ANNUAL WINTER MAINTENANCE REPORT

2018-2019

Raising the Bar on Best Practices

Wisconsin Department of Transportation
Division of Transportation System Development
Bureau of Highway Maintenance
Winter Operations Unit

FINAL December 2019

Acknowledgments

Many people at Wisconsin DOT contributed to the development of this report, including:

- James Hughes, Bureau of Highway Maintenance
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- Peter Wisniewski, Bureau of Highway Maintenance
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Glossary

AVL - GPS: Automated Vehicle Location - Global Positioning System

BHM: Bureau of Highway Maintenance

BMP: Best Management Practice

BTO: Bureau of Traffic Operations

DLA: Direct Liquid Application

FHWA: Federal Highway Administration

GUI: Graphical User Interface

MDSS: Maintenance Decision Support System

NWS: National Weather Service

RWIS: Roadway Weather Information System

STOC: State Traffic Operations Center

WISDOT: State of Wisconsin Department of Transportation

1 Introduction

To Wisconsin Winter Maintenance Professionals,

Fighting winter storms in Wisconsin can vary greatly, depending on whether you are in Bayfield County at the northern-most point in Wisconsin or south in Grant County along the Mississippi River. But geography isn't the only variable in keeping the roads safe for travelers. Many variables impact how we react to a winter storm, such as weather and the roads themselves. Our weather for the winter of 2018-2019 started off rather benign. Until the middle of January, severity was below average across most of the state. However, from that point until the end of February, winter hit with a vengeance. Frequent storms hit the state, and temperatures were well below normal. Lake Michigan and the Mississippi River both froze, causing delays in salt deliveries. More average conditions returned in March. Different, and sometimes crazy weather conditions require different treatments to meet the public's expectation that the road will be passable in a reasonable amount of time after a winter storm.

The longstanding relationship between the Wisconsin Department of Transportation and County Highway departments is over 100 years old. This unique relationship puts Wisconsin on the map for timely response to every winter storm and for cost effectiveness. The partnership between the counties and state DOT continues to prove to be economical for Wisconsin's taxpayers and I thank all who support this partnership by engaging in modern winter maintenance practices and pilot projects in the years to come.

I am a strong proponent of being a good steward of Wisconsin's environment and I stress the importance of improving processes in winter maintenance that use "Evidence-Based Practices" to save money, the environment or both.

As we put together this annual report, the Bureau of Highway Maintenance compiles information and data from many resources:

- winter incident and storm reporting by county staff;
- direct liquid application of salt brine and/or blends reported by county staff participating in the brine pilot study:
- salt purchasing and use data from DOT records and contracts with salt vendors;
- information from partnering states participating in Clear Roads and MDSS pooled-fund studies;
- MDSS (Maintenance Decision Support System).

If you need additional information, you may contact your regional WISDOT representative or Cody Churchill, at cody.churchill@dot.wi.gov.

Sincerely,

James P. Hughes, P.E.
State Highway Maintenance Engineer
Bureau of Highway Maintenance

Table 1.1. Statewide Summary: This Winter Versus Last Winter, by the Numbers

		2017-2018 winter	2018-2019 winter
Infrastructure	Lane miles	34,678	34,774
	Patrol sections[4]	754	756
	Average patrol section length[4]	46.0 lane miles	48.0 lane miles
Weather	Average statewide Winter Severity Index (100=normal)	90.0	105.7
	Number of storms, statewide average and range across counties	Average: 33 Range: 20-61	Average: 37 Range: 23-57
	Snowfall, statewide average and range across counties	Average: 77.8 Range: 25.8 to 222.6	Average: 92.9 Range: 42.9 to 215.6
Materials[1]	Salt used	567,600 tons 16.4 tons per lane mile	553,443 tons 15.9 tons per lane mile
	Average cost of salt	$67.60 per ton	$73.51 per ton
	Total liquids used (prewet, anti-icing, direct liquid application)	6,561,404 gal.	9,393,029 gal.
	Sand used	19,955 cubic yd.	21,019 cubic yd.
Costs, Equipment and Performance	Total winter costs[2]	$97,831,087	$111,681,476
	Total winter costs per lane mile	$2,821	$3,212
	Average crew reaction time from start of storm	2.89 hours	2.45 hours
	Percentage of roads to bare/wet pavement (Within WisDOT target times)	66%	69%
	Road Weather Information System (RWIS) stations	68	70
	Underbody plows	753	753
	Counties that used anti-icing agents during the winter season	64 of 72 (89%)	63 of 72 (88%)
Labor and Services	Regular county winter labor hours[3]	166,741 hrs.	195,223 hrs.
	Overtime county winter labor hours	140,471 hrs.	167,094 hrs.
	Public service announcements aired	9,954 total 8,385 radio; 1,569 TV	None
	Cost of public service announcements	$36,000 ($334,564 market value)	–

1. All material usage quantities are from the county storm reports except for salt. Salt quantities are from WisDOT's Salt Inventory Reporting System.
2. Costs refer to final costs billed to WisDOT for all winter activities, including activities such as installing snow fences and thawing culverts.
3. Labor hours come from county storm reports, and reflect salting, sanding, plowing and anti-icing efforts.
4. Patrol sections and average length include hybrid sections in some counties which may include a portion of county highway.

ABOUT THIS REPORT

Every year, WisDOT gathers a multitude of data on winter weather and the state's response to it. Tracking and analyzing this data helps us become more efficient by identifying good performance as well as areas that need improvement. In this way we use our limited resources to achieve the greatest benefit.

Through this report, WisDOT's Bureau of Highway Maintenance shares data with the department's regional maintenance staff and with our partners in the county highway departments. This allows regional and county staff to compare resource use with that of their peers across the state. The report has also been shared with the WisDOT Secretary's Office, the state legislature, national organizations such as Clear Roads, and the general public.

REPORT STRUCTURE AND DATA SOURCES

Following this section, this report is divided into four main sections:

- Section 2: Weather
- Section 3: Winter Operations
- Section 4: Performance
- Section 5: Looking Ahead

Each section has several subsections; refer to the Table of Contents for more detail. To improve readability, the report includes more statewide summary tables within the text, while county-by-county data appears at the end of each section.

Within many of the county-by-county tables in this report, the counties are grouped by region, in acknowledgement of the role that WisDOT's regional staff plays in coordinating winter maintenance in their counties. In some tables, counties are divided by Winter Service Group (Groups A, B, C , D, E and F), which reflect the difference in the level of service provided on roads in these counties and facilitate comparisons within these groups. See Table 1.3 for more information on Winter Service Groups.

In most tables, raw numbers (such as total salt used) are presented along with data that has been adjusted for differences between counties (such as salt used per lane mile per Winter Severity Index point). This allows more accurate comparisons between regions in different parts of the state.

This report presents data from several sources:

- The weekly winter storm reports completed by the county highway departments, which detail the counties' estimates of the weather they faced and the materials, equipment and labor they used in responding to it. (See Section 4 for more information about storm reports.)
- Final cost and materials data as billed to WisDOT.
- Data on weather, crashes, travel and other topics from other bureaus within WisDOT and other agencies.

The final billed amounts are considered the most accurate source of cost and materials data, and are presented wherever possible.

When interpreting the data in this report, readers should remember that many factors affect a county's response to winter, including the local Winter Severity Index, local traffic generators, the mix of highway types and classifications in a county, the type of equipment being used, and the length of patrol sections. Some tables in this report give data that is adjusted for one or more of these factors (for example, salt use per lane mile per severity index point), while others provide raw data.

WORKING WITH COUNTY HIGHWAY DEPARTMENTS

WisDOT's Bureau of Highway Maintenance, in partnership with the five WisDOT regional offices, is responsible for the maintenance of the state trunk and Interstate highway system. This system includes 34,774 lane miles of highway and around 4,570 bridges.

WisDOT contracts with the state's 72 county highway departments to provide snow and ice control on all state- and U.S.-owned highways in Wisconsin, including the Interstate system. This partnership was set up more than 100 years ago and is unique in the nation.

This relationship benefits both WisDOT and the county highway departments. WisDOT receives the services of a skilled, experienced work force at fair labor rates, and the counties are able to purchase more pieces and types of equipment than they could otherwise afford. This equipment is then available for use on both county and state roads, an arrangement that allows WisDOT and the counties to avoid duplicating equipment and facilities. This arrangement also allows for increased efficiencies in work crews, thus reducing labor costs to taxpayers.

Staff at WisDOT's five regional offices work closely with the county highway departments. Regional managers administer the contracts with the counties, and work with the counties to plan maintenance activities and set priorities. Regional staff oversee county highway departments' maintenance expenditures, and are responsible for ensuring that the counties use resources efficiently and adhere to state guidelines for materials use. Regional staff also serve as a resource for the counties on state and federal rules and regulations, and can provide training assistance.

Snow Removal Strategy

Wisconsin DOT policy in the "Highway Maintenance Manual" specifies two types of snow removal strategies in an effort to be cost-effective while recognizing the public need for clear roads during hours when most travel is done. High-volume highways with the most traffic typically receive 24-hour coverage, while on lower-volume highways, 18-hour coverage is sufficient. On 18-hour routes, the service hours can be adjusted based on the timing of the storms; passing lanes, if present, may require less attention than the driving lanes and ramps.

Table 1.2 shows these categories and what percent of the highways fall into each group. Categories 1 and 2 are the 24-hour routes and categories 3, 4, and 5 receive 18-hour coverage. See Figure 1.1.

To fairly compare counties with similar levels of service, WisDOT assigns the 72 counties into six winter service groups – A, B, C, D, E, and F with winter service group A being the most urban and complex counties and F the most rural. Table 1.3 shows which counties are assigned to each group. These are the original assignments from when this method for comparison was developed about 20 years ago. Today's definition of the group might not fit all the counties assigned to

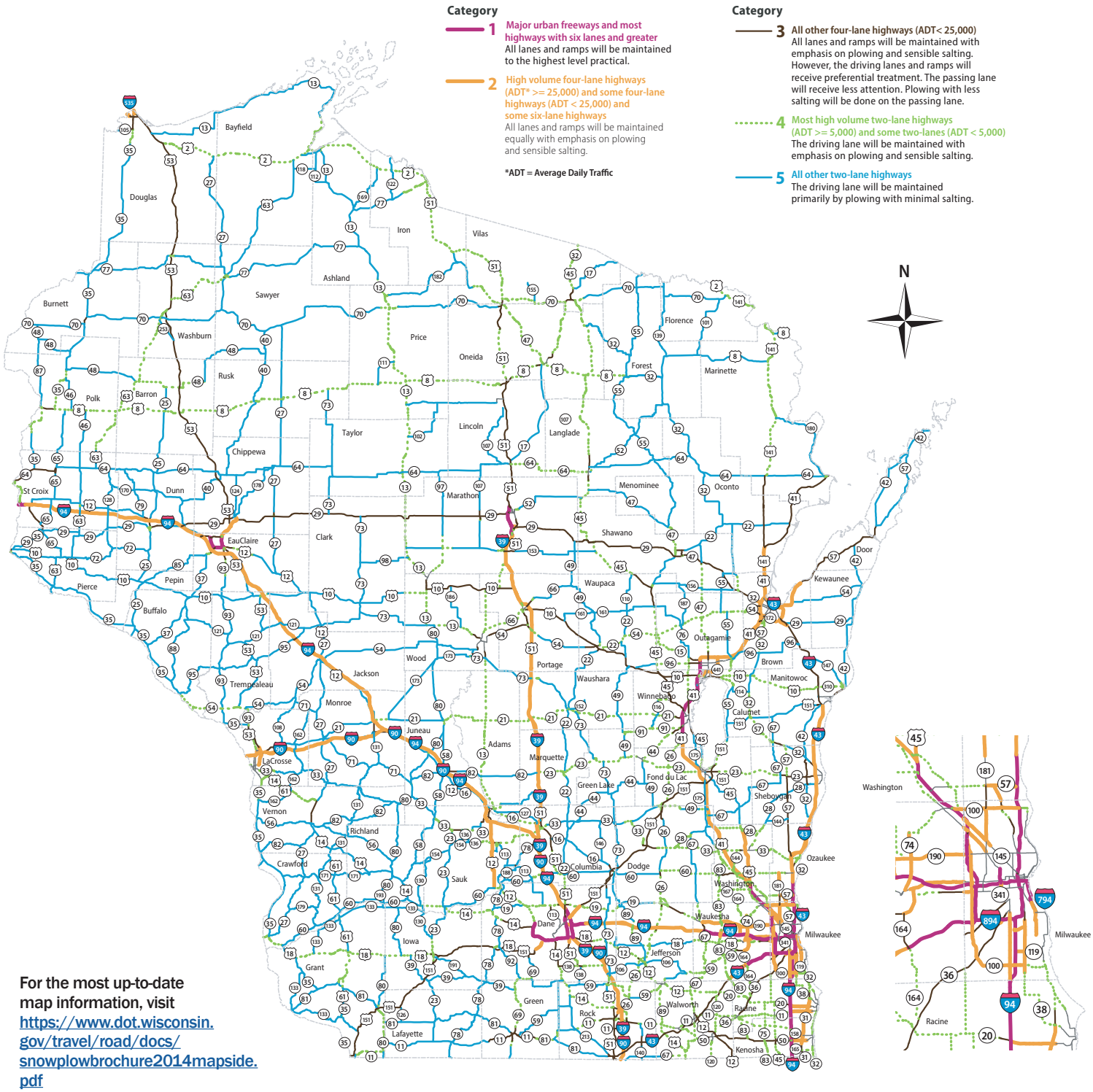
Table 1.2. Highway Categories for Winter Maintenance

Category	Definition	Lane miles	% of total
1	Major urban freeways and highways with six lanes and greater	3,493	10.0%
2	High volume four-lane highways (Average Daily Traffic ≥ 25,000)	3,335	9.6%
3	All other four-lane highways (ADT < 25,000)	8,902	25.6%
4	High volume two-lane highways (ADT ≥ 5,000)	4,694	13.5%
5	All other two-lane highways (ADT < 5,000)	14,353	41.3%
Total		34,777*	

**Total is off due to rounding at the county level. Actual total lane miles is 34,774.*

that group, but for now the counties are still assigned to the Winter Service Group in this table. Be sure to look at Chapter 4B if you are interested in a county by county comparison of plow routes in this table and winter patrol sections – a plow route is the same as a winter patrol section.

Figure 1.1. WisDOT Snow Plowing and Ice Control Categories



For the most up-to-date map information, visit https://www.dot.wisconsin.gov/travel/road/docs/snowplowbrochure2014mapside.pdf

Table 1.3. County Winter Service Groups

Winter Service Group	County Names	Number of Counties	% of Counties
A	Dane, Milwaukee,Waukesha	3	4%
B	Brown, Chippewa, Columbia, Dodge, Eau Claire, Fond du Lac, Grant, Jefferson, Kenosha, Marathon, Monroe, Outagamie, Portage, Racine, Rock, Sauk, St. Croix, Walworth, Washington, Waupaca, Winnebago	21	29%
C	Barron, Clark, Crawford, Douglas, Dunn, Iowa, Jackson, Juneau, La Crosse, Lincoln, Manitowoc, Oconto, Pierce, Shawano, Sheboygan, Vernon, Wood	17	24%
D	Bayfield, Buffalo, Door, Green, Lafayette, Marinette, Marquette, Oneida, Ozaukee, Polk, Richland, Trempealeau, Washburn, Waushara	14	19%
E	Ashland, Burnett, Calumet, Forest, Green Lake, Iron, Langlade, Pepin, Price, Rusk, Sawyer, Taylor, Vilas	13	18%
F	Adams, Florence, Kewaunee, Menominee	4	6%

THIS WINTER IN WISCONSIN

Table 1.4 on the following pages summarizes key data from this winter for all 72 counties, including total salt use and cost data. This table facilitates comparisons in these core areas across regions and counties, and serves as a quick reference for commonly used data. The table uses a similar format to the Storm Report Summary (Table A-1 of the Appendix), but the cost data in Table 1.4 are actual billed costs as submitted to WisDOT by the counties, rather than estimates from the storm reports.

COUNTY-BY-COUNTY
QUICK REFERENCE WINTER SUMMARY TABLE
FOR SECTION 1: INTRODUCTION

WISCONSIN
DEPARTMENT OF TRANSPORTATION

Table 1.4. Winter in Wisconsin, 2018-2019												
	County	Lane miles	MDSS Severity Index	Snowfall (inches)	Total salt used (tons)	Salt used (tons) per lane mile	Salt used per lane mile per Severity Index	Total salt costs	Total salt costs per lane mile	Total winter costs	Total winter costs per lane mile	Total winter costs per lane mile per Severity Index
North Central Region												
	Adams	193.20	102.5	87.1	4,263	22.06	0.22	$ 377,624	$1,955	$ 720,753	$ 3,731	$ 36.39
	Florence	141.07	125.0	110.3	2,544	18.04	0.14	$ 209,927	$1,488	$ 466,068	$ 3,304	$ 26.43
	Forest	312.38	121.7	104.2	6,008	19.23	0.16	$ 494,153	$1,582	$ 1,042,794	$ 3,338	$ 27.43
	Green Lake	158.44	89.4	73.1	1,624	10.25	0.11	$ 121,032	$764	$ 341,688	$ 2,157	$ 24.12
	Iron	249.56	193.3	215.6	4,435	17.77	0.09	$ 373,725	$1,498	$ 1,002,789	$ 4,018	$ 20.79
	Langlade	299.21	122.1	115.0	4,161	13.91	0.11	$ 314,129	$1,050	$ 828,239	$ 2,768	$ 22.67
	Lincoln	405.55	113.8	133.7	4,123	10.17	0.09	$ 356,212	$878	$ 1,201,394	$ 2,962	$ 26.03
	Marathon	874.81	115.6	108.1	9,399	10.74	0.09	$ 797,476	$912	$ 2,969,732	$ 3,395	$ 29.37
	Marquette	245.75	101.6	67.6	4,172	16.98	0.17	$ 361,179	$1,470	$ 819,172	$ 3,333	$ 32.81
	Menominee	90.26	114.4	98.2	2,005	22.22	0.19	$ 139,541	$1,546	$ 258,325	$ 2,862	$ 25.02
	Oneida	396.79	119.5	121.0	6,511	16.41	0.14	$ 555,598	$1,400	$ 1,319,633	$ 3,326	$ 27.83
	Portage	569.76	104.9	105.8	6,269	11.00	0.10	$ 517,737	$909	$ 1,889,667	$ 3,317	$ 31.62
	Price	320.19	124.6	126.0	3,541	11.06	0.09	$ 309,334	$966	$ 1,084,660	$ 3,388	$ 27.19
	Shawano	524.17	107.2	112.1	6,376	12.16	0.11	$ 441,394	$842	$ 1,560,388	$ 2,977	$ 27.77
	Vilas	305.24	134.1	143.2	3,935	12.89	0.10	$ 376,476	$1,233	$ 965,949	$ 3,165	$ 23.60
	Waupaca	546.52	104.9	96.3	9,705	17.76	0.17	$ 725,365	$1,327	$ 1,868,085	$ 3,418	$ 32.58
	Waushara	345.01	102.9	93.9	3,987	11.56	0.11	$ 317,158	$919	$ 717,995	$ 2,081	$ 20.22
	Wood	429.28	96.5	100.3	5,755	13.41	0.14	$ 504,149	$1,174	$ 1,201,046	$ 2,798	$ 28.99
Region total		**6,407.19**			**88,814**			**$ 7,292,209**		**$ 20,258,377**		
Region average		**355.96**	**116.33**	**111.8**	**4,934**	**13.86**	**0.12**	**$ 405,123**	**$1,138**	**$ 1,125,465**	**$ 3,162**	**$ 27.18**
Sources: Cost data are final billed costs as billed to WisDOT by the counties. Salt data is taken from WisDOT's Salt Inventory Reporting System.												

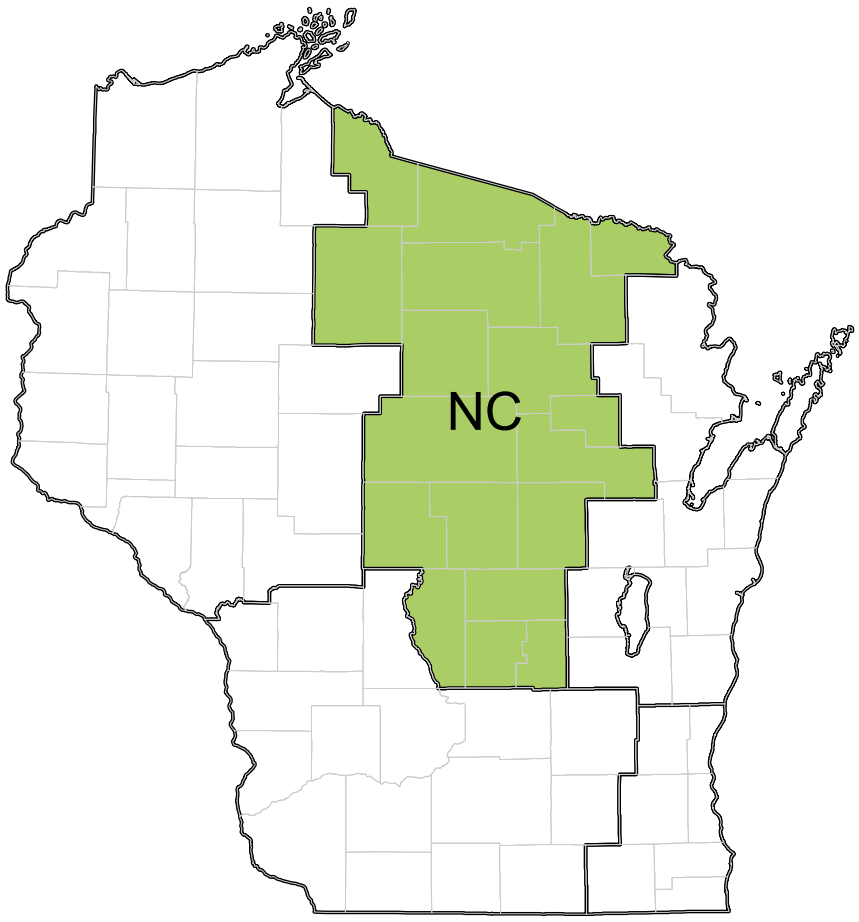


Table 1.4. Winter in Wisconsin, 2018-2019												
	County	Lane miles	MDSS Severity Index	Snowfall (inches)	Total salt used (tons)	Salt used (tons) per lane mile	Salt used per lane mile per Severity Index	Total salt costs	Total salt costs per lane mile	Total winter costs	Total winter costs per lane mile	Total winter costs per lane mile per Severity Index
Northeast Region												
	Brown	902.70	97.3	70.4	16,251	18.00	0.19	$ 1,105,847	$1,225	$ 3,213,754	$ 3,560	$ 36.59
	Calumet	202.44	86.7	80.6	2,215	10.94	0.13	$ 139,713	$690	$ 494,146	$ 2,441	$ 28.15
	Door	271.80	100.9	98.4	3,465	12.75	0.13	$ 224,021	$824	$ 840,471	$ 3,092	$ 30.66
	Fond du Lac	608.36	93.5	90.0	9,031	14.85	0.16	$ 698,762	$1,149	$ 1,885,234	$ 3,099	$ 33.13
	Kewaunee	111.35	101.8	101.7	1,494	13.41	0.13	$ 102,978	$925	$ 371,088	$ 3,333	$ 32.75
	Manitowoc	426.63	93.9	61.3	6,872	16.11	0.17	$ 403,442	$946	$ 1,324,517	$ 3,105	$ 33.06
	Marinette	436.66	112.4	112.2	7,065	16.18	0.14	$ 448,796	$1,028	$ 1,306,949	$ 2,993	$ 26.64
	Oconto	469.52	114.0	96.9	5,114	10.89	0.10	$ 337,233	$718	$ 1,061,907	$ 2,262	$ 19.85
	Outagamie	538.99	98.6	93.1	8,111	15.05	0.15	$ 480,185	$891	$ 2,026,334	$ 3,760	$ 38.11
	Sheboygan	528.68	92.2	83.4	8,125	15.37	0.17	$ 620,529	$1,174	$ 1,822,498	$ 3,447	$ 37.39
	Winnebago	634.28	97.7	83.5	9,512	15.00	0.15	$ 665,192	$1,049	$ 2,061,062	$ 3,249	$ 33.28
Region total		**5,131.41**			**77,255**			**$ 5,226,697**		**$ 16,407,959**		
Region average		**466.49**	**98.99**	**88.3**	**7,023**	**15.06**	**0.15**	**$ 475,154**	**$1,019**	**$ 1,491,633**	**$ 3,198**	**$ 32.30**
Sources: Cost data are final billed costs as billed to WisDOT by the counties. Salt data is taken from WisDOT's Salt Inventory Reporting System.												

