RESPONSE TO A CALL FOR PAPERS

Measuring Winter Maintenance—what's behind the numbers

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in Winter Maintenance Operations

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Introduction

In a paper to the Transportation Association of Canada 2003 Conference in St. Johns Newfoundland, the work of a group of Ontario road professionals was outlined. In that paper, the results of OGRA's annual data collection efforts were reviewed and the format for measuring municipal roads and bridges identified. That paper also contained the results of a case study of winter control activities and costs.

The committee continues to meet and this paper will highlight their efforts to date, which includes:

- a brief review of the activity map developed for winter maintenance
- the measures used to monitor winter maintenance
- a review of the case study outlined in the 2003 TAC paper and the process improvements that have resulted from that case study
- results to date of the process mapping exercise undertaken by a group of municipalities and the best practices identified through that exercise
- next steps

The numbers gleaned from OGRA's annual data collection efforts are reported on OGRA's website (www.ogra.org) in a paper titled "Ontario's Municipal Roads—2002". These numbers are beginning to produce trend lines for productivity and/or cost of service delivery. These trend lines are what has prompted the members to continue their efforts and now look behind the numbers to pursue best practices.

The participants in this project wish to remain anonymous, until the publication of a report similar to this paper is approved for publication by senior management and council of each participating municipality.

Glossary of Terms

UT—Upper tier municipality
LT—Lower tier municipality
Art—Arterial road
CCI—Collector, commercial/industrial road
CR—Collector, residential road
LCI– Local, commercial/industrial road
LR—Local, residential road
HV—High traffic volume
LV—Low traffic volume
HCB—High class bituminous pavement
LCB—Low class bituminous pavement
HCC—High class concrete pavement
A/C—Asphalt/concrete composite pavement
Unpaved—a road with a gravel, stone or other loose traveling surface
Lane km—lane kilometre, is the continuous lane of road that conveys traffic in one direction.
MPMP—Municipal Performance Measurement Program
OMBI—Ontario Municipal CAO's Benchmarking Initiative
ORC—Ontario Roads Coalition, on performance measurement, benchmarking and best practices
TAC—Transportation Association of Canada
V.km—vehicle kilometre, is a measure of the use of the system by a vehicle traveling a kilometre of distance.
Vehicle kilometre traveled—is a measure of the use of the system by a vehicle traveling a kilometre of distance x 365.
Winter Event—is a weather condition affecting roads such as snowfall, wind blown snow, sleet, freezing rain, frost, black ice, etc to which a winter event response is required.
Winter Event Response— is a series of winter control activities performed in response to a winter event.

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The Activity Map

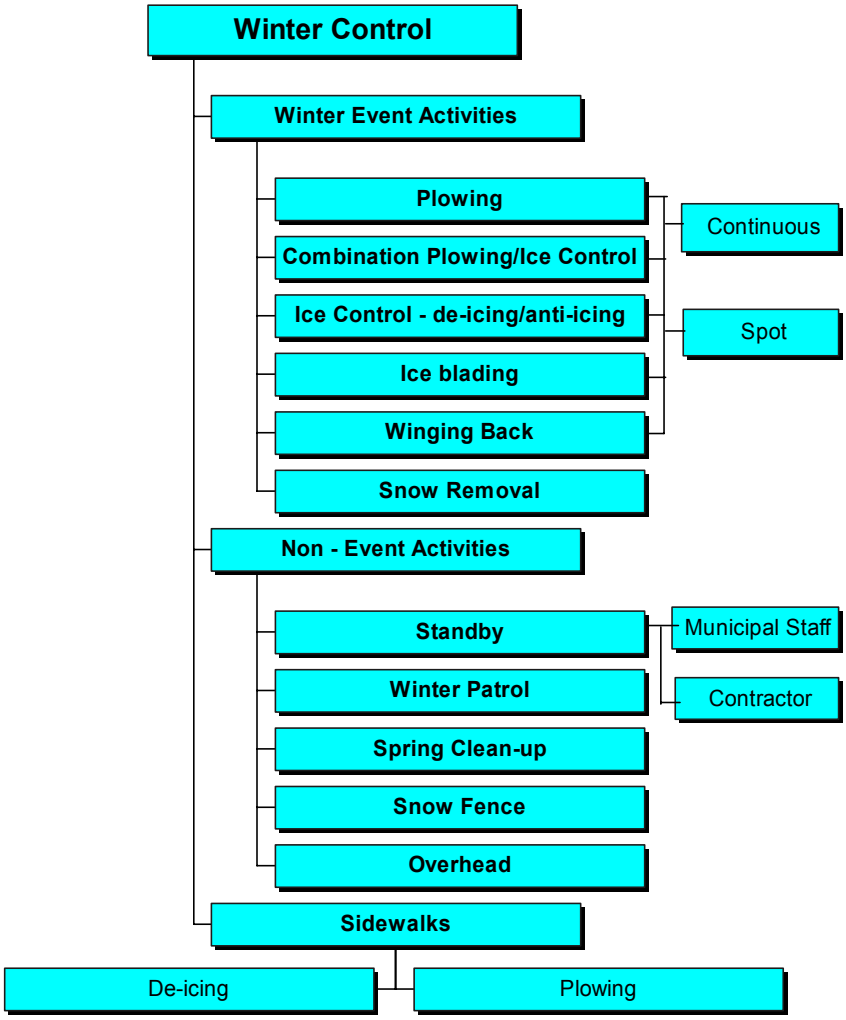
The Ontario Good Roads Association formed a committee of road professionals in 1997 to develop a performance measurement and benchmarking methodology for Ontario's municipal roads. The committee mapped and defined all maintenance and construction/rehabilitation activities completed on a road system. The map was divided into 6 main categories as follows: platform maintenance, both paved and unpaved; traffic management; storm water management; roadside maintenance; structure maintenance; and winter control. Within each category the activities to be included are identified, example Figure 1 and each activity has a corresponding definition.

