (CMA)

The Duluth district used a 25 percent concentration of calcium magnesium acetate to prewet in a rural area and concluded that prewetting melted the ice at colder temperatures and held the mix better on the road surface.

- Anti-icer with PCI (Formerly Freezgard)

District 3's St. Cloud maintenance area used Anti-icer with PCI (magnesium chloride with a rust inhibitor) as a prewetting agent in conditions down to -15° F. However, the area reduced its use because black ice tended to form in very cold weather. Mn/DOT reports a problem with some of the rust inhibitor materials separating and sinking to the bottom of tanks.

- Magnesium Chloride and Sodium Citrate (CG-90 Liquid Deicer)

One truck station in the Twin Cities metro division reported observing no difference between using dry salt/sand mixes and prewetting the mix with CG-90 liquid deicer. The Rochester maintenance area has tested the use of CG-90 on bridges but the corrosion results from those tests are not yet final.

- Tanks for Mixing Salt Brine

Mn/DOT district personnel use a variety of systems for making salt brine. Some use very low-cost systems designed with galvanized cattle tanks. Several districts mounted a 7-foot cattle tank on top of a 10-foot cattle tank. Maintenance personnel use loaders to fill the top tank with salt. They run water into the top tank to form a 23 percent solution of brine (tested with hydrometers for salinity content) that is filtered into the larger, bottom tank. Costs for the system, including the tanks, pump, hose, and hydrometer, are about $400. A disadvantage of the cattle tank system is corrosion to the tanks, requiring tank replacement about every other year.

Although Mn/DOT has had success testing these tanks, it is now converting to fiberglass or plastic tanks that resist corrosion. In addition to problems of tank corrosion, the cattle tank arrangement does not provide secondary containment of the liquid. Minnesota Rules require all aboveground storage tanks containing liquid material, with the exception of water, to have secondary containment. This means that all aboveground storage tanks must have double-walled construction or must have dikes around them that are capable of holding 110 percent of the tank's volume. Commercially produced sys-

tems using corrosion-resistant construction for mak - ing salt brine cost about $4,400.

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9. COMMUNICATE WITH THE PUBLIC

Brochure, Telephone Voice-Mail Hot Line, and Cable Television

City of Bloomington

Bloomington is a city in Hennepin County with a population of 87,000 people who need information about the city's winter street maintenance. To com - municate with residents, the maintenance division of the public works department uses a variety of measures. The division mails a snow and ice con - trol brochure throughout the city and uses telephone voice-mail, street signs, and interactive cable televi - sion.

The brochure, a two-color, fold-out piece mailed to all city residents, accomplishes several objectives. In the brochure the department describes the park - ing regulations and lists the "do's" and "don'ts" for the period following a snowfall. Combining graph - ics with simple text that the public can understand, the brochure provides basic background informa - tion about the number and type of streets in the city, plowing and sanding priorities, the number of main - tenance employees, and the cost of snow and ice control relative to the total property tax dollar. The brochure explains in easily understood language what the parking ban means for residents; it also in - cludes the parking ordinances themselves. The bro - chure uses illustrations to indicate the dangers of approaching too closely behind a plow and de - scribes the plow operator's limited field of vision. The brochure also lists phone numbers and the ca - ble television channels where residents can receive additional information. Production and mailing costs for about 41,000 brochures amounted to $7,200, or roughly 8 cents per capita. Because of mailing costs, the department does not plan to mail the brochure every year.

1994 was the second year that the public works de - partment used a voice-mail telephone number to provide plowing and sanding information to resi - dents. When residents call the number, which is ad - vertised in the snow and ice control brochure, they receive up-to-the-minute information on when plowing or sanding began and when it is expected to be completed. If the de - partment declares a park - ing ban, callers receive that information too. Peo - ple who want to leave a message may do so; the appropriate staff person will return the call.

Bloomington residents receive timely plowing information 24 hours a day through a telephone voice-mail system.

The voice-mail system is beneficial because resi - dents can get information and leave messages at any time of the day or night. If callers request a re - sponse, the system allows the department's person - nel to collect any needed information before re - sponding. An added advantage is the relief to switchboard personnel who in the past had to pro - vide the snowplowing information. The department has not tracked the number of users who have di - aled into the voice-mail system for plowing infor - mation. Because the voice-mail system was instituted citywide, the public works department did not bear a direct cost for it and does not have an es - timate for its share of the costs.

The public works department also uses cable televi - sion to provide updated plowing and sanding infor - mation. During a snowfall, residents can tune into the designated channel to find out when plowing is expected to begin and end or to learn about the park -

ing restrictions. Those with a touch-tone phone and cable television may also use the Bloomington Re - source and Information Network (BRAIN). This network is an interactive service that allows resi - dents to use their touch-tone phone and call up whatever pertinent information on snowplowing they would like to see on their television screen. Residents who use BRAIN are in effect converting their televisions into computer monitors, allowing them to select the appropriate menus of information to meet their needs. Although the city does not track the number of users of this service, about 57 percent of Bloomington homes have cable televi - sion, a relatively high share of cable penetration. Because the public works department bears no di - rect costs for the cable television communications it does not have an estimate of costs for these services.

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10. APPLY APPROPRIATE SNOWPLOWING TECHNIQUES

Multi-Directional Plow for Cul-de-Sacs and Alleys

City of Albert Lea

Albert Lea's street department uses a four-way ar - ticulated plow on a front-end loader to plow cul-de-sacs and alleys. The city has 85 cul-de-sacs, 120 alleys, and 185 lane miles of road. Albert Lea is lo - cated in Freeborn County near the Iowa border and has 18,000 residents.

One-way plows did not work well in Albert Lea's smaller cul-de-sacs. Many of the city's alleys, par - ticularly in the residential area around its two lakes, were too narrow to accommodate regular plows. In 1991 Albert Lea's street department purchased a four-way plow to plow cul-de-sacs and alleys. The four-way plow angles to the right and left, converts to a V-plow for large loads of snow, and also in - verts. The operator adjusts the plow's angle from inside the cab. Operators plowing tight alleys will pull the blade into a tight "v" shape; when they reach a wider alley, the drivers simply widen the "v" to plow the full width of the alley. With the use of a quick hitch on the front-end loader, operators can quickly and easily change from using the plow to a bucket or a snowblower. The department does not use this four-way plow in the higher-speed situ - ations where it uses regular single-axle snowplow trucks.

The cost of the articulated blade with carbide skid shoes was $6,980 in 1991. In four years of using the plow, Albert Lea has experienced no mechani - cal problems with it. Operators will not damage the equipment if the plow hits a hard object because the plow's joints have shear pins that take the impact. Drivers simply carry extra shear pins with them to replace any that break. Because of the street depart - ment's positive experience with the four-way plow, Albert Lea's parks department has since bought a similar plow for clearing city sidewalks.

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Cul-de-Sacs Center Storage

City of Woodbury

Woodbury, a city in Washington County with 30,000 residents, 305 lane miles of roads, and 320 cul-de-sacs, began plowing snow into the center of cul-de-sacs in 1993 after years of pushing the snow onto boulevards. The street department hoped this change would reduce the time and costs associated with its cul-de-sac snowplowing.

Woodbury began exploring alternative cul-de-sacs plowing methods after some residents complained about large piles of snow accumulating in their front yards after plowing onto the boulevards. Be - cause Woodbury's cul-de-sacs contain a large num -

ber of light poles, fire hydrants, and mail boxes, op - erators generally had to plow snow to the same yards throughout the winter season.

The department first experimented with the center snow storage method on five of its cul-de-sacs, af - ter surveys sent to other metro cities indicated that center storage was a successful plowing technique. Due to citizen requests, the trial was extended to 12 cul-de-sacs. The results were encouraging. Not only did the street department eliminate the prob - lem of large boulevard snow piles, but center stor - age also allowed the department to plow its streets faster and at less cost.

The street department uses a plow truck to make a first run through the cul-de-sacs in a clockwise di - rection, plowing the snow to the center of the cul-de-sacs. It then sends in a pickup truck around the outside perimeter to push any remaining snow into the boulevard areas and driveways. The depart - ment believes that this amount of dispersed drive - way and boulevard snow is comparable to mainline street amounts.

Woodbury cul-de-sacs average approximately 90 feet in diameter. The street department keeps an outside perimeter lane width of 20 to 25 feet clear, compared to a normal resi - dential street width of 30 feet. Additionally, the center island storage area is not allowed to exceed the normal snow bank height of other residential streets. The department has not yet experienced a winter when the storage center exceeds height limitations, but if the cen - ter should ever get too tall the street department would be forced to haul snow away from the stor - age island. Both Woodbury's fire department and police department agree that the center storage is - land poses little concern in relation to the services they provide.

Woodbury saves time and money by plowing snow to the center of its cul-de-sacs.

Woodbury's street department estimates that it has saved approximately 30 percent in the average oper - ating cost per cul-de-sac plowed, going from $9.22 in 1991 (221 cul-de-sacs) to $6.51 in 1993 (295 cul-de-sacs). Similarly, the average plowing time per cul-de-sac was reduced by one-third, from 15 to 10 minutes. Cul-de-sac plowing equipment increased from 7 pieces in 1991 to 8 in 1993, but the average number of cul-de-sacs plowed per piece increased from 32 to 37. The department attributes the in - crease in total equipment to a 35 percent growth in the number of cul-de-sacs during those two years.

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11. USE PASSIVE SNOW CONTROL MEASURES

Shelter Belts to Prevent Drifting

City of Alden

Alden is a city of 623 residents in southern Minne - sota that planted a shelter belt of trees to help con - trol blowing snow across city roads. In 1993 the public works department worked through the Free - born County agricultural extension office to pur - chase Colorado blue spruce that would provide a wind break and control snow drifting.

Alden planted the spruce in a northern section of the city where a housing development was under construction. Because of the open area around the development, the department decided a natural shel - ter belt would benefit both snow control and the de - velopment. Although the trees are still young, within five years the department expects to reap the benefit of the shelter belt.

Alden purchased its trees and received information about trees that could be used in a shelter belt through the Freeborn County extension office. Al - den paid approximately $200 for about 300 trees. The extension office offers fact sheets and bulletins

on the selection of trees, the role they play in con - trolling snow, and how to place trees to manage snow placement. It also provides access to Univer - sity of Minnesota staff papers on shelter belts as well as names of individuals who can be resources to local governments that are considering the devel - opment of shelter belts.

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County extension offices

City of Madison

Madison, a city of 1,900 residents in central Minne - sota near the South Dakota border, planted lines of trees in areas of the city that were particularly sus - ceptible to hazards created by blowing snow. Al - though the trees are not yet at their mature height, the streets department expects the rows of trees will eliminate the need for snow fence. The streets de - partment planted an 800-foot length of trees in 1994 and plans to add another 2,800 feet of trees.

Based on recommendations from the Agricultural Stabilization and Conservation Service in Lac Qui Parle County, the department selected maple, green ash, Australian pine, and black hills spruce for planting. The department participated in a cost-sharing program through the Conservation Service, paying about $90 for the bare root trees and slightly more for potted evergreens.

The streets department planted the trees on city-owned property on the west side of the city. The city has a 90-foot easement so that when this prop - erty is developed in the future, the city will retain rights to the areas where it planted trees. On the north side of Madison, the city planted a line of trees on the southern side of city-owned park land.

The streets department was careful to space the trees to reduce the need for tree trimming in the fu - ture. It has found that workers have to spend more time trimming trees in its public park areas than cut - ting grass. Therefore, to make the best use of its staff in the future, it chose trees and spacing that would not require such labor-intensive work.

The department expects the tree belts to reduce its use of snow fence. In the past Madison has used up to 5,000 feet of snow fence in a winter season. Be - fore installing the fence and taking it down each fol - lowing spring, the streets department obtains permission from the land owners.

Areas considering planting shelter belts as wind and snow breaks must select trees suitable for planting in their type of soils and climate. They must also consider the site for the tree ridges and reconcile ownership issues with the landowner. Easements may be necessary. Assistance in selecting what to plant, the design of the shelter belt, and cost sharing of the trees' purchase price is available from the Ag - ricultural Stabilization and Conservation Service lo - cated in county seats and from county extension agents through the University of Minnesota's Agri - cultural Extension Service.

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Regrading Roads

Kittson County

Kittson County's public works department has re - fined the practice of regrading its roads to allow for more effective control of blowing and drifting snow and improve maintenance of the county's 282 miles of gravel roads. Kittson County has a population of 5,700 and is located in the northwestern corner of Minnesota. Historically, the department has "hay stacked" its gravel roads, meaning that it regraded a "crown" or an elevated portion, several inches high, into the road surface each year. While this tech - nique was effective for allowing water to run off in

the spring and summer, it did little to prevent the build up of snow on the road and often made plowing snow more difficult.

The technique of hay stacking the gravel on the road keeps only a narrow strip in the center of the road free of snow. During periods of blowing and drifting snow, it does not prevent the snow from building up in the travel lanes. Vehicles sharing the center of the road during dangerous winter driving conditions encountered a safety hazard. Hay stacking of the gravel made snowplowing more difficult because the curved crown is difficult to plow with the straight blade. The straight edge of the plow is unable to remove the snow built up along the curved shoulders without scraping the gravel and potentially damaging the plow blade.

In response to these problems, Kittson County operators began grading the gravel roads flat every fall as part of the county's routine grading maintenance. This practice allows the snow to blow over the road surface preventing any build up of snow in the shoulders. It also saves on gravel loss. In the spring the roads are regraded or hay stacked to replace the crown and allow the water to run off. Keeping the road surface dry helps prevent the road from breaking up and lowers ongoing maintenance costs.

The department has found that the practice of flattening out gravel roads means operators are less likely to have to replow roads after blowing snow. In addition, road repairs are less frequent.

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Separation of Grades

Kittson County

Kittson County's public works department has used grade separation as an effective method for controlling blowing and drifting snow for approximately 20 years. Because the road is elevated above the surrounding area, the snow blows over the road surface and does not accumulate or cause drifts. Kittson County has a population of 5,700 and 917 lane miles of road.

Typically, the normal grade separation between the road and surrounding area is about four feet. To produce less build up of blowing and drifting snow, the department increases the minimum elevation to between five and six feet. The increased height exposes more of the road surface to the force of the wind, preventing snow build up. Kittson County officials indicate that by observing the road on a windy day one can see the wind carry the snow up and over the surface of the road and deposit it on the road shoulder. This practice is also effective with ice because wind-driven snow acts like sandpaper on the surface of the ice, actually wearing ice off the road.

The county adds the higher elevation as it upgrades its gravel roads to bituminous or rebuilds its existing bituminous roads. Done incrementally, the upgrading provides additional passive snow control at a minimal expense to the county. The result has been savings in time and equipment because of the reduced need to plow and scrape the county roads. Information on the exact cost of the higher elevation for snow and ice control was not available.

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Controlling Blowing and Drifting Snow

Polk County

Polk County's public works department has developed practices to control blowing and drifting snow. The department maintains 6,950 lane miles of road for a county population of 32,600. By eliminating catch areas where drifting snow can accumulate,

the department is able to prevent snow buildup on the roads. The department systematically identifies and removes obstacles that catch snow before snow drifts onto the roads. The practices are: (1) preven - tive mowing, (2) snowplowing techniques, and (3) building snow ridges.

The key to preventive mowing is identifying loca - tions of grass and weeds, such as along bridges or guard rails. In the fall when operators are conduct - ing dry runs of their snowplow routes or blading roads, they identify where tall grass or weeds can catch snow. Mower crews and operators work to - gether to trim the overgrown areas before the snow season.

Snowplowing techniques can also prevent snow buildup. When Polk County operators plow their routes, they typically leave a snow bank wall that is perpendicular to the road surface. This blocks the wind and the area be - tween the road and the flat snowbank wall accu - mulates blowing and drift - ing snow. The department will then slope the snow bank wall. Operators drop their plow wings to an angle and wing back the top of the ridge, leaving the snow - bank with an angled slope instead of a 90 degree wall. The blowing snow flows over and away from the snowbank wall, preventing buildup on the road. Operators start winging back when snowbanks reach approximately 18 inches high. The depart - ment plows both sides of the road in this manner.

Polk County operators build snow ridges to prevent the buildup of blowing and drifting snow.

Operators plow snow from snow banks when they become large enough to cause the accumulation of blowing and drifting snow. They move the snow from the high side of the road to the low side, as needed.

Operator-made snow ridges further prevent the buildup of blowing and drifting snow. Similar in principal to traditional wooden snow fences, snow ridges stop blowing snow from reaching the road by breaking the speed of the wind and depositing the snow down wind from the ridge, before it reaches the road. Prior to the snow season, county personnel get permission from property owners to enter the land abutting the roads where snow drift - ing is likely to occur. After the first snowfall, a mo - tor grader plows a ridge about 12 to 18 inches high. As snow fills in behind the ridge, operators plow snow into two or three ridges about fifty feet apart and approximately three to four feet high. Under more severe conditions, operators add a fourth ridge and pile the snow ridges to heights of seven to eight feet. In a mild winter the department uses only one ridge.

With these preventive practices, the department saves staff time and needs less equipment. The snowbank walls and snow ridges are easier than in - stalling traditional wooden fences. Unlike the tradi - tional snow fence, the ridges melt on their own and do not have to be taken down. Snow ridges provide flexibility because the department can keep adding ridges, as needed, all winter long. The department now uses two snow blowers instead of three and has eliminated two motor graders out of a fleet of seven, yet provides a higher level of service using the same number of operators. These practices are especially useful for those jurisdictions in flat parts of the state where blowing and drifting snow is a problem.