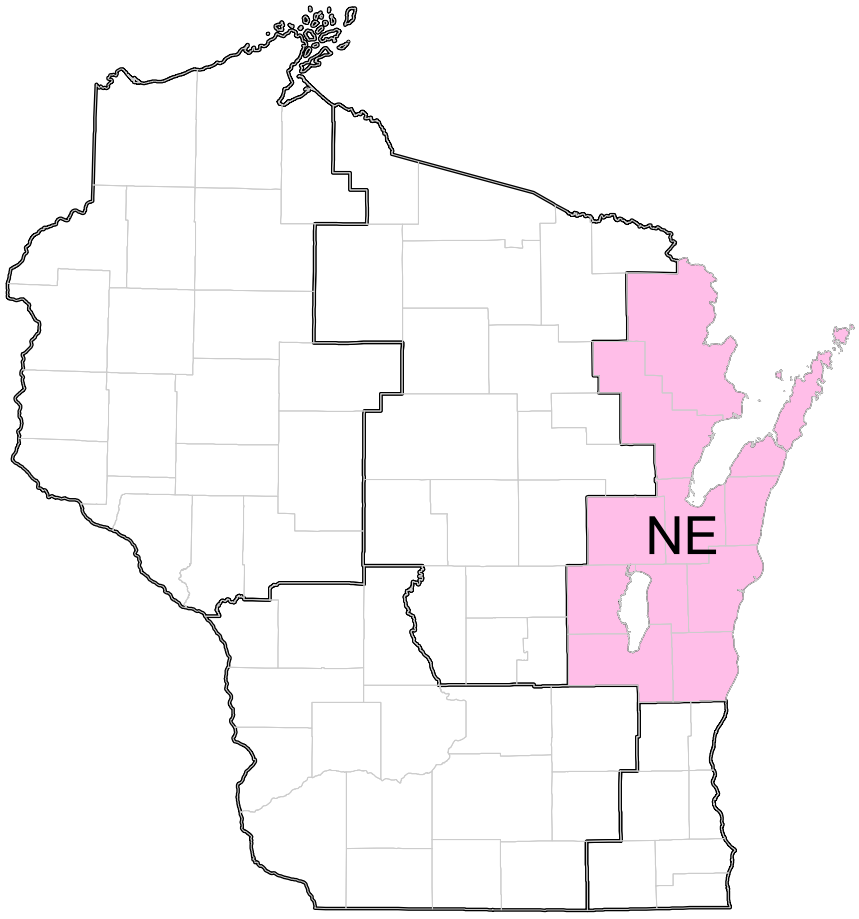


Table 1.4. Winter in Wisconsin, 2018-2019												
	County	Lane miles	MDSS Severity Index	Snowfall (inches)	Total salt used (tons)	Salt used (tons) per lane mile	Salt used per lane mile per Severity Index	Total salt costs	Total salt costs per lane mile	Total winter costs	Total winter costs per lane mile	Total winter costs per lane mile per Severity Index
Northwest Region												
	Ashland	245.35	154.1	172.2	3,048	12.43	0.08	$ 242,721	$989	$ 775,428	$ 3,160	$ 20.52
	Barron	428.77	107.0	117.2	4,006	9.34	0.09	$ 316,139	$737	$ 1,288,204	$ 3,004	$ 28.08
	Bayfield	316.42	133.4	138.2	5,477	17.31	0.13	$ 357,851	$1,131	$ 1,050,043	$ 3,319	$ 24.87
	Buffalo	317.02	101.6	127.1	3,049	9.62	0.09	$ 234,628	$740	$ 691,237	$ 2,180	$ 21.45
	Burnett	237.93	108.9	86.1	2,674	11.24	0.10	$ 178,845	$752	$ 582,586	$ 2,449	$ 22.48
	Chippewa	654.65	100.3	85.3	9,676	14.78	0.15	$ 755,924	$1,155	$ 2,199,251	$ 3,359	$ 33.49
	Clark	402.56	102.1	108.7	5,064	12.58	0.12	$ 444,294	$1,104	$ 1,121,590	$ 2,786	$ 27.30
	Douglas	451.40	129.6	134.6	7,636	16.92	0.13	$ 455,431	$1,009	$ 1,478,547	$ 3,275	$ 25.27
	Dunn	519.24	110.4	108.9	9,031	17.39	0.16	$ 651,318	$1,254	$ 1,629,272	$ 3,138	$ 28.43
	Eau Claire	540.70	106.2	89.7	8,501	15.72	0.15	$ 657,077	$1,215	$ 2,053,041	$ 3,797	$ 35.76
	Jackson	515.44	105.9	106.9	8,758	16.99	0.16	$ 686,165	$1,331	$ 1,625,328	$ 3,153	$ 29.79
	Pepin	112.38	102.6	89.7	961	8.55	0.08	$ 72,200	$642	$ 285,426	$ 2,540	$ 24.75
	Pierce	369.46	96.3	83.5	4,674	12.65	0.13	$ 329,493	$892	$ 1,066,646	$ 2,887	$ 29.97
	Polk	385.81	101.3	74.1	5,394	13.98	0.14	$ 432,317	$1,121	$ 1,129,984	$ 2,929	$ 28.91
	Rusk	213.47	113.9	97.2	2,639	12.36	0.11	$ 223,378	$1,046	$ 532,329	$ 2,494	$ 21.89
	Saint Croix	646.54	99.0	103.5	10,715	16.57	0.17	$ 723,688	$1,119	$ 2,106,377	$ 3,258	$ 32.91
	Sawyer	367.44	125.2	115.5	4,836	13.16	0.11	$ 392,359	$1,068	$ 832,923	$ 2,267	$ 18.11
	Taylor	233.90	113.0	99.4	2,232	9.54	0.08	$ 203,589	$870	$ 767,852	$ 3,283	$ 29.04
	Trempeleau	443.67	101.5	106.8	6,058	13.66	0.13	$ 460,192	$1,037	$ 1,247,165	$ 2,811	$ 27.70
	Washburn	372.14	122.1	86.4	6,059	16.28	0.13	$ 400,562	$1,076	$ 1,141,199	$ 3,067	$ 25.12
Region total		**7,774.29**			**110,490**			**$ 8,218,172**		**$ 23,604,429**		
Region average		**388.71**	**111.72**	**106.6**	**5,525**	**13.55**	**0.12**	**$ 410,909**	**$1,057**	**$ 1,180,221**	**$ 3,036**	**$ 27.18**
Sources: Cost data are final billed costs as billed to WisDOT by the counties. Salt data is taken from WisDOT's Salt Inventory Reporting System.												

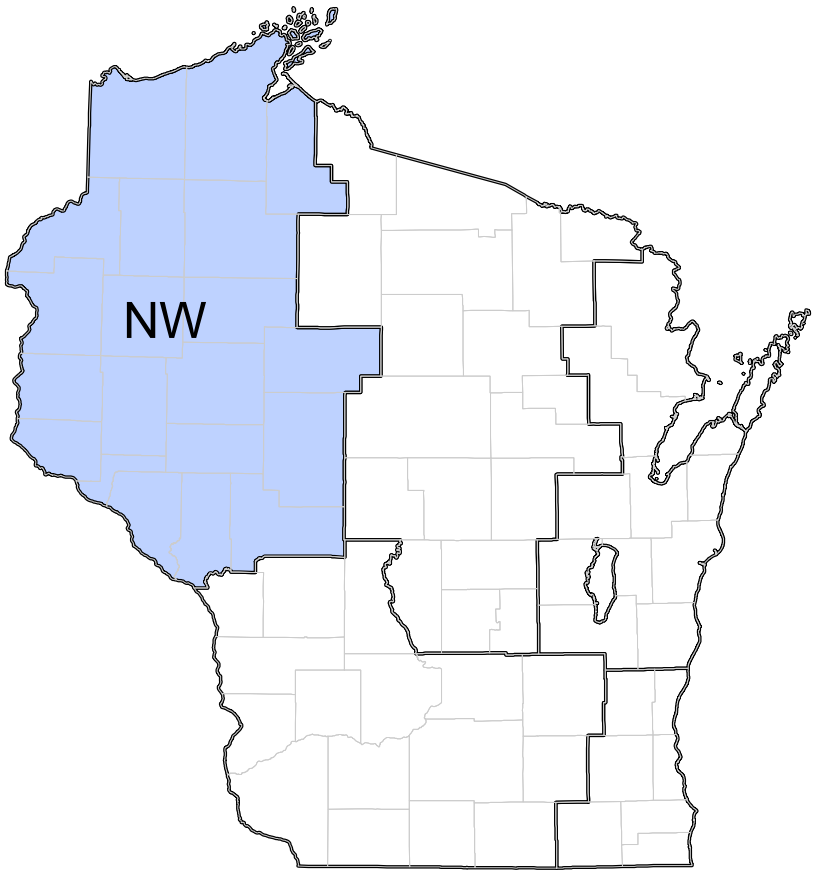
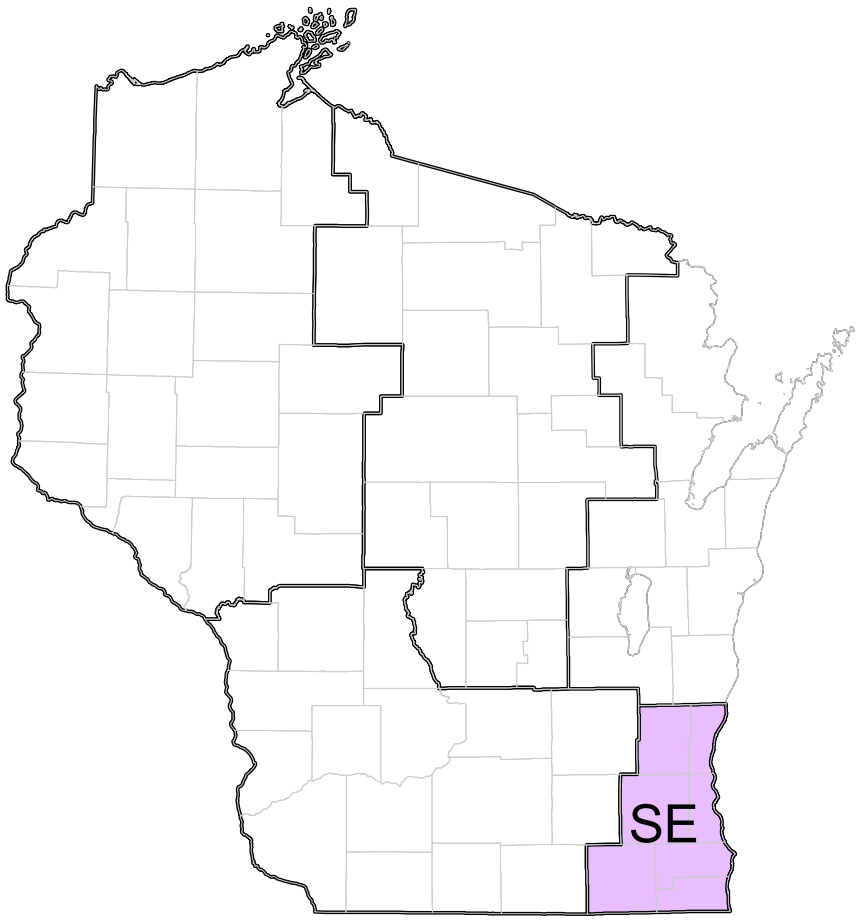


Table 1.4. Winter in Wisconsin, 2018-2019												
	County	Lane miles	MDSS Severity Index	Snowfall (inches)	Total salt used (tons)	Salt used (tons) per lane mile	Salt used per lane mile per Severity Index	Total salt costs	Total salt costs per lane mile	Total winter costs	Total winter costs per lane mile	Total winter costs per lane mile per Severity Index
Southeast Region												
	Kenosha	664.20	85.2	42.9	11,629	17.51	0.21	$ 693,325	$1,044	$ 1,935,718	$ 2,914	$ 34.21
	Milwaukee	1,973.24	89.7	55.6	35,105	17.79	0.20	$ 2,403,961	$1,218	$ 8,710,517	$ 4,414	$ 49.22
	Ozaukee	309.54	96.7	72.4	4,023	13.00	0.13	$ 248,468	$803	$ 978,215	$ 3,160	$ 32.67
	Racine	691.78	85.4	53.1	13,001	18.79	0.22	$ 902,686	$1,305	$ 2,152,992	$ 3,112	$ 36.46
	Walworth	707.92	99.2	65.1	15,505	21.90	0.22	$ 1,000,363	$1,413	$ 2,084,609	$ 2,945	$ 29.70
	Washington	612.97	96.8	74.1	13,779	22.48	0.23	$ 1,004,642	$1,639	$ 2,245,167	$ 3,663	$ 37.82
	Waukesha	1,087.33	81.5	75.9	21,990	20.22	0.25	$ 1,536,678	$1,413	$ 3,456,848	$ 3,179	$ 39.01
Region total		**6,046.98**			**115,032**			**$ 7,790,123**		**$ 21,564,066**		
Region average		**863.85**	**90.64**	**62.7**	**16,433**	**19.02**	**0.21**	**$ 1,112,875**	**$1,288**	**$ 3,080,581**	**$ 3,566**	**$ 39.34**
Sources: Cost data are final billed costs as billed to WisDOT by the counties. Salt data is taken from WisDOT's Salt Inventory Reporting System.												



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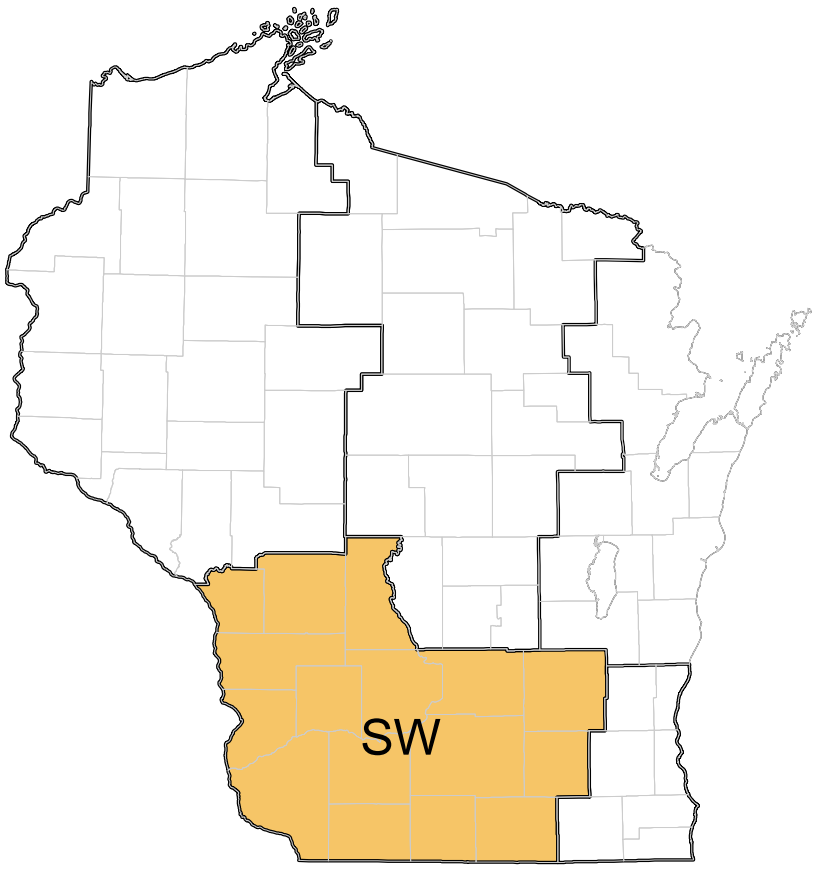
Southwest Region												
	Columbia	788.10	99.1	62.0	19,130	24.27	0.24	$ 1,556,037	$1,974	$ 3,091,899	$ 3,923	$ 39.57
	Crawford	397.19	96.8	77.1	4,816	12.12	0.13	$ 344,560	$867	$ 869,690	$ 2,190	$ 22.62
	Dane	1,545.15	87.2	53.2	40,634	26.30	0.30	$ 3,007,705	$1,947	$ 7,337,600	$ 4,749	$ 54.49
	Dodge	637.85	93.7	68.0	11,296	17.71	0.19	$ 759,985	$1,191	$ 1,850,331	$ 2,901	$ 30.97
	Grant	624.93	88.0	76.4	8,273	13.24	0.15	$ 552,804	$885	$ 1,442,194	$ 2,308	$ 26.21
	Green	314.64	85.4	54.5	3,233	10.27	0.12	$ 266,616	$847	$ 700,498	$ 2,226	$ 26.07
	Iowa	473.13	93.2	76.3	5,429	11.47	0.12	$ 376,129	$795	$ 1,226,299	$ 2,592	$ 27.82
	Jefferson	549.67	93.3	63.4	5,116	9.31	0.10	$ 381,278	$694	$ 1,462,935	$ 2,661	$ 28.53
	Juneau	496.27	108.8	75.0	9,256	18.65	0.17	$ 706,658	$1,424	$ 1,709,609	$ 3,445	$ 31.66
	LaCrosse	500.84	106.8	94.0	8,300	16.57	0.16	$ 538,593	$1,075	$ 1,601,421	$ 3,197	$ 29.93
	Lafayette	299.38	86.1	57.3	2,055	6.86	0.08	$ 142,578	$476	$ 616,405	$ 2,059	$ 23.90
	Monroe	666.31	112.3	87.6	11,652	17.49	0.16	$ 849,110	$1,274	$ 1,920,773	$ 2,883	$ 25.67
	Richland	327.64	97.9	73.0	3,584	10.94	0.11	$ 271,488	$829	$ 718,417	$ 2,193	$ 22.39
	Rock	690.06	90.5	56.1	11,363	16.47	0.18	$ 912,340	$1,322	$ 1,962,666	$ 2,844	$ 31.43
	Sauk	625.18	102.5	82.9	11,498	18.39	0.18	$ 1,027,830	$1,644	$ 2,108,902	$ 3,373	$ 32.91
	Vernon	477.82	117.1	80.7	6,217	13.01	0.11	$ 423,484	$886	$ 1,227,006	$ 2,568	$ 21.92
Region total		**9,414.16**			**161,851**			**$ 12,117,195**		**$ 29,846,645**		
Region average		**588.39**	**97.42**	**71.1**	**10116**	**17.19**	**0.18**	**$ 757,325**	**$1,287**	**$ 1,865,415**	**$ 3,170**	**$ 32.54**
Statewide total		**34,774.03**			**553,443**			**$ 40,644,396**		**$ 111,681,476**		
Statewide average			**105.70**	**92.9**		**15.92**			**$1,158**		**$ 3,212**	**$ 29.33**
Sources: Cost data are final billed costs as billed to WisDOT by the counties. Salt data is taken from WisDOT's Salt Inventory Reporting System.												



WISCONSIN
DEPARTMENT OF TRANSPORTATION

2 Winter Weather

In this section...

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This Winter's Weather.....20
Winter Severity Index.....21

Every winter is different. The number and type of storms, the range of temperatures, the amount of snow – these factors, along with many others, combine to create varying challenges for Wisconsin's county highway departments each year.

This section describes the weather Wisconsin experienced during the 2018-2019 winter, and the tools and methodologies WisDOT uses to analyze individual storms and the winter as a whole. The Winter Severity Index is one such tool – WisDOT uses it to facilitate comparisons from one winter to the next, and from county to county within the same season.

Winter Weather, 2018–2019

	Statewide average	Range across counties
Total snowfall[1]	**92.9 inches**	**43-216 inches**
Winter Severity Index[2]	**105.7**	**79-193**
Winter storms	**36.8**	**23-57**
Frost events	**3.7**	**0-29**
Freezing rain events	**14.8**	**0-18**

1. All data in this table is from Winter Storm Reports, 2018–2019.
2. Winter Severity Index is calculated from the Maintenance Decision Support System (MDSS) tool.

Tracking the Winter

Each week during winter, representatives from the 72 county highway departments complete winter storm reports. These reports give WisDOT the tools to manage statewide materials use and maintenance expenses as the winter progresses. *See page 65 for more information.*

Photo Credit: Pixabay- Creative Commons License

WINTER WEATHER CHALLENGES

Each year county highway departments face unique combinations of temperatures and storms, and draw on their experience in deciding what combination of snow and ice control strategies to employ. The number of storms has a more significant impact on resources expended than snowfall totals, since staff and equipment may be mobilized even if only 0.1 inches of snow or freezing rain falls. Weekend and evening storms may also be more costly than weekday storms because of overtime pay.

Storms with low temperatures can be difficult for crews because deicing agents become less effective at lower temperatures. Storms with high winds also are a challenge, because snow blows back onto the roadway quickly after the plows pass.

Counties in the northern half of the state tend to face colder temperatures and heavier snowfall than those in the southern half. Wisconsin's average annual snowfall ranges from about 40 inches in the south to as much as 160 inches along the shores of Lake Superior. In 2018-2019 snowfall ranged from 43 in the south to 216 in the north. The statewide average annual snowfall is 54.4 inches (30-year normal as recorded by the Wisconsin State Climatology Office).

On average, about 35 to 40 winter weather events hit Wisconsin each winter. While only a couple of large freezing rain events normally strike the state each winter, the state experiences numerous freezing drizzle and freezing fog events that cause roads to ice over.

THIS WINTER'S WEATHER

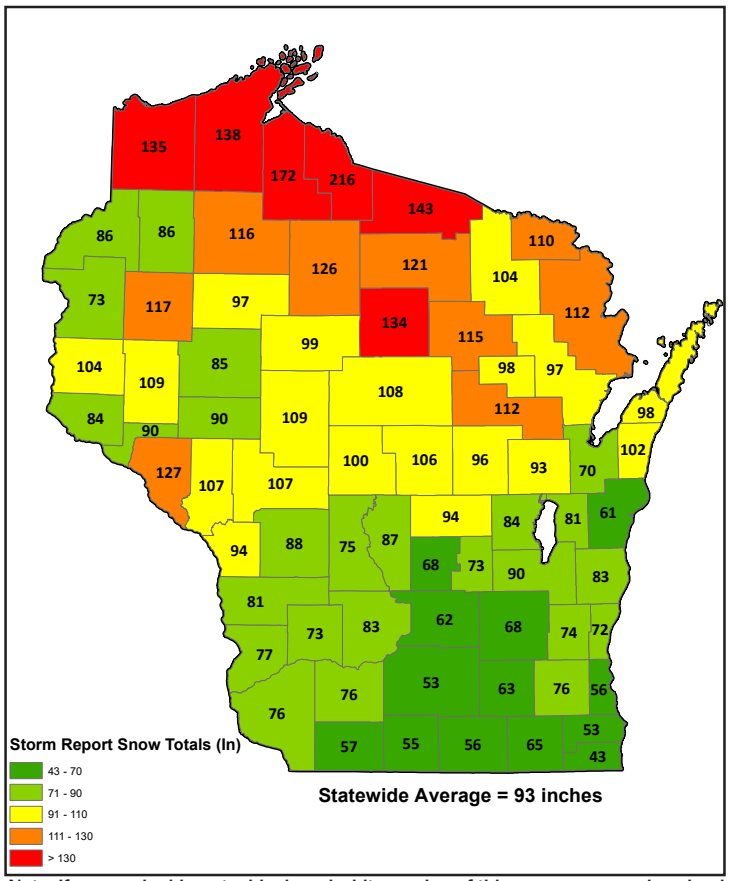
The winter season started off rather benign. Until the middle of January, severity was below average across most of the state. However, from that point until the end of February, winter hit with a vengeance. Frequent storms hit the state, and temperatures were well below normal. Lake Michigan and the Mississippi River both froze, causing delays in salt deliveries. More average conditions returned in March.