It is this activity map and definitions that OGRA uses in their annual data collection efforts. The map and corresponding definitions are reviewed and updated every year by the committee. For this year the winter control activity map was updated by adding sub-groups for event and non-event activities. The activities for plowing, combination plowing/salting/sanding, ice control, ice blading, winging back and snow removal were grouped together under the heading winter event activities. These winter event activities represent the work required in the field to respond to a winter event. A second group was created for those activities that must be undertaken to either support the activities completed in the field or enable an event response. These non-event activities would include standby, patrolling, spring clean-up, snow fence placement and removal and overhead.

The activity map has been adopted provincially by the Ministry of Municipal Affairs for their Municipal Performance Measurement Program (MPMP) and by the Ontario Municipal CAO's Benchmarking Initiative (OMBI) for their measurement and benchmarking work.

The activity map for winter control, as shown in Figure 1, will be the thrust of the remainder of this paper.

Figure 1



"The activity map has been adopted by the Ontario Ministry of Municipal Affairs for their Municipal Performance Measurement Program (MPMP)"

The Numbers

The numbers are derived from the data received in response to OGRA's annual questionnaire on the extent, condition and cost to deliver services, the results of which are presented each year in a report titled "Ontario's Municipal Roads" the latest update being 2002. In that report, respondents are grouped into 7 peer groups. They are: Rural High Traffic Volume Arterial System; Rural Low Traffic Volume Arterial System; Urban High Traffic Volume Local Residential System; Urban Low Traffic Volume Local Residential System; Rural High Traffic Volume Local Residential System; Rural Low Traffic Volume Local Residential System and; Northern Rural. These peer groups are created based on the type of road system the municipality reported and the traffic volume on that road. This is not to say that there are not other roads within each system that perform other functions. The peer grouping is an identification of the predominant road function within the system. Five million vehicle kilometers for the system per day is the cut-off for high and low traffic volumes and ≥50% is the cut-off for road function peer grouping, at this time.

For the balance of this paper a select group of municipalities have been working to benchmark their performance and use this information to find best practices. This select group of municipalities are from two of the peer groups, included in the province wide report. Group one who maintain primarily rural high traffic volume arterial road systems and group two who maintain primarily urban high traffic volume local residential systems (the titles have been shorten on the attached charts due to space constraints).

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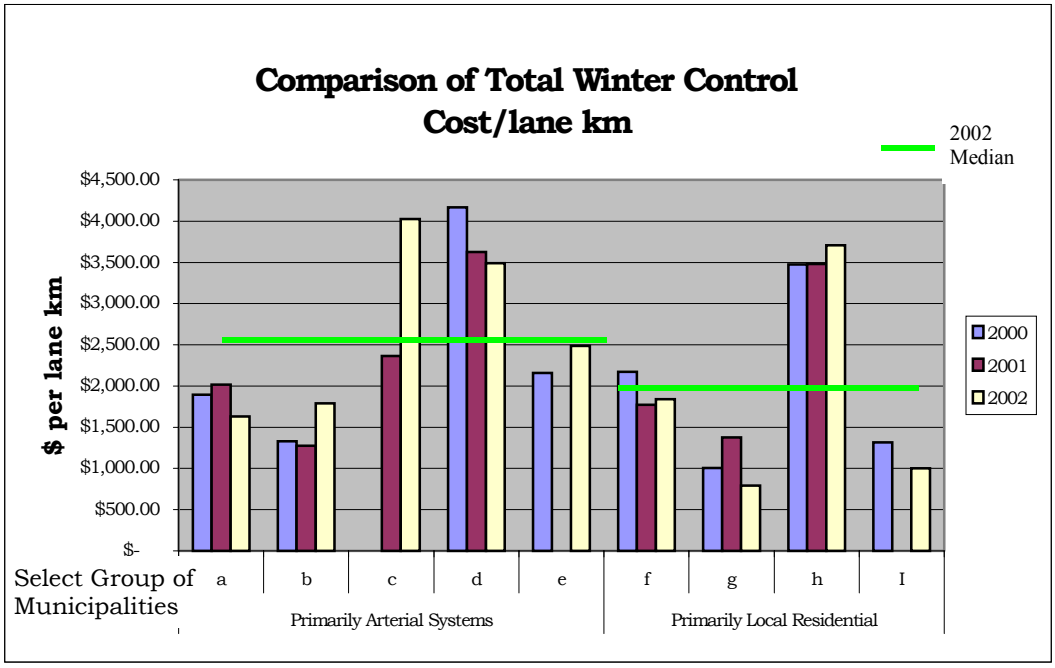
Figure 2



Performance Measures used by the Select Group of Municipalities

		Primarily Arterial Systems					Primarily Local Residential Systems			
		a	b	c	d	e	f	g	h	i
Cost per lane km	2000	1,896.85	1,311.42	N/A	4,168.53	2,160.43	2,172.60	1,005.59	3,474.86	1,317.88
	2001	2,017.61	1,276.36	2,364.40	3,624.77	N/A	1,770.69	1,376.57	3,482.02	N/A
	2002	1,630.76	1,789.49	4,024.09	3,489.77	2,485.60	1,840.50	793.40	3,705.76	1,007.20
annual cm of snowfall	2000	155.2	336.0	229.2	240.9	289.5	262.2	127.8	135.7	198.0
	2001	131.6	354.2	139.4	112.0	246.4	287.6	175.8	81.6	50.5
	2002	65.2	452.3	296.4	120.9	338.4	120.9	98.4	114.9	140.3
total annual tonnes of abrasive including salt/s. km	2000	61.9	65.9	N/A	191.6	52.0	32.4	32.7	40.7	21.3
	2001	57.3	65.9	70.5	95.0	N/A	31.6	39.7	41.0	N/A
	2002	51.7	15.1	80.0	75.7	37.4	31.4	37.9	11.4	13.4
total annual tonnes of salt per system kilometer	2000	9.6	11.0	N/A	52.3	43.6	25.9	11.2	39.9	21.3
	2001	6.8	11.2	38.6	48.1	N/A	23.2	13.8	40.2	N/A
	2002	7.3	4.1	39.4	49.2	33.2	22.6	17.7	10.7	13.4
usage of the road system (v. km/lane km)	2000	3735.0	788.0	N/A	N/A	4283.7	2561.8	N/A	1861.7	2124.7
	2001	3127.0	788.0	2294.9	5100.4	N/A	2579.1	988.4	1719.3	N/A
	2002	4113.5	788.0	4196.8	5799.9	4899.5	2586.8	993.9	1719.3	2373.8