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12. EMPLOY EQUIPMENT IMPROVEMENTS AND PREVENTIVE MAINTENANCE

Ground-Oriented Sanders

Anoka County

Anoka County operators began using ground-ori - ented sanders in 1992, after the highway mainte -

nance department acquired specific information and feedback from seminars on ground-oriented sanders. The maintenance department believes that the sanders enhance the management of materials, increase the efficiency and effectiveness of salt and sand applications on its 893 lane miles of county road, and generally increase the level of service provided to its 243,000 residents.

Anoka County's maintenance department has experienced multiple benefits from using ground-oriented sanders. The sanders adjust for the truck's velocity, dispensing sand at a constant rate per ton regardless of truck speed. The department cut its number of loads by one-half in one year, decreasing from an average of four loads of material per storm before using ground-oriented sanders to two loads of material after. The department achieved this 50 percent decrease in material loads in 1993 with a mix of 60 percent salt to 40 percent sand in the main shop and a mix of 25 percent salt to 75 percent sand in outlying shops. The department believes the decrease was independent of the number of plowing and sanding events (approximately 65 in 1992 and 55 in 1993) with operators generally cutting their average load needed for each event in half.

Reducing the average number of loads led to a decrease in the number of return plowing trips required by operators and equipment down time from reloading, saving approximately two hours per operator per event as well as overtime costs. Operators using ground-oriented sanders averaged six hours per plowing or sanding event in 1993, compared with eight hours in 1992.

The maintenance department has also been increasing the concentration of salt in its mixes. The county used a mixture in its main shop of 40 percent salt to 60 percent sand in 1992, increased the mix to 60 percent salt to 40 percent sand in 1993, and increased the mix to 100 percent salt in 1994. The department finds that using higher concentrations with its ground-oriented sanders allows the department to achieve a higher level of service with approximately the same amount of salt used. The efficiencies gained through the use of ground-oriented sanders and decreased sand concentrations also cut the county's sweeping costs, with the department spending less time, labor, and rental expense during spring road sand sweepings.

The cost of adding ground-oriented sanders to a new truck was approximately $1,500 to $2,000 per vehicle. County officials discovered that purchasing ground-oriented controls was more economical than converting their old sanders which would have cost an estimated $4,000 per truck. The maintenance department believes that the benefits gained with ground-oriented sanders are worth the cost, with Anoka County recovering the costs through savings in labor, materials, and road sand sweeping. County officials do not attribute the savings solely to ground-oriented sanders, but rather to a combined approach of ground-oriented sanders, operator familiarity, and higher concentrations of salt. Consequently, jurisdictions using a low percentage of salt in their mixes may not experience as dramatic benefits with ground-oriented sanders as Anoka County.

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City of Woodbury

Woodbury's street department first purchased ground-oriented sanders in 1991 as part of the options package selected for its new vehicles. Woodbury, a city in Washington County with 30,000 residents and 305 lane miles of roads, had first looked at electronic control units for its plowing and sanding trucks, but ground-oriented controls were part of a more cost-effective vehicle options package.

Ground-oriented sanders allow operators to put down the exact amount of salt or sand desired regardless of truck speed, with a spinner that dispenses the salt or sand while automatically adjusting for travel speed. This proves to be a more efficient sand application technique when the ground-oriented sanders work properly. Woodbury

has experienced some problems keeping the sand - ers calibrated, but has worked out most mechanical problems. The ability to better control material ap - plication has contributed to lower costs and more ef - fective sand dispersion in the city.

Although the initial cost of the ground-oriented con - trols is approximately $1,500 to $2,000, the sanders produce real savings. The department indicates that it is averaging 15 to 30 tons less sand and salt per storm event. This means that, using a mix of 50 percent salt to 50 percent sand which costs $30 per ton, the department saves a minimum of $450 for each snow event. In addition to the money saved with the ground-oriented sanders, the department believes that using less material reduces spring street sweeping costs and is an environmentally-friendly approach to snow and ice control.

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Polyurethane Plow Blades

City of Chisholm

Chisholm's public works depart - ment has been satisfied with the performance of polyurethane plow blades. Chisholm is a city located in St. Louis County with a popula - tion of 5,200 and 62 lane miles of road. A local fabrication shop manufactures the polyurethane blades from two-inch thick forms. Chisholm mechanics use their own template to counter sink and punch holes for bolting the blade to the plow. A steel retainer plate pre - vents the polyurethane blade from being pulled off the mold board dur - ing operation. Trucks with front plows use the polyurethane blade, while the department's motor graders use steel blades.

Operators developed the blade in response to prob - lems experienced with steel and carbide blades. They had problems with brittle carbide blades chip - ping and breaking. Operators found that polyure - thane blades lasted longer than carbide blades. The cost for an 11-foot carbide blade is about $450 com - pared to $350 for polyurethane. Steel blades did not have the chipping or cracking problems, but op - erators had to replace them frequently. Operators changed steel blades four or five times a season in contrast to changing polyurethane blades twice a season.

Operators have found that polyurethane blades float over road obstructions and ride smoothly over road surfaces. Polyurethane blades ride up over protru - sions, saving considerable wear and tear on equip - ment and preventing broken plows. The polyurethane is less likely to damage curbs and plows because it helps operators to sense the loca - tion of the curbs better than metal blades. Opera - tors designed and added a curb runner blade that allows them to get close to the curb and clear snow without damaging the blade or curb.

One disadvantage of the polyurethane blades is that they will not cut snow pack and ice as effectively as

Chisholm mechanics punched holes to bolt the polyurethane blade to the plow.

steel or carbide. Therefore, Chisholm's operators still use motor graders for this purpose. Also, polyurethane blades wear excessively during the early part of the season because of direct contact with the road surface. This is usually not a problem later in the season. The polyurethane blade would not likely withstand high-speed plowing on highways.

Chisholm's public works department has been using the polyurethane blade for about five years with considerable success. The department feels it is ideal for small cities where traffic levels and speeds are low. Having a nearby fabrication facility allowed the department to refine the design of the blade as needed to meet its needs and local weather conditions.

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City of Chisholm
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Carbide Blades

Douglas County

Douglas County's public works department has used carbide blades in its snow and ice control operations since 1975. Carbide blades have been particularly effective in dealing with compacted snow and ice. With the exception of gravel roads, the department plows all county roads with carbide blades on one-way plows. Douglas County contains 1,083 lane miles of road and has about 29,000 residents.

The primary advantage of carbide blades over steel is the carbide's hardness. The department has found that carbide blades last three seasons compared to steel blades that can burn out in two days after a major snow storm. Steel blades present higher labor costs because of the need to frequently change blades. The down time of plows equipped with carbide blades is less than plows equipped with steel blades.

Because carbide blades are harder than steel, they are especially durable with the county's bigger, heavier plows and trucks. Typically, the county's new trucks weigh about 33,000 pounds compared to older trucks that weighed 24,000 pounds; plows are now 11 feet in length as compared to older plows that were 9 feet in length. Carbide holds up well against the increased weight and pressure of the plows and trucks.

Douglas County has experienced significant savings using carbide blades because they last considerably longer than steel. A carbide blade at $28.50 per foot costs an average $105 per year, whereas a steel blade at $13 per foot averages $429 per year because of the need for frequent blade replacements. The biggest obstacle to using carbide blades in Douglas County was convincing elected officials that carbide blades were worth the additional up-front cost.

According to county officials, a disadvantage of carbide blades is brittleness, which makes them more susceptible to breaks. Also, operators have to be careful not to leave the plow down on bare road because this heats the blade and grinds its surface.

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City of Little Canada

Little Canada, a city in Ramsey County with 9,800 residents and 44 lane miles of paved roads, began using carbide blades on plows in 1994. The blades are cost-effective equipment improvements for the city, largely due to the time and labor saved from fewer blade changes and replacements.

The city believes the difference in blade cost between carbide and non-carbide is minimal. For example, the price of a steel blade for its articulated loader is approximately $104, while the price for a carbide is $134. The higher carbide blade price is

justified by the higher life expectancy of the carbide blade. In 1993, operators changed their plow blades an average of once every two plowings, a process lasting 30 to 45 minutes per blade change. In 1994, operators had not changed any blades since the original carbide installation. The number of sanding and salting operations were comparable for 1993 and 1994, while 1993 had slightly more plowing events.

Most jurisdictions could benefit from the use of carbide blades. Although slightly more costly in purchase price, the expected life of the carbide blade reduces the total number of blades required per winter snow season. Carbide blades additionally save the time and physical labor necessary for blade changes.

For more information contact:

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City of Little Canada
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Waseca County

Waseca County's highway department uses dual carbide blades on its motor patrols to plow paved roads. Because the carbide blade has a longer-lasting cutting edge than steel, the department saves on labor and equipment costs. Waseca County is located in south central Minnesota; it has 760 lane miles of road and about 17,700 residents.

Waseca's highway department has found that dual carbide blades outlast steel cutting edges. The department could wear down a steel blade in one day of plowing concrete roads following a major snowstorm. At $83 per foot, the carbide blade had to provide about 120 hours of use to make it as efficient as its steel counterpart. The first set of carbide blades used in the department comfortably exceeded that benchmark, providing the highway department with 300 hours of use. The department has continued to receive long-lasting service from carbide blades, with one set providing about 800 hours of use.

Replacing a blade requires about one and one-half hours of downtime each time the edge needs changing. Because the carbide blades require fewer changes, the highway department avoids the costs of labor and time that would be necessary for frequently replacing steel blades. Less down time means the county is able to use its snowplowing equipment more efficiently during snowstorms.

In addition to their longer wear, carbide blades cause less back strain for workers who change the blades. Workers have found it much easier to maneuver the four-foot sections of carbide blades than the weight of the heavier steel blades.

Moreover, the highway department believes the carbide blades provide quality snowplowing service that is comparable to steel. The department restricts the use of the carbide blades to concrete and blacktop surfaces. It also uses the dual carbide blades for summer road maintenance.

For more information contact:

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Heated Mirrors and Other Vehicle Enhancements

City of Jordan

When Jordan bought a new plow truck in 1992, it purchased the vehicle option of heated mirrors. The public works department felt that driver safety could be enhanced through the use of heated mirrors. This appeared especially true for instances that require operators to back up while plowing.

The heated mirror option, as listed in the vehicle specifications, costs approximately $188. The Jordan public works director believes the cost is small for ensuring the safety of the department's operators by keeping the mirrors clear. A switch located inside the truck cab turns on the mirror heat, which operators now view as a standard vehicle accessory.

Heated mirrors, in addition to their manageable cost and ease of use, have no problems with precipitation buildup, which enhances driver safety through improved visibility.

Purchasing the heated mirror option on new trucks is a relatively inexpensive means of increasing the visibility of operators and improving the overall safety of snow and ice control operations. Jordan, a city in Scott County with 3,000 residents and 24 lane mile of roads, also purchased additional driver and vehicle enhancements with its new 1992 and 1994 trucks. A stationary cab protector mounted to the frame instead of the box saves three feet when raising the box, an important advantage in a city where low overhead wires cross many streets. The city also purchased rubber fenders to protect the underbody of the trucks, and heated fuel tanks to prevent fuel from hardening to gel.

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Underbody Plows

City of Jordan

Jordan first began using underbody plows in 1992, after talking with other jurisdictions who had experienced success with underbodies. Jordan, a city in Scott County with 3,000 residents and 24 lane miles of roads, felt it could do a better job at plowing the roads and maintaining a higher level of service. After three years of experience using underbody plows, the city maintains that streets are plowed both clearer and faster.

The city of Jordan rests in a valley and plows numerous hills during its snow season. Operators find underbodies a necessity because the plows sit directly on the road, allowing for closer contact and improved scraping of ice and compacted snow. This helps Jordan to meet its goal of bare pavement, generally leaving the roads not more than five percent snow and ice covered.

Jordan bought the underbody plows as options on newly purchased trucks and estimates the cost per plow to be approximately $4,000. Because of the expense, the city council needed some persuasion before purchasing underbodies for all city trucks. Jordan practitioners used a major 1992 storm as an example of the improved service underbodies provide and convinced members that underbodies were a worthwhile investment.

The benefits underbody plows provide could extend to most jurisdictions and prove especially useful in areas prone to ice buildup. Enhanced scraping, faster plowing, and versatility contribute to this attachment's utility.

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Otter Tail County

Otter Tail County's public works department began using underbody plows in 1992, chiefly to remove compacted snow and ice. Currently, 8 of the county's mainline fleet of 26 trucks have underbody plows. The department plans on equipping all new trucks with underbody plows. Otter Tail County has 2,095 lane miles of roads and 51,300 residents.

The underbody plow's primary advantage is its downward pressure, generated by the trucks' hydraulics, on hard-packed snow and ice. Underbodies can be highly effective in scraping ice and frozen snow at intersections and in sheltered areas with compacted snow. The department uses trucks with underbodies instead of motor graders for plowing. Motor graders travel at speeds of approximately 10 to 18 mph while trucks travel up to 30 mph while plowing. Also, the truck can serve a dual function with its front plow for higher speed snowplowing and its underbody plow for scraping

packed snow and ice. Because of their higher speed, trucks equipped with underbodies have reduced plowing times in Otter Tail County.

Adding the underbody plow to trucks also has a cost advantage over the motor grader. Motor graders cost about $120,000 compared to the truck cost of about $98,000, including the $5,000 for an underbody plow. The useful life of an underbody is about 15 years. In addition, the department saves on material costs because when it uses underbodies it applies fewer deicing chemicals.

Underbody plows can have drawbacks. The downward pressure on the cutting edge means that blades wear quickly, requiring carbide blades or frequent blade changes. Also, the downward pressure can wear down the center line and edge striping and scrape off seal coating. Underbody plows cannot cut glare ice or scrape snow and ice from wheel ruts without the department first applying chemicals to break the bond between snow or ice and the road surface.

Another consideration for the department's use of underbody plows on trucks was the type of roads on which the plows would be used. Otter Tail County has no gravel roads and, therefore, no special need for motor graders.

Otter Tail's public works department found that retrofitting an existing truck for an underbody plow can be twice as expensive as purchasing the plow new because of the need to relocate items such as fuel tanks and hydraulics. Retrofitting trucks with underbody plows requires at least 24 inches of vertical space under the truck. The department believes that a better time to install an underbody plow is when purchasing the truck. When buying new, departments can specify the underbody along with the other truck components in the bid.

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Two-Way Radios

City of Little Canada

The Little Canada public works department has been using two-way radios in their trucks for over ten years, to enhance operator safety and effective communication. The department also has six portable radios for use in vehicles without two-way radios. Little Canada officials believe that the radios are a cost-effective safety tool for their snow and ice control operations.

The Little Canada public works superintendent could not provide a meaningful cost estimate for the permanent two-way radios because they were purchased over ten years ago. The six portables, however, average the city $100 each year for purchases and repairs. The public works department believes the cost is relatively small for the improvements in communication the radios offer. Radios also provide comfort in the knowledge that operators have a means of outside contact if ever needed. Finally, the radios increase customer service in Little Canada, a city in Ramsey County with 9,800 residents and 44 lane miles of roads, allowing for a quicker and more efficient response to snow and ice control challenges.

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Radial Tires on Motor Graders

Martin County

During the 1993-1994 snow season, Martin County, located on the southern border of Minnesota with 1,015 lane miles of road, experimented with a set of all-season radial tires that proved very effective for motor grader use. Martin County's highway department was so pleased with the performance of the radials that it replaced all motor grader tires the following year.

The radials provide excellent traction in very snowy conditions. As an example of the radials' traction, the grader equipped with the radials was able to pull out another motor grader that had become stuck in the snow. In fact, the department was able to forego the use of tire chains on its motor graders with the radials. Besides the convenience of foregoing chains, operators have saved time by not having to put chains on the tires.

The radials cost about $100 more than other motor grader tires. Although the department has not had these radials long enough to test their long-term durability, the tires have already provided 4,000 hours of use compared to about 3,200 hours for regular lug tires. Wear on the radial tires appears minimal. Moreover, by avoiding the need for chains, operators eliminate wear on the tires from contact with the metal chains.

Radial tires improve traction and allow Martin County to forego tire chains.

Although Martin County officials find the radials particularly useful in the winter season, they use the radials year-round. The radials are not particularly suited for mud and clay that might accompany road construction projects, but they prove effective for the county's road maintenance during winter and summer months.

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Plow Wheels

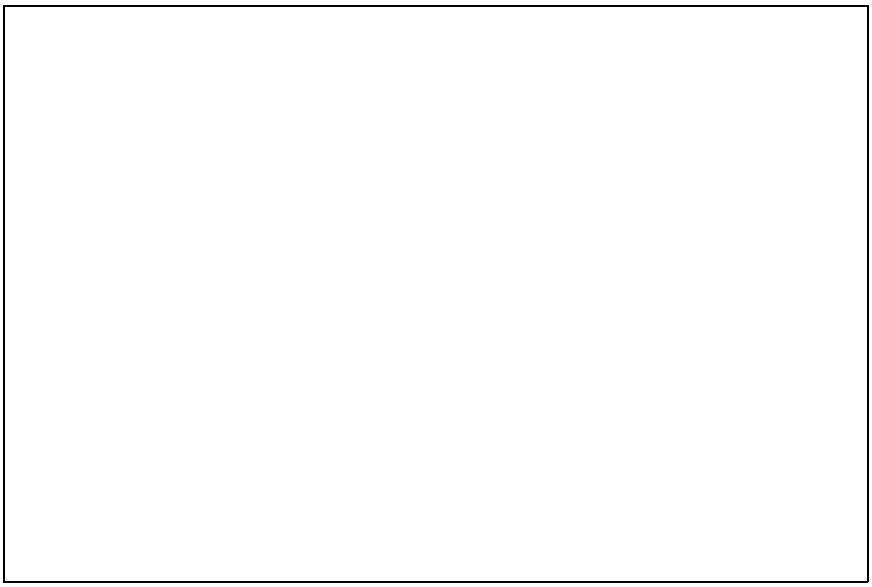
Martin County

For the past 12 years, Martin County has equipped all of its plows with snow wheels as a way to save time and money. The county has 1,015 lane miles of road and is located in the south-central part of the state on the Iowa border. Typically, the weight of the plow (more than a ton) bearing down on the cutting edge contributes to the deterioration of the edge as it pushes against the road surface. Snow wheels attached to a plow can be adjusted to vary the weight on the cutting edge to just the right amount needed to clear the pavement. On aggregate surface roads, the plow can be rolled back onto the snow wheels entirely so that the cutting edge is off the surface. This not only saves on the cutting edge but also on the amount of aggregate that gets plowed into the ditch.