During the 2018-19 winter season, county highway departments responded to:

- A statewide average of 37 winter events per county, or 4 more than the previous winter. The high was 57 events in Iron County and the low was 23 events in Fond du Lac County.
- A statewide average of 4 frost events.
- A statewide average of 15 freezing rain events.

Figure 2.1 shows the total snowfall received in Wisconsin this winter based on storm report data. Snowfall varied significantly across the state; the highest snowfall recorded was in Iron County, at 216 inches; the lowest was in Kenosha County, at 43 inches. This winter's statewide average total snowfall was 92.9 inches.

Figure 2.1. Statewide Snowfall, 2018-2019
From Winter Storm Reports



Note: If you are looking at a black-and-white version of this map, you may download a color version of this report at http://wisconsindot.gov/Pages/doing-bus/local-gov/hwy-mnt/winter-maintenance/default.aspx

WINTER SEVERITY INDEX

WisDOT's Winter Severity Index is a management tool that allows the department to maximize winter maintenance efficiency by evaluating the materials, labor and equipment used based on the severity of the winter in a given county or region.

Developed in 1995, the severity index is calculated using a formula that includes:

- Number of snow events
- Number of freezing rain events
- Total snow amount
- Total storm duration
- Total number of incidents

Since all of these factors can affect materials use, the severity index gives the department a simple way to quantify severity that incorporates multiple factors into a single number. WisDOT uses the severity index in two ways:

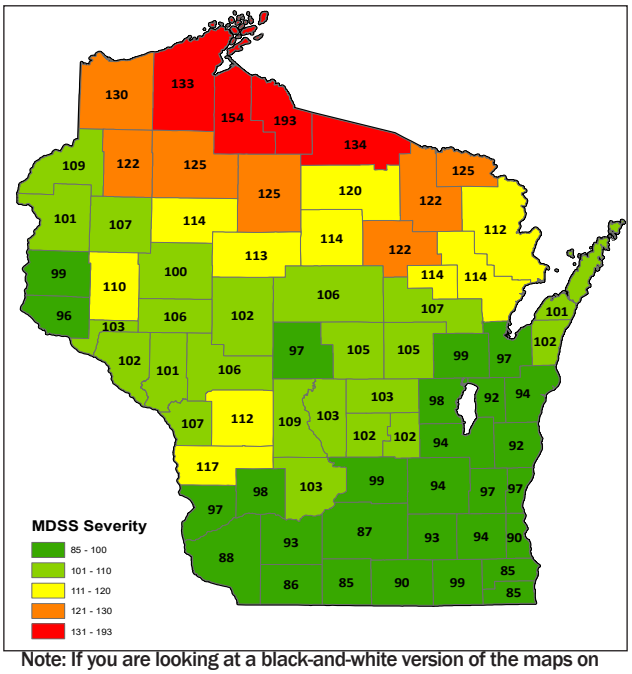
1. Season-to-season comparisons. This lets the department compare apples to apples when evaluating materials use and costs over several seasons, and identify trends in winter weather that can be useful in planning materials purchases. In the case of cost trends, adjusting cost data for severity index ranking can help WisDOT separate cost increases due to more severe winters from those due to increased labor costs, equipment costs, lane miles and other factors.

2. Regional comparisons. Since snowfall, number of storms, and other factors vary widely across the state, the severity index also helps WisDOT compare resources use from one region or county to another within a single winter. This allows WisDOT to assess whether materials are being used consistently, whether counties have enough staff, and other factors that affect each region's response to winter.

The Maintenance Decision Support System (MDSS) is used to compute the Winter Severity Index. Results are scaled such that the 5-year average is 100. A number above 100 indicates higher-than-average severity; a number below 100 indicates lower-than-average severity. We have begun scaling severity this way in order to make the numbers more easily understood. This winter:

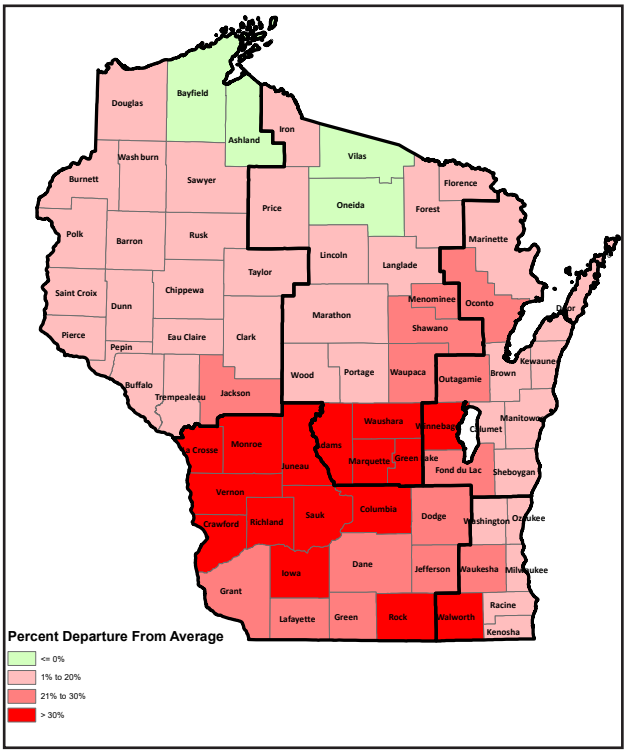
- The statewide average Winter Severity Index for 2018-19 was 105.7, which is 3.5 percent greater than the average of the previous five winters (102.4), and 4.3 percent greater than the average of the previous ten winters (101.6).

Figure 2.2. Winter Severity Index, 2018-2019



Note: If you are looking at a black-and-white version of the maps on this page, you may download a color version of this report at http://wisconsindot.gov/Pages/doing-bus/local-gov/hwy-mnt/winter-maintenance/default.aspx

Figure 2.3. 2018-2019 Winter Severity Index vs. 5-Year Average (2014–2015 to 2018-2019)



- Iron and Ashland Counties had the highest severity indexes, 193 and 154 respectively.
- Green, Kenosha and Racine Counties had the lowest severity index of 85.

With some exceptions across the state, this winter was slightly more severe than normal. Figure 2.2 on the previous page shows how severity index varied by county this winter, while Figure 2.3 shows how this winter's severity index for each county compares to the average of the previous five years in that county. The winter was most sever in the Southwest and South Central parts of the state.

Since the Winter Severity Index is an important tool for comparing cost and materials data from year to year, this report includes several charts that compare trends in winter measures over time with changes in severity index. This includes Figure 3.1, as well as Figure 3.2 (salt used per lane mile), Figure 4.1 (winter costs), and Figure 4.6 (winter crashes).

More information on the severity index is available by request from WisDOT:

- A report describing the process that was used to develop the severity index, including data on the five-year-average severity index for each county (March 1998).
- A table showing Winter Severity Index values for each county for the previous 10 winter seasons.

On the following pages, Table 2.1 gives details about the types of storms and other incidents (such as frost, ice, and drifting or blowing snow) that each county experienced this winter, as reported by the counties in their winter storm reports.

COUNTY-BY-COUNTY
TABLES FOR SECTION 2
WINTER WEATHER

WISCONSIN
DEPARTMENT OF TRANSPORTATION

Table 2.1 Storms and Incidents

From Winter Storm Reports, 2018-2019

Region	County	Snow Depth	Lane Miles	Salt Used	Tons /LM	Number of Storms	Types of Storms				Number of Incidents	Types of Incidents						Anti-Icing applic.
							Wet Snow	Dry Snow	Freezing Rain	Sleet		Drifting	Blowing Snow	Frost	Ice	Bridge Decks	Clean Up	
NC	LINCOLN	133.7	405.55	4123	10.17	39	26	15	18	16	18	6	3	0	10	5	11	14
	GREEN LAKE	73.1	158.44	1624	10.25	30	10	17	8	10	14	10	2	2	2	0	8	2
	MARATHON	108.1	874.81	9399	10.74	46	22	17	8	6	46	10	10	2	27	6	21	38
	PORTAGE	105.8	569.76	6269	11.00	44	29	16	16	1	24	10	7	1	7	2	18	10
	PRICE	126.0	320.19	3541	11.06	57	31	15	14	4	14	2	0	4	2	0	12	12
	WAUSHARA	93.9	345.01	3987	11.56	29	14	15	3	7	15	9	11	0	1	0	6	0
	SHAWANO	112.1	524.17	6376	12.16	39	9	32	8	5	37	7	6	0	7	14	31	7
	VILAS	143.2	305.24	3935	12.89	55	24	24	14	5	33	3	8	2	12	1	26	6
	WOOD	100.3	429.28	5755	13.41	47	34	22	16	16	17	7	7	5	7	0	13	13
	LANGLADE	115.0	299.21	4161	13.91	38	20	23	12	4	29	9	5	5	14	1	10	17
	ONEIDA	121.0	396.79	6511	16.41	38	16	21	13	5	12	1	1	3	7	0	7	6
	MARQUETTE	67.6	245.75	4172	16.98	30	7	30	9	11	15	5	4	2	2	0	12	11
	WAUPACA	96.3	546.52	9705	17.76	35	19	17	7	6	17	8	9	2	2	2	14	5
	IRON	215.6	249.56	4435	17.77	57	21	34	7	7	18	4	1	1	7	3	11	1
	FLORENCE	110.3	141.07	2544	18.03	44	26	12	11	10	28	6	3	4	9	5	20	5
	FOREST	104.2	312.38	6008	19.23	49	32	12	11	0	23	5	4	0	3	1	20	2
	ADAMS	87.1	193.20	4263	22.07	32	13	14	8	8	14	6	9	3	6	3	5	17
	MENOMINEE	98.2	90.26	2005	22.21	42	12	21	7	0	29	1	0	1	14	0	14	0
Region Average		111.8	355.96	4934	14.87	42	20	20	11	7	22	6	5	2	8	2	14	9

Final totals as of Friday, September 13, 2019

Table 2.1 Storms and Incidents

From Winter Storm Reports, 2018-2019

Region	County	Snow Depth	Lane Miles	Salt Used	Tons /LM	Number of Storms	Types of Storms				Number of Incidents	Types of Incidents						Anti-Icing applic.
							Wet Snow	Dry Snow	Freezing Rain	Sleet		Drifting	Blowing Snow	Frost	Ice	Bridge Decks	Clean Up	
NE	OCONTO	96.9	469.52	5114	10.89	40	18	31	10	13	23	11	4	7	6	7	17	14
	CALUMET	80.6	202.44	2214	10.94	32	14	21	5	0	24	8	1	2	2	1	13	9
	DOOR	98.4	271.80	3465	12.75	31	21	21	5	17	38	25	23	9	22	0	14	6
	KEWAUNEE	101.7	111.35	1494	13.42	35	17	20	8	7	16	13	12	1	4	0	7	6
	FOND DU LAC	90.0	608.36	9031	14.84	23	11	13	0	8	23	15	7	8	6	4	6	4
	WINNEBAGO	83.5	634.28	9512	15.00	30	12	20	3	8	24	1	2	5	1	10	18	6
	OUTAGAMIE	93.1	538.99	8111	15.05	37	24	11	3	12	16	8	5	4	5	2	8	3
	SHEBOYGAN	83.4	528.68	8125	15.37	28	13	16	13	15	36	13	8	29	6	5	27	39
	MANITOWOC	61.3	426.63	6872	16.11	31	13	11	8	2	12	1	1	2	3	0	5	7
	MARINETTE	112.2	436.66	7065	16.18	48	19	17	12	0	37	4	0	3	18	13	17	38
	BROWN	70.4	902.70	16251	18.00	34	13	16	8	9	4	1	1	1	2	0	1	26
Region Average		88.3	466.49	7023	14.41	34	16	18	7	8	23	9	6	6	7	4	12	14

Table 2.1 Storms and Incidents

From Winter Storm Reports, 2018-2019

Region	County	Snow Depth	Lane Miles	Salt Used	Tons /LM	Number of Storms	Types of Storms				Number of Incidents	Types of Incidents						Anti-Icing applic.
							Wet Snow	Dry Snow	Freezing Rain	Sleet		Drifting	Blowing Snow	Frost	Ice	Bridge Decks	Clean Up	
NW	PEPIN	89.7	112.38	961	8.55	25	10	17	5	8	20	12	13	7	10	13	13	9
	BARRON	117.2	428.77	4006	9.34	45	17	24	6	9	39	13	9	1	5	3	25	5
	TAYLOR	99.4	233.90	2232	9.54	42	27	18	11	2	42	17	12	6	23	10	19	20
	BUFFALO	127.1	317.02	3049	9.62	45	25	24	10	9	23	16	4	0	15	0	16	8
	BURNETT	86.1	237.93	2674	11.24	32	9	21	4	4	18	9	5	0	7	1	10	0
	RUSK	97.2	213.47	2639	12.36	43	26	8	11	8	17	6	3	0	6	3	10	2
	ASHLAND	172.2	245.35	3048	12.42	56	18	37	5	5	21	6	0	5	5	1	18	6
	CLARK	108.7	402.56	5064	12.58	41	20	15	8	3	29	16	0	5	9	0	17	11
	PIERCE	83.5	369.46	4674	12.65	36	13	22	9	8	21	14	9	0	13	6	20	1
	SAWYER	115.5	367.44	4836	13.16	44	26	14	8	6	14	2	3	0	8	2	6	0
	TREMPEALEAU	106.8	443.67	6058	13.65	47	16	23	12	13	9	6	5	3	4	1	6	2
	POLK	74.1	385.81	5394	13.98	41	9	21	10	1	30	11	15	0	19	0	11	1
	CHIPPEWA	85.3	654.65	9676	14.78	29	26	0	8	2	19	3	2	10	6	5	13	7
	EAU CLAIRE	89.7	540.70	8501	15.72	36	14	18	6	2	7	0	1	0	5	0	3	3
	WASHBURN	86.4	372.14	6059	16.28	47	30	13	8	8	13	2	3	2	2	3	9	1
	SAINT CROIX	103.5	646.54	10715	16.57	33	14	25	5	2	7	2	3	4	2	3	2	0
	DOUGLAS	134.6	451.40	7636	16.92	52	17	31	6	3	24	4	1	0	0	3	18	3
	JACKSON	106.9	515.44	8758	16.99	28	15	10	5	11	4	2	1	0	3	1	3	1
	BAYFIELD	138.2	316.42	5477	17.31	37	12	23	1	7	38	9	8	5	18	8	28	6
	DUNN	108.9	519.24	9031	17.39	42	14	21	9	2	11	5	5	3	0	2	1	5
Region Average		106.6	388.71	5524	13.55	40	18	19	7	6	20	8	5	3	8	3	12	5

Final totals as of Friday, September 13, 2019

Table 2.1 Storms and Incidents

From Winter Storm Reports, 2018-2019

Region	County	Snow Depth	Lane Miles	Salt Used	Tons /LM	Number of Storms	Types of Storms				Number of Incidents	Types of Incidents						Anti-Icing applic.
							Wet Snow	Dry Snow	Freezing Rain	Sleet		Drifting	Blowing Snow	Frost	Ice	Bridge Decks	Clean Up	
SE	OZAUKEE	72.4	309.54	4023	13.00	30	16	15	10	8	4	1	1	11	3	2	0	12
	KENOSHA	42.9	664.20	11629	17.51	32	16	10	9	2	0	0	0	0	0	0	0	7
	MILWAUKEE	55.6	1,973.24	35105	17.79	26	21	7	6	7	5	0	4	3	2	4	0	8
	RACINE	53.1	691.78	13001	18.79	30	14	23	4	6	15	10	6	0	13	8	9	18
	WAUKESHA	75.9	1,087.33	21990	20.22	35	17	14	4	9	0	0	0	0	0	0	0	0
	WALWORTH	65.1	707.92	15403	21.76	38	18	11	12	6	22	6	7	9	6	2	13	21
	WASHINGTON	74.1	612.97	13779	22.48	36	20	11	9	5	20	8	0	10	5	3	7	10
Region Average		62.7	863.85	16419	18.79	32	17	13	8	6	9	4	3	5	4	3	4	11

Table 2.1 Storms and Incidents

From Winter Storm Reports, 2018-2019

Region	County	Snow Depth	Lane Miles	Salt Used	Tons /LM	Number of Storms	Types of Storms				Number of Incidents	Types of Incidents						Anti-Icing applic.
							Wet Snow	Dry Snow	Freezing Rain	Sleet		Drifting	Blowing Snow	Frost	Ice	Bridge Decks	Clean Up	
SW	LAFAYETTE	57.3	299.38	2055	6.86	28	22	4	10	12	13	1	10	1	2	0	9	9
	JEFFERSON	63.4	549.67	5116	9.31	33	17	14	12	6	13	6	3	4	1	0	8	6
	GREEN	54.5	314.64	3233	10.28	32	11	14	12	5	10	3	3	3	0	0	7	9
	RICHLAND	73.0	327.64	3584	10.94	27	18	12	5	10	35	5	8	3	17	1	23	10
	IOWA	76.3	473.13	5429	11.47	32	20	11	6	6	23	8	5	8	3	2	13	11
	CRAWFORD	77.1	397.19	4816	12.13	37	12	20	11	9	41	18	6	9	10	1	19	9
	VERNON	80.7	477.82	6217	13.01	46	17	10	15	2	17	3	7	2	0	0	14	9
	GRANT	76.4	624.93	8273	13.24	29	22	6	7	7	33	6	11	6	4	3	20	4
	SAUK	82.9	709.92	11498	16.20	30	19	11	8	7	7	2	4	1	2	1	0	14
	ROCK	56.1	690.06	11363	16.47	32	16	21	9	0	10	1	0	0	4	3	5	3
	LA CROSSE	94.0	500.84	8300	16.57	26	24	10	6	7	11	6	4	11	1	0	6	14
	MONROE	87.6	666.31	11652	17.49	33	23	11	7	6	36	13	7	5	25	10	10	6
	DODGE	68.0	637.85	11296	17.71	26	19	5	2	7	11	2	3	2	6	0	1	11
	JUNEAU	75.0	496.27	9256	18.65	24	12	13	1	7	4	1	2	2	2	1	1	0
	COLUMBIA	62.0	788.10	19130	24.27	29	15	17	2	6	40	14	16	5	16	15	20	23
	DANE	53.2	1,545.15	40634	26.30	34	17	17	12	4	3	1	2	10	1	0	0	15
Region Average		71.1	593.68	10116	15.06	31	18	12	8	6	19	6	6	5	6	2	10	10

Final totals as of Friday, September 13, 2019

Table 2.1 Storms and Incidents

From Winter Storm Reports, 2018-2019

Region	County	Snow Depth	Lane Miles	Salt Used	Tons /LM	Number of Storms	Types of Storms				Number of Incidents	Types of Incidents						Anti-Icing applic.
							Wet Snow	Dry Snow	Freezing Rain	Sleet		Drifting	Blowing Snow	Frost	Ice	Bridge Decks	Clean Up	
Statewide Averages		--	484	7685	14.86	36.8	18.1	17.0	8.2	6.5	19.9	6.7	5.1	3.7	6.9	2.9	11.5	8.9

3 Winter Operations

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Wisconsin county highway departments use an array of strategies to combat winter storms. Materials, equipment and labor are three key pieces of the puzzle; county patrol superintendents use their skills and experience to combine these pieces in the most efficient way possible for each storm.

This section describes the counties' response to the 2018-2019 winter season, including materials use, best practices in equipment and technology, and training efforts. Most counties have added prewetting and anti-icing to their arsenal of best practices—strategies that help them use materials efficiently, save money and minimize environmental impacts.

Statewide Materials Use, 2017-2018

Total salt used[1]	**553,443 tons**
Total salt used per lane mile	**15.9 tons**
Total cost of salt used[2]	**$40,644,396**
Average cost per ton of salt	**$73.51**
Total abrasives used	**21,019 cubic yards**
Total brine and blends used	**9,393,029 gal.**

There's More on the Web!

Looking for more information about winter maintenance in Wisconsin? WisDOT's extranet site features detailed reports on products, equipment, best practices and more.

See http://wisconsindot.gov/Pages/doing-bus/local-gov/hwy-mnt/winter-maintenance/default.aspx

1. Salt use data is final data from WisDOT's Salt Inventory Reporting System.
2. Cost data is actual salt costs as billed to WisDOT by the counties.

Photo Credit: Pixabay-Creative Commons License

3A. MATERIALS

Salt remains the primary material used in winter maintenance. The advent of prewetting has improved the efficiency of materials use (by keeping more of the material on the road instead of scattering off the edges), and proactive anti-icing applications have reduced the amount of salt needed to keep roads clear. Direct Liquid Application is also becoming increasingly more common across the State as it saves taxpayer dollars, and reduces harm to the groundwater and environment.

Salt

Salt is a critical part of a highway crew's response to winter storms in Wisconsin. When salt combines with ice or snow, it creates a brine solution with a lower freezing point than water. This solution then acts to break the bond between the ice or packed snow and the pavement, which allows the snow to be removed more easily through plowing.

Due to cost and environmental concerns, maintenance crews strive to use the smallest amount of salt necessary to provide an appropriate level of service for each roadway. Best practices to reduce salt use include Direct Liquid Application, prewetting, anti-icing, under body plows, etc.

Historically, counties have used disproportionately more salt during more severe winters. Between the winters of 2006 -07 and 2015-16, Winter Severity Index fluctuated greatly, as did salt usage. Since 2016 both Winter Severity Index and salt usage have remained relatively stable. Figure 3.1 plots the average statewide salt use per lane mile versus the average statewide Winter Severity Index. Looking back over the past 20 plus years of data, this year's salt use and severity index was most similar to 1992-1993. This winter's statewide Winter Severity Index of 106.0 was 8.6 percent higher than the previous year, while salt use declined 2.4 percent from the previous year, at 553,443 tons. See Table 1.4 for county-by-county salt use data for this winter.

Wisconsin counties applied a statewide average of 15.9 tons of salt per lane mile on state highways, a decrease of three percent compared with the 2017-2018 winter. (See Figure 3.10 for a county-by-county comparison.) When compared with nearby states, which differ by winter severity and level of service standards, Wisconsin salt use is relatively high. In 2018-2019 Wisconsin used 15.9 tons of salt per lane mile on state highways. Better use of BMPs may contribute to other states' lower rates of salt used per lane mile.

Figure 3.2 shows salt use per lane mile in each county, overlaid with severity index to allow a further "apples to apples" comparison of salt use in each county. The counties in Winter Service Groups A and B have more urban highways and tend to use more salt per lane mile for a given level of severity. See Figure 3.11 for a statewide map of tons of salt used per lane-mile.