N/A = not available

Other Performance Measures used in 2002—by the select group of municipalities

- *Median operating $ per lane km—primarily arterial system = $2,486*
- *Median operating $ per lane km—primarily local residential system = $1,792*
- *Average # of winter event responses = 62*
- *Average usage—primarily arterial system = 3,959.5 vehicle km/lane km*
- *Average usage—primarily local residential system = 1,910 vehicle km/lane km*
- *Average % of plows/salters/combination units, municipally owned = 43.6*
- *% of municipalities pre-wetting salt prior to application to the road surface = 55.5*
- *Average length of plow route—primarily local residential system = 85.1 lane km*
- *Average length of plow route—primarily arterial system = 47.5 lane km*
- *% of municipalities who use a wingman in the truck = 55.5%*

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Figure 3

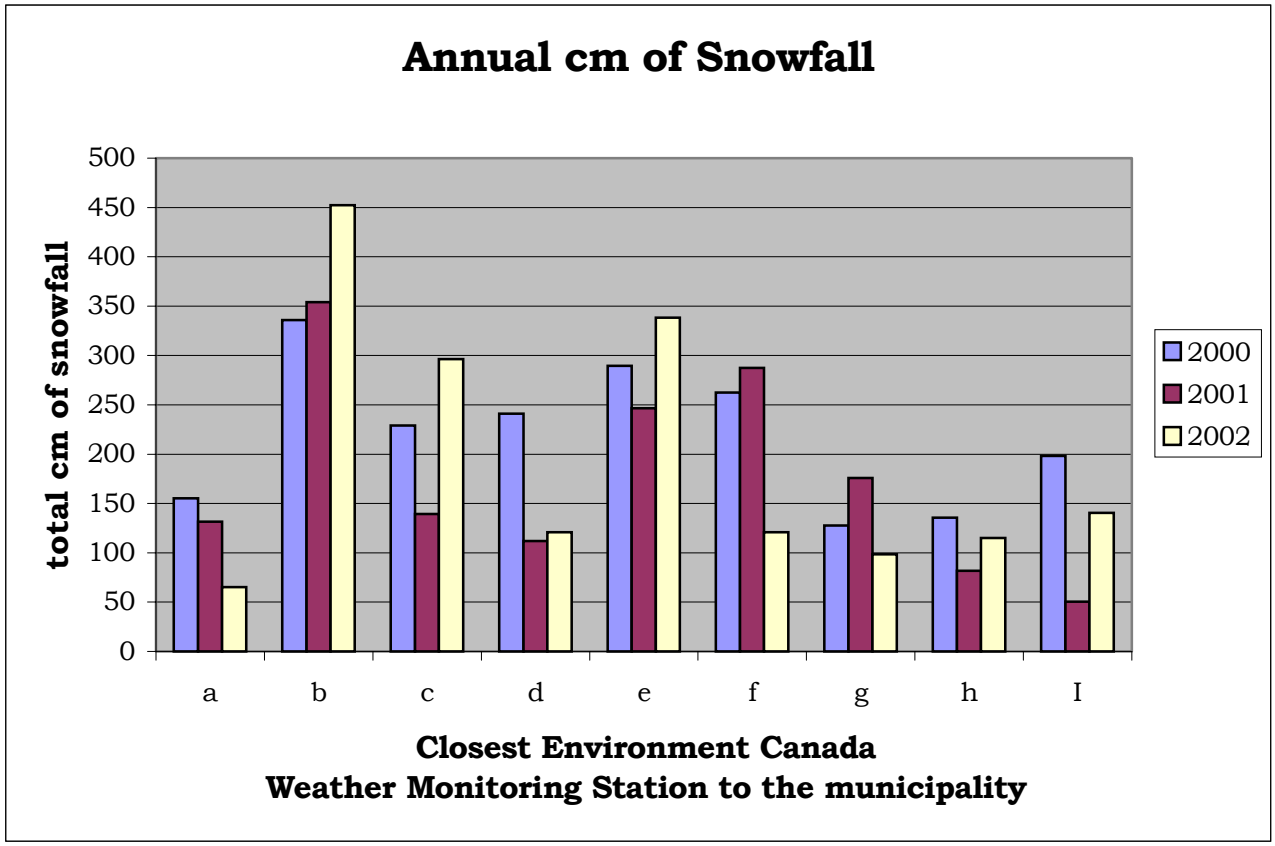


Figure 4

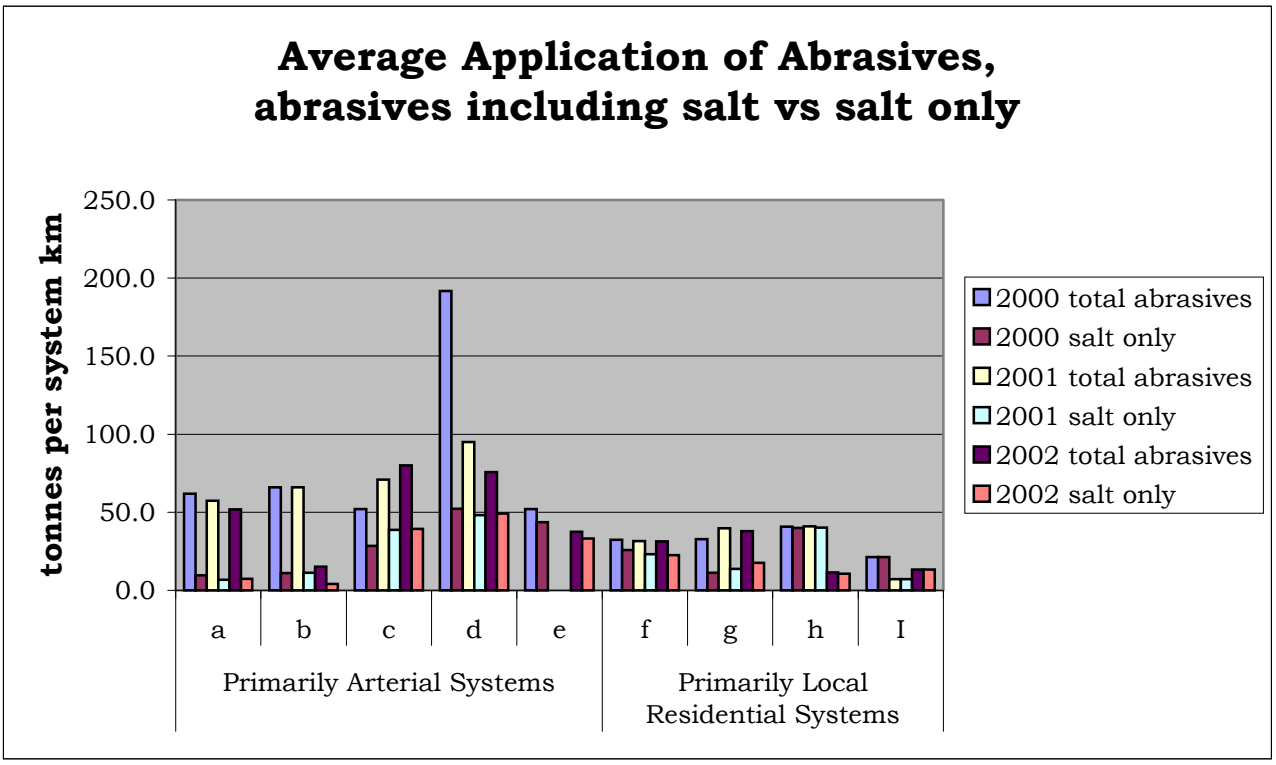


Figure 5

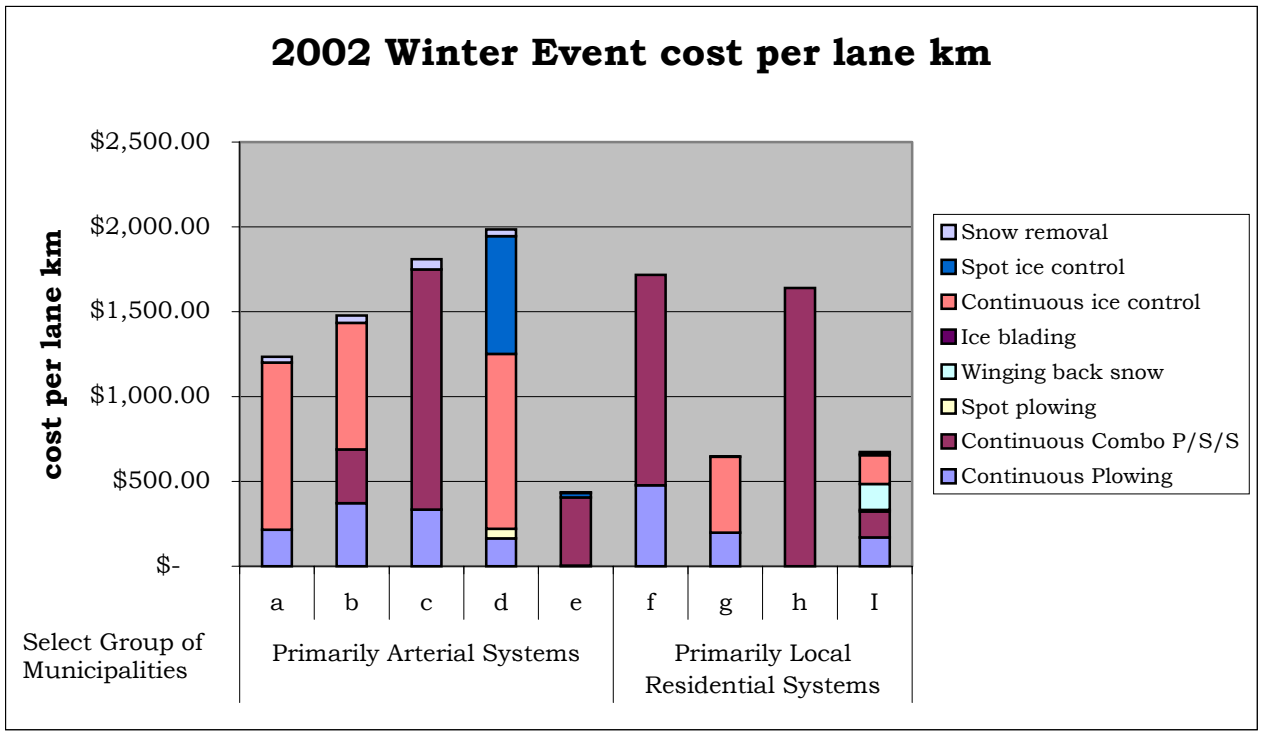
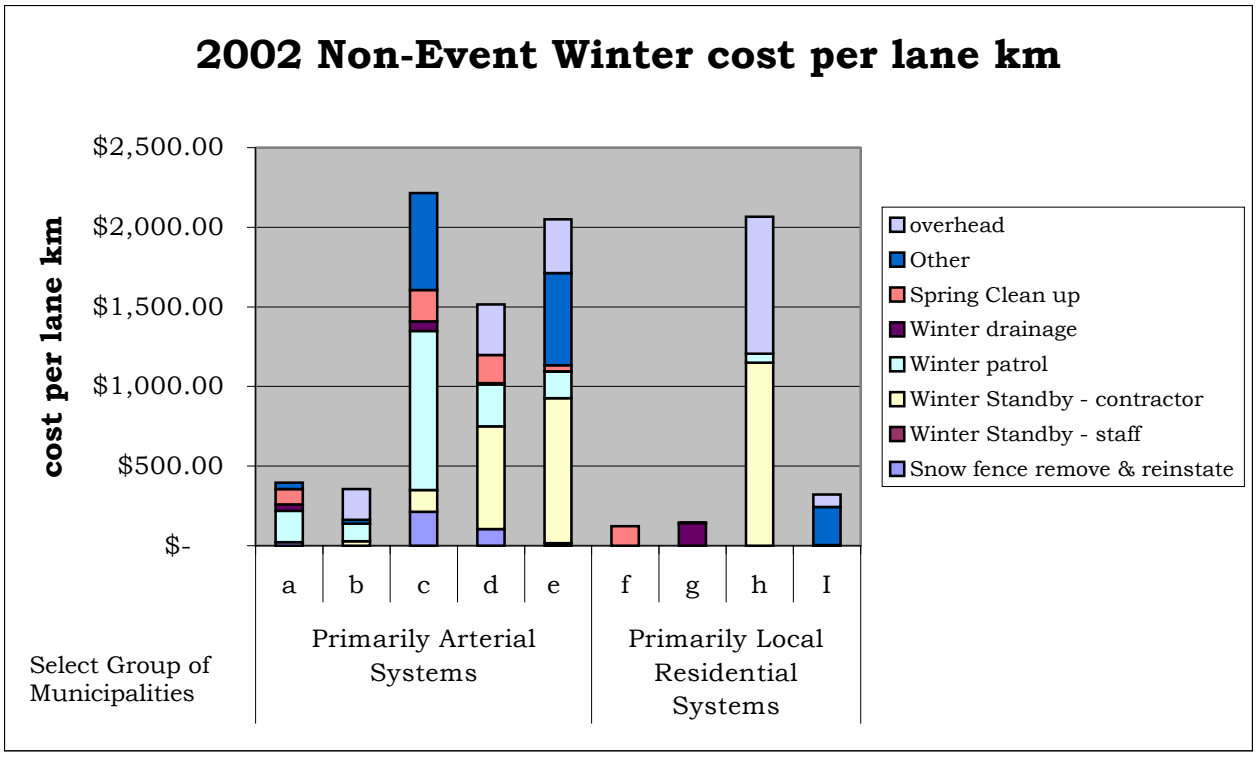