Each of the county's 15 V-plows has three sets of snow wheels and each of its 11 one-way plows has two sets. A set of snow wheels contains two rubber composite wheels approximately seven inches in diameter. Martin County paid $685 for a set of snow wheels about eight years ago; a more recent cost estimate is not available. With just minimal maintenance (annual greasing), the wheel assemblies have lasted over the years; the county replaces the rubber wheels about every two years and replaces the bearings approximately every ten years.

Martin County uses snow wheels in place of plow skids that require more force to push along the

roads. With snow wheels on the plows, the county saves fuel and labor costs above what it would with plow skids. Although the county has not formally measured fuel use with and without using snow wheels, it has observed fuel savings with snow wheels. An operator driving a plow with snow wheels could stay out all day while another operator, using a similar plow with skids, had to return for refueling. Skid shoes had to be replaced at a replacement cost of $60 to $80 after every one to two days of plowing, whereas snow wheels did not. In addition, snow wheels saved Martin County labor costs of replacing skid shoes and the downtime of the equipment while under repair.



Plow wheels save time and money for Martin County.

Operators find it easy to adjust plows equipped with snow wheels. They can put more weight on the cutting edge or raise it off the ground by hand-twisting a toggle bolt. This allows operators to quickly adjust the plow to changing road surface conditions. However, county maintenance personnel suggest periodically checking the snow wheels for wheel alignment. If out of alignment, a wheel can be lost while in use and the plow can suffer damage.

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Equipment Versatility

McLeod County

McLeod County's public works department, which maintains 2,195 lane miles of road for 43,000 residents, emphasizes equipment flexibility and versatility. Interchangeable attachments allow the department to adapt its equipment for multiple uses. The department can swiftly change from one-way plows to "V" plows or push-blade plows, and has designed equipment to ease changing the cutting edges and attaching or removing sanders.

The department uses quick-change hitches on all of its one-way, front-end plows. The quick-change hitch costs about $900 with hydraulics. Operators can replace a damaged plow with a new plow in a matter of minutes. Quick-change hitches save labor and keep equipment in service for the time that would otherwise be needed to change attachments.

The department also equips all of its front-end loaders with "quick-tach" hitches. The quick-tach hitch costs about $3,600 with hydraulics due to its heavy-duty construction. The quick-tach hitch allows for the easy attachment of buckets, "V" plows, push-blade plows, and snow blowers. The department, for example, uses push-blade front-end plows on its front-end loaders to push snow banks. Designed with more height and reach, this plow pushes snow farther away from the road surface than other types of front-end plows. The quick-tach hitch allows the

department to quickly attach the push-blade plows when they are needed.

The department designs and constructs devices to facilitate quick changes of attachments. For instance, it uses blade carts for changing the cutting edges on motor grader blades which are typically longer than other blades. Operators wheel the blade carts into position under the blade, jack the cart into position, and release the blade from the mold board onto the cart. Another device, a sander stand, enables operators to quickly attach or remove sanders. Operators jack the stands to the correct height of the sander, and then remove the sander from the truck onto the stand. The primary advantage of sander stands and blade carts is that they reduce the number of operators involved with changing attachments by approximately one-half, from two or three operators to one or two operators. Because the department makes the stands from scrap material in the shop they represent no additional cost.

McLeod County's sander stands allow easy removal of sanders from plow trucks.

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McLeod County
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Rubber Edges on Sidewalk Plow

City of New Hope

New Hope's public works department recently changed from steel blades to rubber edges for its sidewalk plows. Located in northern Hennepin County, New Hope has 21,700 residents and 130 lane miles of road. The public works department plows all city sidewalks. As a service to city residents, the department also plows homeowners' sidewalks, even though a city ordinance gives homeowners responsibility for clearing their own sidewalks.

The department owns two 4-wheel drive trackless sidewalk plows that use both plow and snow blower attachments. Because sidewalk surfaces are not uniformly even, steel plow blades had a tendency to catch on slightly raised edges. This not only slowed down the operators, but was also dangerous. A sudden, unexpected stop could pitch the operator forward or even topple the vehicle.

As an alternative to steel edges and their problems, New Hope's public works department changed to rubber edges on its sidewalk plows in 1994. The department's experience with the rubber edges through one season is positive. The rubber plowing edges provide service that is comparable to the steel blades in almost all situations. They allow operators to plow sidewalks at greater speed without the fear of catching the blade on surface irregularities. The only downside to the rubber edges is that they are not able to cut through frozen, hardened slush.

A set of rubber blades for the sidewalk plow costs about $40 compared to about $80 for steel blades. Although the department does not expect the rubber blades to last as long as steel, it believes the advantages in speed and safety offset the shorter life span.

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City of New Hope
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Coal Tar Epoxy as a Corrosion Inhibitor

City of Owatonna

In 1993 Owatonna's street department had coal tar epoxy applied to one of its snowplow trucks and sander. Owatonna is a city in Steele County with 20,100 residents and 184 lane miles of road.

By using the coal tar epoxy, the department hoped to inhibit corrosion of the truck's cross members and supports resulting from contact with chloride-based materials. Over the period of one year, the truck shows no sign of corrosion. The department is considering having the same coal tar epoxy applied to its other trucks. Even though the experiment has proven successful so far, the department considers the results preliminary because of the short time frame it has had to view the outcome.

Mn/DOT District 7 in Mankato also tried the coal tar epoxy on a half dozen trucks with sanders and reported similar results. Mn/DOT also is reserving full judgment on the material while awaiting the test of time.

Coal tar epoxy is a material used to resist corrosion on fertilizer equipment that is especially susceptible because of the highly corrosive nature of fertilizer. In the cases of Owatonna and Mn/DOT District 7, the trucks were first sandblasted to remove paint down to the bare metal, which is key to the epoxy's effectiveness. A contractor applied the coal tar epoxy and repainted the trucks including the box, frame, and sander. Owatonna paid about $400 for sandblasting the frame, the box (both inside and outside), and the underside of the truck, and applying the coal tar epoxy. Painting costs were extra. The epoxy can be either sprayed or brushed on although spraying seemed to produce more consistent results.

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Back-Lit Map Display Units

City of Woodbury

Woodbury, a growing Twin Cities suburb in Washington County with 30,000 residents and 305 lane miles of roads, has back-lit map display units for all snow and ice control vehicles. In the past, Woodbury's street department distributed loose copies of map routes to its operators, which they used during plowing, sanding, and clearing operations. The vehicles used for snow and ice control, however, had no convenient location for operators to place maps for easy viewing. In addition, since many plowing and sanding operations take place during late night hours, operators had a difficult time inspecting maps in the dark. Operators often had to interrupt operations briefly to turn on a light, get out a map, and confirm routes, which cost time and proved a burden to operators. To make the process more user-friendly, Woodbury's street department purchased back-lit map display units in 1994.

The back-lit map display units are approximately one foot wide, one foot long, and four inches thick, with a removable lighting track and outer slot for map insertion. The plastic units are attached by hinges to a plastic frame, allowing operators to rotate the unit to the position which best suits them. The units are located in all snow and ice control vehicles, including tandem and single axle trucks, front-end loaders and pick-up trucks. Each unit sits between the driver and passenger seats and plugs into the cigarette lighter for power. The street department encouraged its operators to oversee unit installation, so they could tailor placement to best suit their individual needs. Because Woodbury uses its vehicles year-round, the city made certain that the

units were removable so the space containing the unit could be used for a passenger or other transportation needs during summer operations.

The Woodbury street department supervisor, creator of the back-lit display idea, drew up some initial drawings for the units and presented the concept to a plastics company. Woodbury had hoped to use fluorescent lighting in the units, but the company was unable to locate any fluorescent bulbs that could meet the units' specifications. Consequently, the street department provides its own incandescent lighting, using 10 small round bulbs placed in a circle inside each unit. The lighting units have a dimmer switch that allows operators to adjust the displayed brightness.

Back-lit map display units illuminate plowing and sanding route maps for Woodbury operators.

The street department then contacted its consulting engineers to computerize each route map, based on a grid of the city, and reproduce color-coded copies for each operator. Woodbury provides the engineers with city road additions by grid. This allows for quick and ongoing map routing based on the most current information available. Each vehicle's back-lit map display unit carries a copy of all nine city routes, so that operators can easily assist or fill in for others.

The 27 units cost approximately $90 each, which includes the cost of the plastic prototype, the lights and wiring, and installation. The 27 sets of 9 route maps cost a total of $550 (approximately $20 per set), with the investment increasing operator efficiency and contributing to a decrease in the number of public complaints. Because of Woodbury's large number of cul-de-sacs (320 total), operators, especially substitutes, could easily bypass some cul-de-sacs on their routes. The back-lit map display units clarify the routes for Woodbury operators, decreasing the time operators spend on the radio verifying routes and ultimately decreasing the number of missed cul-de-sacs. Woodbury has not received one complaint yet during the 1994-1995 winter season regarding a cul-de-sac not cleared during plowing and sanding operations.

The back-lit map display units would benefit most larger jurisdictions with multiple routes and operators. Smaller jurisdictions, however, might not need or benefit from the units if they have a limited number of routes or operators.

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City of Woodbury
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Flexible Wing Markers

City of Woodbury

Woodbury's street department uses flexible wing markers to assist snowplow operators view the edge of their wing. Woodbury snowplow operators previously experienced difficulty seeing the full length of the wing during night plowing and sanding operations, but find that the new flexible wing markers correct the problem. Woodbury is located in Wash -

ington County, has 30,000 residents, and maintains 305 lane miles of road.

The street department bolts a flexible rubber heater hose, approximately six inches in length and one-half inch in diameter, directly to the outer edge of the wing. It then inserts a glow stick, again approximately one-half inch in diameter, into the hose. The glow stick, once "snapped," projects a fluorescent glow sufficient to allow operators to see the edge of their wing. The glow stick lasts about eight hours, which is generally enough time to complete night plowing operations.

The department had used various wing markers in the past, but found that the hard, inflexible, plastic markers often tended to damage mailboxes upon contact. Although those markers allowed operators to increase the level of service by plowing closer to the curb, the mailbox damage caused from the markers decreased their usefulness. Because the new rubber wing markers bend upon contact, they allow operators to plow as close to the curb as possible without fear of mailbox damage. Replacements markers are affordable, with each hose costing approximately 50 cents and each fluorescent glow stick costing $1.05.

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Extendible Snowplow; 16-Foot Fixed Plow

Mn/DOT

Mn/DOT continues to test extendible plows that could replace the standard plow and wing combination for plowing snow. The plows extend an additional three feet beyond the length of the front plow. About 18 inches of the plow's left point folds back toward the truck. Extendible plows are intended to replace the need for a wing. Although Mn/DOT is still field testing these plows, preliminary results appear generally positive. [5] In addition to the extendible plow, Mn/DOT's Willmar district is testing a fixed 16-foot plow that cuts approximately the same path through snow as a 12-foot plow with an 8-foot wing.

A wing adds extra width and weight to the plow truck and can be cumbersome moving around items. The extendible plow is meant to reduce the weight and unwieldy feature of the plow/wing arrangement, while allowing the driver to hydraulically adjust the width of the plow as needed.

During 1993-1994, Mn/DOT tested two of the extendible plows in Willmar. It continued this testing in 1994-1995 and added a third extendible plow for use in the metropolitan area. Operators on mainline roads in the Willmar test area reported good performance in clearing lanes and shoulders in one pass. The extendible plow worked well mechanically and added versatility for snowplowing. On interchange ramps the extendible plow provided the additional plow length to allow one-way plowing. On the other hand, Mn/DOT did not find the extendible plow to be as effective in the metropolitan area. Although the mechanics of the plow worked well, the extendible plow's size was too big for easy flow around traffic.

Mn/DOT's Willmar district will continue testing the extendible plow. Because of the relatively light winter in 1994-1995, Mn/DOT did not have an opportunity to measure the durability of the plow. One drawback was that at highway speeds, the extendible plow tended to throw the snow higher than usual, creating a large snow cloud. At lower speeds, such as those used while plowing streets in a city, the snow cloud problem did not occur.

The 16-foot fixed plow has a uniform height (like a bulldozer blade) instead of having one side lower than the other, as most plows do. Mn/DOT's Willmar district found that this design shoots the snow out horizontally and neither casts the snow as high as the extendible plow at high speeds, nor creates the snow cloud problem. A downside with the

5 Minnesota Department of Transportation, *Statewide Maintenance Operations Research Report 1994,* December 1994.

fixed plow is some difficulty with driving the plow into and out of the shop. The 16-foot fixed plow does not have the feature allowing the left point to fold back toward the truck.

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Snow Scoop

Mn/DOT

Mn/DOT has tested a snow scoop researched by the Strategic Highway Research Program. The scoop's design is intended to reduce the snow cloud created around the truck by traditional plows during high-speed plowing. The scoop is a shallow angle deflector mounted to the plow. It rests approximately 45 degrees relative to the road surface (compared to typical reversible plows with blades oriented about 80 degrees to the road surface).

Although the snow scoop worked well in light, fluffy snow, Mn/DOT found that it was not effective in heavy, wet snow. Wet snow tended to pack on the plow so thick that it became difficult to lift the plow to avoid manhole covers or other obstructions. Minnesota's varied snow conditions reduce the scoop's utility. To be useful in a climate with a variety of snow conditions such as Minnesota's, the scoop would need a quick-release connection. This would enable operators to easily remove the snow scoop when conditions warranted.

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Zero-Velocity Spreader

Mn/DOT
Ramsey County
City of Edina

Mn/DOT and a few local governments, including Ramsey County and the city of Edina in Hennepin County, are testing the use of zero-velocity spreaders for controlled spreading of salt and sand. Results of the tests are preliminary; however to date, the zero-velocity spreader seems to work effectively in higher-speed applications (around 35 mph), such as those Mn/DOT frequently uses. The use of zero-velocity spreaders is still experimental and the manufacturer continues to refine its product based on field test results.

Zero-velocity spreaders are designed to drop sand and salt to the pavement with little bounce or scatter. These spreaders blow the sand and salt in one direction at about the same speed as the truck moves forward in the opposite direction, with the sand/salt moving at zero velocity relative to the road. Designed to spread sand/salt as well as liquid deicers, the zero-velocity spreaders allow the operator to adjust the amount and pattern of the materials being spread.

Controlling the sand and salt application in this way can reduce the amount of materials used due to more precise placement on the roadway and less material lost to the shoulders. Initial tests by Mn/DOT resulted in reducing sand and salt usage by about 30 percent at speeds up to 35 mph. Conceivably, the zero-velocity spreader should allow sanding trucks to travel at speeds closer to that of

the prevailing traffic, which will enhance the safety of the sanding operation.

Two local governments had less success using zero-velocity spreaders in their jurisdictions due to their low-speed, frequent-stop applications. Ramsey County's public works department experimented with a zero-velocity spreader, configured with a pre-wetting device, for the 1994-1995 winter season. Ramsey County is an urban county with 486,000 residents and 652 lane miles of road. Ramsey County maintenance personnel believe that zero-velocity spreaders work better at constant speeds near to or higher than 40 mph. Ramsey County operators, however, generally do low-speed sanding (under 30 mph) because of the county's heavily traveled roads and numerous intersections. Although pre-wetting prevented snow and ice from bonding with the pavement, the zero-velocity spreader dispensed the salt brine in a trail just one and one-half feet wide. The department believes that higher speeds are necessary to obtain a wider dispersion.

Edina's public works department used a sanding truck equipped with a zero-velocity spreader to follow a plow truck over the 1994-1995 winter. Edina has 47,000 residents and 413 lane miles of road. Used to sand city street intersections, the zero-velocity spreader did not spread the materials as the department desired. For instance, at stop signs the spreader dispensed the material in too narrow of a path for adequate coverage. The department also experienced excessive down time with the spreader because of problems with computerized components.

Additional equipment refinements and testing are ongoing.

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Discussion

CHAPTER 4

During the course of our review of snow and ice control, recurring themes emerged. We now present a broad analysis of the observations and information gained through our statewide surveys, focus groups, and site visits to a sample of Minnesota local governments. We address the following issues in this chapter:

- **What are the current trends in snow and ice control in Minnesota?**
- **What were the constraints of our snowplowing review?**
- **What information or research on snow and ice control do local governments need?**

Although we consulted extensive literature for our review, our discussion of trends relies on Minnesota experiences.

TRENDS AND OBSERVATIONS

Analysis of our survey results, site visits, and other data revealed some common trends and observations about snow and ice control. The trends generally follow the objectives of increasing the level of service in a jurisdiction and broadening the base of knowledge on snow and ice control practices.

- **Public expectations substantially affect the levels of service for snow and ice operations within a particular jurisdiction.**

Local road departments would benefit from additional winter maintenance research that focuses on experiences at the local government level.