For more detail on salt use in previous years, see Table A-7, "History of Salt Use on State Trunk Highways," in the Appendix.

Figure 3.1. Salt Use per Lane Mile and Average Severity Index From Salt Inventory Reporting System, 1992–2019

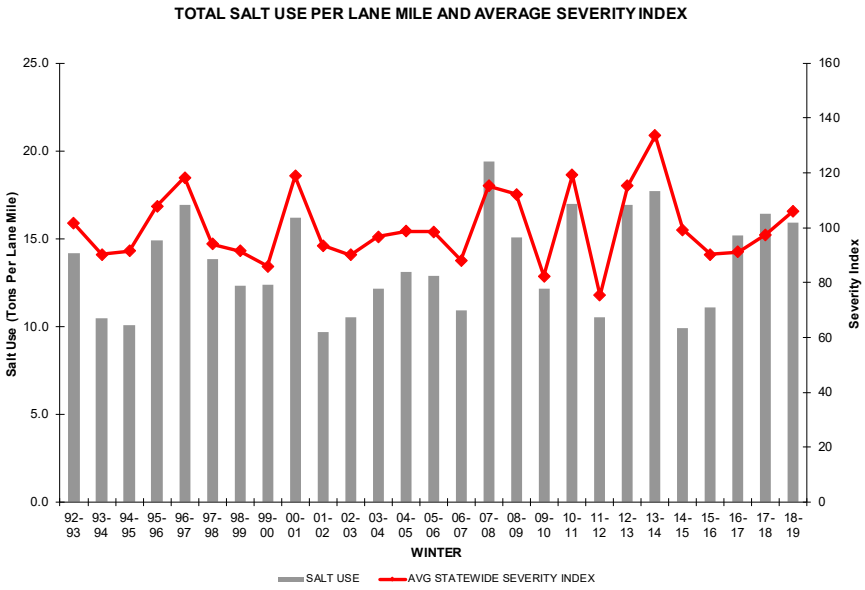
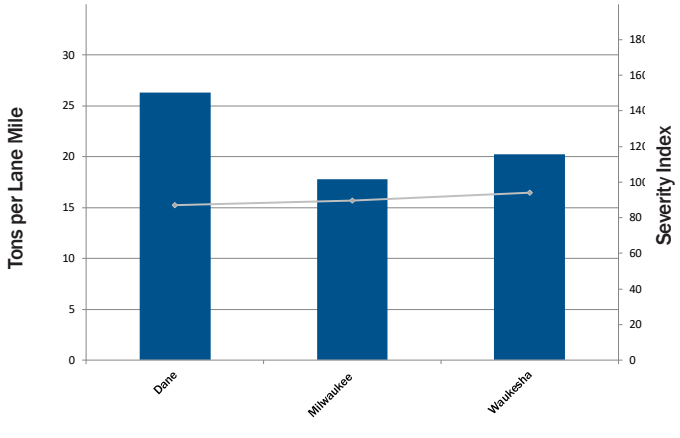


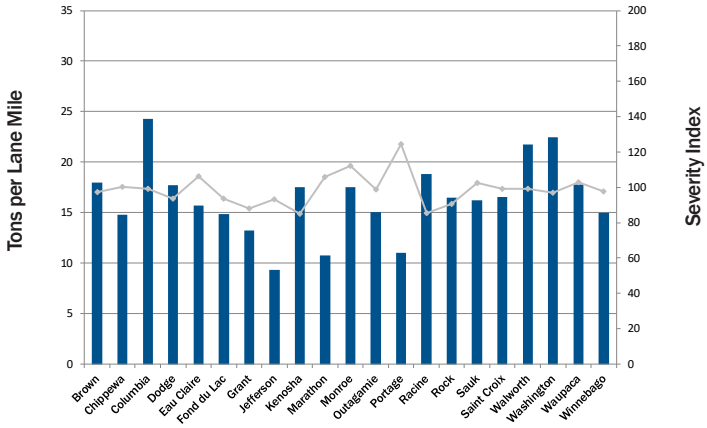
Figure 3.2. Salt Used per Lane Mile and Severity Index

From Salt Inventory Reporting System, 2018-2019

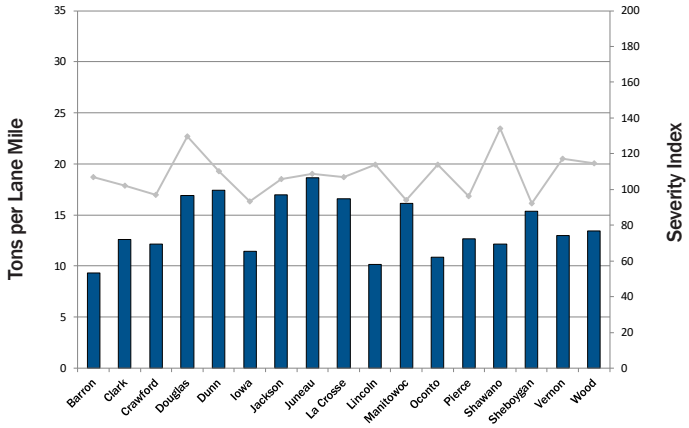
Salt Used per Lane Mile and Severity Index (Group A)



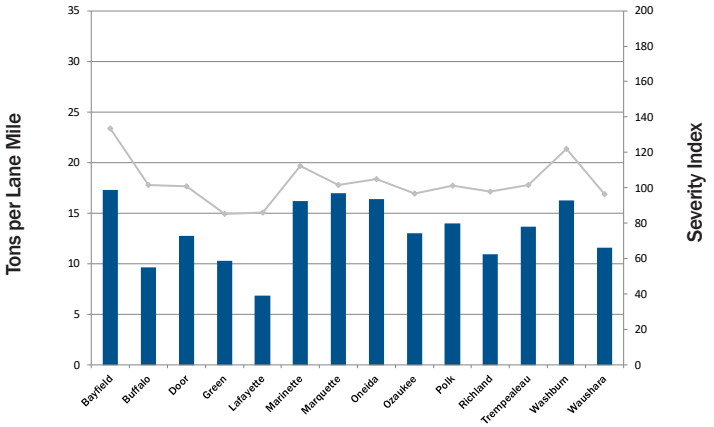
Salt Used per Lane Mile and Severity Index (Group B)



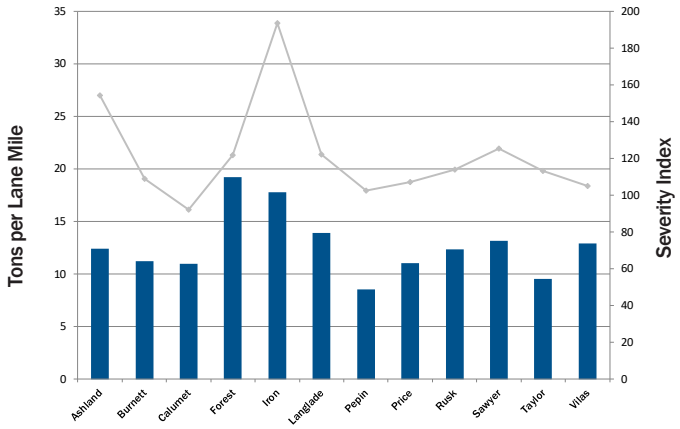
Salt Used per Lane Mile and Severity Index (Group C)



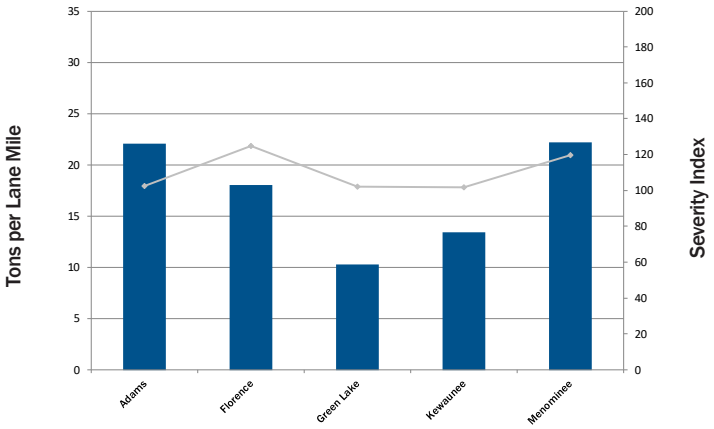
Salt Used per Lane Mile and Severity Index (Group D)



Salt Used per Lane Mile and Severity Index (Group E)



Salt Used per Lane Mile and Severity Index (Group F)

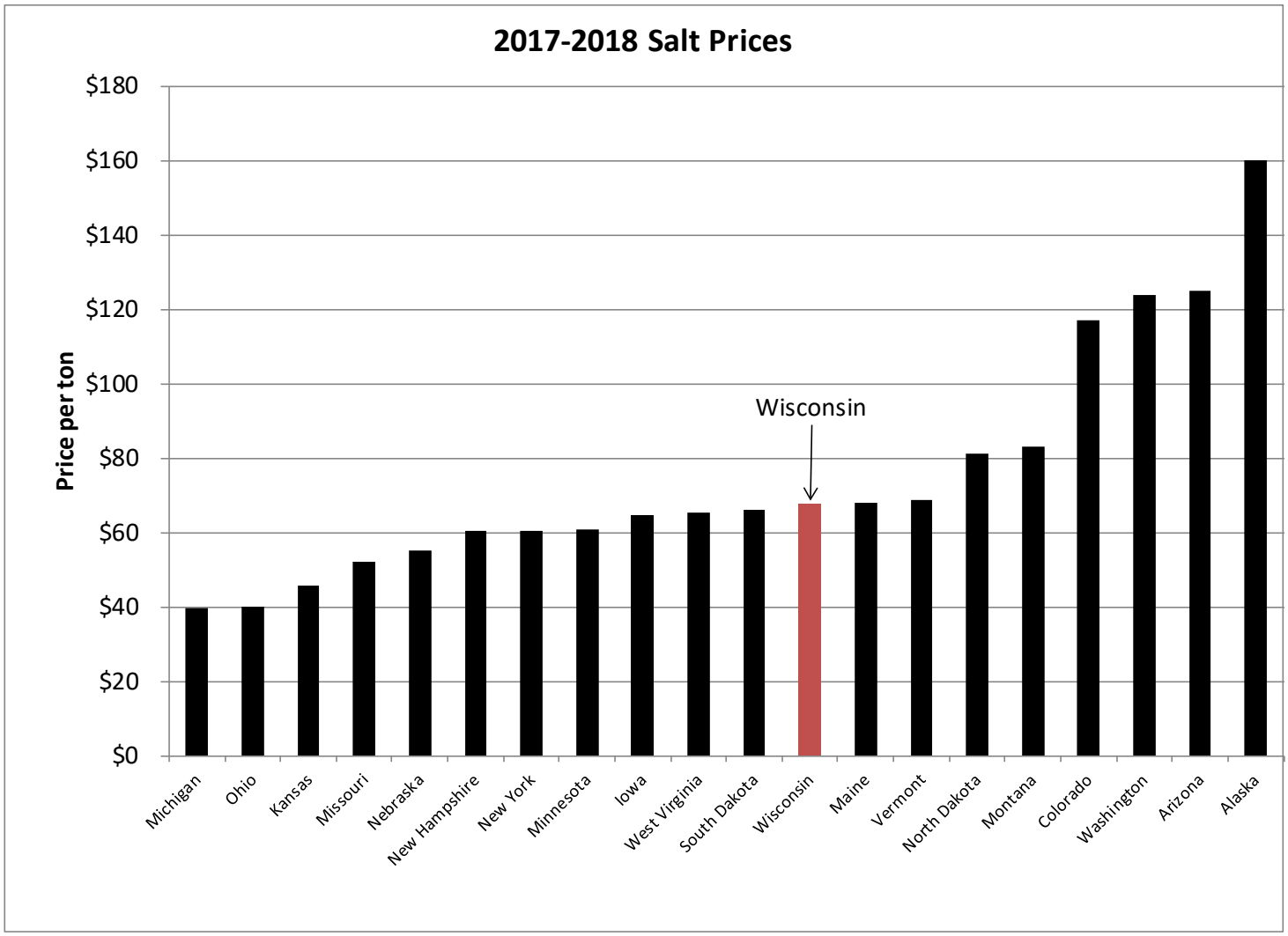


Salt used (tons) per lane mile — Severity Index

Figure 3.3. Salt Prices Across the United States 2017-2018

Source: Clear Roads

Note: Updated data for 2018-2019 has not yet been released



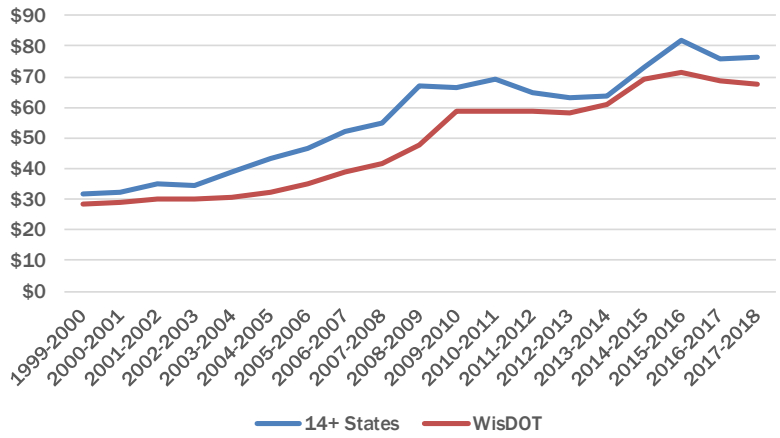
Cost of Salt

This winter, WisDOT spent $40,644,396 on salt statewide, purchasing salt at an average of $73.51 per ton. This is an increase of 8.7 percent from last year. Despite this increase, WisDOT still pays less per ton of salt than a number of other snowy states across the county, according to data compiled by Clear Roads. See Figure 3.3. Note this is 2017-2018 data as the 2018-2019 data has not been released yet.

Figure 3.4. Salt Prices Over Time (through 2017-2018)

Source: Historical data supplied by Clear Roads. From 1999 to present, the number of states reporting data has increased from 14 to 35 states.

Note: Updated data for 2018-2019 has not yet been released



The department speculates that the flexibility of its contracting method might account for lower prices when compared to its peers. Wisconsin's contracts include a 100 percent provision, which means that the department guarantees that it will purchase 100 percent of the contracted amount of salt. Some other states' contracts include an 80/120 provision that requires the salt vendor to keep 120 percent of the contracted salt amount on reserve, and commits the state to purchasing only 80 percent of the contracted amount. This 40 percent spread could translate to higher costs for states under an 80/120 contract.

For more on costs, see Section 4.

A Note About Materials Data

This winter marks the tenth year that all salt data in this report comes from WisDOT's Salt Inventory Reporting System (SIRS). In previous years, some tables used preliminary salt use data collected in the weekly winter storm reports. Sand use data continues to come from the storm reports, as does some detailed anti-icing and prewetting data. These materials use estimates are included in this report because they provide a level of detail and correlation with storm events that is not available from SIRS or from final financial data. The source of each table's data is indicated below the table title.

Abrasives

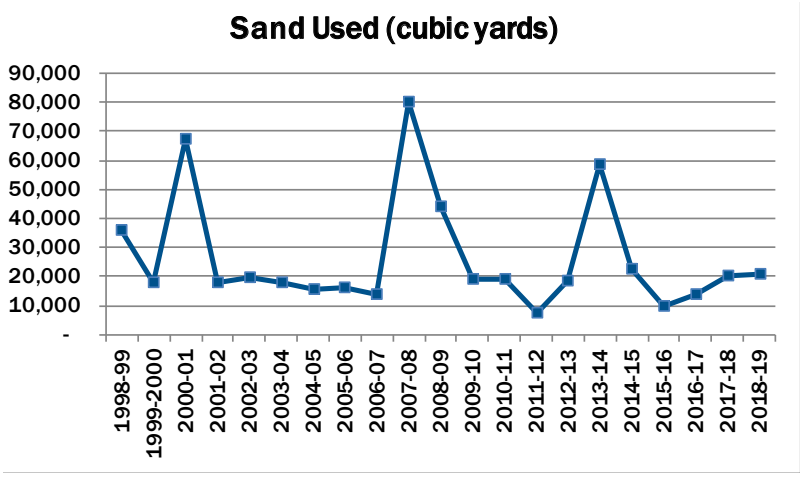
County highway departments sometimes use sand and other abrasives to improve vehicles' traction on icy or snowy roads or when temperatures are too low for salt to be effective. Abrasives are somewhat effective in low-speed trouble spots and intersections. Abrasives should be prewetted with a liquid agent for better adherence to the roadway.

A total of 21,019 cubic yards of sand was used by 61 counties on state highways this winter, a 16 percent decrease from the average of the five previous winters (24,992 cubic yards).

In 2008, the Bureau of Highway Maintenance commissioned a synthesis report, "Limitations of the Use of Abrasives in Winter Maintenance Operations" to substantiate WisDOT's guidance to Wisconsin counties on reducing sand use. The report cites factors recommending against the use of sand that have been supported by research, and offers the following general conclusions:

- Sand used in a salt-abrasive mixture has not been shown to reduce accidents.
- Salt is more cost-effective than sand in winter maintenance operations.
- A salt-sand mixture requires approximately three times more material applied to the road to achieve the same effectiveness as pre-wetted salt and results in plows making more frequent return trips to the sand pile to fill up.

Figure 3.5. Statewide Sand Use From Storm Reports Data, 1998-2019



The 2008 synthesis report is available on-line at: http://clearroads.org/wp-content/uploads/dlm_uploads/tsr-limitations-of-abrasives.pdf

Figure 3.5 compares this winter's statewide sand use with previous years'. The spikes in the figure are due to salt shortages.

Prewetting

Prewetting salt and sand with liquid deicing agents before or during their application to the pavement has several advantages. When used with dry rock salt, prewetting reduces loss of salt from bouncing and traffic action, which reduces the amount of material needed. Prewetting also improves salt penetration into ice and snow pack, and begins dissolving the dry salt, which allows it to work more quickly. When used with abrasives, prewetting helps keep the sand on the pavement and may allow crews to use higher truck spreading speeds.

WisDOT encourages all county highway departments to prewet their salt and sand, and to explore stocking one or more deicing agents so that different agents can be used as conditions warrant. For example, salt brine can be reasonably used at pavement temperatures down to about 15°F, whereas agents such as magnesium chloride and calcium chloride are effective at lower pavement temperatures, to about 0°F. See Table 3.1 for details on statewide prewetting agent use.

Salt brine is a relatively inexpensive choice for prewetting. Salt brine use has increased significantly since counties first tested it a decade ago; 68 counties used salt brine for prewetting this winter (see Table A-5 of the Appendix for details). Counties used more salt brine and salt brine blends for prewetting this winter—6,377,338 gallons. Overall use of prewetting salt brine use increased by 66% percent. The increase in salt brine for prewetting is significant. While most counties in the state are applying salt brine as a prewetting agent, counties applying salt brine during winter storm events (direct liquid application) are reporting this liquid as prewetting. In winter 2019-20, the storm report form will be modified to provide an additional option for liquids applied during a storm event to better track how liquids are used in winter maintenance.

In addition to salt brine, some counties used calcium chloride, magnesium chloride, or agricultural-based products for prewetting this year. See Table A-6 in the Appendix for details. Organic blends seem to be preferred over the straight chemical products because they adhere to the pavement longer. The addition of the organics helps reduce corrosion of equipment. Although once the only option for prewetting, calcium chloride is a more corrosive chemical than other prewetting liquids and can damage equipment and be more difficult for operators to handle.

BEST PRACTICES: On-Board Prewetting

WisDOT encourages counties to prewet salt before applying it to the roadway. Agencies across the country and worldwide consider prewetting a best practice, and some require that all material be prewetted before it is placed. Studies have shown that prewetting significantly improves the amount of material that stays on the road. On-Board prewetting is preferred because it is the simplest way to ensure that salt is being uniformly prewetted.

Some counties choose to prewet their salt directly in the pile. The benefit to this approach is that less equipment is required on salt trucks. Juneau County has had success with this method.

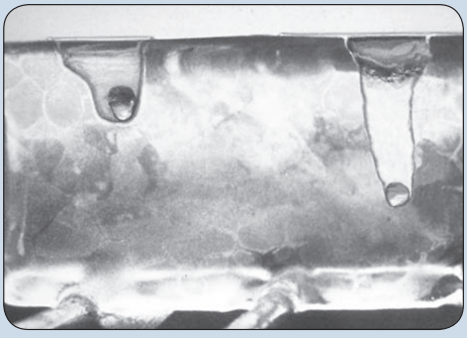
Wisconsin Transportation Bulletin No. 22 (December 2005) notes that as much as 26 percent more salt stays on the roadway when prewetted versus dry salt is used. Pre-wetting salt has been used since the late 1960s. In addition to reduced loss of salt from bounce and scatter, advantages of pre-wetting salt include:

1) Quicker melting.

2) Better salt penetration into ice and snow pack.

3) Salt melts at lower temperature if wetted with other deicing chemicals (generally limited to pavement temperatures above 20°F).

For more information on prewetting, see Chapter 6, Section 20 of the State Highway Maintenance Manual.



Faster melting action is the main benefit of pre-wetting salt. After 20 minutes the difference is significant. This photo shows two salt particles penetrating ice. The one on the right was pre-wetted.

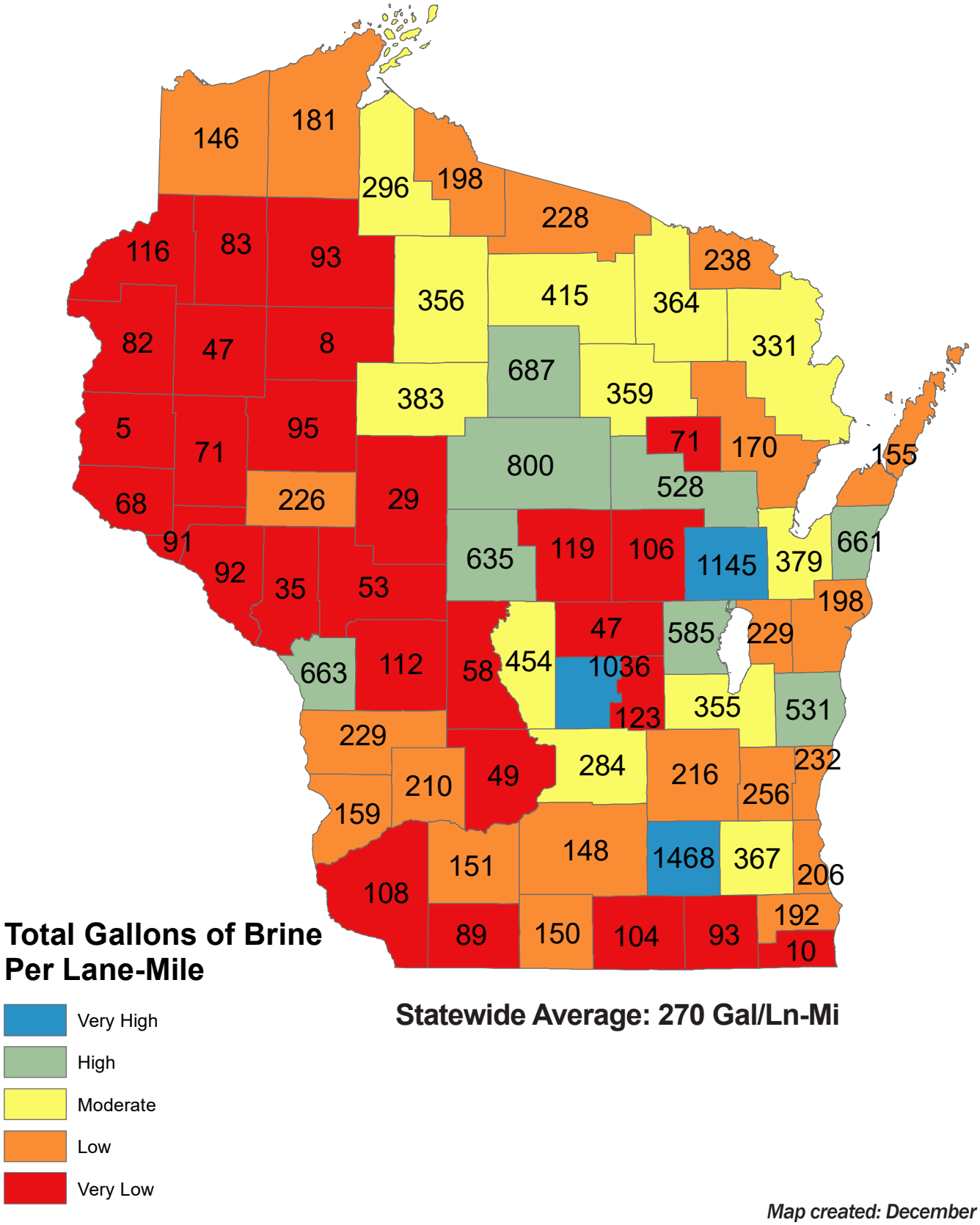
Nearly all counties (94 percent) pretreat salt, in which a liquid prewetting agent is spray-applied to the salt supply before the salt is placed in storage. According to the Minnesota Snow and Ice Control Field Handbook for Snowplow Operators (published by the Minnesota Local Road Research Board), when treating a stockpile of salt, a liquid deicing chemical should be applied at a rate of 4 to 6 gallons/ton. Since liquid prewetting increases the leach risk of the stockpile, salt should be stored on an impervious pad.