Figure 6



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For the 2003 questionnaire additional information is being requested for the following performance measures:

- # of winter event response hours
- % of municipalities required to have a salt management plan
- # of days with measurable snowfall
- # of days with freezing rain
- # of continuous winter event responses
- # of spot winter event responses
- % of municipalities who anti-ice

Figure 2, 3 and 4 compares the high level results of monitoring winter control over the last 3 years. Figure 2 represents the total cost of winter before splitting the costs into the two sub-groups for event and non-event activities. These results generally show, as we would have anticipated, cost is dependant on snowfall. However some participants showed reduced salt usage over the three year comparison yet the cost per lane kilometer did not reflect the reduced salt usage. To determine why, for the 2002 results, a drill down of the high level cost per lane kilometer was undertaken as shown in figures 5 and 6. Figures 5 and 6 was created using the revise activity map which contains two subgroups of activities. One subgroup for activities completed in response to a winter event (Figure 5) and includes; continuous plowing, continuous combination plowing/salting/sanding, spot plowing, winging back snow, ice blading, continuous ice control, spot ice control and snow removal. A second group for non-event response activities and includes; snow fence remove & reinstate, winter standby - municipal staff, winter standby - contractor, winter patrol, winter drainage, spring clean up and overhead (Figure 6).

Splitting winter control into two subgroups (table 1) brings the total cost per lane kilometre down to a cost which begins to reflect the cost to provide service in the field and the cost to support the service in the field.

The non-event cost reveal that some of the select group expended a significant percent of their budgets for contractor standby and winter patrol. Also, both (e) and (f) were not consistent with their peer group and need to examine their numbers. Municipality (e) had the highest cost for patrolling and placed a considerable amount of money in the "other" activity as compared to their peer group. If the amount of money in "other" were applied to the event response group their cost per lane km would have been brought in line with the other municipalities in the peer group. Likewise (f) has placed all their winter cost in plowing and combination plowing with nothing shown for patrolling, standby or overhead. These numbers are partially a result of the municipality's accounting program that lumped costs together instead of breaking them out as per the activity map. Municipality (h) reduced salt usage yet did not see a reduction in overall cost per lane kilometer, due to their significant cost for contractor

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Table 1

	Total $/lane km	Event $/lane km	Non-event $/lane km
a	1,638.76	1,234.27	404.49
b	1,782.49	1,476.80	305.69
c	4,024.09	1,809.48	2,214.61
d	3,498.77	1,984.23	1,514.54
e	2,485.60	435.50	2,050.30
f	1,840.50	1,717.43	123.07
g	793.44	647.89	145.55
h	3,705.76	1,639.53	2,066.23
i	1,001.28	674.48	326.80

(Continued from page 8)

standby and overhead. It is anticipated that the process mapping exercise will eventually answer questions as to why costs vary.