We found that the level of service expected by the public or its elected officials affects staffing, equipment, and material needs for a public works department. For example, if a jurisdiction demands bare pavement, the department needs the support (e.g., staffing, equipment, and materials) to achieve that demand. On the other hand, if a jurisdiction expects main roads to be substantially bare but requires secondary roads to be cleared only to the point that safe travel is maintained, different resources are required. Practices resulting in bare pavements can be more expensive and are not universally needed. What is considered a best practice, therefore, differs among jurisdictions according to the particular level of service demanded.

- **By starting their snowplowing efforts earlier during a snow event, departments focus on preventing the snow and ice from bonding to the pavement.**

Many departments with whom we spoke are starting their snowplowing routes earlier than in the past to plow snow off the roads before heavy traffic packs it down. Not only do departments begin their snowplowing efforts earlier in a snow event, but they call in their plowing crews earlier in the morning. This preventive tactic improves the level of service and reduces the

amount of time and labor needed to plow snow af - ter it has hardened.

- **A supportive governing body may lead to increased innovation and effectiveness in a department's snow and ice control practices.**

A number of the sites we visited attribute the effec - tiveness of their snow and ice control to supportive governing bodies. Departments that are able to in - crease their efficiency and effectiveness often have elected boards and councils which encourage and reward safety, innovation, and change. Many pub - lic works officials noted the importance of gaining the support of a governing body when proposing a new practice. They indicated that the ability to track and report the effectiveness of a new practice, through performance records, cost savings, or pub - lic comments, can increase the confidence and sup - port imparted by the board or council.

- **Some local departments use higher ratios of salt in their sand and salt mixes.**

Some departments told us that increasing the ratio of salt to sand in their mixes produces a faster reac - tion time which leads to safer roads and a higher level of service. Most de - partments using a higher salt concentration do not believe that their annual salt consumption has in - creased markedly, if at all. In fact, departments using higher ratios of salt told us that they have cut the number of plow passes necessary during a storm, sometimes in half. They believe that the con - centrated salt or mix works more effectively, requiring less total tonnage of the materials overall. Some also prewet their salt or mix for faster melt - ing action and better undercutting of ice than dry salt.

Some use higher ratios of salt to reduce the number of plow passes and lower salt use overall.

- **Cul-de-sacs present a snowplowing challenge for jurisdictions that have them in their road systems.**

Departments consistently noted in our surveys, fo - cus groups, and interviews the problems that they encounter plowing cul-de-sacs. First, the size and configuration of some cul-de-sacs prevent a regular snowplow truck from plowing them effectively, and therefore, require different equipment. Second, op - erators face a dilemma because, while they do not want to fill homeowners' driveways with snow as they make their pass, there is limited space to put the snow.

Because cities' road systems typically have many more cul-de-sacs than other local governments, this plowing challenge is largely confined to cities. Most departments try several snowplowing meth - ods before settling on one particular practice. Be - cause of the diversity among cul-de-sacs in width, length, and center storage space, the transferability of plowing techniques from one jurisdiction to an - other can prove difficult.

- **Some practices that appear to be effective or innovative at first glance may not be so under greater scrutiny.**

During the course of this review we encountered some ideas that appeared innovative but that actu - ally proved unsuccessful. In some cases, an idea that seems to work well in other states or other countries simply has not worked well in Minnesota tests. For example, we learned about a product that mixes a deicer (calcium chloride) in pellet form into asphalt for the top layer of a road. When main - tenance workers lay the asphalt, they are essentially building the deicer into the road surface. The fric - tion of normal traffic crushes the deicer pellets, forming a film on the paved surface to prevent snow and ice from adhering. Although conceptu - ally attractive, the product did not prove cost effec - tive when Mn/DOT tested it here.

- **Local jurisdictions are concerned about liability for accidents on their roads.**

In addition to concern about the possibility of road accidents, many local governments are concerned with the prospect of liability arising from our snow and ice control best practices review. Some local officials fear that the practices highlighted in this review will become performance standards admissible in a court of law. We believe that the best practices included in this review are examples of effective approaches to snow and ice control that some local jurisdictions have found to work well. Each local government must individually evaluate the potential benefit and transferability of a particular practice to its own jurisdiction. Because every jurisdiction is unique, no one best practice necessarily fits all jurisdictions.

CONSTRAINTS AND LIMITATIONS

This snow and ice control best practices review faced some constraints which influenced both its scope and direction. Principal constraints included a lack of comparative performance measures, inadequate record keeping, unquantifiable organizational differences among communities, and a lack of independent evaluation of local practices. This section briefly addresses each constraint.

- **Comparative "baselines" of snowplowing performance measures can be inadequate when levels of service vary among jurisdictions and when winter storms differ from area to area.**

As mentioned earlier, different jurisdictions require different levels of snow and ice control service. Traffic levels, types of roads, and public expectations vary around the state, as do service levels. Consequently, we found it difficult to develop any baseline of performance against which departments could readily compare themselves. The data we collected did not show us what level of service is appropriate for particular jurisdictions.

Similarly, because winter storms vary considerably, we found it difficult to develop a general set of measures to use for comparing snowplowing performance across jurisdictions. Because the amount, type, and time of precipitation differs from one jurisdiction to the next for the same snow or ice storm, responses will differ. A storm might arrive in western jurisdictions with light drizzle two hours before hitting eastern jurisdictions, where it builds in intensity and produces several inches of snow. Even within a jurisdiction, especially the larger ones, weather conditions vary; what happens in the northern section of a county, for example, may be different from what happens in the southern.

Further, no two winter storms are identical. Storms produce different types and amounts of precipitation, requiring somewhat different responses. The most effective type of material, method of application, plowing technique, and time of call out differs for each particular storm based upon that specific storm's characteristics. Responses also vary according to whether roads are paved or gravel. We believe that one set of performance standards is inadequate to compare different jurisdictions with unique conditions and distinct responses to storms.

Variations in snow storms and road conditions make comparisons of multiple departments difficult.

Recognizing these constraints, however, does not mean local governments should avoid measuring their snow and ice control performance. Rather, it points to the need for departments to set their own standards of performance. Departments should make careful measurements over several snow seasons, particularly when comparing multiple jurisdictions. Examples of measures that departments use today include measuring for each snowstorm, and for different street and weather conditions, the amount of staff hours spent for plowing and cleanup activities, the equipment and fuel used, the amount of sand, salt, or other materials used, and the time between the call out and when plowing begins. Appendix F describes other measures of performance.

- **Record keeping for snow and ice control varies across jurisdictions. Some**

departments have no systematic method of snow and ice control record keeping; others keep complete and precise records.

The scope of recording costs, personnel, materials, equipment, miles, and time, varies greatly among jurisdictions. Some departments do not have separate budgets for snow and ice control, but instead combine winter maintenance activities with other road maintenance throughout the year, using a single annual budget. Departments that do record snow and ice control expenditures do not necessarily separate the costs of the various kinds of snow and ice control activities, such as plowing snow, applying materials, or repairing equipment. In addition, some departments include vehicle depreciation or shared equipment costs in their operating expenses while others do not.

Likewise, some departments rigorously record information on the outputs or outcomes of their snow and ice control services, such as time required to adequately plow routes, amount of materials used per route or per storm, responses to complaints, and repairs of property damage. Other departments might record little more than the annual amounts of sand or salt they use. The lack of uniform data limits the possibility of measuring and comparing performance, cost effectiveness, and efficiency among departments.

- **Organizational differences among jurisdictions are difficult to quantify in a reliable manner.**

The scope of our review does not include organizational differences among jurisdictions that might influence snow and ice control practices. We found that intangible variables, such as the level of support from elected officials, the degree of decentralized decision-making, and the organizational culture (flexibility, creativity, and willingness to change) likely affect the success of snow and ice control in a jurisdiction. Yet we found it difficult to incorporate these factors into this best practices review due to their subjective nature and the impracticability of measuring them.

- **We did not independently verify the costs or effectiveness of the practices in this review.**

Although the local departments we interviewed indicated that they either improved their service or saved time, money, difficulties, or labor by using a given practice, we have not independently measured the effect of the practices in the jurisdictions. We asked the departments whether the practice produced any type of savings for them, and whether they evaluated its effectiveness. Most often, department officials believed the practices generated savings but did not explicitly evaluate them. We relied on departments' experience with, and perceptions of, the practices and their effectiveness for this review.

We relied on local departments' assessments of the practices' effectiveness.

- **Departments may readily duplicate some of the practices identified in this review but may find others less easy to transfer to their own jurisdiction.**

Our list of effective practices includes examples that can be implemented in other jurisdictions with similar characteristics. However, some practices that one particular department found effective may not be readily transferable to others, due to the specific nature of the practice (such as meeting a public demand, responding to a geographic constraint, or working within ordinances peculiar to a particular jurisdiction). Because jurisdictions are unique, each department must evaluate the potential for cost savings and ease of transferability for itself.

ADDITIONAL RESEARCH ORIENTED TO LOCAL GOVERNMENTS

Effective snow and ice control practices and equipment continue to evolve. While some practices have been around a long time, others have been

gaining prominence more recently. For example, local departments are gradually increasing their focus on preventing snow and ice from bonding to the road, even as they still attend to the traditional business of plowing and scraping roads. With the added emphasis on prevention comes many questions about the best preventive strategies, and the circumstances where they work best. In addition, insufficient research focuses on local road systems and their needs.

- **Local road departments would benefit from additional winter maintenance research that focuses on experiences at the local government level.**

Local practitioners are interested in objective information that will allow them to make decisions about the cost effectiveness and practical applications of winter maintenance practices and equipment in their own jurisdictions. For any given practice with local applications, they want to know: how is it done, when is it effective, how much does it cost, what are its drawbacks, what is its best timing, and what road temperatures or conditions, traffic levels, and weather conditions make it most effective.

Some of the areas which warrant additional research are:

- Prewetting salt and sand, both as an anti-icing measure and for deicing,
- Using only liquids, such as salt brine, for anti-icing,
- Selecting the proper gradation of salt and sand for various uses,
- Recycling road sand sweepings for reuse,
- Using prototype equipment such as zero-velocity salt/sand spreaders and salt brine mixing systems,
- Using anti-corrosive compounds to lengthen the life span of equipment,
- Using various weather prediction systems,
- Storing materials such as salt, sand, and salt brines, and
- Determining the localized impacts of salt or other chemicals on the environment.

In addition, an economic analysis with uniform cost accounting of the various components of snow and ice control would allow local governments to compare themselves with others similar to them. Much of the current data collected on costs do not allow comparisons because local governments do not necessarily include the same items, such as overhead expenses, when they report costs.

Although many Minnesota jurisdictions are using effective snow and ice control practices, local governments often want additional comprehensive information. In addition, many local public works departments develop low-cost, innovative equipment in their shops to aid their work, but the innovations do not reach other jurisdictions. Constraints of cost, geography, and time all limit communication among jurisdictions. Yet departments responding to our survey indicated that they want and need information on current snow and ice control practices used throughout the state.

- **Local governments would benefit from improved access to the information and research findings of Mn/DOT and others.**

Jurisdictions we visited or surveyed conveyed an interest in the snow and ice control research conducted by Mn/DOT. Many local governments view Mn/DOT's research as innovative and want ongoing updates on its findings, especially on research that can be generalized to the needs of local road systems.

Local departments told us that they want additional information on current snow and ice control practices.

Some efforts at providing information to local governments have already proven helpful. For instance, the Technology Transfer (T^2) Program at the University of Minnesota's Center for Transportation Studies and the Minnesota Local Road Re -

search Board (LRRB) each have as part of their mis - sion the communication of transportation research results to local governments. The T 2 program col - laborated with Mn/DOT and the Federal Highway Administration in developing a "circuit rider van." The van's purpose is to travel around the state with information about the latest technologies and infor - mation on road construction and maintenance. De - spite these efforts, many local governments with whom we spoke want more winter maintenance in - formation, including the results of Mn/DOT re - search. At the local level, the desire to increase cost effectiveness and levels of service has led to a heightened interest in Mn/DOT's research results. A comprehensive system of disseminating informa - tion would allow local departments to keep abreast of gains in effectiveness and efficiency from new practices.

- **Local service providers want ongoing sharing of snow and ice control information among themselves.**

Opportunities for sharing transportation informa - tion already exist. Besides the LRRB and T 2 pro- gram, the Minnesota Street Superintendents Association meets monthly to share information among its members. Various organizations, such as the Minnesota Chapter of the Public Works Associa - tion, the City Engineers Association of Minnesota, and the Minnesota Association of County Engi - neers, conduct seminars and hold conferences on a variety of transportation topics including winter maintenance. Yet, according to our survey, not all departments have as much current, comprehensive information on effective snow and ice control prac - tices as they would like.

Sharing winter maintenance information encour - ages local governments to continually seek and adopt approaches that will enhance the cost effec - tiveness and efficiency of their service delivery. This best practices review is one tool to facilitate the ongoing sharing of snow and ice control infor - mation across Minnesota jurisdictions. But as tech - nology continues to change and improve, and as additional field applications of innovations are tested, local governments will need ongoing sources of both comprehensive research and infor - mation sharing.

Appendix A: Survey Methodology and Results

We surveyed 520 counties, cities, and townships in Minnesota. We received 427 responses, or approximately 80 percent of our survey sample. The purpose of the surveys was to gather information on snow and ice control in local governments. Because no comprehensive data on snow and ice control costs, operations, or practices had ever been collected, we needed to build our own data base of information. We subsequently used that information to help identify examples of effective practices and to report current findings and trends in snow and ice control across the state.

SURVEY DESIGN

We developed 24 principal questions for our survey. Because most questions had more than one specified part, the total number of sub-questions was 136.[1] The questions were open-ended (30 sub-questions), closed-ended (88 sub-questions), and a mix of both (18 sub-questions). The questions generated both quantitative and qualitative data. We developed questions on general information (*e.g.*, size, roads, and lane miles), snow and ice control information (*e.g.*, costs, snowfall, operations, and practices), and summary information (*e.g.*, challenges, innovations, and needs). We used an 11-page survey to gather systematic, comprehensive information on all major facets of snow and ice control. Our technical advisory panel pretested the survey before we sent it to our sample.

DATA COLLECTION

We surveyed all 87 Minnesota counties, all 186 cities with a population of 2,500 or more, a sample of cities with a population less than 2,500, and a sample of townships. We randomly sampled ten percent (72 cities) of all cities with populations less than 2,500 and ten percent (175 townships) of all townships, with both samples stratified across 13 districts to achieve geographic representation. We additionally surveyed all eight Mn/DOT district headquarters, as well as five Mn/DOT subdistricts where appropriate. We allowed departments two weeks from the mailing date to return the survey in a self-addressed, stamped envelope provided by this office. We then sent another survey and follow-up letter to departments which had not responded by the deadline, again asking departments to complete and return the survey. We mailed the surveys to county engineers, city public works directors or street superintendents, and township clerks.

DATA ANALYSIS

We completed data entry internally and inspected the data for response and entry errors. We used frequency distributions and descriptive statistics to summarize and report data. Departments which returned a survey but answered questions incompletely (non-responses) were included in frequencies of responses but omitted in median statistics. Survey results found in this report are sample responses, not estimates for all local governments in the state.

RESULTS

We report the survey results on the following pages for each type of jurisdiction. A total of 414 local government respondents, or 80 percent of those surveyed, returned the survey as indicated in Table A1. Figure A1 shows the distribution of the local governments that responded to our survey. All 13 Mn/DOT districts and subdistricts returned their surveys.

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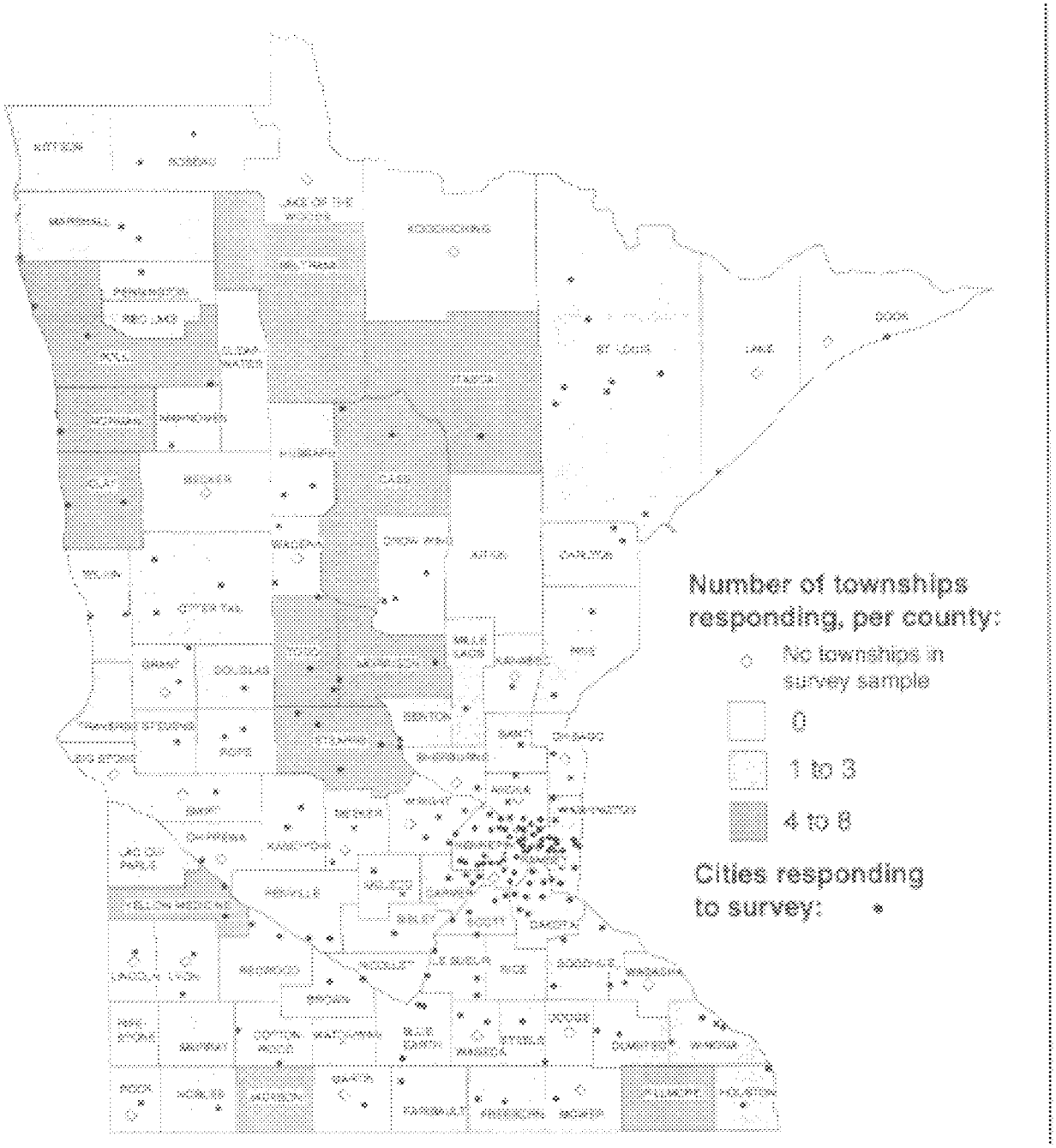
1 A sub-question is any question or part of a question in the survey specified with a number (*e.g.*, 1, 2, 3) or letter (*e.g.*, a, b, c).