While prewetting salt is the best practice in Wisconsin—68 of 72 counties prewetted their salt this winter—prewetting abrasives is far less common, but still considered a best practice. WisDOT strongly encourages counties to prewet their sand, since keeping sand on the pavement can reduce the amount of material used, which saves money and reduces environmental impacts. The Minnesota Snow and Ice Control Field Handbook for Snowplow Operators recommends prewetting sand at a rate of 4 gallons of salt brine/ton of sand.

Table 3.1. Statewide Brine Agent Usage

Agent	*Prewet Gallons Used*	*# counties using PreWet*	*Anti-Icing Gallons Used*	*# counties using Anti-Icing*
Salt Brine	6,070,558	68	2,790,475	63
Calcium Chloride				
$CaCl_2$ - Liquid	132,121	13	57,502	4
Magnesium Chloride				
$MgCl_2$ - Liquid	15,602	5	2,260	2
Proprietary Mixtures				
IceBan M80	6,885	1	-	-
FreezeGuard	29,399	11	13,053	3
Dow Armor	4,091	2	-	-
M95	5,846	4	-	-
M90	-	-	-	-
GeoMelt	962	1	4,150	1
BioMelt 55	-	-	-	-
IceBite 55	350	1	-	-
Beet 55	51,845	7	7,677	7
AMP	22,460	4	18,636	3
BeetHeet	184,942	15	14,393	7
Total Liquid Used	**6,525,061**		**2,908,146**	

Figure 3.6. Total Gallons of Brine Per Lane-Mile

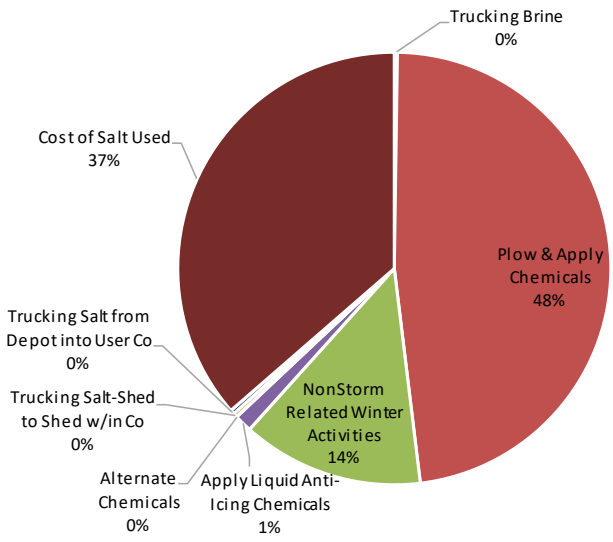


Map created: December 2019

Anti-icing

Anti-icing is a proactive snow and ice control strategy that involves applying a small amount of liquid deicing agent to pavements and bridge decks before a storm to prevent snow and ice from bonding with the surface. It is often used prior to light snowfall or freezing drizzle, and is also effective at preventing frost from forming on bridge decks and pavements. Anti-icing can reduce salt use, reduce materials costs, and improve safety.

Figure 3.7. Winter Costs by Activity Code, 2018-2019



Note: Total cost data differs slightly from cost data elsewhere in this report due to rounding.

This winter, counties used a record 2,908,146 gallons of anti-icing liquid (see Table A-3 in the Appendix for details). Currently, 63 of 72 counties (88 percent) are equipped to perform anti-icing operations, and this winter all 63 counties made at least one anti-icing application. (Counties may choose not to anti-ice if weather conditions do not warrant it.) The total statewide salt brine and salt brine blend usage of 2,848,384 gallons was a 124% increase from the total used in 2017-18. Similar to brines used in prewetting operations, some counties aplying salt brine during storm events could be reporting this liquid as anti-icing. By adding a direct liquid applications section to the storm report, the accuracy of liquids used during winter maintenance activities should improve. See Table A-5 in the Appendix for county-by-county data on salt brine use.

WisDOT encourages counties to explore stocking one or more agent for prewetting and anti-icing, so that a choice of agents is available for use according to pavement temperature and weather conditions. Table 3.1 shows the agents used for anti-icing in Wisconsin this winter.

BEST PRACTICES: Anti-icing (see Figure 3.7)

Anti-icing is a best practice not only nationwide, but across the globe. Anti-icing is the process of applying brine to the dry pavement- in the right conditions- prior to a winter storm. Agencies are finding that this technique, once reserved for bridge decks and trouble spots, yields excellent results on highways as well. More agencies are turning to anti-icing to help them use labor and materials efficiently, and to reduce overall salt usage.

This winter, Wisconsin counties used 2,908,146 gallons of anti-icing liquid—the most on record and an increase of 14% over last winter's total. Yet at 1.3 percent of total winter expenditures, anti-icing continues to represent a small fraction of winter costs which is why anti-icing is a highly recommended practice when appropriate. For more information on anti-icing, see Chapter 6, Section 15 of the State Highway Maintenance Manual.

Direct Liquid Application

The use of Direct Liquid Application (DLA) is relatively new in Wisconsin. Liquids applied directly to the pavement for deicing replace rock salt as the primary storm management tool. This not only reduces the amount of salt applied, but has been found to be more effective than solid salt.

In an effort to implement this practice in Wisconsin, WisDOT funded the purchase of 15 high-capacity brine makers for a number of counties (see Figure 3.8). Most of these counties began using DLA in 2018-19. The counties also outfitted some or most of their trucks with tanks capable of holding enough liquid to treat specific routes, along with high-pressure spray nozzles. This type of nozzle has proven more effective at penetrating the snow pack and reaching the road surface.

In addition, Jefferson County moved DLA directly to the interstate for the first time and found it to be more valuable for applying brine at higher speeds which were more equivalent to traffic speeds during winter operations. In addition, UW tops lab estimated time to bare wet pavement increased by 31%.

Figure 3.9 shows the counties that implemented DLA this past winter. In conjunction with this, WisDOT contracted with the University of Wisconsin Traffic Operations and Safety (UW TOPS) Lab to conduct an analysis of this technique in these counties. Preliminary results of the study are highly encouraging. Pavement time to bare/wet decreased significantly, and large savings in salt use were common. Phase 2 of this study will occur in the winter of 2019-20, with a final report due Summer 2020.

Jefferson County 2018/2019

- Reduction of **52.9%** in salt use (over 5-year average using winter severity)
- Averaged **1,468 gallons** of brine per lane mile (Iowa ~1,324 gal/lm)
- At $74.53/ton saved the State **$427,496** in salt purchase
- Extra Cost to produce the brine was ~ $45,000
- Jefferson County reported saving $206,000 on their county system
- Jefferson below region average labor and equipment costs AND salt use!

	Southwest Region Average per Lane Mile	Jefferson County results per Lane Mile
Total Labor Cost	$800.36	$652.53
Total Equipment Cost	$978.55	$904.52
Total Salt Used (including salt used in brine)	17.19 tons	9.31 tons

BEST PRACTICES: Direct Liquid Application (see Figure 3.9)

Direct Liquid Application is a best practice in Iowa and is slowly gaining traction in Wisconsin. Salt brine (possibly combined with other agents) is applied directly do the roadway during winter events to break the bond between snow and the pavement. High-capacity brine-makers are used to mix brines of various recipes. Specially equipped plow trucks with large tanks are used to apply the brine instead of rock salt. This results in faster time to bare/wet pavement and greatly reduced amounts of salt used.

Figure 3.8. Counties with High-Capacity Brine Makers or Brine Equipment

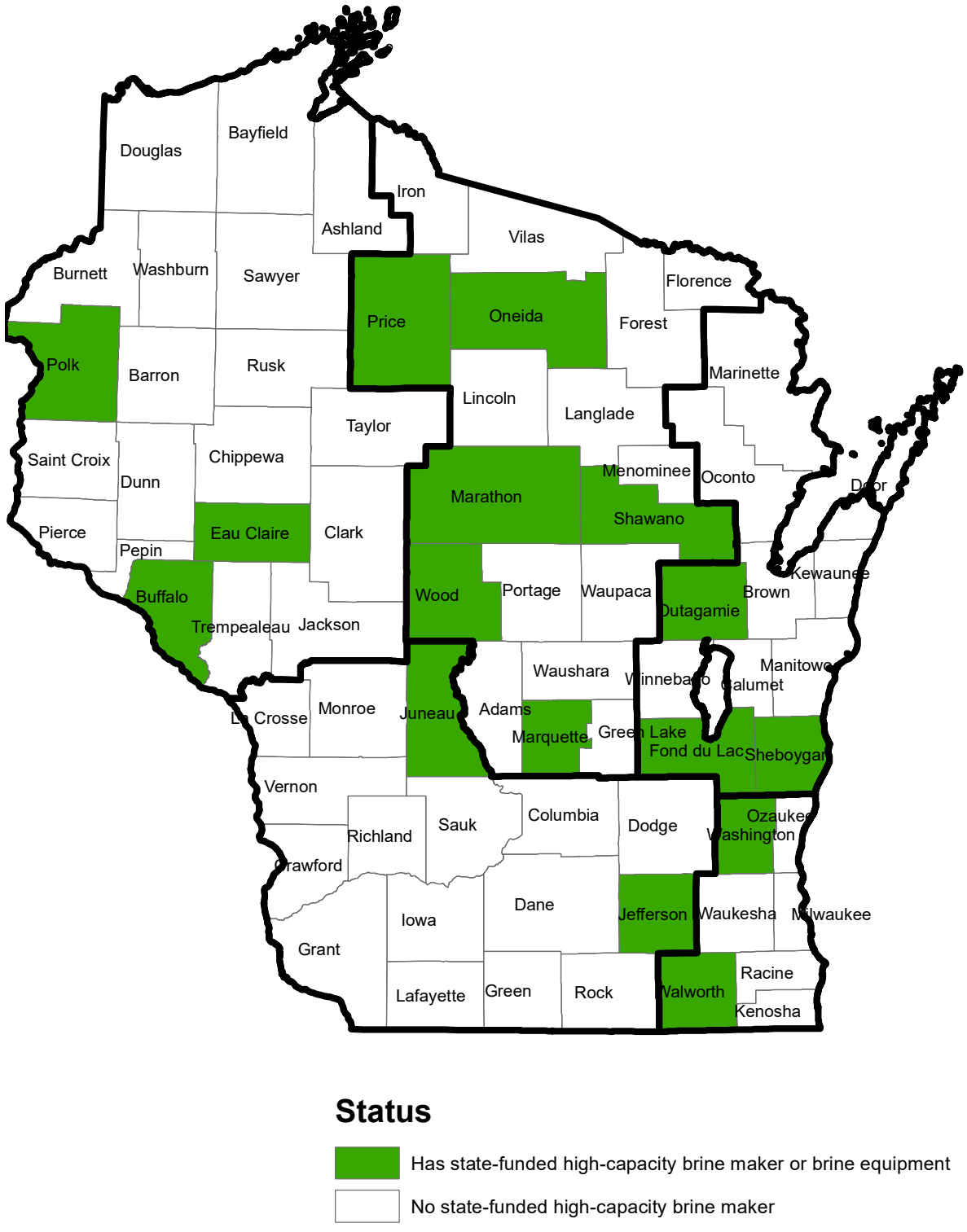
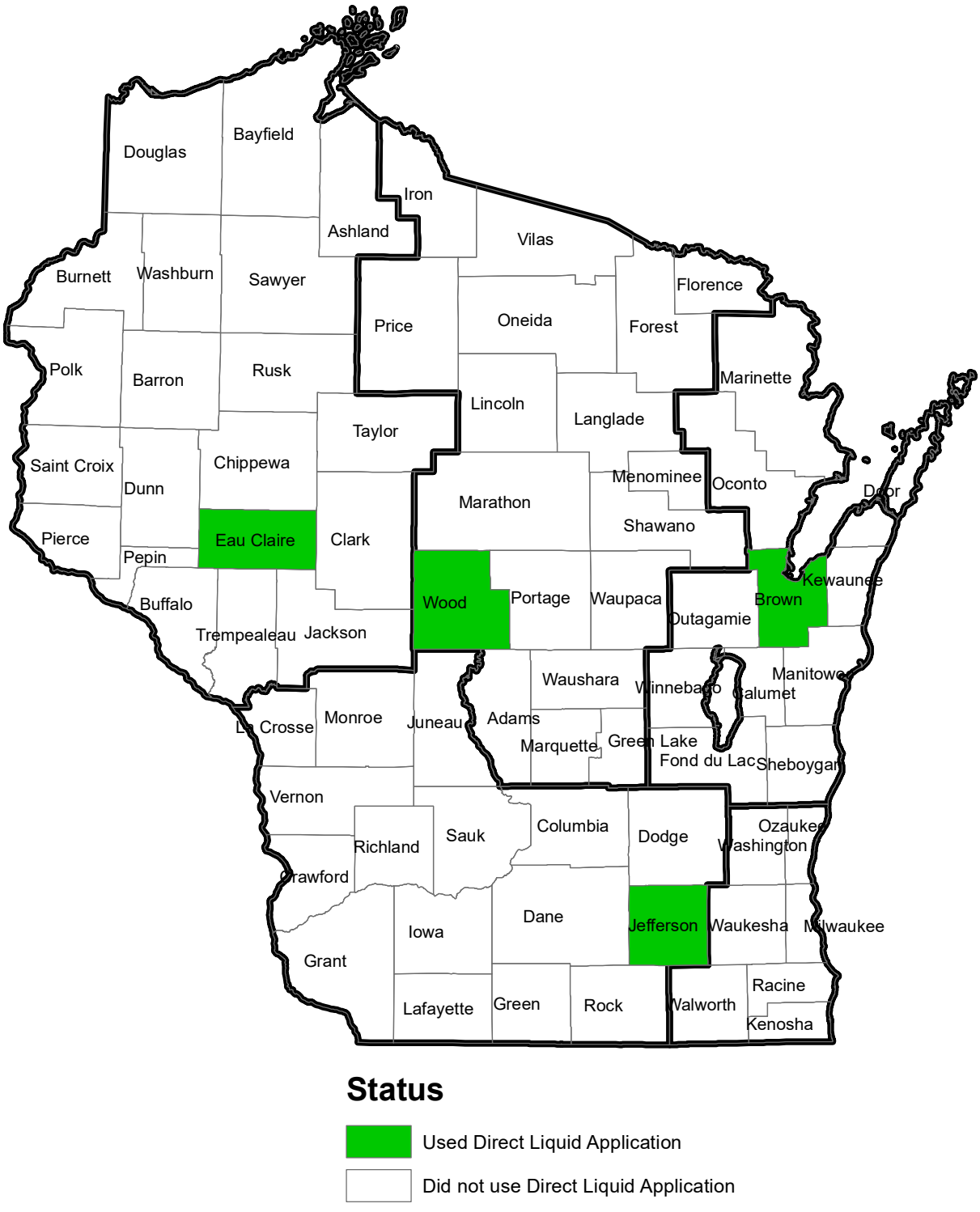


Figure 3.9. Counties Using Direct Liquid Application



Map created: October 2019

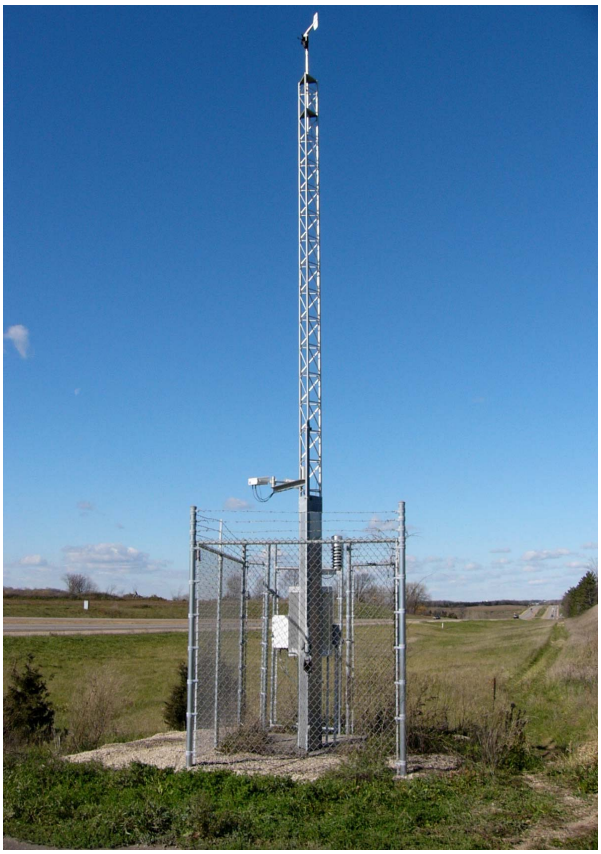
3B. EQUIPMENT AND TECHNOLOGY

As winter maintenance technology and practices evolve, the counties are continually expanding their arsenal of snow and ice control strategies. In recent years, Road Weather Information Systems (RWIS) have become an effective tool for anticipating winter weather. These systems are automatic weather stations and measure real-time conditions. The Maintenance Decision Support System (MDSS) is another key system WisDOT has implemented. MDSS assists in assessing conditions and recommends appropriate treatments for routes. Equipment calibration is another strategy which not only ensures materials are applied to the roadway consistently, but also reduces product waste and costs. Winter Maintenance Research is also important to help crews continue to stay up to date on the latest tools and practices. There are several research initiatives that WisDOT is part of including Clear Roads and Aurora.

Road Weather Information Systems (RWIS)

WisDOT has had a Road Weather Information System in place since 1986, and continues to expand and enhance the information available through this system. Designed to provide maintenance crews with the most accurate information about current and future weather conditions, WisDOT's RWIS system includes:

- 70 weather and pavement condition sensors along state highways.
- Detailed weather forecasts via the Maintenance Decision Support System (MDSS).
- A winter storm warning service for WisDOT and county highway departments.
- Over 1,000 mobile infrared pavement temperature sensors on patrol trucks around the state.



A roadside weather station.

WisDOT contracts with an RWIS consultant to manage its RWIS program. This onsite consultant serves as WisDOT's staff meteorologist and RWIS program manager and provides ongoing technical and administrative support for the state's RWIS systems.

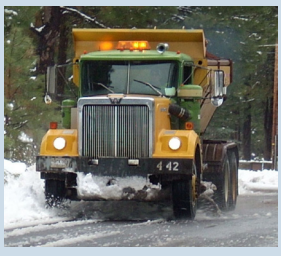
Major activities in WisDOT's RWIS program this year included:

- Management of the MDSS, as well as attending three meetings of the MDSS Pooled Fund Technical Panel.
- Assisting with WisDOT's AVL-GPS.

BEST PRACTICES: Underbody Plow

WisDOT encourages counties to use underbody plows when possible. If the plow blade is positioned in this way, it will apply downward pressure and can remove more snow pack and ice than a front-mounted plow. The underbody plow is most effective when removing hard packed snow and ice. In light and fluffy snow conditions, snow will compact a under truck with an underbody blade. Unevenness in pavement can also cause operating issues for this type of blade.

Photo credit: fancy-cats-are-happy-cats (https://commons.wikimedia.org/wiki/File:DesCoPlow.tif)



- Coordinating with Iteris on forecast services.
- Performing an annual weather forecast verification study, and monitoring comments from counties using the service.
- Providing MDSS and RWIS training for regional operations staff, the STOC, and county highway departments.
- Overseeing maintenance and repair of the department's RWIS equipment.
- Representing WisDOT on the Aurora Program board and the MDSS Technical Panel.

In addition, the RWIS program manager works to coordinate WisDOT's RWIS activities within Wisconsin and with other states and national agencies, including:

- Coordinating activities with the National Weather Service.
- Participating in national RWIS initiatives, such as Pathfinder.
- Providing RWIS presentations to WisDOT groups and agencies both inside and outside WisDOT.
- Working with NWS and BTO to develop the FHWA Pathfinder initiative

Other ongoing services provided by the RWIS program manager include:

- Managing contracts for weather forecast and winter storm warning services, and for system maintenance.
- Coordinating use of Winter Severity Index data as an accurate tool to measure the relative severity of winter seasons and researching a potential new winter severity index based on MDSS data.
- Establishing a plan for replacement of aging infrastructure, such as roadside towers and communications
- Ongoing assessment of new RWIS technology.
- RWIS program management (budgeting, billing, planning, etc.).
- Developing enhanced methods of data display using GIS technology.

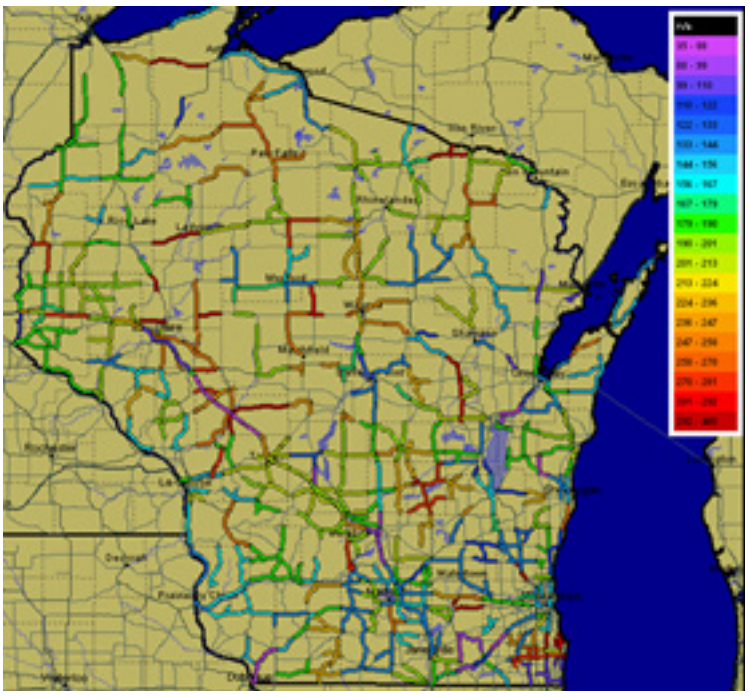
BEST PRACTICES: Ground speed controllers

Ground speed controllers have been shown to reduce salt use by controlling the amount of salt spread according to the speed of the truck. These controllers can also provide accurate data on salt use.