In the next section of the report the processes used to provide winter control activities were identified. Within the process mapping exercise the cost of each process was to be identified if possible. All of the select group of municipalities did complete the process mapping exercise, unfortunately not everyone could provide process cost. For some process costs were assigned to other cost centers or buried within the financial system or simply were not tracked. Table 2 shows the identified process costs included in winter control. These costs are used to further reduce the event cost per lane kilometre for each of the select group of municipalities as follows: Municipality A's cost is reduced from $1,234.27 to $1,233.07/lane km; Municipality D's cost is reduced from $1,984.23 to $1,621.48/lane km; Municipality F's cost is reduced from $1,717.44 to $1,367.65; Municipality G's cost is reduced from $647.88 to $643.44/lane km and; Municipality H's cost is reduced from $1,639.53 to $1505.84/lane km. Subtracting these process costs is an important step in achieving apples to apples comparison of the cost of providing service on the road.

Finally the last calculation of the numbers for winter control, is to normalize the event cost per lane kilometre. There are a number initiatives including one underway by TAC to develop winter severity indices or normalize the cost for comparison purposes. The select group decided that total snowfall is not always the best indicator of the effort to control snow and ice in winter. Secondly traffic has a sig-

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Table 2

		a	d	f	g	h
	Process	Process Cost				
Included in Event Costs	Winter Weather info	2,500	9,000	5,000	4,470	12,100
	Prepare and map routes			20,000		
	Training staff		183,620			6,116.40
	Remove obstruction and clean drainage		102,788			
	Inspect and repair equipment		229,255	1,200,000	5,000	1,789,150.28
	Calibrate Equipment		2,556			
Non event costs	Respond to requests for service		8,709			
	Accident reporting		4,000			

Normalization = event $ per lane km x WF^1 x WF^2

$$WF^1 = \frac{1}{\text{\# of winter event responses per municipality/average winter event responses per peer group}}$$

$$WF^2 = \frac{1}{\text{Vehicle km per municipality/average vehicle km per peer group}}$$

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nificant affect on a winter event response in that heavy traffic requires a response sooner and traffic often impedes progress. Therefore as a first start into normalization, factors using traffic volume and total effort were developed. A formula was created as shown above.

The normalization revises the event cost per lane kilometre as follows (not every municipality tracked the data needed): Municipality A's cost is changed from $1,233.07 to $1,329/lane km; Municipality D's cost is changed from $1621.48 to $1,580/lane km; Municipality F's cost is changed from $1,367.65 to $1,153/lane km; Municipality H's cost is changed from $1,505.81 to $660/lane km (Figure 7). Future normalization will use total winter event hours instead of number of winter events. Total winter event hours should provide a better indication of the effort required to control snow and ice. While this data has been requested reliable total winter event hour data has not been received.

To compare with peer group members level of service must be considered. The primarily arterial systems all provide a bare pavement service within 4 to 6 hours of the end of a storm. Primarily local residential systems on the other hand vary in

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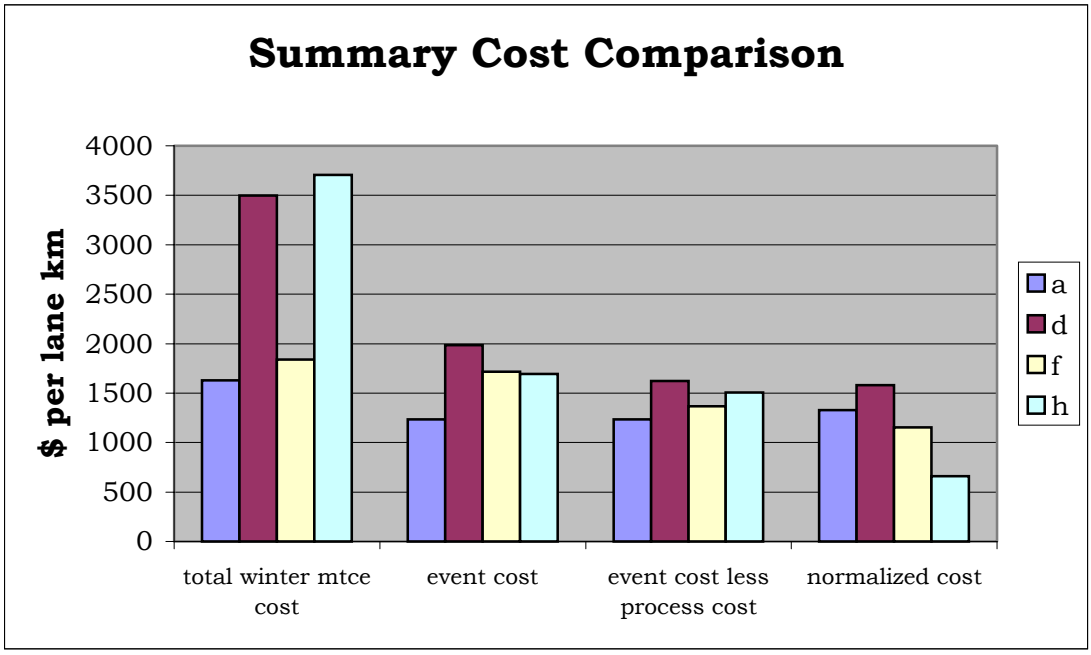
Figure 7



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their level of service. Arterials receive bare pavement in 4 to 16 hours, all other roads vary from bare to track bare to snow packed in a timeframe from 12 to 24 hours with one member reporting 72 hours before service level is achieved. An attempt was made to create a formula to normalize for level of service. However, with the variations in the level of service and the differences in the type of road system over which service is delivered, creation of a formula to account for so many variables could not be accomplished at this time.