Table A1: Local Governments Responding to Snow and Ice Control Survey

Jurisdiction	Number of Surveys Returned	Number of Surveys Sent	Percent of Surveys Returned
Counties	81	87	93%
All Cities	204	258	79
Cities >2,500	154	186	83
Cities <2,500	50	72	69
Townships	129	175	74
ALL JURISDICTIONS	414	520	80%

Responses found on the following survey instrument are reported for counties, cities (all sizes combined), and townships, respectively.

Figure A1: Cities and Townships Responding to Snow and Ice Control Survey, by County



Note: All 87 counties were surveyed and 93 percent responded. Aitkin, Chisago, Crow Wing, Ho uston, Redwood and Rice counties did not respond in time for analysis. Of 258 cities surveyed, 204 cities (79 percen t) responded in time for analysis. Of 175 randomly selected townships, 129 townships (74 percent) responded in time for analysis .

Source: Office of the Legislative Auditor snow and ice control survey.

Note: Responses are listed first for counties, second for cities, and third for townships.

Office of the Legislative Auditor
Best Practices Reviews

SNOWPLOWING PRACTICES SURVEY

INSTRUCTIONS Please complete this survey with information from your 1993-1994 winter snowplowing season. If you do not have information on a particular question, or the question does not apply to your jurisdictio n, simply write "NA" in the corresponding question blank. You may attach a separate sheet for responses as needed.

Please return this survey in the enclosed envelope by January 18, 1995.

Person Completing Survey _____ _____

Position _____ Phone Number _____ _____

GENERAL INFORMATION

1. Jurisdiction _____
   (name of county, city, or township)

2. Population _____
   (number of residents in jurisdiction)

3. Centerline miles of roadway (total miles under your jurisdiction by type of road):

County Jurisdictions	*City/Town Jurisdictions*
a) gravel roads **194** centerline miles	d) gravel roads **3 30** centerline miles
b) two-lane **314** centerline miles	e) local streets **30 3** centerline miles
c) multiple lane **3** centerline miles *(more than two-lane)*	f) major arterials **8 --** centerline miles

4. Number of:

a)	cul-de-sacs/dead-ends	**median:**	**3**	**24**	**5**
b)	bridges		**90**	**3**	**4**
c)	alleys		**25**	**15**	**2**
d)	other *(Please specify)*:		**65**	**10**	**5**

5. What type of curbs does your jurisdiction have? *(Check all that apply)*

Percent Who Checked Yes							Medians		
25%	49%	2%	☐	a)	surmountable	_____ percent surmountable curbs	10	20	--
32	39	2	☐	b)	bituminous	_____ percent bituminous curbs	5	10	51
20	26	1	☐	c)	right angle	_____ percent right angle curbs	15	25	--
86	82	2	☐	d)	concrete	_____ percent concrete curbs	95	95	4
10	6	--	☐	e)	barrier	_____ percent barrier curbs	95	25	--
5	18	4	☐	f)	other *(Please specify type and percent):*_____		87	25	--
10	5	66	☐	g)	N/A				

SNOWPLOWING DATA

6. a) What is the estimated 1993-94 cost of your snow and ice operations (excluding capital) ?

Medians
$231,528
35,775
4,295

b) What percent of your estimated 1993-94 winter operating costs went toward:

	Medians		
(1) Snowplowing personnel costs	33%	50%	50%
(2) Snowplowing materials and equipment (operating and maintenance) costs	67%	46%	59%

7. Total 1993-1994 Winter Snowfall	55	52	37	inches
8. Total 1993-1994 Winter Snow Events	26	17	13	events
9. Total 1993-1994 Winter Snowplowing Operations	34	15	10	operations
10. Total 1993-1994 Winter Sand/Salt Operations	25	24	8	operations

11. Routes

a) How many snow plowing routes are in your jurisdiction?

Medians: 13 4 1 routes *(total number of routes or average number of routes if jurisdiction has multiple snowplowing policie s)*

b) What were the total man-hours spent on snow/ice control in the 1993-94 season?
Medians: 5,799 1,080 130 hours

d) Do you establish priority routes that are plowed first following a snow fall?

☐ no			☐ yes		
9%	12%	43%	90%	84%	29%

e) How often do you re-evaluate or change your routes?

☐ every year			☐ every 2-5 years			☐ every 5 + years			☐ never		
62%	55%	26%	30%	11%	3%	4%	5%	0%	2%	20%	45%

Note: Responses adding to less than 100% indicate that some local governments did not respond.

Note: Responses are listed first for counties, second for cities, and third for townships.

12. PERSONNEL

SNOWPLOWING EMPLOYEE DATA (responses are medians unless otherwise designated)		**SNOWPLOWING PERSONNEL**																	
		SUPERVISORS			SNOWPLOW OPERATORS														
					Regular Staff						Back-Up Staff (additional non-contract persons used in full call-out)						Contract Staff					
					full-time			*part-time*			*full-time*			*part-time*			*routinely used*			*used only in full all-out*		
Number of Snowplowing Employees		1	1	1	15	5	1	3	2	1	3	4	1	2	2	2	2	2	2	2	4	--
1993-1994 Employee Man-Hours (1993-94 winter hours worked)	*regular hours*	450	131	313	4,442	975	334	390	62	148	80	120	148	80	50	27	852	47	210	--	277	--
	overtime hours	99	42	59	801	200	48	60	25	--	39	100	--	--	--	--	--	--	--	--	--	--
Average Hourly Employee Wage (1993-94 hourly dollar rate)	*regular rate*	15	17	10	12	14	10	8	8	10	13	15	10	8	9	8	42	39	23	60	50	55
	overtime rate	22	22	16	18	20	18	13	14	12	19	22	12	11	10	--	--	--	--	--	--	--
Unionized (circle one)	*yes*	14%	12%	0%	74%	44%	0%	5%	3%	0%	15%	13%	0%	17%	1%	0%	1%	1%	1%	1%	1%	0%
	no	64%	50%	5%	11%	23%	6%	17%	15%	11%	1%	6%	1%	6%	8%	3%	9%	8%	4%	2%	9%	1%

13. MATERIALS

MATERIALS USED	**1993-1994 WINTER SNOW SEASON**							
	TOTAL USE (tons or gallons)			**UNIT COST** (dollars per ton/gallon)			**PROPORTION AND CONDITIONS FOR USE** (percent material used and winter weather conditions necessary for application)	
Sand Only	5,500	564	6	$2.52	$3.98	$6.00		
Salt Only (no sand mixed)	883	141	5,020	$29.62	$28.50	--		
Salt/Sand Mix	2,500	750	20	$12.09	$12.43	$12.50	average % salt mixed:	10 15 10
							average % sand mixed:	90 80 90
Salt Brine	1,000	70	--	--	--	--	(a) average % salt mixed:	-- 18 --
							average % water mixed:	-- -- --
							(b) average % brine mixed:	-- -- --
							average % sand, salt or mix mixed:	-- 59 --
Dry Calcium Chloride	2.5	5.5	--	$275	$210	--		
Liquid Calcium Chloride	3,250	1,680	--	$.675	--	--		
Alternative Deicers (please specify)	--	--	--					
Other	2	2	--					

14. EQUIPMENT

a) Motor Vehicles

MOTORIZED EQUIPMENT USED FOR PLOWING	**NUMBER** medians			**OWNERSHIP** *(number owned, leased or shared with another jurisdiction)* percentages						
				Own			Lease			Share
Total Dump Trucks	**10**	**4**	**1**	**95%**	**77%**	**9%**	**--**	**1%**	**1%**	
Tandem dump trucks with plow	**5.5**	**2**	**--**	**32**	**14**	**1**	**--**	**--**	**2**	
Tandem dump trucks with plow & wing	**7**	**2**	**--**	**86**	**19**	**1**	**--**	**1**	**1**	
Tandem dump trucks with underbody plow	**2.5**	**1**	**--**	**32**	**7**	**--**	**--**	**--**	**--**	
Single axle dump trucks with plow	**2**	**3**	**1**	**35**	**52**	**3**	**--**	**1**	**--**	
Single axle dump trucks with plow & wing	**2**	**2**	**1**	**53**	**46**	**6**	**--**	**--**	**1**	
Single axle dump trucks with underbody plow	**2.5**	**2**	**--**	**17**	**24**	**1**	**--**	**1**	**--**	
Total Front-End Loaders	**2**	**2**	**--**	**85**	**73**	**4**	**--**	**2**	**--**	
Loaders with bucket	**2**	**1**	**--**	**79**	**62**	**3**	**--**	**1**	**--**	
Loaders with plow	**1**	**1**	**--**	**7**	**25**	**--**	**--**	**--**	**--**	
Loaders with plow and wing	**2**	**1**	**--**	**4**	**1**	**--**	**--**	**1**	**--**	
Total Pick-Up Trucks	**8**	**2**	**--**	**53**	**65**	**2**	**--**	**1**	**--**	
Total Tractors	**4**	**1**	**1**	**46**	**37**	**3**	**--**	**2**	**--**	
Graders	**5**	**1**	**1**	**88**	**63**	**17**	**1**	**1**	**4**	
Snowthrowers/Snowblowers	**2**	**1**	**4**	**57**	**54**	**--**	**--**	**1**	**1**	
Sidewalk Plow	**1**	**1**	**--**	**9**	**43**	**--**	**--**	**--**	**--**	
Other (please specify): (percent who specified other)	**12%**	**10%**	**2%**							

b) Vehicle Attachments

ATTACHMENTS	NUMBER medians		
Plows	**5**	**20**	**2**
Standard One-Way	**11**	**2**	**1**
Two-Way Reversible	**1**	**4**	**1**
V-Plow	**9**	**1**	**1**
Underbody	**4**	**2**	**1**
Rotary	**2**	**1**	**--**
Other (please specify):	**1**	**1**	**--**
Wings	**14**	**3**	**1**
Sanders/Spreaders	**9.5**	**3**	**1**
Tailgate	**9**	**3**	**1**
V-Box, Permanent Mount	**2**	**2**	**--**
V-Box, Slip In	**1**	**1**	**--**
Towed	**--**	**--**	**--**
Other (please specify):	**1**	**1**	**--**
Sander Controls	**10**	**3**	**--**
Manual	**10**	**3**	**1**
Automatic	**7**	**2**	**3**
Ground-Oriented	**5.5**	**1**	**--**
Other (please specify):	**--**	**1**	**--**
Buckets	**2**	**2**	**1**
Snow Scoops	**1**	**1**	**--**
Other (please specify):	**1**	**1**	**2**

Note: Responses are listed first for counties, second for cities, and third for townships.

Note: Responses are listed first for counties, second for cities, and third for townships.

15. Do you have a capital equipment replacement plan?

			☐ no				☐ yes
10%	**21%**	**55%**		**90%**	**74%**	**10%**	

If yes, how is it funded?

75%	**46%**	**8%**	☐ annual budget
--	**5**	**--**	☐ bond issue
1	**9**	**2**	☐ equipment depreciation
--	**5**	**4**	☐ other *(Please specify):*_____

SNOWPLOWING PRACTICES

16. Snow Plans and Policies *(Please attach to this completed survey copies of your jurisdiction's snow-related policies. As with other information in this survey, the policies are solely for the purpose of gathering information and comparing data and will not be the subject of audits or evaluations.)*

a) Does your jurisdiction have a written snow plan or policy?

			☐ no *(If no, proceed to "b")*				☐ yes
46%	**41%**	**56%**		**52%**	**50%**	**17%**	

(1) If yes, has it been approved by your governing body?

			☐ no				☐ yes
11%	**8%**	**2%**		**42%**	**43%**	**19%**	

(2) Are there different policies in effect for different snow storms and conditions?

			☐ no				☐ yes
25%	**25%**	**16%**		**27%**	**25%**	**4%**	

(3) Within your policies do you set snowplowing procedures according to:

☐ class of street			☐ level of service desired			☐ time of day			☐ amount of traffic		
17%	**18%**	**2%**	**21%**	**18%**	**8%**	**20%**	**23%**	**2%**	**31%**	**16%**	**2%**

☐ weather conditions			☐ other *(Please specify)*:_____								
40%	**35%**	**10%**	**3%**	**6%**	**4%**						

(4) How frequently are you able to follow the policy(ies)?

☐ all of the time			☐ most of the time			☐ some of the time			☐ rarely		
9%	**15%**	**10%**	**43%**	**34%**	**11%**	**1%**	**3%**	**2%**	**--**	**--**	**--**

b) Does your jurisdiction have a citizen parking plan or policy during snow plowing?

			☐ no *(If no, proceed to "c")*				☐ yes
90%	**21%**	**67%**		**6%**	**74%**	**2%**	

(1) If yes, is this parking policy enforced?

☐ all of the time			☐ most of the time			☐ some of the time			☐ rarely		
--	**27%**	**2%**	**3%**	**30%**	**2%**	**3%**	**14%**	**--**	**1%**	**4%**	**2%**

(2) If yes, how effective do you consider the parking policy?

☐ highly effective			☐ moderately effective			☐ somewhat effective			☐ little effect		
3%	**30%**	**1%**	**--**	**26%**	**2%**	**3%**	**12%**	**1%**	**1%**	**6%**	**1%**

Note: Responses adding to less than 100% indicate that some local governments did not respond.

Note: Responses are listed first for counties, second for cities, and third for townships.

c) What other policies, not included in your general snow control policies (mentioned above), does your jurisdiction have?

27%	**37%**	**60%**	☐ (1)	no others
27	**41**	**2**	☐ (2)	policies for repairing items or ground damaged during plowing
53	**34**	**4**	☐ (3)	policies regarding construction and placement of mailboxes
--	**8**	**1**	☐ (4)	policies regarding placement of refuse or recycling containers
11	**5**	**3**	☐ (5)	other *(Please specify):* _____

e) How do you communicate these policies with the public? *(Check all that apply)*

41%	**22%**	**43%**	☐ (1)	no active strategy for communicating polices
6	**19**	**2**	☐ (2)	distribute flyers to all residences and businesses
--	**28**	**1**	☐ (3)	cable t.v. announcements
10	**22**	**--**	☐ (4)	radio/t.v. public service announcements
48	**57**	**7**	☐ (5)	community newspaper articles
--	**13**	**6**	☐ (6)	post notices at community buildings
16	**7**	**11**	☐ (7)	other *(Please describe):*_____
--	**6**	**--**	☐ (8)	local newsletter

17. Snow Plowing

a) Do you plow roads belonging to other jurisdictions *(counties, cities, towns, or the state)*?

☐ no			☐ yes		
38%	**49%**	**65%**	**62%**	**45%**	**9%**

b) Does your jurisdiction have a "bare pavement" (100% clearance of snow and ice until pavement is visi ble) policy for:

☐ no roads			☐ some roads			☐ all roads		
69%	**64%**	**64%**	**26%**	**21%**	**2%**	**3%**	**7%**	**1%**

c) (1) Does your jurisdiction clear sidewalks?

☐ no			☐ some			☐ all			☐ N/A		
80%	**22%**	**50%**	**14%**	**60%**	**--**	**1%**	**11%**	**--**	**4%**	**3%**	**21%**

(2) If you do not clear sidewalks, or clear only some of them, who is responsible to clear them?

☐ property owner			☐ contractor			☐ volunteers			☐ other		
65%	**77%**	**23%**	**1%**	**--**	**--**	**--**	**--**	**--**	**21%**	**5%**	**10%**

d) (1) Does your jurisdiction plow alleys?

☐ no			☐ some			☐ all			☐ N/A		
68%	**12%**	**33%**	**3%**	**14%**	**2%**	**--**	**58%**	**--**	**28%**	**12%**	**30%**

(2) If you do not plow alleys, or clear only some of them, who is responsible to clear them?

☐ property owner			☐ contractor			☐ volunteers			☐ other		
11%	**13%**	**17%**	**1%**	**2%**	**--**	**--**	**--**	**1%**	**53%**	**8%**	**12%**

Note: Responses adding to less than 100% indicate that some local governments did not respond.

e) After what amount of fallen snow do crews in your jurisdiction begin plowing snow?