In addition to reducing costs, controlling salt application can help limit the amount of chlorides that get into the environment, minimizing the degradation of plant species and water quality near roadways. See Chapter 6, Section 20 in the Winter Maintenance Manual for more information.

Photo credit: apwa.net

Maintenance Decision Support System (MDSS)



BACKGROUND. Project management of MDSS activities continued to be a major focus for WisDOT.

CONFIGURATION. WisDOT continued its effort to improve route configuration in MDSS. Some progress has been made, but much work remains.

- WisDOT developed new ways to integrate MDSS and Geographic Information System (GIS). We downloaded data from the State's Metamanager system that contains details on all state highways. We then "overlaid" that information onto MDSS. By doing so, WisDOT was able to calculate the lane-miles on each MDSS route, something that had heretofore not been available. This should enable much easier salt use calculations in the future.

- WisDOT plans to revise county route information in those counties that are now using optimized routes.

MANAGEMENT TOOLS. WisDOT continued to collaborate with the MDSS Pooled Fund Technical Panel to develop new management tools for WebMDSS. Some new tools have already been implemented, but huge gaps remain between what was available in the desktop version and what is currently available in the web version. The pooled fund plans to have this completed by the end of summer 2019.

TRAINING. Training was once again held at the region level. WebMDSS and the mobile application were highlighted, with more emphasis on how to use the system in operations rather than just the basics of the system. WisDOT discussed a possible major revision to the training with Iteris that would hopefully make it much more interactive in the future.

MONITORING. WisDOT began using new Google Analytics data to monitor usage. There are questions about whether all user data is being collected.

COORDINATION. WisDOT attended three MDSS Pooled Fund Study Technical Panel meetings in Sioux Falls, SD. We interacted with other pooled fund members to elicit ideas that would help WisDOT. We provided two presentations on WisDOT's experience in implementing MDSS and its winter operations. We worked with Iteris on a continuing basis to resolve any issues that arose and to better understand the workings of the system.

We made several suggestions to the Pooled Fund Technical Panel for projects to be funded in the FY 2019 work plan, then coordinated WisDOT's response to project voting.

WisDOT worked closely with Southwest Region on numerous issues they discovered with route configurations in MDSS. Perhaps the biggest of them was that some routes were not aligned with the roads they were supposed to represent. WisDOT worked with Iteris to correct minor issues, and they agreed to examine major issues over the summer.

Equipment Calibration

Ensuring correct calibration of winter operations equipment—including salt spreaders, anti-icing applicators, and prewetting application equipment—is a key step in providing precise, consistent materials application, which reduces waste and saves money. Winter vehicles should be calibrated prior to the start of the season and whenever equipment is repaired. WisDOT regional staff are tasked with working with the counties to ensure proper calibration.

CALIBRATION SCALES. Proper calibration has been and always will be an important part of winter maintenance. If the calibration is off by even 10 percent, thousands of dollars worth of salt can be wasted in one winter season. The purchase of three ScaleTech scales has shown that to be a benefit with respect to the process of calibrating salt spreaders. The scales increase the accuracy, speed up the process, and make the process safer for the technicians doing the work. Originally there was going to be a two-year study on the scales but after calibrating a few spreaders it was very obvious that the scales would help the process. Therefore the study was discontinued and an email was sent to all the counties recommending that each county consider adding a scale to their inventory. At about $3k per scale the costs of the scales can be recovered in less than one winter season.

Product and Equipment Innovations

Winter maintenance is a continuously evolving field—new technology and innovations are developed each year and best practices are being disseminated to staff as efficiently as possible. One tool that has facilitated winter road maintenance staff's evaluation of deicing chemicals is a training DVD that was developed by Clear Roads and funded by twenty DOTs across the US (including Wisconsin).

The DVD was created to help DOTs meet level of service requirements under increasing budget and environmental constraints. The training helps DOTs determine the "best value" for both chemical and mechanical snow/ice removal practices. Initially, Clear Roads developed a step-by-step Field Guide for Testing Deicing Chemicals. More recently, Clear Roads has developed a step-by-step instructional video to accompany the field guide which demonstrates three levels of field testing that can be performed to determine the effectiveness of a deicing chemical. The final result was a DVD of approximately 15 minutes in length that is distributed to state DOTs for use in training their maintenance staff on basic field testing. The video is also available on YouTube. More information can be found on the Clear Roads website: http://clearroads.org/project/developing-a-training-video-for-field-testing-of-deicing-materials/.

Winter Maintenance Research

WisDOT joins other state DOTs in funding research projects of common interest. The two pooled fund groups where WisDOT participates are Clear Roads and Aurora. The projects from these entities allow WisDOT to combine funds with other states to provide more effective research for the dollar.

CLEAR ROADS. Clear Roads research is grouped into six areas: methods, equipment, materials, training, technology and safety. Launched in 2004 by Wisconsin and a few other states, Clear Roads now has 36 member states. They have completed 40 research projects conducted by universities and consultants, 19 projects in-house, and 9 projects that are currently in progress.

See the Clear Roads website for a complete list of completed projects: http://www.clearroads.org/completed-research/

Examples of recently completed research include:

- Snow Plow Operator and Supervisor Training – 22 modules
- Utilization of AVL/GPS technology
- Implementation of Liquid-only plow routes
- Emergency Operations Methodology for Extreme Winter Storm Events

Recent in-house synthesis projects include:

- Use of Prewetted Solid Materials for Roadway Anti-icing (in-progress)
- Annual Survey of State Winter Maintenance Data (some of this data is reflected in this report)
- Effective Snow and Ice Personnel and Equipment Management for Storm Activation

The synthesis projects can be found at this link: http://www.clearroads.org/synthesis-reports/

AURORA. Aurora is an international pooled fund partnership of public agencies that work together to perform joint research on road weather information systems (RWIS). Its membership includes 15 state DOTs, FHWA, and one international agency. WisDOT attended two meetings in person and participated in two web conferences. WisDOT is a member of several project technical panels. The most notable of these is a study of weight restriction models.

For a full list of Aurora projects, please go to http://www.aurora-program.org

3C. LABOR

Over 1,500 employees of Wisconsin's county highway departments are licensed to operate a snowplow, and over 1,000 of them are permanently assigned to the state highway system. Because a snowstorm can hit at any time of day, snowplow operators frequently put in overtime, and may plow for extended periods during heavy snowfall.

Labor costs vary from county to county according to each area's contracts, which also defines when overtime hours can be charged. This winter, counties spent over $31.3 million on labor, for an average of $900 per lane mile. Per-lane-mile labor expenditures increased 27 percent compared with last year's winter. An average of 28 percent of counties' winter maintenance costs were spent on labor, with a high of 35 percent in the Southeast Region, where hourly labor rates tend to be higher. Labor hours were up 17 percent for regular hours and 19 percent for overtime hours compared with last winter. See Table 4.10 for county-by-county labor expenditures and Table 3.4 for county-by-county estimated labor hours and costs from the winter storm reports.

Photo Credit: Pixabay Commons License

Winter Operations Training

Before each winter season, BHM provides and supports a variety of training efforts for WisDOT regional staff and county highway departments. Recent efforts have included:

- AASHTO Computer-Based Training. AASHTO offers eight computer-based training courses that can be completed by winter maintenance staff at their own pace as schedules permit. Course topics include anti-icing/RWIS, mitigating environmental impacts, equipment maintenance, plowing techniques, deicing, mitigating blowing snow, performance measures, and winter maintenance management. Counties are encouraged to have their operators complete the appropriate training courses, including courses for supervisors.
- RWIS Training. WisDOT's RWIS program manager provides training for both WisDOT regional operations staff and county highway departments. A summary of these training activities can be found in the RWIS Annual Report, available at https://dot-auth-prod.wi.gov/Pages/doing-bus/local-gov/hwy-mnt/winter-maintenance/reports.aspx.
- Regional Operations/County Fall Training Sessions. These sessions are held in all regions in preparation for the upcoming winter season, at some locations in conjunction with Snowfighters' Roadeos. WisDOT provided support and participated in some of these training sessions.
- Snowfighters' Roadeos. These events are held by some counties annually, with some roadeos held jointly by two or three counties. WisDOT has a Roadeo Manual to assist counties in organizing these roadeos. In addition, organizations such as the Wisconsin chapter of the American Public Works Association and the Wisconsin County Highways Association periodically host statewide Snowfighters' Roadeos.
- Clear Roads. Clear Roads began developing snowplow operator/supervisor training modules in 2015. The Wisconsin County Highway Association training committee reviewed the modules and made comments from the Wisconsin perspective. Twenty-four (24) modules were completed in Fall 2016.
- Winter Tech Talk. Hosted at Jefferson County Highway Department, including presentations from Dr. Wilf Nixon, Dr. Scott Koefod, and Dr. Hilary Dugan. This gave the counties an opportunity to come together to discuss winter maintenance as well as any problems or successes they have been having.
- Plow Driver Training. The Bureau of Highway Maintenance prepared and gave plow driver training to eight counties throughout the state. When comparing numbers from years past, this saved approximately $1.5 million in salt costs in those counties.

COUNTY-BY-COUNTY TABLES AND FIGURES FOR SECTION 3: SNOW AND ICE CONTROL

WISCONSIN
DEPARTMENT OF TRANSPORTATION

Figure 3.10. 2018-2019 Salt Use per Lane Mile vs. 5-Year Average

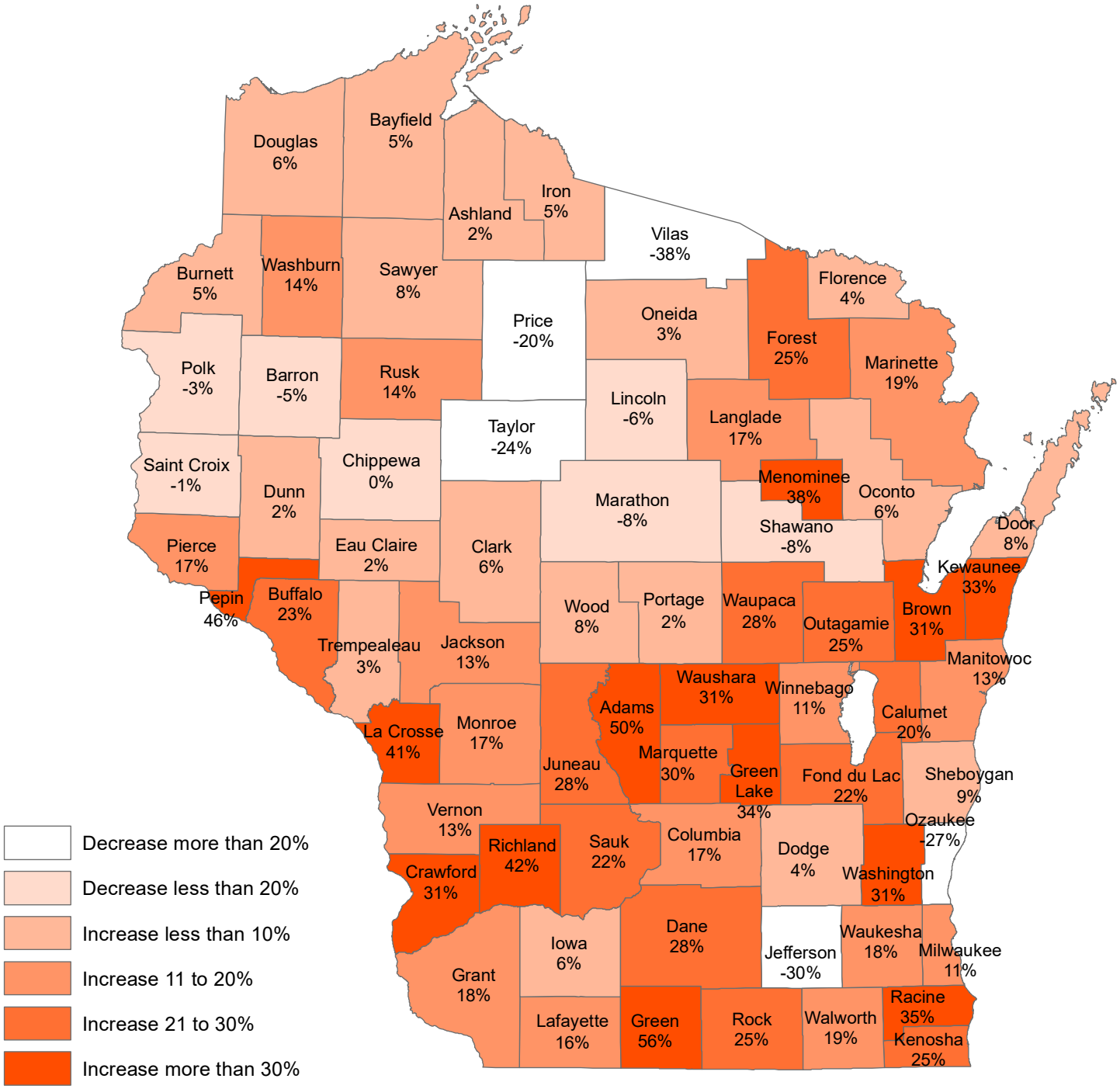


Figure 3.11 Tons of Salt/Lane-Mile 2018-2019

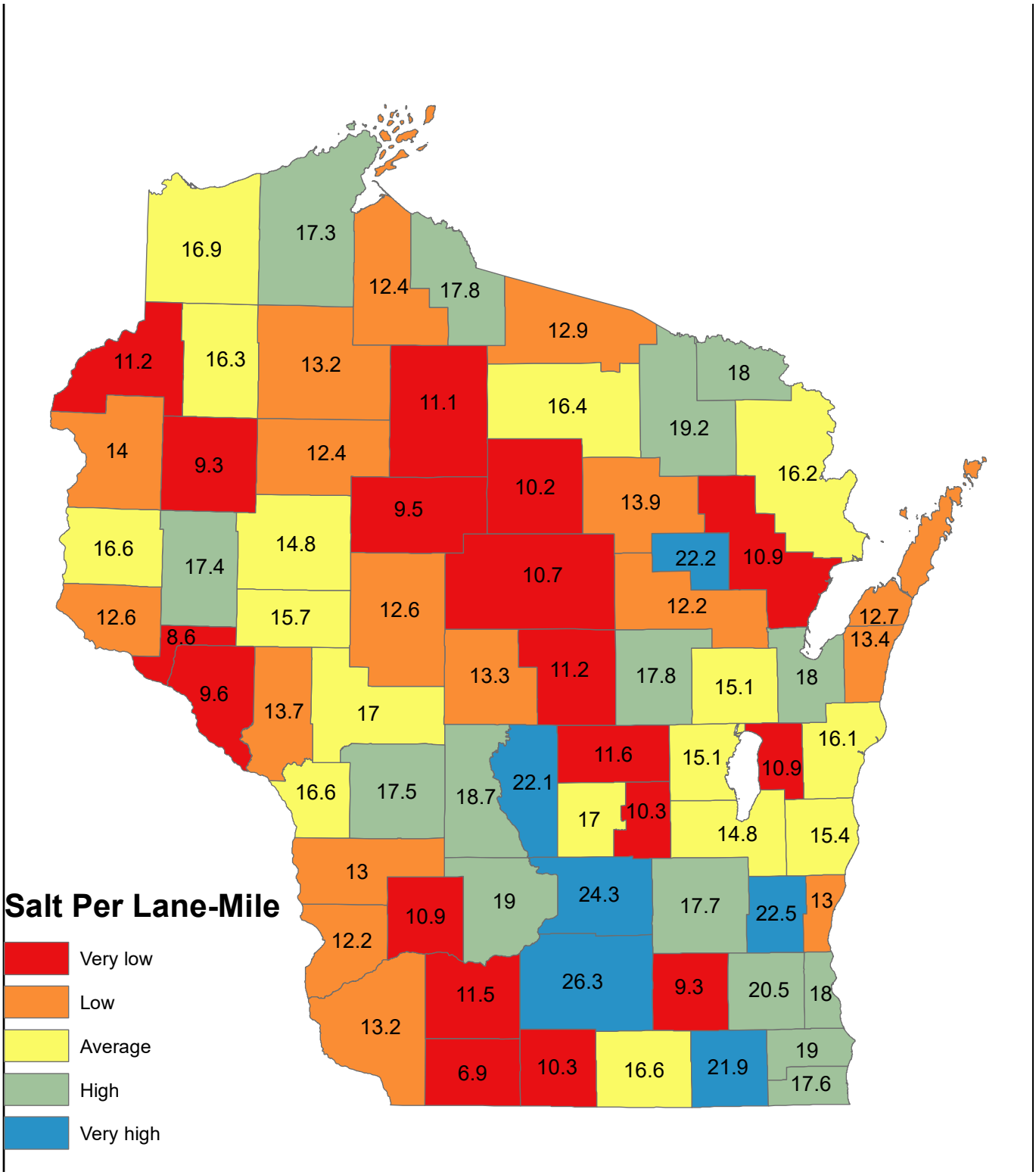


Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group A)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
MILWAUKEE	SE	1973.24	94.36	17.79	$922	10640	13928	24568	56.7%	12.45	0.13
DANE	SW	1545.15	110.58	26.30	$980	6341	15214	21555	70.6%	13.95	0.13
WAUKESHA	SE	1087.33	86.34	20.22	$451	6018	3282	9300	35.3%	8.55	0.10
Group F Avg		1,535.24	97.09	21.44	$784	7666	10808	18474	54.2%	11.65	0.12

Final totals as of **Monday, September 23, 2019**

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group B)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
KENOSHA	SE	664.20	97.61	17.51	$724	7183	1904	9087	21.0%	13.68	0.14
WINNEBAGO	NE	634.28	87.92	15.00	$595	4047	3656	7703	47.5%	12.14	0.14
EAU CLAIRE	NW	540.70	104.02	15.72	$546	4113	2750	6863	40.1%	12.69	0.12
BROWN	NE	902.70	97.40	18.00	$581	4283	6279	10562	59.4%	11.70	0.12
DODGE	SW	637.85	78.72	17.71	$448	2152	3548	5700	62.2%	8.94	0.11
OUTAGAMIE	NE	538.99	109.91	15.05	$589	4336	2256	6592	34.2%	12.23	0.11
FOND DU LAC	NE	608.36	91.32	14.84	$529	2411	3740	6151	60.8%	10.11	0.11
RACINE	SE	691.78	90.67	18.79	$575	3431	3344	6775	49.4%	9.79	0.11
PORTAGE	NC	569.76	145.57	11.00	$692	6143	2769	8912	31.1%	15.64	0.11
WAUPACA	NC	546.52	113.42	17.76	$479	3283	2271	5554	40.9%	10.16	0.09
COLUMBIA	SW	788.10	122.46	24.27	$566	4180	4392	8572	51.2%	10.88	0.09
CHIPPEWA	NW	654.65	93.85	14.78	$422	2228	3153	5381	58.6%	8.22	0.09
WASHINGTON	SE	612.97	122.72	22.48	$580	2666	3871	6537	59.2%	10.66	0.09
SAINT CROIX	NW	646.54	105.86	16.57	$523	2364	3533	5897	59.9%	9.12	0.09
ROCK	SW	690.06	90.11	16.47	$445	2057	3243	5300	61.2%	7.68	0.09
MONROE	SW	666.31	130.92	17.49	$475	2972	4185	7157	58.5%	10.74	0.08
JEFFERSON	SW	549.67	104.51	9.31	$449	1693	2966	4659	63.7%	8.48	0.08
SAUK	SW	709.92	100.33	16.20	$369	2228	3522	5750	61.3%	8.10	0.08

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group B)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
GRANT	SW	624.93	109.39	13.24	$385	2519	2849	5368	53.1%	8.59	0.08
WALWORTH	SE	707.92	118.18	21.76	$436	5267	1184	6451	18.4%	9.11	0.08
MARATHON	NC	874.81	160.89	10.74	$550	6962	3599	10561	34.1%	12.07	0.08
Group F Avg		660.05	108.37	16.41	$522	3644	3286	6930	48.8%	10.51	0.10

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group C)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
LA CROSSE	SW	500.84	90.56	16.57	$551	2208	3147	5355	58.8%	10.69	0.12
SHAWANO	NC	524.17	121.93	12.16	$573	4857	2184	7041	31.0%	13.43	0.11
MANITOWOC	NE	426.63	98.50	16.11	$446	3202	1125	4327	26.0%	10.14	0.10
JUNEAU	SW	496.27	84.43	18.65	$444	1950	2313	4263	54.3%	8.59	0.10
BARRON	NW	428.77	142.10	9.34	$648	4169	1879	6048	31.1%	14.11	0.10
IOWA	SW	473.13	110.57	11.47	$474	2068	2524	4592	55.0%	9.71	0.09
DOUGLAS	NW	451.40	140.72	16.92	$556	3928	1600	5528	28.9%	12.25	0.09
JACKSON	NW	515.44	96.50	16.99	$384	2039	2264	4303	52.6%	8.35	0.09
PIERCE	NW	369.46	117.63	12.65	$521	2070	1555	3625	42.9%	9.81	0.08
DUNN	NW	519.24	134.50	17.39	$609	2463	2842	5305	53.6%	10.22	0.08
SHEBOYGAN	NE	528.68	120.45	15.37	$416	3299	1361	4660	29.2%	8.81	0.07
CLARK	NW	402.56	139.59	12.58	$469	1959	1956	3915	50.0%	9.73	0.07
LINCOLN	NC	405.55	166.80	10.17	$526	3000	1637	4637	35.3%	11.43	0.07
VERNON	SW	477.82	134.16	13.01	$404	1938	2450	4388	55.8%	9.18	0.07
WOOD	NC	429.28	143.74	13.41	$443	2123	2072	4195	49.4%	9.77	0.07
OCONTO	NE	469.52	135.39	10.89	$400	2258	1677	3935	42.6%	8.38	0.06
CRAWFORD	SW	397.19	139.89	12.13	$348	1709	1395	3104	44.9%	7.81	0.06

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group C)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
Group F Avg		459.76	124.56	13.87	$483	2661	1999	4660	43.6%	10.14	0.08

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group D)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
BAYFIELD	NW	316.42	131.16	17.31	$574	2874	1322	4196	31.5%	13.26	0.10
MARQUETTE	NC	245.75	94.13	16.98	$455	1166	1111	2277	48.8%	9.27	0.10
RICHLAND	SW	327.64	95.53	10.94	$416	1483	1319	2802	47.1%	8.55	0.09
MARINETTE	NE	436.66	139.47	16.18	$575	3669	1691	5360	31.5%	12.27	0.09
DOOR	NE	271.80	127.39	12.75	$631	989	1900	2889	65.8%	10.63	0.08
OZAUKEE	SE	309.54	96.22	13.00	$408	1331	1074	2405	44.7%	7.77	0.08
WASHBURN	NW	372.14	125.73	16.28	$477	1903	1760	3663	48.0%	9.84	0.08
POLK	NW	385.81	138.00	13.98	$555	2383	1729	4112	42.0%	10.66	0.08
WAUSHARA	NC	345.01	93.02	11.56	$265	1962	416	2378	17.5%	6.89	0.07
ONEIDA	NC	396.79	141.70	16.41	$479	3103	986	4089	24.1%	10.31	0.07
GREEN	SW	314.64	102.08	10.28	$260	967	1310	2277	57.5%	7.24	0.07
LAFAYETTE	SW	299.38	94.96	6.86	$287	899	1090	1989	54.8%	6.64	0.07
GREEN LAKE	NC	158.44	102.13	10.25	$330	635	464	1099	42.2%	6.94	0.07
TREMPEALEAU	NW	443.67	135.97	13.65	$436	2209	1818	4027	45.1%	9.08	0.07
BUFFALO	NW	317.02	148.79	9.62	$408	1936	992	2928	33.9%	9.24	0.06
Group F Avg		329.38	117.75	13.07	$437	1834	1265	3099	42.3%	9.24	0.08

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group E)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
PEPIN	NW	112.38	98.37	8.55	$567	866	525	1391	37.7%	12.38	0.13
CALUMET	NE	202.44	97.27	10.94	$486	1592	656	2248	29.2%	11.10	0.11
BURNETT	NW	237.93	102.14	11.24	$395	956	917	1873	49.0%	7.87	0.08
RUSK	NW	213.47	128.32	12.36	$390	1643	429	2072	20.7%	9.71	0.08
FOREST	NC	312.38	141.60	19.23	$395	2086	1153	3239	35.6%	10.37	0.07
ASHLAND	NW	245.35	160.75	12.42	$521	1863	923	2786	33.1%	11.36	0.07
LANGLADE	NC	299.21	139.91	13.91	$420	1839	1012	2851	35.5%	9.53	0.07
PRICE	NC	320.19	168.78	11.06	$458	2080	1598	3678	43.4%	11.49	0.07
TAYLOR	NW	233.90	156.98	9.54	$473	1510	960	2470	38.9%	10.56	0.07
IRON	NC	249.56	193.23	17.77	$576	1746	1176	2922	40.2%	11.71	0.06
VILAS	NC	305.24	172.06	12.89	$464	1976	1157	3133	36.9%	10.26	0.06
SAWYER	NW	367.44	126.05	13.16	$330	1332	1166	2498	46.7%	6.80	0.05
Group F Avg		258.29	140.46	12.76	$456	1624	973	2597	37.2%	10.26	0.08

Final totals as of **Monday, September 23, 2019**

Table 3.2. Labor Hours/Lane Miles/Severity Index Ranking (Group F)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Salt per Lane Mi	Labor Cost per Lane Mi	Reg Hrs	OT Hrs	Total Hours	% OT	Total Hrs per Lane Mi	Total Hrs per Lane Mi/SI
ADAMS	NC	193.20	108.96	22.07	$389	1279	410	1689	24.3%	8.74	0.08
FLORENCE	NC	141.07	141.53	18.03	$417	1078	337	1415	23.8%	10.03	0.07
KEWAUNEE	NE	111.35	116.83	13.42	$365	714	174	888	19.6%	7.97	0.07
MENOMINEE	NC	90.26	117.59	22.21	$197	397	100	497	20.1%	5.51	0.05
Group F Avg		133.97	121.23	18.93	$342	867	255	1122	22.0%	8.06	0.07

4 Performance

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Since weather can vary drastically from year to year, planning and budgeting for winter highway maintenance can be challenging. Throughout the winter, WisDOT staff and county highway departments evaluate progress in several areas, including materials use, money spent, and response time. When the season is complete, WisDOT can gather all the data and analyze this winter's performance across all regions and compared to previous winters.