Behind the Numbers

In 2000, a case study was undertaken between two municipalities that were similar in that both provided service on high volume primarily arterial road systems, both have similar geography and geographical location, both have similar amount of snowfall received, etc. What was evident, after monitoring 3 years of data collection, is that one municipality continually delivered service at a higher cost per lane kilometer than the other. The case study looked behind the numbers to review the processes used by each to deliver service in winter. What was found with the data available was that there were at least six main factors (there may be others) which have increased the cost to deliver service in the higher cost municipality. These factors include: the use of a two shift system; 24/7 patrolperson; the complement of fleet; the amount of de-icing agent used; no wing zones, which require snow removal and; a 24/7 call center.

The case study did not identify a best-in-class performer due to the fact that the effectiveness (customer satisfaction) of both municipality's operations was not measured. The case study was written to examine the differences found in service delivery between the two municipalities studied and determine how those differences affect the cost to deliver service. To that end the cases study was a success as it set the starting point for future benchmarking discussions. In a report to the commissioner the high cost municipality writes; "*The data comparisons and case study indicate several areas in which our municipality should be devoting time and effort in order to ensure the best possible service at the best possible price for our customers. It is important that we build on the benchmarking process, with follow up discussion with our peer municipalities to* ***flesh*** *out opportunities for improvement and to find the best practices that meet our unique factors and conditions".*

As a result of the case study the high cost municipality has been working to improve salt management and/or reduce salt usage (the top priority identified in the case study). As a result of their efforts, they did reduce salt usage and cost in spite of the fact they received more snow in 2002 than 2001.

Since the case study was published this group of select municipalities realized the benefit of the mapping exercise undertaken by the case study municipalities and formalized a process map (Figure 8) so they to could benefit from knowing what was behind their numbers.

The process map was developed using the winter control activity map (Figure 1). This new map requested answers to questions on how service is delivered in the

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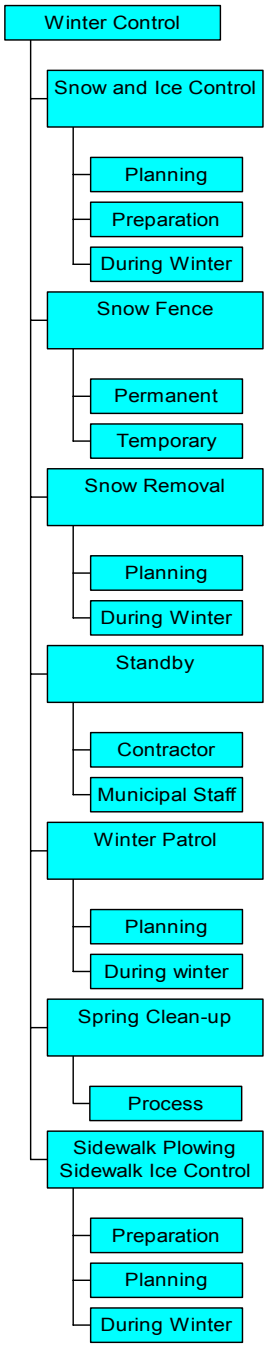
Figure 8

Process Map



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field or what processes are used to support service delivery. Three main areas of questions were developed for planning, preparation and during winter as follows:

1. How does your municipality plan for the upcoming winter? Questions would include: Is a post mortem of the previous winter undertaken; how is policy changed; how is budget derived and; what is used for weather forecast information and so on.
2. How does your municipality prepare for winter in the month/weeks prior to the on-set of winter. Questions would include: What is done for equipment preparation; Does the municipality install snow fence, plow markers and are they inspected and repaired throughout the season.
3. The processes that are used to provide service during winter would include questions such as: How is staff and contractors called out to respond to an event; how and when is snow removal completed; how and when is winter patrolling completed and so on.

A total of 57 questions were asked for the activities required to deliver winter control services.

Many of the processes used to deliver winter control services were the same or similar for all. Everyone plowed snow, everyone used salt to control the formation of ice, although some blended the salt with sand. For other processes; some pre-wet salt, some didn't, some used a wingman in the plow truck others didn't. In the process mapping exercise some processes/ practices worthy of being noted were identified. Figure 9 is an example of the questions asked and the best practices found for the planning portion of the snowplowing, combination plowing, ice control and winging back activities. Questions were also asked regarding process used to prepare for winter and processes used during winter for this same group of activities and for all other activities included in the winter control map (Figure 1). A total of 20 best practices were identified through the process mapping exercise (as shown in Appendix 1 on page 15). These best practices may not be best in class (as the sample size is small), but they are best for the group being analyzed. That is not to say that the participants should not seek to adopt these practices into their own municipality. These practices may improve the way they do their business.

A total of 20 best practices were identified through the process mapping exercise.

Within the questions on the process map, each participant was asked to identify (where they could) what affect the process/practice had on the cost to deliver service. For some, the process/practice costs could not be shown as they were either imbedded in other cost centers within their maintenance programs or the cost were not tracked or they were not charged against winter maintenance.

The process mapping exercise will form the benchmark for all future peer group comparisons.

Figure 9

Activity(s)	When	Question asked	BP Municipality	Better Practice
Snowplowing, combination plowing, ice control, winging back	Planning	How do you evaluate the effects of last years winter, including complaints received?	f	Post event meeting with supervisors. Cost reported on monthly reports with rationale for over/ under. Managers meet at the end of the season. Based on review of previous winter would revise policies as required. All complaints throughout the year are logged into our Amanda Call Centre computer system, which are given to supervisor for action.
		How do you analyze predictions for this winter?	d	Farmers almanac, 5 year trends and El Nenio, etc.
		How do you determine if policy revisions are required?	h	As part of the annual analysis and review the following areas are revisited: Management practices—Level of service; Equipment—Fleet audit; calibration audit; Materials—Salt usage summaries; storage facilities audit; Storm response summary –weather forecast; equipment summary; Snow and ice control training; Snow removal and disposal; Technology Review
		How do you determine budget?	a	Based on average of the last 4 years
		How do you tender contracted operations?	a	Equipment tenders publicly advertised as primary or a backup to Regional forces and will be used as required to provide winter maintenance services. Terms are based on a 24/7 operation including an hourly work and daily standby rate. Contracts are reviewed annually for a five year term.
		How do you determine/ contract sources of weather forecasts and information?	e h	World Weather Watch provides four standard daily reports to the dispatch centre which are in turn emailed to all operations managers and faxed to all yards. A dedicated website is provided with all forecast information. Four RWIS stations have been installed.
		Do you prepare and map plow and salter routes: identify route length, mix of road types, cycle timing, etc?	f	Plow, salt & sand routes are analyzed using database developed in house, route maps and policies are reviewed with staff, operators and contractors
		Is equipment procurement and repair part of the planning process?	None identified	
		Does staff receive annual training on winter operations?	e	All of our Road Maintenance staff receive extensive training. This training involves First-Aid, CPR, Health and Safety, Defensive Driving, and the Winter Maintenance Operations Training Program for Equipment Operators.