☐ trace - 1" **17% 6% 2%** ☐ 1" - 2" **36% 42% 9%** ☐ 2" - 4" **12% 34% 20%** ☐ no set policy **24% 8% 33%**

☐ other *(Please specify):*_____ **9% 4% 9%**

f) What is part of your clean-up operations following the initial snow plowing? *(Check all that apply)*

94%	**62%**	**43%**	☐ (1)	widening lanes
48	**54**	**6**	☐ (2)	removing snow windrows
44	**67**	**--**	☐ (3)	hauling and disposing snow
93	**64**	**13**	☐ (4)	cleaning intersections
11	**14**	**--**	☐ (5)	cleaning medians
21	**20**	**16**	☐ (6)	other *(Please specify):*_____

Note: Responses are listed first for counties, second for cities, and third for townships.

g) How much additional time do these clean-up activities typically take in your jurisdiction? _____ hours

Median Hours: 9 12 8

18. Snow and Ice Control Practices

a) (1) Do you routinely **pre-wet** your salt or salt/sand mix?

☐ no routine pre-wetting *(Proceed to 18a)(3))*	**89%**	**91%**	**32%**
☐ we use pre-wetting tanks on back of truck	**7%**	**4%**	**--**
☐ we pre-wet bucket of salt or salt mix before loading truck	**--**	**2%**	**1%**
☐ we pre-wet truck box before it leaves station	**1%**	**1%**	**--**
☐ other *(Please describe):*_____	**3%**	**3%**	**4%**

(2) What materials do you use to pre-wet?

☐ salt brine	**3%**	**3%**	**--**
☐ chemical *(Please specify):*_____	**7%**	**3%**	**1%**
☐ water	**--**	**1%**	**1%**
☐ other	**--**	**--**	**1%**

(3) Have you ever pre-wet your salt or mix in the past?

☐ no **79% 78% 41%** ☐ yes **15% 5% 1%**

b) What winter **facilities for salt and sand storage** do you use ?

Facility	Salt *(circle one)*	Sand *(circle one)*	Salt/Sand Mix *(circle one)*
(1) permanent enclosed storage facility	own / lease / share **42% -- 1%** **19 -- 4** **-- -- --**	own / lease / share **4% 1% --** **5 -- 2** **-- -- --**	own / lease / share **24% -- 4%** **13 1 4** **-- -- --**
(2) permanent semi-enclosed storage facility	own / lease / share **27% -- 3%** **9 1 3** **-- -- --**	own / lease / share **6% -- 1%** **3 -- 2** **-- -- --**	own / lease / share **19% -- 9%** **10 -- 3** **-- -- --**

Note: Responses adding to less than 100% indicate that some local governments did not respond.

b) What winter **facilities for salt and sand storage** do you use (continued)?

	Facility	Salt *(circle one)*	Sand *(circle one)*	Salt/Sand Mix *(circle one)*
(3)	outside covered piles on impermeable pad	own / lease / share **1% -- --** **4 -- --** **-- -- 1**	own / lease / share **3% -- --** **3 -- --** **-- -- 1**	own / lease / share **5% -- 1%** **8 -- 1** **-- -- 2**
(4)	outside covered piles on ground surface	own / lease / share **-- -- --** **1 -- --** **-- -- --**	own / lease / share **1% -- --** **2 1 --** **-- -- --**	own / lease / share **4% -- 1%** **5 -- --** **-- -- --**
(5)	outside uncovered piles on impermeable pad	own / lease / share **3% -- --** **3 -- --** **1 -- --**	own / lease / share **10% -- 1%** **8 1 --** **1 -- 1**	own / lease / share **28% -- 4%** **19 1 3** **1 1 --**
(6)	outside uncovered piles on ground surface	own / lease / share **3% -- --** **4 -- 1** **-- 1 --**	own / lease / share **19% -- 1%** **12 -- 1** **-- 1 1**	own / lease / share **28% -- 1%** **19 1 --** **1 1 --**
(7)	other_____	own / lease / share **3% -- --** **-- -- --** **-- -- --**	own / lease / share **1% -- --** **-- -- --** **-- -- --**	own / lease / share **3% -- --** **1 -- --** **-- -- --**
(8)		N/A **-- -- --** **2% -- --** **4 1 --**	N/A **-- -- --** **2% -- --** **4 1 --**	N/A **-- -- --** **1% -- --** **5 1 --**

c) Do you **control runoff** around storage facilities?

Note: Responses are listed first for counties, second for cities, and third for townships.

47% 34% 13% ☐ no control
15 19 1 ☐ runoff is to storm sewer system
17 10 2 ☐ runoff is collected and recycled
-- 3 -- ☐ runoff is collected and treated prior to discharge
20 17 5 ☐ other *(Please specify):*_____

d) Do you routinely use **anti-icing** measures or pavement treatment prior to a snowfall?

☐ no **93% 83% 46%** ☐ yes **6% 7% --**

e) Do you **recycle some or all road sand**?

☐ no **93% 67% 47%** ☐ yes **5% 25% 1%**

f) Do you use **snow fences**?

☐ no **65% 74% 58%** ☐ yes **33% 21% 7%**

g) Do you use **natural plantings** or shelter belts to control snow blowing and drifting?

☐ no **72% 77% 57%** ☐ yes **25% 15% 6%**

Note: Responses adding to less than 100% indicate that some local governments did not respond.

Note: Responses are listed first for counties, second for cities, and third for townships.

h) What **weather forecasting** information do you use? *(Check all those that apply and **STAR** (*) the one you find most useful/important.)*

93%	**85%**	**29%**	☐	(1)	television or radio weather reports
35	**37**	**2**	☐	(2)	radio scanner for weather information
17	**11**	**2**	☐	(3)	private weather forecasting service
7	**2**	**2**	☐	(4)	forecast modeling software
6	**10**	**27**	☐	(5)	no formal weather forecasting information
12	**7**	**5**	☐	(6)	other *(Please specify):*_____

i) Does your jurisdiction use **pavement-specific forecasting or sensors**?

☐	no		☐	yes	
99%	**94%**	**64%**	**1%**	**--**	**--**

j) Do you use **computerized routing** software?

☐	no		☐	yes	
99%	**95%**	**63%**	**1%**	**--**	**--**

k) Other than advertising your snow policies, such as a parking policy, do you use **public relations** to publicize your snowplowing activities?

☐	no		☐	yes	
67%	**47%**	**57%**	**32%**	**49%**	**4%**

If yes, what types of activities?

24%	**30%**	**3%**	☐	(1)	news articles/press releases	**1%**	**28%**	**1%**	☐	(4)	newsletters/brochures
1	**2**	**--**	☐	(2)	public school workshops	**14**	**22**	**--**	☐	(5)	radio/television announcements
1	**6**	**1**	☐	(3)	telephone hot lines/information lines	**3**	**3**	**1**	☐	(6)	other *(Please describe):*

l) Do you have a routine **maintenance program to prepare** your snowplowing vehicles and equipment prior to each snow season?

☐	no		☐	yes	
3%	**4%**	**29%**	**96%**	**89%**	**20%**

m) Do you keep ongoing **records for your snowplowing vehicles and equipment,** such as type, number of hours of use, and maintenance schedule?

☐	no		☐	yes	
3%	**21%**	**32%**	**96%**	**70%**	**14%**

19. Measures of Effectiveness

a) How do you **evaluate** your snowplowing effectiveness? *(Check all that apply)*

12%	**17%**	**24%**	☐	(1)	no routine evaluation of effectiveness
75	**77**	**50**	☐	(2)	by responding to customer requests/complaints
63	**53**	**14**	☐	(3)	by comparing our work with other similar jurisdictions
47	**44**	**9**	☐	(4)	by comparing previous snow events
25	**22**	**3**	☐	(5)	by measuring how well we adhere to guidelines set out in our policy
17	**5**	**--**	☐	(6)	by using formal statistical measures such as: lane miles cleared per operator, lane miles cleared p er hour, lane miles cleared per plow
9	**8**	**5**	☐	(7)	other *(Please specify):*_____

Note: Responses adding to less than 100% indicate that some local governments did not respond.

Note: Responses are listed first for counties, second for cities, and third for townships.

b) Do you **measure public satisfaction** of your snowplowing? *(Check all that apply)*

4%	**15%**	**2%**	☐	(1)	yes, with periodic citizen surveys
77	**60**	**30**	☐	(2)	yes, by monitoring customer request/complaints
67	**64**	**37**	☐	(3)	yes, by informal word of mouth
16	**17**	**23**	☐	(4)	no active measurement of public satisfaction
3	**3**	**3**	☐	(5)	other *(Please specify):*_____

20. Snowplow Operators

a) Does your jurisdiction provide or require **training** for snowplow operators? *(Check all that apply)*

16%	**30%**	**33%**	☐	(1)	no formal training required
7	**6**	**2**	☐	(2)	require formal classroom training
15	**13**	**--**	☐	(3)	require operator certification
36	**31**	**2**	☐	(4)	require dry-run/trial runs prior to snowfall
75	**57**	**3**	☐	(5)	require in-house training on procedures and safety
3	**8**	**2**	☐	(6)	training is offered but not required
1	**4**	**6**	☐	(7)	other *(Please specify):*_____
--	**1**	**12**	☐	(8)	contract service

b) Approximately what share of your routes are plowed by the following operators: *(Please fill in the appropriate percentage)*

TYPE OF OPERATOR	PERCENT OF ROUTES								
	75 - 100%			50 - 74%			< 50%		
(1) Own jurisdiction's operators	**96%**	**84%**	**22%**	**2%**	**2%**	**0%**	**2%**	**14%**	**78%**
(2) Contract operators	**0**	**3**	**40**	**1**	**2**	**0**	**99**	**95**	**60**
(3) Other local government jurisdictions	**0**	**2**	**9**	**0**	**1**	**0**	**100**	**97**	**91**
(4) State	**0**	**0**	**0**	**0**	**0**	**0**	**100**	**100**	**100**
(5) Volunteers/non-profits	**0**	**0**	**1**	**0**	**0**	**0**	**100**	**100**	**99**
(6) Other	**0**	**0**	**2**	**0**	**0**	**0**	**100**	**100**	**98**
TOTAL	= 100%								

c) What is the normal/standard **shift time** for an operator to plow after a snowfall? _____average hours

Median Hours: 6 9 9

d) How long do operators usually **operate equipment without a rest** during a full call-out? _____average hours

Median Hours: 8 5 8

e) Does your jurisdiction use rotating shifts to provide **24-hour coverage** after a snowfall?

☐ no			☐ yes			☐ sometimes		
90%	**75%**	**35%**	**4%**	**6%**	**3%**	**5%**	**11%**	**2%**

Note: Responses adding to less than 100% indicate that some local governments did not respond.

Note: Responses are listed first for counties, second for cities, and third for townships.

f) Do operators typically use the **same truck** or equipment each snow event?

☐ no ☐ yes

-- 4% 6% 100% 86% 36%

g) Do you assign operators to the **same routes** for each snow event?

☐ no ☐ yes

1% 10% 12% 99% 81% 26%

h) Have you established a **procedure to notify** the appropriate personnel for snow events?

☐ no ☐ yes

3% 13% 16% 97% 77% 24%

21. Does your jurisdiction **share** or cooperate in the use of equipment, personnel or duties?

☐ no *(If no, proceed to question 22)* ☐ yes

44% 48% 50% 56% 41% 7%

a) If yes, which of the following do you share or cooperate in the use of?

46% 22% 3% ☐ materials

32 24 3 ☐ equipment

15 23 3 ☐ operators

26 14 5 ☐ plowing service

1 1 1 ☐ other *(Please specify)*:_____

b) If yes, with whom do you cooperate or share?

51% 28% 7% ☐ other government jurisdictions

19 25 1 ☐ other departments *(Please specify)*:_____

1 3 -- ☐ other groups/interests *(Please specify)*:_____

4 1 -- ☐ other *(Please specify)*:_____

CLOSING INFORMATION

22. In your opinion, what is the biggest challenge in keeping your roads plowed?

23. In your opinion, what are the more innovative and effective methods of snow and ice control used in your jurisdiction or other communities you know of? *(For instance, your methods for plowing cul de sacs or bridges, de-icing, routing, use of staff, or innovative equipment such as carbide or rubber-tipped blades, hazard markers, heated operator windows, two-way radios, computerized information systems, etc.)*

24. What information do you want or need in your jurisdiction regarding snowplowing practices?

Note: Responses adding to less than 100% indicate that some local governments did not respond.

Appendix B: Focus Group Methodology

Part of the snow and ice control information used in this review came from a series of small-group meetings, or focus groups, held around Minnesota. Participants were practitioners in the field of snow and ice control. This appendix describes the purpose and general results of the focus groups.

PURPOSE

The purpose of holding focus groups was two-fold. First, we wanted input on defining effective snow and ice control from people knowledgeable about winter maintenance. Based on our preliminary research, we developed a list of 13 items that we believed were important to effective snow and ice control. We wanted practitioners to verify whether these items were indeed important to snow and ice control.

Focus Group Discussion Items

1. **Snow policies and plans**
2. **Route planning**
3. **Operator training and scheduling**
4. **Snowplowing techniques**
5. **Applying and storing materials**
6. **Communications with employees and the public**
7. **Passive snow control measures**
8. **Preventive maintenance and equipment improvements**
9. **Cooperation/coordination of snowplowing services and equipment**
10. **Contracting for services**
11. **Measuring performance of services**
12. **Budgeting for equipment replacement**
13. **Information systems**

Second, we wanted ideas about effective practices from professionals in the field. We asked focus group participants to help identify counties, cities, and townships that had innovative or effective snow and ice control operations. We wanted to add the names of local governments identified in focus groups to others that had already come to our attention through survey analysis as possible sites to visit. After identifying local governments with effective practices, we planned to visit those jurisdictions and gather detailed information about their practices.

METHODOLOGY

To organize and conduct the focus groups, we used a firm experienced in facilitating small group meetings and working with local governments. We decided to hold focus group meetings in a variety of locations to attain the viewpoints of practitioners from different regions of Minnesota. We held two in the Twin Cities metropolitan area and four outside the metropolitan area: in Owatonna, Willmar, Detroit Lakes, and Virginia. In addition to the focus groups, we held one-on-one interviews with representatives from the public works departments in Minneapolis and St. Paul.

Participants came from counties and cities with both large and small populations. Although we contacted townships, most of the township representatives declined to participate because they do not provide plowing services directly but instead contract with other entities for those services. Public works directors comprised some of the groups, and street superintendents and operators comprised the others. Participants came from 55 counties and cities in Minnesota. (See Table B1.)

Each of the focus groups followed the same format and lasted about two and a half hours. Participants spent about one-third of the time discussing what they thought were the key ingredients of an effective snow and ice control program as well as any innovative practices they themselves used or knew others to use. During the remainder of the time, participants learned about and reacted to the 13 items that we believed were important to effective snow and ice control.

SUMMARY RESULTS

The focus groups provided us with reactions to the material we had prepared regarding effective snow and ice control. Participants concluded it was useful to divide the items defining effective snow and ice control between those affecting daily operations and those related to longer-term planning and administration.

Although participants generally believed the 13 items were a fairly comprehensive set of considerations about snow and ice control, they thought some elements deserved greater emphasis. For example, several groups indicated that public information and education about snowplowing and ice control are particularly important. Other participants thought the environmental ramifications of storing and spreading materials on the roads required special emphasis.

We also received names of cities and counties identified by focus group participants as jurisdictions that were effective or that were trying innovative practices. We included some of these local governments among the group of 34 that we visited or called for interviews regarding their best practices. (See Appendix C for more information about the site visits.)

Focus group participants also gave us their general impressions about this review of snow and ice control practices. They were eager for new information about snow and ice control, particularly ideas from their colleagues elsewhere in the state. They also indicated they would not be receptive to a review that requires local governments to adopt practices mandated by the state.

Overall, participants stressed the need to recognize that because conditions vary greatly from community to community, it is unrealistic to expect one set of practices to apply in all circumstances. Variations exist not only in the size of community, number and type of roads, and geographic location, but also in the preferences of residents and leadership philosophy within a jurisdiction.

Table B1: Jurisdictions Participating in Focus Groups

10 COUNTIES

Brown	Mahnoman	Steele
Clay	Nicollet	Waseca
Faribault	Otter Tail	Wilkin
Hubbard		

45 CITIES

Aitkin	Cook	New Hope
Apply Valley	Crookston	New Ulm
Atwater	Detroit Lakes	North Mankato
Babbitt	Eagan	Oakdale
Belgrade	Freeport	Owatonna
Bemidji	Gilbert	Paynesville
Bird Island	Golden Valley	Pine City
Biwabik	Grove City	Raymond
Blaine	Hinckley	Richfield
Bloomington	Hoyt Lakes	Roseville
Brooklyn Park	La Crescent	Saint Peter
Buhl	Madison	Silver Bay
Burnsville	Maplewood	Spicer
Chanhassen	Minnetonka	White Bear Lake
Clara City	Moorhead	Woodbury

Appendix C: Site Visit and Phone Interview Methodology

The examples of best practices found throughout this report come from 34 jurisdictions we visited or called for in-depth interviews. We selected the jurisdictions based upon data collected from our snow and ice control survey and six focus groups held around the state. We used information obtained from the interviews to describe the effective snow and ice control practices found in Chapter 3.