This section begins with a description of the winter maintenance portion of Compass, WisDOT's operations performance measurement program, which measures trends in areas like response time and winter costs per lane mile. This section also discusses costs, using charts to visually compare spending in different categories from region to region and from year to year, and presents winter crash rates and customer satisfaction data.

Performance and Costs, 2018-2019

Total lane miles	**34,774**
Total patrol sections	**754**
Average lane miles per patrol section	**48.0**
Roads to bare/wet pavement within WisDOT targets[1]	**69%**
Total tons of salt/lane-mile	**15.9**
Total gallons of brine and blends/lane-mile	**270.1**
Average crew reaction time from start of storm	**2.45 hours**
Total winter costs[2]	**$ 111,681,476**
Total winter costs per lane mile	**$ 3,212**
Total winter crashes[3]	**9,182**
Total winter crashes per 100 million VMT	**30**

1. Time to bare/wet pavement and crew reaction time data are from storm reports.
2. Cost data are actual costs as billed to WisDOT by the counties.
3. Crash data are from WisDOT's Bureau of Transportation Safety.

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An Economical Choice

Proactive anti-icing operations are about three times less costly than treating frost once it has formed. Anti-icing costs made up only 1 percent of total winter maintenance costs this year. *See page 39 for more information on anti-icing costs.*

4A. COMPASS

Developed in 2001, Compass is WisDOT's quality assurance and asset management program for highway maintenance and operations. Annual Compass reports provide information on winter maintenance activities as well as other aspects of highway maintenance and operations.

Measures for winter operations were established in 2003, and data from the winter of 2003–2004 was used to establish baseline measures for future winter seasons. The measures that were chosen include:

- time to bare/wet pavement
- winter weather crashes per vehicle miles traveled
- cost per lane mile per Winter Severity Index point

Table 4.1 gives the statewide average values for these measures for the last five winters. More detail on these measures is provided later in this section.

WisDOT has gathered several years of baseline data, this data can be used to make a year-to-year comparison in these areas.

Table 4.1. Statewide Compass Measures for Winter

	2014-15	2015-16	2016-17	2017-18	2018-19
Percentage of roads to bare/wet pavement (Within WisDOT target times)	70%	74%	70%	66%	69%
Cost per lane mile	$2,155	$2,087	$2,537	$2,821	$3,212
Winter Severity Index	99.28	90.35	91.14	97.53	105.7
Cost per lane mile per Winter Severity Index point	$21.71	$23.09	$27.85	$28.93	$30.39
Winter weather crashes	25 per 100 million VMT	18 per 100 million VMT	18 per 100 million VMT	24 per 100 million VMT	30 per 100 million VMT

Annual Compass reports are available at
http://wisconsindot.gov/Pages/doing-bus/local-gov/hwy-mnt/compass/reports/reports.aspx

4B. WINTER MAINTENANCE MANAGEMENT

History of Snow and Ice Control in Wisconsin

The counties' plowing and salting strategies have evolved considerably over the past several decades. For many years beginning in the 1950s, WisDOT maintained a "bare pavement" policy for state highways, striving to ensure that the roadways were kept essentially clear of ice and snow during winter. Snowplows operated continuously during storms and simultaneously applied deicing salts. In the 1970s, however, economic and environmental concerns compelled the department to modify this policy. The national energy crisis and the high cost of employee overtime strained the maintenance budget, and WisDOT made the decision to reduce winter maintenance coverage on less traveled state highways. To address the risk of environmental damage by chloride chemicals, the policy was modified further to include provisions calling for the prudent use of chemicals, and limiting each application of salt to 300 pounds per lane mile.

In 2002, a detailed salt application table was added to the maintenance manual's winter guidelines. The table provides variable salt application rates for initial and repeated applications, depending on the type of precipitation, pavement

temperature, wind speeds, and other weather variables. Anti-icing application rates were also established; county highway departments were instructed to perform anti-icing applications prior to predicted frost, black ice, or snow events in order to minimize the amount of salt used during the event. With the implementation of MDSS, this process has become more automated. Patrol superintendents receive treatment recommendations based on the characteristics of the route, such as traffic volume and pavement type, residual de-icers, actions already performed and forecasted weather.

Storm Reports

One way that WisDOT has worked to increase efficiency in recent years is through the Winter Storm Reports. Every week during the winter, the county highway departments complete online storm report forms. These storm reports let county and WisDOT staff track the season's weather and the counties' response to it throughout the season, which allows the counties to adjust their resource use midseason if necessary. Storm reports track data such as types of storm events, salt use, anti-icing applications, labor hours, and cost estimates. Uses for this data include:

WisDOT Central Office

- Create weekly reports and maps that track salt use and costs. These can help identify inconsistencies in service levels provided by neighboring counties.
- MAPSS measures.
- DTSD Performance Measures.

WisDOT Regional Offices

- Justify additional funding if conditions are more severe than normal.
- Manage salt inventory.
- Post-storm analysis of county's response.
- Training tool for new staff.

Counties

- Post-storm analysis of crew's response.
- Compare their response (materials use, anti-icing, labor hours, etc.) to that of neighboring counties.
- Justify funding to county boards.

See https://transportal.cee.wisc.edu/storm-report/ for more detail on how to use the storm report data.

WisDOT relies on the county highway departments to make the storm reports a reliable tool by entering data accurately each week. Historically, the cost and salt use data in the storm reports has been relatively accurate when compared with final costs billed to WisDOT and end-of-season salt inventory figures.

BEST PRACTICES: Automatic Vehicle Location (AVL-GPS)

AVL-GPS is used to determine the location of a vehicle and allows management to monitor the location of an entire fleet. This system can assist in the management of labor, equipment and materials. WisDOT primarily uses data from AVL-GPS to improve MDSS recommendations.

Additionally, AVL can record and transmit operational data from snowplows. Data such as application rates, pavement temperatures, and the position of blades and plows can all be captured. This data can be stored and used for reporting and analysis at a later date.

Winter Patrol Sections

Many factors influence a county's response to winter storms, including the timing of snow events, the mix of highway types and classifications in a county, and the type of equipment being used. Another important factor is the length of each county's patrol sections.

Each county highway department divides the state highways it is responsible for plowing into patrol sections. In general, one snowplow operator is assigned to each patrol section. This winter, the state highway system was divided into 756 winter patrol sections, an average of 10.5 sections per county. The length of patrol sections varies, with counties that are more urban (Group A) tending to have shorter patrol sections than more rural counties (Groups D, E and F). Local traffic patterns, highway geometrics, number of traffic lanes, intersections, interchanges, and other factors affect the length of patrol sections in each county.

In responding to a storm, operators in longer patrol sections may use more salt in an effort to melt any snow that accumulates between plowings. In addition, drivers may notice that some roads appear to be cleared faster than others, since the longer a patrol section, the longer it takes a snowplow operator to clear all the roads in his section.

Table 4.2 shows the average patrol section length for the counties in each Winter Service Group. For county-by-county patrol section data, see Table 4.8.

Table 4.2. Average Patrol Section Lengths by Winter Service Group

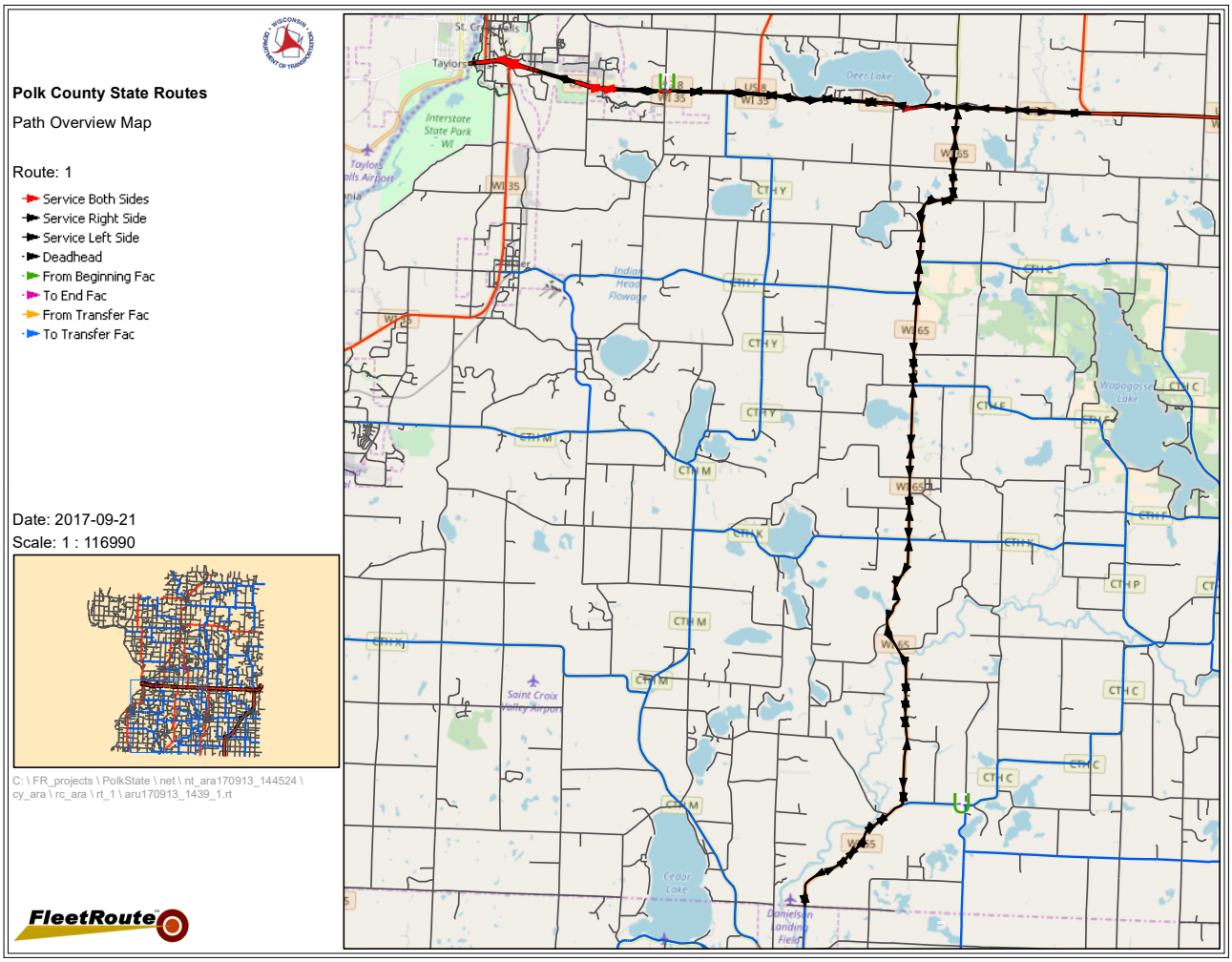
Winter service group	Average patrol section length (lane miles)	Range of average patrol section lengths by county (lane miles)
A	49.0	34.0 - 59.8
B	46.5	30.8 - 60.8
C	45.8	35.7 - 57.7
D	49.4	30.2 - 64.3
E	48.0	33.7 - 61.2
F	42.0	37.1 - 47.0
Statewide average	46.0	30.2 - 64.3

Route Optimization

After a discussion about Winter Patrol Sections, it is appropriate to mention the newest trend across the country, Route Optimization. Route Optimization is just what it implies – optimizing a route traveled by taking less left turns or U-turns and equalizing the length of time between routes. Winter road maintenance route optimization highway segments are designed for plow speeds of 25-32.5 mph and a maximum rate of 300 lbs. of salt/lane-mile over the course of 2.5-3 hours. The 2.5-3 hours optimal plow route time is used because that is typically how long salt or salt brine will remain on the road before it becomes too diluted to be effective. Route optimization is used by major private sector companies including FedEx and UPS, and is considered a best practice for efficiency. In recent years, the public sector has seen success with the process too.

To date, 44 Wisconsin counties have volunteered to collaborate with WisDOT to determine the value of using GIS technology to optimize snow plow routes. Of the 44 Wisconsin counties involved, Dane, Jefferson and Waukesha have implemented Route Optimization and have seen a return on the investment. Return on investment will be unique to each county. WisDOT expects to experience significant savings related to operations, salt use, fuel consumption and increases in safety as more counties implement route optimization. Cost savings during winter months means more funding is available for maintenance work during summer months, which Wisconsin residents view as a high priority. Preliminary numbers from route optimization show:

- When routes are absorbed into larger routes through optimization, it creates savings of roughly $85,000 annually per route.



Route Optimization mapping completed for Polk County.

- There is still more work that could be done; based on 2.5 hour route cycle times, the existing 756 patrol sections could be reduced to 639 routes according to route optimization throughout the state.
- Dane County was able to eliminate four additional trucks from its fleet after a second round of optimization. The further analysis was performed to incorporate new shop and shed locations.

Figure 4.1 shows the counties that have committed to invest in route optimization.

4C. RESPONSE TIME

WisDOT tracks two types of response time data—the time it takes a maintenance crew to get on the road after the start of a storm, and the time it takes the pavement to return to a bare/wet condition after the end of a storm. The first measure can impact the second. In general, a quicker response means the crews are dealing with less packed snow. However, WisDOT guidelines dictate that lower-volume highways receive 18-hour winter maintenance coverage rather than 24-hour coverage, so slower average reaction times are expected on 18-hour roads.

Figure 4.1. Counties Using Route Optimization

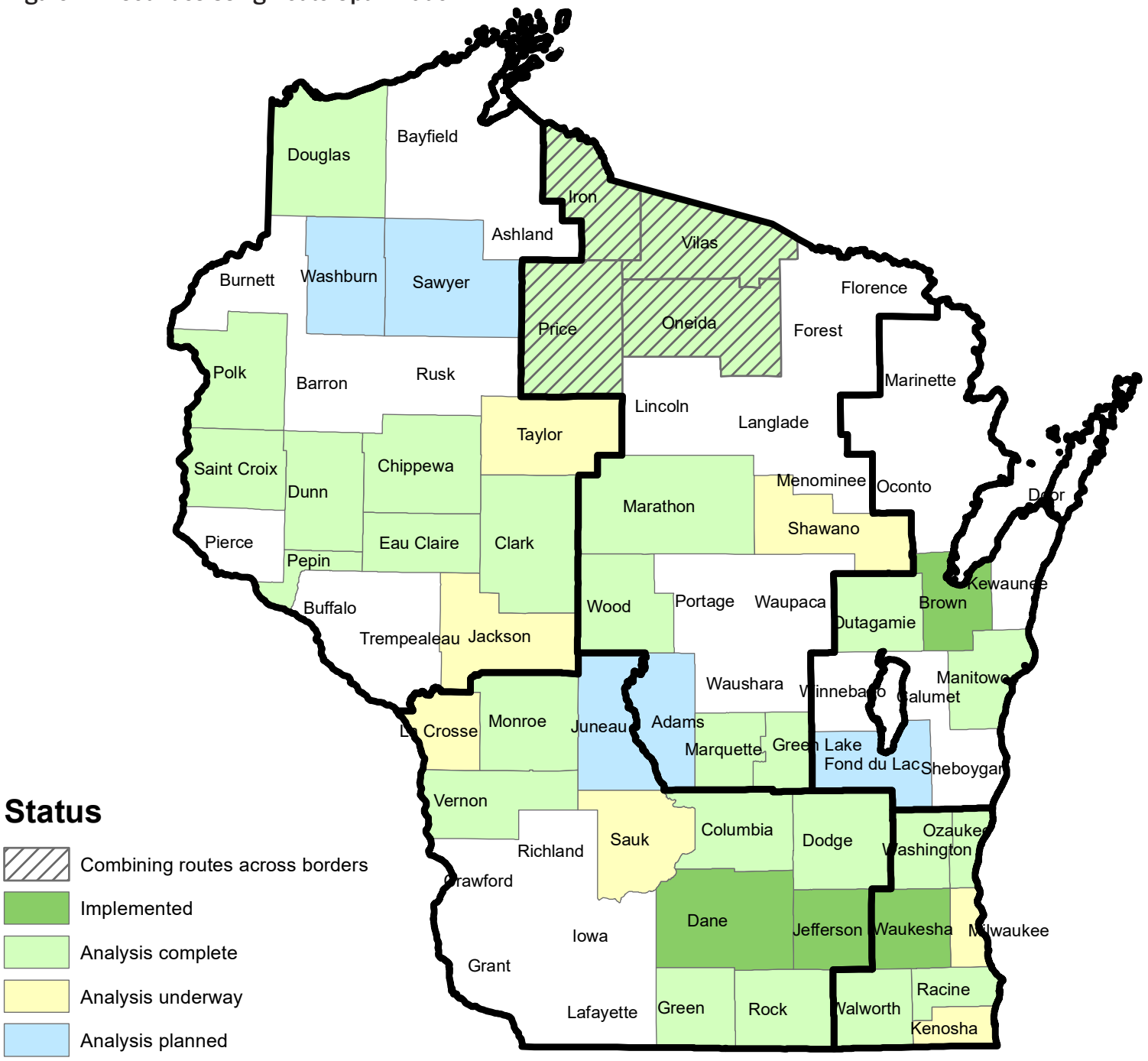


Table 4.3. Maintenance Crew Reaction Time

From winter storm reports, 2008/2009–2018/2019

	10-Year avg. reaction time (hrs.)										10-year Avg.	Avg. reaction time (hrs.)	Percent change
Winter Service Group	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2008-2009 to 2017-2018	2018-2019	2018-2019 vs. 10-year Avg
A	1.02	1.74	0.49	0.19	0.63	2.31	0.32	1.21	0.37	0.52	0.88	0.48	-54%
B	1.46	1.78	1.60	1.11	1.27	4.48	1.67	2.40	1.07	1.34	1.82	1.16	-36%
C	2.70	3.37	2.87	2.15	2.38	4.99	2.57	3.19	2.22	2.61	2.91	2.16	-26%
D	3.46	4.23	3.25	2.54	3.77	6.23	2.86	3.91	2.06	2.70	3.50	2.61	-25%
E	4.00	4.71	3.48	3.16	2.99	9.36	3.77	6.72	3.94	5.04	4.72	4.40	-7%
F	5.08	5.79	5.68	3.39	3.79	14.81	4.78	8.62	3.64	5.13	6.07	3.91	-36%
Statewide avg. (unweighted)	2.78	3.38	2.74	2.08	2.42	7.03	2.66	4.34	2.22	2.89	3.25	2.45	-25%

Maintenance Crew Reaction Time

Being proactive in getting on the road—even before the start of a storm—can result in bare/wet pavement being achieved faster and with less effort. Knowing this, county highway departments are becoming more proactive in their response to winter storms. Plows and salt spreader trucks are often on the road before a storm starts or shortly afterward. Sometimes counties wait until the sun comes out so their salting and plowing are more effective, which can increase average reaction times.

Bare/wet condition is when the lanes of travel are wet and snow is no longer visible in the lane. Some winter levels of service are not expected to achieve a bare/wet condition as quickly as others.

Using data from the weekly winter storm reports, Table 4.3 shows the average reaction time to storm events in each Winter Service Group. This winter the average reaction time of 2.45 hours was 25 percent faster than the latest 10-year average. As expected, average reaction times for Group A counties, which provide the highest level of service (24-hour coverage), were less than those counties that provide 18-hour coverage.

Last year's average reaction time of 2.45 hours was one of the quickest reaction times recorded in recent years.

Time to Bare/Wet Pavement

As explained in Section 1, county highway departments provide different levels of effort during and after a storm according to each highway's category rating, as determined by average daily traffic. It would be expected that an urban freeway would receive more materials, labor and equipment—and would show a quicker recovery to bare/wet pavement—than a rural, two-lane highway. For more information on these categories, see page 8.

Table 4.4. Percentage to Bare/Wet Pavement

	Percent of Time the Highway Category Target Time to Bare/Wet Pavement was Met *(Target Times: 4 hours for 24-Hour Roads; 6 hours for 18 Hour Roads)*										
Highway Category	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
24-Hour Roads	61%	70%	69%	83%	75%	66%	75%	78%	79%	73%	73%
18-Hour Roads	56%	65%	66%	76%	70%	59%	67%	71%	70%	60%	65%
Target	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%

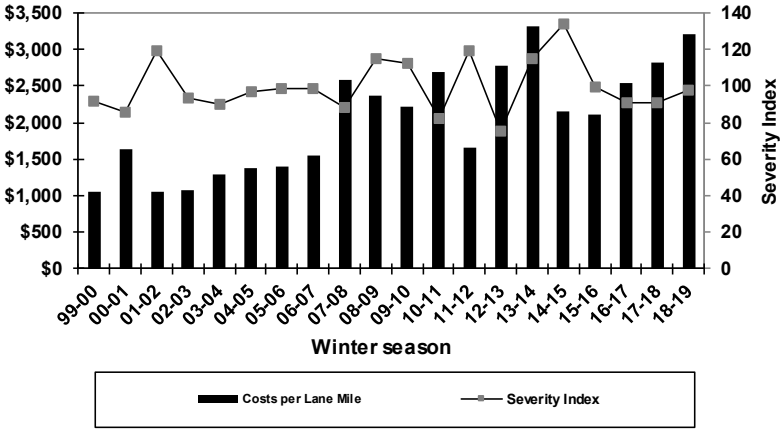
"Time to bare/wet pavement" is measured from the reported end time of a storm. Table 4.4 shows that the trend for average time to bare/wet pavement is as expected: More heavily traveled highways show a shorter average time to bare/wet pavement. From storm to storm, however, most variability is due to weather effects (type, duration and severity of storms throughout the winter season), according to analysis performed through the Compass program.