Conclusion

The efforts in Ontario to measure performance of road maintenance and capital activities is starting to pay off. While we are taking small incremental steps, each step is building on the previous and we are closer today to understanding what drives the cost of winter services and which activity/process/practice we should concentrate our benchmarking efforts on.

From the responses received to OGRA's annual questionnaire trend lines on extent, condition and cost to deliver service are reported for each peer group. These trend lines can then be used as a starting point to benchmark performance and pursue best practices.

For one Ontario municipality, benchmarking works. Through a case study, priorities were set and the municipality able to look to their peers to improve performance and save money. The balance of this select group of municipalities who participated in the process mapping exercise, realized the benefits and tried for themselves to look behind the numbers. That look found who was performing a number of activities better than others in their peer group. While most could not extract the cost of the various processes that does not signify failure. What we have learned over the last few year's is that you will travel down the benchmarking road several times before achieving results. This select group of municipality's will try to fill in the blanks that couldn't be answered this year and will then reap the benefits that benchmarking offers.

"We are taking small incremental steps, each step is building on the previous and we are closer today to understanding what drives the cost of winter services"

"What we have learned over the last few year's is that you will travel down the benchmarking road several times before achieving results".

Next Steps

1) The select group of municipality's will update the process map using 2003 data. This will be a much easier task as they only need to update cost and identify which process, if any, was changed in 2003.
2) Gather and report the total winter event hour data. Use this data to substitute the number of winter event data in the normalization formula.

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For further information on the performance measurement and benchmarking work in Ontario call:
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WE'RE ON THE WEB AT WWW.OGRA.ORG

The Ontario Good Roads Association provides our members with a format and definitions for measuring one of the most important assets they maintain, their road system. Using this measurement program as a management tool, members will be able to determine their operational strengths and weaknesses. Once you have measured and determined that an activity requires improvement, OGRA's 10 step benchmarking methodology allows you to compare your performance with that of the best-in-class, adapt the practices of that best performer and bring the adapted practice into your own organization.

Appendix 1—Best Practices Found From the Process Mapping Exercise

1. INSPECT ALL EQUIPMENT. All city owned equipment procurement and repair is managed by the Corporate Facilities and Equipment Division. All staff completes a circle check of their equipment before and after operating it, noting defects and forwarding to the Corporate Facilities and Equipment Division for remediation. The Facilities & Equipment Division use an automated Fleet Management Information System (SAP) to schedule all maintenance for the corporation. The system lets them know when equipment needs to be prepared for the season, as well as all legislative requirements related to licensing and regulations.
2. CALIBRATE SALTING AND PRE-WETTING EQUIPMENT. Under the municipalities Salt Management Plan a calibration procedure was developed and implemented in October of 2002. All spreaders are to be calibrated by Fleet Services each fall. Equipment are recalibrated after any repair that affects the delivery system. Calibration history for all spreaders are maintained by the Supervisors and reviewed annually.
3. RECORD KEEPING. Sanding & Salting - Staff using spreading equipment or plow completes a Log and submits it to their supervisor at the end of every shift. Dispatch records all time outs and time done on dispatch log. GPS/AVL system records all responses when trucks are on the road and tracks salt use to compare against Operator's Log.
4. ANALYZING SNOW FENCE EFFECTIVENESS. Annually in conjunction with collision analysis
5. PERMANENT SNOW FENCE. Several areas have permanent snow fence in form of evergreen planting strips some 30 metres wide (planted 40 years ago and still maintained) Use corn rows where farmers agree to leave 10-12 rows standing for winter season.
6. ACCESS ENVORONMENTAL IMPACTS AT SNOW DUMPS. Salt Mgmt Plan will address the impact on environment, following MOE guidelines
7. STANDBY AT HOME. Rate of pay is based on Union agreement. Staff are on standby to cover priority 1 roads when winter events are forecasted during holidays, statutory holidays, weekends and emergencies.
8. DETERMINE WINTER PATROL ROUTES. Patrols have maps showing specific locations to check (bridges, hills) and their overall boundary.
9. ASSIGN PATROL SHIFTS. Shifts are reviewed each year and revised as necessary to accommodate current needs.
10. MONITOR ROAD CONDITIONS DURING A STORM. Patrollers monitor conditions before, during, and after a storm. Weather information is constantly referred to personnel in charge of winter control duties. ARWIS information monitors road conditions at all times. All patrollers have access to internet, have cell phones and portable and/or mobile two-way radios, have Blackberry pagers with internet access to GPS/AVL system and through this are able to access truck whereabouts and road conditions.
11. ACCIDENT REPORTING. All accidents are reported to duty supervisors who attends scene and records all pertinent info and forwards to risk department.
12. DISPOSAL OF MATERIAL DURING SPRING CLEAN-UP. Material is transferred to road maintenance yards were it's tested and then transferred to municipally owned landfill sites for use as ground cover.

PLUS THE PRACTICES SHOWN ON PAGE 9.