PURPOSE

The purpose of the site visits and phone interviews was to supplement our survey information and give us a first-hand look at local governments' effective practices. Although the surveys indicated which jurisdictions used particular snow and ice control practices, they did not provide a detailed account of jurisdictions' experiences with those practices. We wanted to observe, when appropriate during our site visits, the practices first hand. Direct observation allowed us to examine the practices' convenience and usefulness. Observing the practices also provided information regarding their transferability, especially problems that other local governments might be able to avoid. Further, both site visits and phone interviews gave practitioners the opportunity to give us a complete description of their departments' practices, including: the history behind the practice; how, when, and why it works; its advantages and disadvantages; and its cost effectiveness.

METHODOLOGY

We used information obtained from our surveys and from six focus groups to select jurisdictions with a high number of potentially innovative or effective practices. We also looked for jurisdictions representing a range of types (county, city, and township), sizes (population), and locations (geographic distribution). Because of time constraints, we could not interview all jurisdictions that appeared to have effective practices.

We selected 34 jurisdictions, all of which participated in the interviews. Once we contacted a jurisdiction and arranged an interview, we left the choice of interview participants to the discretion of the person we contacted. We conducted site visit interviews with 30 jurisdictions and phone interviews with the other four. Although we designed the interviews to be approximately 60 to 90 minutes in length and allowed another 30 minutes for observation during site visits, some visits lasted longer. The jurisdictions interviewed include the counties, cities, and townships listed in Table C1.

We obtained permission from those we interviewed to use their jurisdictions' name, as well as contact persons and phone numbers, if we included their practices in our report.

QUESTIONNAIRE

We designed 25 largely open-ended interview questions for the site visits and phone contacts. We developed the questions to obtain general information about the jurisdictions, information on the best practices, and concluding information. We repeated the questions regarding best practice information for each practice identified as effective in a jurisdiction. In this appendix, we condensed the interview schedule to save space, omitting much of the open areas used to record interview responses.

Table C1: Jurisdictions Visited or Telephoned

11 Counties	Population
Anoka	243,641
Douglas	28,674
Hennepin	1,032,431
Kittson	5,767
Martin	22,914
McLeod	32,030
Otter Tail	50,714
Polk	32,498
Ramsey	485,765
Waseca	18,079
Washington	145,896

20 Cities	County	Population
Albert Lea	Freeborn	18,300
Alden*	Freeborn	623
Bloomington	Hennepin	89,000
Chisholm	St. Louis	5,280
Edina	Hennepin	35,000
Hoyt Lakes	St. Louis	2,324
Jordan	Scott	3,000
Little Canada	Ramsey	9,081
Madison	Lac Qui Parle	1,935
Mankato	Blue Earth	31,510
Moorhead	Clay	32,000
Mounds View	Ramsey	12,638
New Hope	Hennepin	20,000
Owatonna	Steele	19,718
Paynesville	Stearns	2,285
Rochester*	Olmsted	76,000
St. Peter	Nicollet	9,200
Virginia	St. Louis	9,307
White Bear Lake	Ramsey	24,930
Woodbury	Washington	30,000

3 Townships	County	Population
Forest Lake Twp.	Washington	6,690
Hawk Creek Twp.*	Renville	228
Pine City Twp.*	Pine	973

Note: An asterisk (*) indicates jurisdictions interviewed by telephone.

Office of the Legislative Auditor

Snow and Ice Control Best Practices Review

SITE VISIT AND PHONE INTERVIEW QUESTIONNAIRE

Site Interviewer: Date:

Jurisdiction Visited:

Best Practice(s) Identified:

Individual(s) Interviewed:

I. General Questions

1. Have you defined a level(s) of snow and ice control service in your jurisdiction? *(For instance, main roads will be plowed in "x" hours; main roads will be cleared to the pavement; "y" tons of snow will be removed in "z" hours; etc.)*

2. If yes, have you had success in meeting this level?

   ☐ all of the time ☐ most of the time ☐ some of the time
   ☐ little of the time ☐ none of the time

   Why or why not?

3. Thinking about your own jurisdiction and snow and ice control, are there factors which influence the practices you use? What characteristics make your particular jurisdiction unique? Are there elements which distinguish your jurisdiction from other jurisdictions? *(What characteristics require you to tailor or construct your activities differently?...size and population; geographic location; political structures or entities; administration; rules and regulations; tax base or burden; budget and expenditures; type of streets, roads and highways; environmental constraints; public needs and demands; etc.)*

II. Best Practice(s) Questions

1. Please describe this practice. *(What is it?...How does it work?...When do you use it?...Why do you use it?...Who uses it?...etc.)*

Interviewer Questions
(site-specific best practice questions devised by interviewer)

2. When did you first implement this practice? How long have you been using this practice?

3. Why did you initially implement this practice? What problems, if any, were you hoping to over come?

4. Has your reason for implementing this practice been achieved? *(Have you solved your problem(s)? Have you accomplished your goal(s)? Have you realized your objective(s)?)* Why or why not?

5. Did you have any problems implementing this practice? If so, what? Why were these problems?

6. Have you had any problems with this practice since implementation? Have you made any modific ations? If so, what problems and / or modifications? Why?

7. What are the benefits (advantages) of this practice? Why?

8. What are the drawbacks (disadvantages) of this practice? Why?

9. What do you estimate is the yearly cost of this practice? Upon what do you base this cost estim ate?

10. Does this practice produce any type of savings for your jurisdiction? *(i.e. time, money, resources, hassle, etc.)* Why or why not? What types? Explain.

11. Do you believe this is an effective practice? Why or why not?

12. Have you evaluated the effectiveness of this practice? If no, how do you determine whether this particular practice is more effective than an alternative? If yes, what method(s) did you use to determ ine if this par - ticular practice is more effective than an alternative?

13. Are the residents in your jurisdiction aware of this practice?

☐ no **(if no, proceed to question 14)**
☐ yes

a) If yes, what is their perception of this practice?

☐ excellent ☐ good ☐ fair ☐ poor
☐ they are not aware of the practice ☐ I don't know

Why? Upon what do you base your answer?

14. Are the members of your city council / county board aware of this practice?

☐ no **(if no, proceed to question 15)**
☐ yes

a) If yes, what is their perception of this practice?

☐ excellent ☐ good ☐ fair ☐ poor
☐ they are not aware of the practice ☐ I don't know

Why? Upon what do you base your answer?

15. Do you think other counties, cities or towns could also use this practice in their own jurisdic tion? Why or why not?

16. What characteristics or attributes does a jurisdiction need to have if it is considering u sing this particular practice?

17. What "tips" or advice would you offer to a jurisdiction to help make this practice a success?

III. Closing Questions

1. Are there other unique and/or innovative snow and ice control practices in your jurisdiction of which we should be aware? If yes, what practices? Why are they noteworthy?

2. Are there other communities or jurisdictions with unique or innovative snow and ice contro l practices you believe we should contact? If yes, which jurisdictions?

3. Do you have any final comments, suggestions or recommendations concerning this project?

4. Do you have any questions you'd like to ask?

5. If we decide to note your jurisdiction as an example of a "best practice" in our report, may we include a name and phone number for interested jurisdictions to contact if they would like more informati on about your practice?

Appendix D: Statute Establishing Best Practices Reviews

***Minn. Stat.* §3.971, Subd. 4.**

(a) To perform best practices reviews, the legislative auditor through the program evaluat ion division shall examine the procedures and practices used to deliver local government services, inc luding municipalities and counties, determine the methods of local government service delivery, identify varia tions in cost and effec - tiveness, and identify practices to save money or provide more effective service delivery. The legislative auditor shall recommend to local governments, service delivery methods and practices to i mprove the cost-effectiveness of services. The legislative auditor and the board of government innovat ion and cooperation shall notify each other of projects being conducted relating to improving local government serv ices.

(b) The commission shall identify local government services to be reviewed with advice fro m an advisory council whose membership shall consist of:

(1) three representatives from the Association of Minnesota Counties;

(2) three representatives from the League of Minnesota Cities; and

(3) two representatives from the Association of Metropolitan Municipalities.

(c) This subdivision expires June 30, 1999.

Appendix E: Developing Written Snow Policies

PURPOSES

Snow and ice control policies provide a common understanding of the extent of a jurisdiction's win - ter road maintenance activities. A department sys - tematically defines the scope and level of its services in a snowplowing policy. The policy clearly states what services the department will and will not provide. It describes the priority roads or routes that receive immediate attention in a jurisdic - tion. The policy also describes priorities the juris - diction places on various winter maintenance activities, while acknowledging limitations of re - sources, personnel, and equipment. Snowplowing policies can afford jurisdictions some protection against liability, instruct maintenance employees about their department's expectations, and help the public understand the operations of the department.

Written snow policies, adopted by a jurisdiction's governing body and illustrating the policy decisions over competing needs for safe roads, personnel safety, and budget constraints, can help protect against liability in lawsuits. The policy should re - flect thoughtful consideration of service delivery constraints such as time, money, equipment, local traffic demands, public safety, and personnel safety. Operators following reasonable policies based on decisions by elected officials that balance limited re - sources and demands for services can reduce a juris - diction's exposure to liability, absent negligence on the part of operators. [1]

Snowplowing and ice control policies also serve an important informational function. Written policies communicate to members of the public what serv - ices they can reasonably expect. The documents de - scribe information about winter operations that are matters of policy affecting citizens' lives such as parking restrictions and the typical time plowing be - gins. In addition, written policies clarify a depart - ment's expectations of operators in the performance of their duties.

ELEMENTS IN A SNOW POLICY

Each jurisdiction's snow policy should reflect its in - dividual needs and circumstances. Agencies may want to consider the following elements as they de - velop their policies:

Setting Snowplowing Priorities

The department may classify roads by priority and assign a level of service based on their priority. The policy can make clear that operators will plow high-priority roads first. In jurisdictions with many roads or routes, maps can show the location and pri - ority for plowing.

Commencing Snowplowing Operations

The policy may state when plowing of all roads, or when other plowing or sanding operations, will typi - cally begin. For instance, the policy could state that snowfall accumulations of a certain depth will trig - ger the start of snowplowing operations. For some winter operations, such as sanding icy spots, the pol - icy may specify that road and weather conditions dictate the start. The policy may include informa - tion about how the department will notify residents about the start of plowing, if necessary for effective plowing.

Spreading Sand, Salt, and Other Chemicals

The department may describe its policies regarding what materials, such as sand, salt, or other chemi -

1 Much of the discussion on liability results from the outcomes of two Minnesota court cases: Hennes v. Patterson, 443 N.W. 2d 198 (Minn. App. 1989) and Gorecki v. County of Hennepin, 443 N.W. 2d 236, 239 (Minn. App. 1989). Alth ough the cases were similar, the court decided in the first case that the public agency involved was immune from liability because operators followed policies result - ing from planning level decisions requiring the evaluation of financial, social, economic, and other effects of the policy.

cals, it will spread on roads. The department may identify the areas, such as intersections or hills, where operators will typically spread these materi - als. The policy may suggest that use of materials could vary depending on weather and road condi - tions.

Regulating Parking

Jurisdictions with roads that allow on-street parking may need to regulate parking during plowing opera - tions. The policy may describe what parking restric - tions the jurisdiction will enforce, when parking restrictions commence, and how the department will notify residents about the restrictions.

Plowing Sidewalks and Alleys

In jurisdictions with sidewalks and alleys, depart - ment officials can state whether it is their policy to plow them. The department can set priorities among sidewalks and alleys and determine in what order operators will plow sidewalks or alleys rela - tive to other plowing or sanding operations. Maps can show the location of sidewalks and the level of priority for plowing.

Plowing Procedures

If a department has plowing procedures it intends operators to routinely follow as a matter of policy, it may describe them in the written document. How - ever, to retain flexibility, agencies should take care to keep the description to issues of policy and leave details about techniques to other plans or docu - ments. As an example, agencies may make it their policy to plow snow in a residential area to the curb line and follow the initial plowing by later winging the snow back onto the boulevard. If this is a pol - icy that the department routinely follows, the policy document may specify that the department wings back snow, but only as a secondary priority.

In addition, the policy may address specific con - cerns dealing with the unique characteristics of a ju - risdiction. For instance, jurisdictions with bridges may have policies for plowing bridges and for the timing of that plowing.

Removing Snow

The policy may state whether operators load and haul snow, and if so, from what areas. If the juris - diction's policy is to haul snow, the department may describe what priority the hauling takes relative to other operations. In addition, the department may specify its usual clean-up activities, such as widen - ing turn lanes, and indicate the lower priority of these activities.

Allowing for Variable Weather Conditions

Climatic factors influence the methods used to com - bat snow and or ice. Department officials can indi - cate in their policy that snow and ice control operations will proceed when weather conditions do not endanger the safety of employees. In addition, they can state that varying conditions may necessi - tate changes from normal operations.

Outlining the Responsibilities of Residents

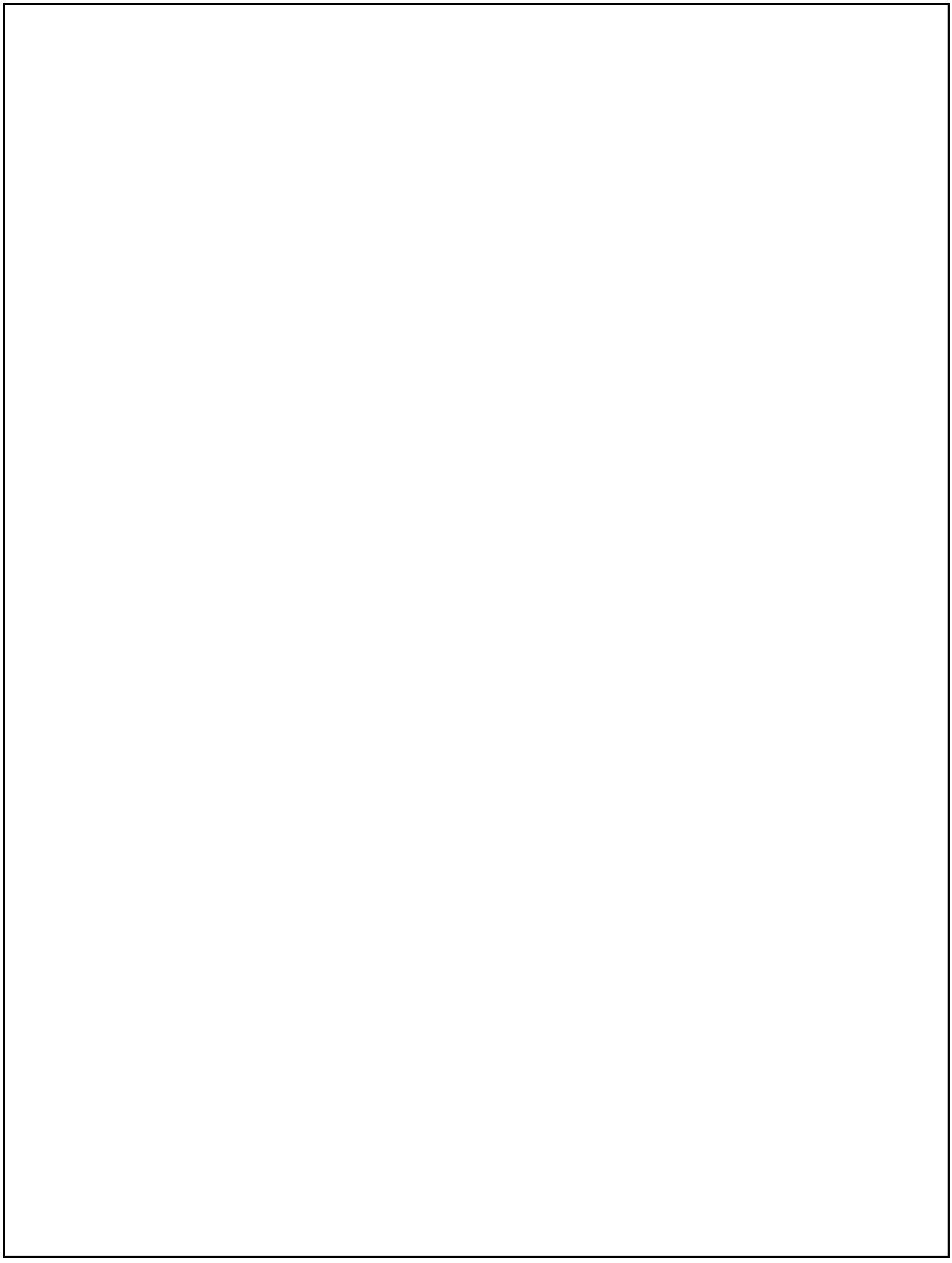
Officials may want to use the policy to delineate the responsibilities of residents. This can distinguish the services provided by the department from those the jurisdiction expects residents to provide. Resi - dential responsibilities may include clearing: drive - ways, sidewalks, areas around trash cans, mailboxes, newspaper tubes, and fire hydrants.

Repairing Property Damage

Officials can state whether it is their policy to repair damage to property, such as mailboxes or sod, caused during plowing operations. The policy can describe the type and extent of repairs for which the jurisdiction is responsible.

Managing Complaints and Requests for Service

A department may outline its policy regarding han - dling complaints and requests for service from resi - dents or other road users. The policy may indicate what priority the department will give to such re - quests.



Appendix F: Evaluation and Performance Measurement

The process of developing goals, objectives, and performance measures can help departments evaluate and measure the level of service they provide. Goals are the general ends toward which departments direct their efforts. Objectives are measurable statements about the results that departments expect to achieve in a given period of time. Performance measures are quantifiable indicators that assess the actual impact of a department's programs.

PURPOSE

Measures of performance provide quantifiable information on an organization's impact, efficiency, and effectiveness. They allow department officials to make better, more informed decisions about service delivery. Performance measures can show what value a department is getting for the dollars it spends on winter maintenance. Departments that evaluate their snow and ice control performance over time can track both achievements in service delivery and areas needing improvement. Systematic performance evaluation can also justify spending requests by demonstrating real maintenance needs of the road system. Moreover, information obtained from measuring a department's efforts and accomplishments can improve communication with elected officials and the public by focusing on the actual results achieved instead of perceptions.

DEVELOPING PERFORMANCE MEASURES

Collecting information on performance allows a department to compare winter road maintenance against baseline data. For example, a department can compare the cost of its snow and ice control across districts, geographic areas, or over time (year-to-year or month-to-month). Once a department sets goals or adopts standards, performance information can tell officials how well a department is meeting those goals or what additional resources may be needed. Only by systematically reviewing how well it meets its goals and objectives can a department identify practices that improve its service.

This appendix provides a sample of performance measures that departments can use to measure and report the efficiency and effectiveness of its snow and ice control. These measures are a guide for departments to evaluate their performance. Departments should consider the examples below to be a menu from which they can select measures most useful for their individual needs. However, agencies need not feel limited to the measures listed here and can develop others appropriate to their particular circumstances.

Performance measures may include measures of inputs, outputs, outcomes, effectiveness, or efficiency. We describe these below.

Inputs

Input measures are the resources used to provide a particular service or activity. Collecting basic information on snow and ice control operations is the first step to developing meaningful performance measures. Examples of input measures for snow and ice control include:

Labor Hours

- Regular and overtime hours,
- Full-time and part-time hours, and
- Contract hours.

Equipment Hours

- Vehicle hours (by type), and
- Attachment hours (by type).

Material Usage

- Type and amount of material used.

Expenditures

- Material costs,
- Equipment costs,
- Labor costs,
- Contract costs,
- Administrative costs,
- Damage repair costs, and
- Spring road sand recycling costs.

Outputs

Output measures indicate the number of units produced or services provided by a department or its programs. Specific output measures related to snow and ice control can include the following, although not all examples will be applicable in every jurisdiction:

- Number of plowing and sanding operations (responses),
- Number of responses by type of storm,
- Number of lane miles plowed and sanded,
- Number of routes (primary and secondary) plowed or sanded,
- Number of cul-de-sacs, alleys, or miles of sidewalk plowed and sanded,
- Number of damage repairs (*e.g.*, mailboxes, sod) completed, and
- Number of requests or complaints answered.

Other indirect output measures include:

- Number of items damaged while plowing or sanding,
- Number of requests or complaints,
- Number of parking violations, and
- Number of accidents.

Outcome Measures

Outcome measures indicate the actual impact of a department's actions. Examples of outcome measures include the percent of roads plowed per storm response or the percent of residents satisfied with snow and ice control services. Outcome measures are the effects of the department's actions on its customers.

Effectiveness and Cost-Effectiveness Measures

Effectiveness is a measure of how well the job is done. It is a measure of input per unit of outcome. Effectiveness in snow and ice control measures the extent to which winter maintenance departments achieve their goals and meet their objectives.

Cost-effectiveness measures indicate the capacity to produce desired results with a minimal expenditure of time, energy, money, or other resources. Assessing cost effectiveness allows departments to determine whether there are other ways of achieving their objectives with the same effectiveness but with lower costs, or higher effectiveness at the same cost.

Efficiency Measures

Efficiency measures indicate the value of the work a department produces. In other words, a measure of efficiency is the cost per unit of output. Examples of efficiency measures include the average cost of snow and ice control per: storm response, type of response, route, or lane mile. Departments can also break down their total costs into individual components, such as the costs for operators, equipment, materials, and repairs. If departments want more detailed information, they can further subdivide those cost components by type. For instance, departments can distinguish between full-time or part-time operators, or divide materials into salt, sand, or calcium chloride. The more specific the measure, the better a department can isolate the efficient and inefficient elements of its snow and ice control operation.

Examples of Snow and Ice Control Performance Measures

The following are examples of possible goals, ob - jectives, and performance measures for depart - ments' snow and ice control. This list is not exhaustive, and presented only as an illustration of possible evaluation measures available to depart - ments. Individual departments should select meas - ures that are appropriate for their own set of goals and objectives.

Goal: To plow snow and ice off the roads in a timely manner.

Objectives: To plow snow and ice from all priority roads in "X" hours, and from all other roads in "X" hours. [1]

Measures: Average time to plow or sand routes (to - tal labor hours to plow or sand / total number of routes);

Average time to plow or sand routes per: storm response, storm type, lane mile, operator, and crew or shift; and

Average plowing or sanding start time (difference between time snow event began and time plowing or sanding action began / total plowing responses).

Goal: To satisfy the public's need for safe winter travel.

Objectives: To reach partially bare pavement within "X" hours of the storm.

To reduce the number of accidents and complaints from snow and ice covered roads by "X" percent each year.

To decrease the response rate for requests/complaints and accidents by "X" percent each year. [2]

Measures: Total number of lane miles plowed or sanded within "X" hours as deter - mined for the department's recom - mended level of service per: storm response, storm type, and route;

Average request or complaint re - sponse time (difference between time complaint registered and time complaint answered / total number of complaints); and

Average accident response time (dif - ference between time accident re - ported to department and time department responds (when ap-

propriate) / total number of acci - dents).

Goal: To maintain an effective parking policy.

Objective: To reduce the number of parking violations by "X" percent each year .

Measure: Total number of parking violations or ve - hicles towed per: storm response, storm type, and route.

Goal: To mitigate damage caused by snow and ice control activities .

Objective: To reduce the damage caused by snow and ice control activities by "X" per - cent each year.

To decrease the response rate for repair damage by "X" percent each year.

---

1 We use "X" to designate information jurisdictions would fill in based on their own level of service.

2 The response rate measures the time required for a jurisdiction to respond to an event such a s a complaint, accident, or storm.

Measure: Average damage response time (difference between time of damage report and time report answered / total number of damage reports).

Explanatory Data and Background Information

Other explanatory data that may provide useful background information to departments or help them evaluate their effectiveness and efficiency in - clude:

General

- Date, day, and time of recording,
- Individual completing form, and
- Unit/vehicle/equipment number.

Equipment

- Time of use,
- Activity, and
- Mileage (when appropriate).

Materials

- Conditions for use.

Operators

- Start and end time.

Damage

- Date and type of item damage,
- Route and operator, and
- Date and type of repair.

Storm Condition

- Temperature,
- Type and amount of precipitation, and
- Other weather conditions.

Response

- Full or partial call-out,
- Time crew contacted and time crew arrives,
- Shift filled (day/night or 1st/2nd/3rd),
- Time storm event starts and ends, and
- Time response activities start and end.

Violations of Parking Restrictions

- Date, location, and type of violation.

Accidents

- Date, location, and type of accident,
- Vehicles involved, and
- Department response.

Appendix G: Local Government Practices Described in This Review, by Jurisdiction*

JURISDICTIONS INTERVIEWED	ACTIONS FOR EFFECTIVE SNOW AND ICE CONTROL	1. Adopt Written Snow Policies	2. Encourage Cooperative Snowplowing Services & Facilities	3. Contract for Services When Appropriate	4. Measure Performance and Maintain Records	5. Plan for Equipment Replacement	6. Foster a Quality Work Force	7. Prepare Plans for Routing, Scheduling, and Obtaining Weather Forecasts	8. Select, Store, and Apply Materials Appropriately	9. Communicate with the Public	10. Apply Appropriate Snowplowing Techniques	11. Use Passive Snow Control Measures	12. Employ Equipment Improvements and Preventive Maintenance
Albert Lea								•	•		•		
Alden			•									•	
Anoka County								•	•				•
Bloomington								•	•	•			
Chisholm					•								•
Douglas County			•										•
Edina		•				•							
Forest Lake Township									•				
Hawk Creek Township			•										
Hennepin County					•								
Hoyt Lakes					•	•							
Jordan									•				•
Kittson County												•	
Little Canada									•				•
Madison			•									•	

*Local governments' use of effective practices is not limited to the practices noted in the table. Examples of MnDOT practices are also included in this review, where appropriate.

JURISDICTIONS INTERVIEWED	ACTIONS FOR EFFECTIVE SNOW AND ICE CONTROL	1. Adopt Written Snow Policies	2. Encourage Cooperative Snowplowing Services & Facilities	3. Contract for Services When Appropriate	4. Measure Performance and Maintain Records	5. Plan for Equipment Replacement	6. Foster a Quality Work Force	7. Prepare Plans for Routing, Scheduling, and Obtaining Weather Forecasts	8. Select, Store, and Apply Materials Appropriately	9. Communicate with the Public	10. Apply Appropriate Snowplowing Techniques	11. Use Passive Snow Control Measures	12. Employ Equipment Improvements and Preventive Maintenance
Mankato		•						•	•				
Martin County													•
McLeod County													•
Moorhead				•									
Mounds View								•	•				
New Hope					•		•						•
Otter Tail County									•				•
Owatonna		•						•	•				•
Paynesville		•	•	•									
Pine City Township		•							•				
Polk County							•					•	
Ramsey County								•	•				
Rochester									•				
St. Peter		•							•				
Waseca County													•
Washington County					•		•						
White Bear Lake				•			•						
Woodbury					•		•		•		•		•

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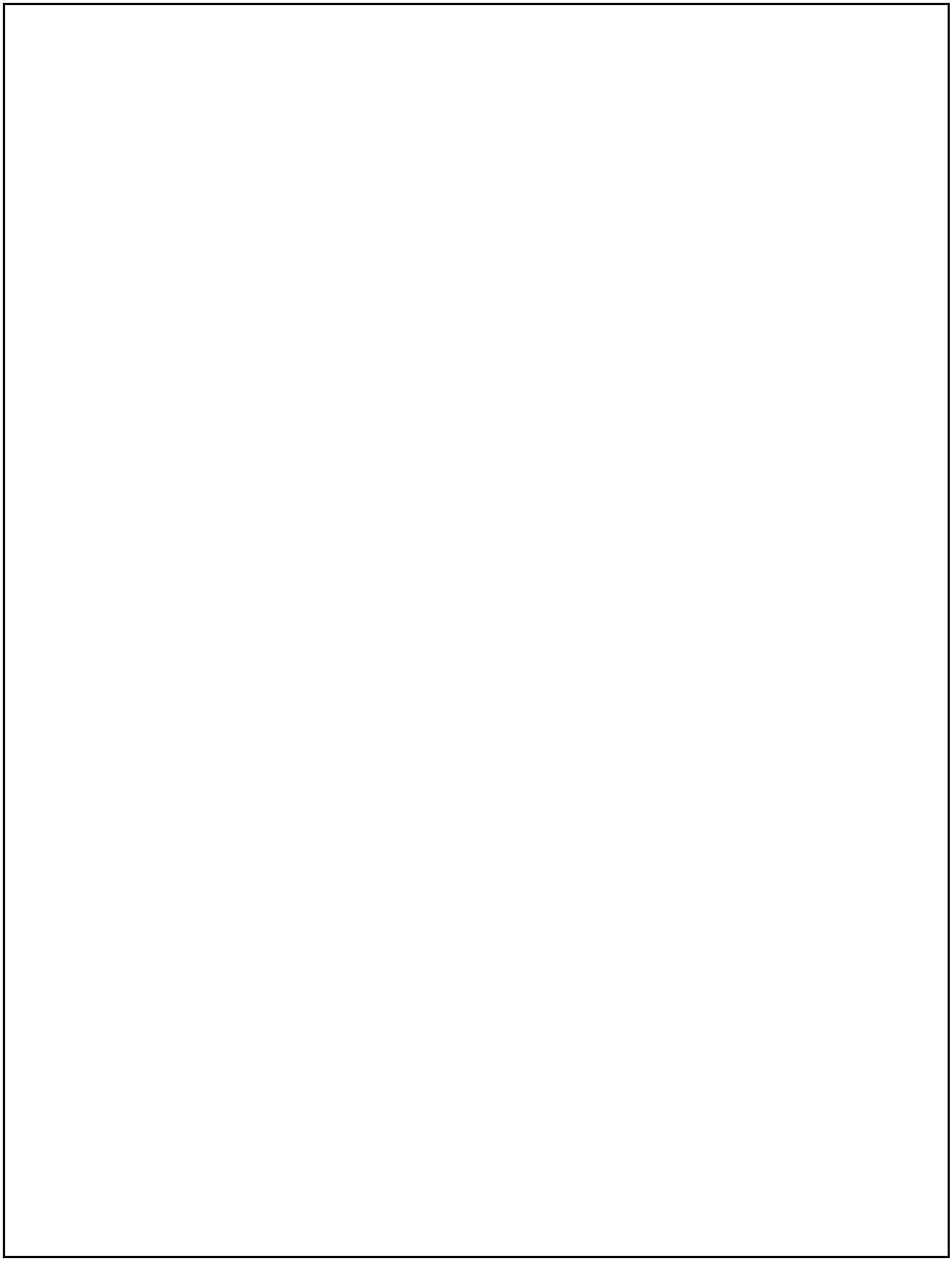

Appendix I: External Review

The following individuals assisted us in our review of snow and ice control. We gratefully acknowledge their help and advice. Any errors in this review are the responsibility of this office.

TECHNICAL ADVISORY PANEL

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Dave Childs
Minnetonka City Administrator

Lynn Lander
Hermantown City Administrator

Charles Meyer
St. Louis Park City Administrator

Brandt Richardson
Dakota County Administrator

Steve Sarkozy
Roseville City Administrator

James Schug
Washington County Administrator

Michele Timmons
Ramsey County Attorney's Office

The 1994 Minnesota Legislature charged the local government advisory council with identi fying local govern - ment services to be reviewed by the Office of the Legislative Auditor. In addition, the co uncil provided input and advice during the review of snow and ice control.

Glossary

Abrasives or aggregates — Materials such as sand or chipped rock that are spread on paved roads to increase vehicle traction.

Anti-icing — The process of applying chemicals (such as salt brine, liquid calcium chloride, or calcium magnesium acetate) to the road before snow and ice bond to the surface.

Bare pavement — A road condition where pavement is visible and substantially free of snow and ice following plowing, scraping, or other means.

Bond — The adherence of snow or ice to the road surface, creating a composite that is stronger than the snow or ice itself.

Brine — A liquid composed of water and salt, often used as an agent to prewet salt before applying it to the roads.

Calcium chloride — A soluble compound produced from calcium carbonate and hydrogen chloride generally used in cold temperatures (0° - 15° F) to deice roads or to prewet salt before applying to roads.

Calcium magnesium acetate — A compound produced from limestone and acetic acid used for anti-icing and deicing that is less corrosive but more expensive than salt.

Call-out — The mobilization of operators to initiate snow and ice control activities.

Carbide blade — A blade composed of a carbon compound that generally wears longer and requires less frequent changes than other steel blades when used for snowplowing.

CG-90 — A product composed of magnesium chloride with an anticorrosive additive that is used as an alternative to road salt.

Compacted snow — Snow that has been compressed by the movement of traffic and has bonded to the road surface.

Deicing — The process of applying chemicals to the road surface to remove snow, ice, or frost after it has bonded to the pavement.

Freezgard — A product composed of approximately 25 percent magnesium chloride and 75 percent water that is used as an alternative to road salt or to prewet salt.

Gradation — The size (diameter) of sand or salt particles.

Ground-oriented sander — A sander that applies chemicals and abrasives at a constant rate independent of truck speed.

Hauling snow — The loading, removing, and disposing of snow piles after snowplowing operations.

Lane mile — A measure of road length that reflects the number of miles in each driving lane (*e.g.*, one mile of highway with four driving lanes equals four lane miles).

Level of service — A standard of performance defined by a local government detailing the types and amounts of winter maintenance needed to achieve desirable road conditions.

Magnesium chloride — A soluble compound produced from magnesium carbonate and hydro -

gen chloride used to deice roads or prewet salt before applying it to roads.

Plowing snow — Using mechanical means to push or clear snow away from the road surface.

Polyurethane blades — A plow blade composed of hard plastic that provides more flexible blade action over road obstructions than steel blades.

Prewetting — The process of applying liquids to salt (before spreading salt on paved roads) to accelerate the ice melting process and prevent salt from bouncing off of the road surface.

Primary and secondary roads — Primary roads are those designated by an agency to have higher priority for plowing and sanding; secondary roads are those designated to have lower priority.

Recycle — The process of recovering and reusing materials. *Salt brine recycling* generally refers to collecting brine runoff and reusing it as a prewetting agent for salt. *Sand recycling* generally refers to collecting road sand used one winter and processing it for reuse the next winter or for other applications.

Response — Any activity to plow, sand, or otherwise remove snow and ice or reduce hazardous conditions due to snow and ice.

Screening — The process of mechanically sifting used road sand through a mesh to separate out particles and debris so that the sand can be reused.

Snow and ice control — All activities, including administration, management, planning, and operations, associated with responding to winter road conditions.

Snow emergency — A declaration by a local government, based on weather and road conditions, that plowing operations will begin and parking restrictions (if any) will be enforced.

Snow and/or ice event — Any weather condition which necessitates snow and ice control operations, such as plowing or sanding.

Snow plan — A document that details specific agency procedures for planning snow and ice control, including equipment, materials, routes, scheduling, use of operators, training, safety, communication, emergency plowing, and clean-up activities.

Snow policy — A document that clearly states the principles guiding the scope of an agency's snow and ice control, the level of service, and what services the public can reasonably expect. It describes agency priorities (roads, routes, and activities) and commencement of operations.

Wing — A second plow attached to the side of a truck that extends the total plowing surface area beyond the reach of a front-mounted plow.

Zero-velocity spreader — A spreader that uses air flow to dispense chemicals (liquid and/or dry deicers) in a continuous controlled pattern with material blown onto the road in one direction at approximately the same speed the truck moves in the other direction. The deicing materials strike the pavement at zero velocity and stay where they fall.