The 2018-19 percentage of roadways cleared to bare/wet pavement increased from the previous year, despite the 2018-19 winter being more severe.

Table 4.5. Total Winter Costs Relative to Winter Severity, 2018-2019

Region	Average Winter Severity Index	Actual cost per lane mile	Relative cost per severity index point
SW	97.42	$3,170	$32.54
SE	90.64	$3,566	$39.34
NE	98.99	$3,162	$32.30
NC	116.33	$3,036	$27.18
NW	111.72	$3,041	$27.18
Statewide	105.7	$3,212	$29.33

Figure 4.2. Statewide Average Winter Costs per Lane Mile and Winter Severity Index, 1999-00 thru 2018-19



4D. COSTS

The total billed cost of statewide winter operations this winter was $111.7 million, making it 14 percent more costly than 2017-18. A number of factors drive the cost of winter maintenance, including both the nature and severity of the winter (i.e. how much work has to be performed), as well as the unit costs of the component elements of winter maintenance (i.e. cost per lane mile for salt, labor and equipment).

Winter maintenance costs per lane mile increased in 2018-19 by about 8 percent from 2017-18. See Figure 4.4 for a statewide map of winter cost per lane-mile. Figure 4.2 shows the statewide average winter cost per lane mile and Winter Severity Index since the 1998-99 winter. The average Winter Severity Index was significantly higher in all regions compared with the previous winter.

Table 4.5 shows total winter maintenance costs statewide and for each region per lane mile, as well as relative to the region's average Winter Severity Index. The level of service provided in each county affects the total costs, and the mix of counties in a region affects the overall comparative costs.

Figure 4.3. Total Winter Maintenance Cost by Region, 2018-19 vs. 2017-18 vs. Previous 5-Year Average

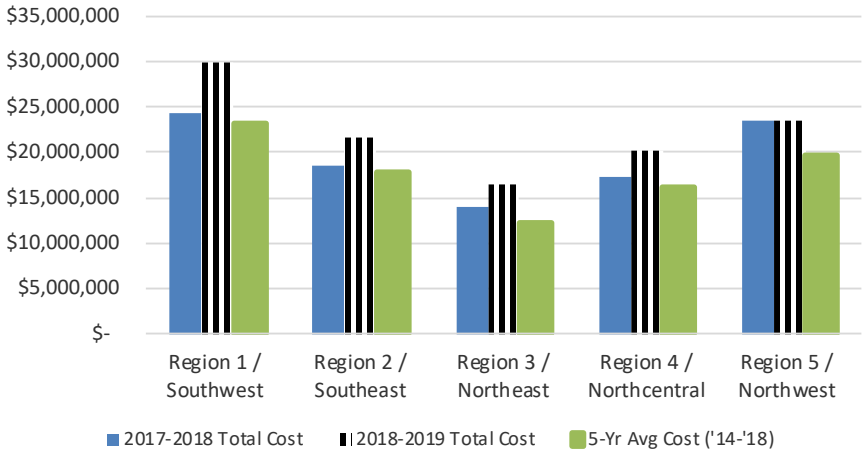
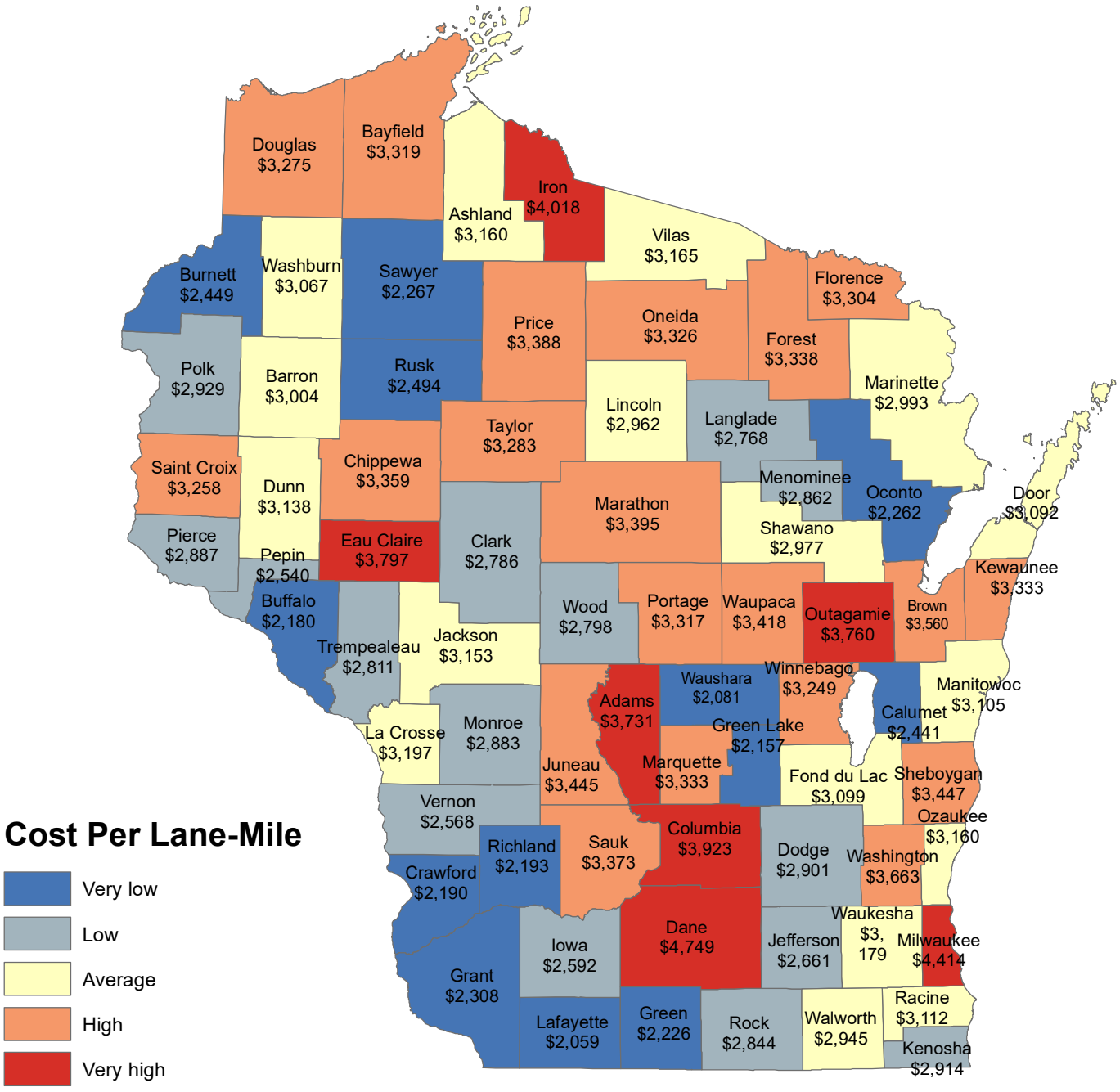


Figure 4.3 shows, in 2018-19, all regions experienced higher winter maintenance costs as compared to 2017-2018. All regions also had costs above their most recent 5-year average. This year's increase in costs can be attributed to a much higher winter severity index, 18 percent more severe than the severity index of the previous winter.

Figure 4.4 Winter Cost/Lane-Mile 2018-2019



There are five major cost categories in the Department's winter maintenance billing system. These include: cost of salt used, labor costs, cost of other materials furnished by the county, and administration costs. Figure 4.5 below shows the breakdown of the $111.7 million in 2018-19 statewide winter maintenance costs by these billing categories.

Figure 4.5. Statewide Winter Costs by Category

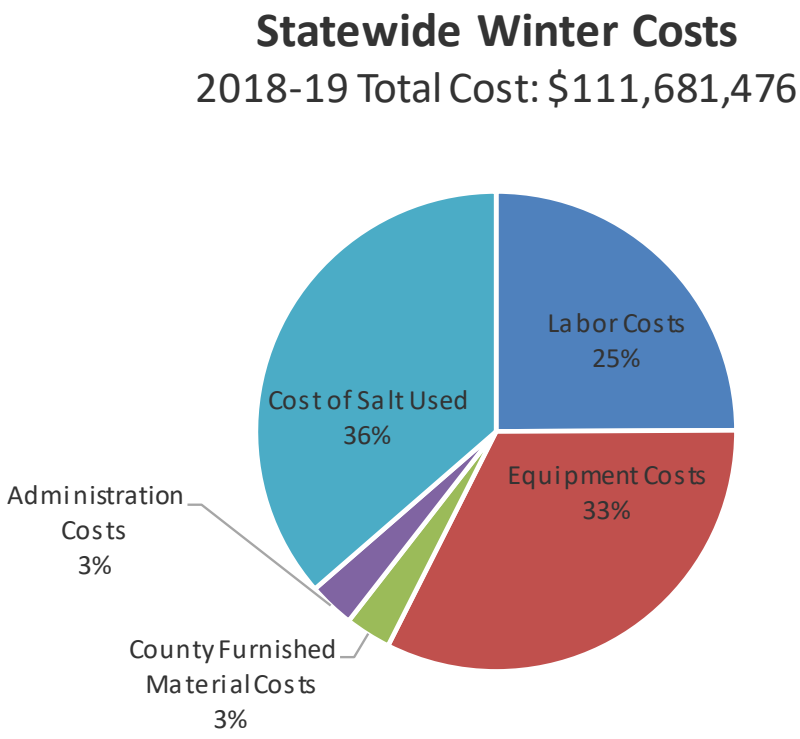


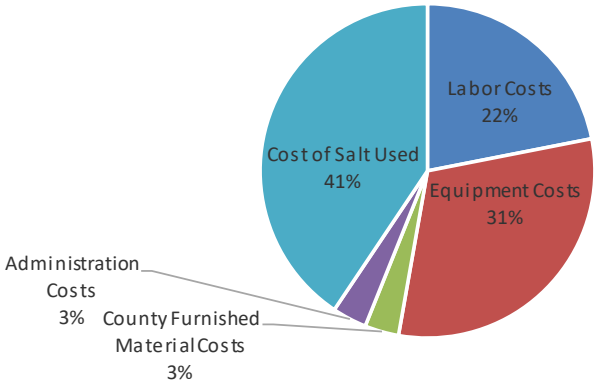
Figure 4.6 shows the breakdown of costs by billing category for each of the five regions. More specific, detailed cost figures by region and for the state as a whole are shown in Table 4.6.

In the five individual winter maintenance expenditure categories for 2018-19 statewide, the following trends were noted:

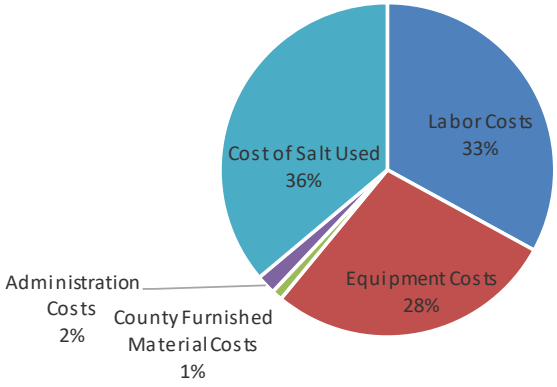
- Salt expenditures were $40.6 million - a six percent increase compared to the previous winter. The Northwest region saw a 13 percent reduction from the previous winter, the Southeast region had a 21 percent increase and the Southwest region had a 12 percent increase from last winter. The North Central and Northeast regions both increased salt use by 8 percent.
- Equipment expenditures were $36.3 million, an increase of 24 percent compared to the previous winter.
- Labor expenditures were $31.3 million, an increase of 16 percent from the previous winter.
- County Furnished Material Costs were $3.5 million, an increase of one percent compared with the previous winter.

Figure 4.6. Regional Winter Costs by Category, 2018-19

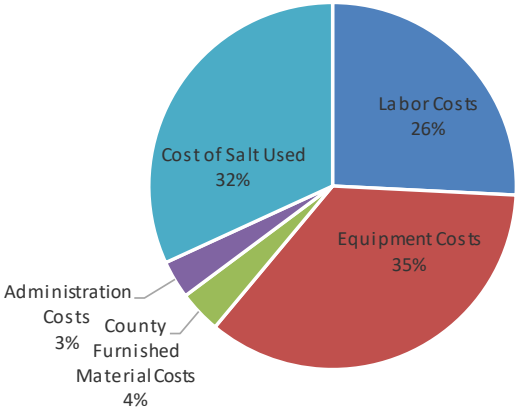
Southwest Region Winter Costs
2018-19 Total Cost: $29,846,645
Brine Used: 2.27 M Gallons



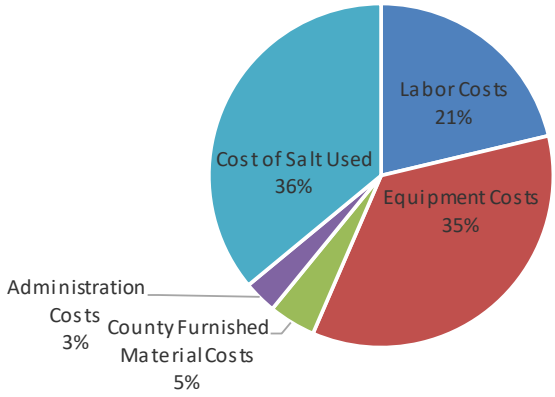
Southeast Region Winter Costs
2018-19 Total Cost: $21,564,066
Brine Used: 1.11 M Gallons



Northeast Region Winter Costs
2018-19 Total Cost: $16,407,959
Brine Used: 2.20 M Gallons



Northcentral Region Winter Costs
2018-19 Total Cost: $20,258,377
Brine Used: 2.64 M Gallons



Northwest Region Winter Costs
2018-19 Total Cost: $23,604,429
Brine Used: 0.64 M Gallons

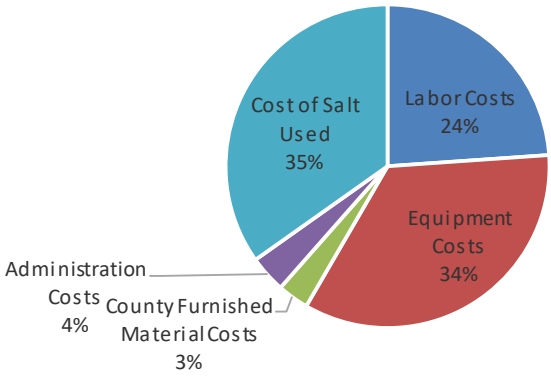


Table 4.6

Winter 2018-19 Experience for County Services

Region	Labor Costs	Equipment Costs	County Furnished Material Costs	Administration Costs	Cost of Salt Used	Total Costs for Winter	Five Year Average Cost for Winter ('14-'18 avg)	% Total Costs over Five Year Average
Southwest	$6,540,475	$9,212,219	$982,557	$994,199	$12,117,195	$29,846,645	$23,217,700	29%
Southeast	$7,111,700	$6,036,776	$223,529	$401,938	$7,790,123	$21,564,066	$17,804,100	21%
Northeast	$4,231,472	$5,786,451	$613,946	$549,393	$5,226,697	$16,407,959	$12,249,600	34%
North Central	$4,311,289	$7,130,002	$892,722	$632,155	$7,292,209	$20,258,377	$16,098,400	26%
Northwest	$5,640,943	$8,137,320	$737,497	$870,497	$8,218,172	$23,604,429	$19,695,000	20%
Totals	**$27,835,879**	**$36,302,768**	**$3,450,251**	**$3,448,182**	**$40,644,396**	**$111,681,476**	**$89,064,800**	**25%**

Figure 4.7. Costs per Lane Mile by Category

Figure 4.7 shows the total cost per lane mile for winter maintenance in each region, along with the region's Winter Severity Index. The level of service provided in each county affects total costs, as do the factors listed below. For these reasons, the Southeast Region historically experiences significantly higher costs relative to winter severity than the other regions.

Components of Winter Costs

Major components of winter costs include labor, equipment, salt, other materials such as sand and chemicals, and administrative costs. A region's expenditures in each area are affected by the severity of its winter and the portion of its highways receiving 24-hour coverage. In addition:

- Labor costs are based on rates set in each county's union contracts. Hourly rates tend to be higher in more urban counties. Timing of storms can increase labor costs if more overtime hours are required.
- Equipment costs are determined by the state Machinery Management Committee, which assigns an hourly rate to each piece of equipment that includes depreciation from the purchase price, maintenance costs, and fuel costs. Rising fuel costs have contributed to increased equipment costs, as have some counties' purchase of larger, more expensive vehicles. These larger vehicles are often more useful for year-round maintenance tasks and are also more efficient in the winter, as they can accommodate larger plows and carry more salt.
- Salt costs are affected by salt prices per ton, which vary because of transportation costs. For example, salt entering the state at the Port of Milwaukee doesn't have to travel as far to reach counties in the Southeast region

as it does to reach counties in the center of the state.

- Costs for materials other than salt, such as sand, are also affected by transportation costs. In addition, some counties use more expensive deicing agents that are more effective at lower temperatures (see Table 3.1 for details on deicing agent costs).
- Administrative costs are calculated at 4.25 percent of each county's combined labor, equipment and materials costs, and cover the overhead costs for office activities.

However, the breakdown of expenditures by category varies among regions because of the factors described above. For example, the Southeast Region spends more on labor because hourly labor rates tend to be higher in those counties, while equipment expenditures make up a smaller percentage of that region's total expenditures. Figure 4.6 shows the distribution of costs by category for each region.

County-by-county cost data is available in Table 4.10.

A Note About Cost Data

The tables at the end of this section were generated with data from two sources—final costs as billed to WisDOT, and preliminary costs from the winter storm reports. The tables created from preliminary storm reports data (such as Table 4.11 Cost per Lane Mile per Severity Index Ranking) are included in this report because they provide county-by-county breakdowns of cost data not available elsewhere. Many of the tables in the Appendix also include cost data from the storm reports. The source of each table's data is indicated below the table title.

Final cost data includes expenses for all winter activities, including putting up snow fence, transporting salt, filling salt sheds, thawing out frozen culverts, calibrating salt spreaders, producing and storing salt brine, and anti-icing applications, as well as plowing and salting. Cost data from storm reports, however, include only plowing, sanding, salting and anti-icing expenses.

4E. TRAVEL AND CRASHES

From black ice to freezing rain to white-out snowstorms, winter weather creates challenging conditions for even the most careful drivers. Many factors influence winter crash rates, most of which cannot be controlled by winter maintenance crews. However, by keeping roads as clear as possible within their expected level of service (18- or 24-hour coverage), maintenance crews have an opportunity to help prevent some winter crashes.

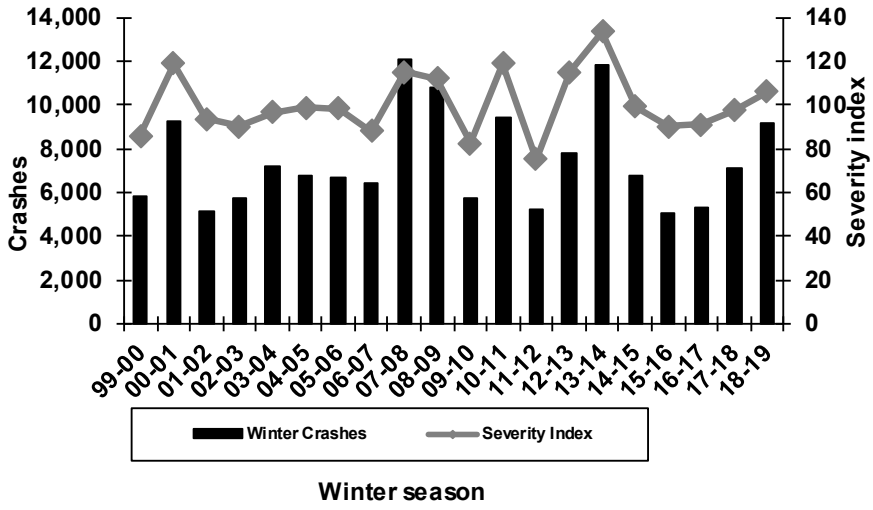
In the winter of 2018-2019, there were 9,182 reported winter weather crashes (those that occurred on pavements covered with snow, slush or ice), a 29 percent increase over the previous winter. The statewide average crash rate (number of crashes per 100 million vehicle miles traveled) increased from 24 to 30, a 25 percent increase over the previous winter.

Crash rates tend to increase in more severe winters. Figure 4.8 shows the trends in total crashes statewide over the last 19 years overlaid with the Winter Severity Index. Compared to the severe winter in 2013-2014, it is no surprise to see the crash rate increase last year given the severity of the winter.

It's important to note that crash rates provide only a portion of the picture of overall winter safety. Crash rates include only "reportable" crashes, which exclude those that cause property damage under $1,000 that aren't required by law to be reported to police. Also, crashes in urban areas are more likely to occur at lower speeds and cause fewer deaths, while crashes on high-speed rural roads are more likely than low-speed crashes to be fatal.

Crashes and Vehicle Miles Traveled

Figure 4.8. Winter Crashes and Winter Severity Index



Source: WisDOT Bureau of Transportation Safety

More urban areas such as the Southeast Region often have fewer winter weather crashes per 100 million vehicle miles traveled. This is partly due to the fact that a single crash in a county with low VMT has a bigger impact on the overall crash rate. In addition, urban regions have more highways with 24-hour coverage, which means that these roadways are more likely to be in passable condition. This year, all regions saw increases in crash rates. The Northeast region saw the greatest percentage increase in crash rates (a 43 percent increase), with this year's crash rate at 38 crashes per 100 million VMT (see Table 4.7). The Northwest region saw the smallest percentage increase in crash rates (a 16 percent increase), with this year's crash rate at 30 crashes per 100 million VMT. Table 4.12 gives the estimated number of vehicle miles traveled in each county this winter (November 2018 to April 2019), and the number of crashes that occurred in each county.

WisDOT tracks crashes according to the type of road where they occurred (urban or rural, and Interstate or other state or U.S. highway), and whether the road was divided or nondivided. Figure 4.9 shows that most winter crashes occur on rural state or U.S. highways, largely because there are more lane miles in this category than in the others. Table 4.13 shows the breakdown of crashes in each county according to highway type.

Photo Credit: Pixabay Commons License

Table 4.7. Crashes and Vehicle Miles of Travel by Region

Region	Winter Severity Index (2018-19)	VMT (100 million) (Nov 2018 - April 2019)	Snow/Slush/Ice Crashes (Nov 2017 - April 2018)	Crashes per 100M VMT (2017–18)	Crashes per 100M VMT (2018–19)
NC	116.33	38.16	1,434	30	38
NW	111.72	48.87	1,475	26	30
NE	98.99	54.49	2,058	26	38
SE	90.64	85.96	1,838	18	21
SW	97.42	74.75	2,377	23	32
Statewide	105.7	302.23	9,182	24	30

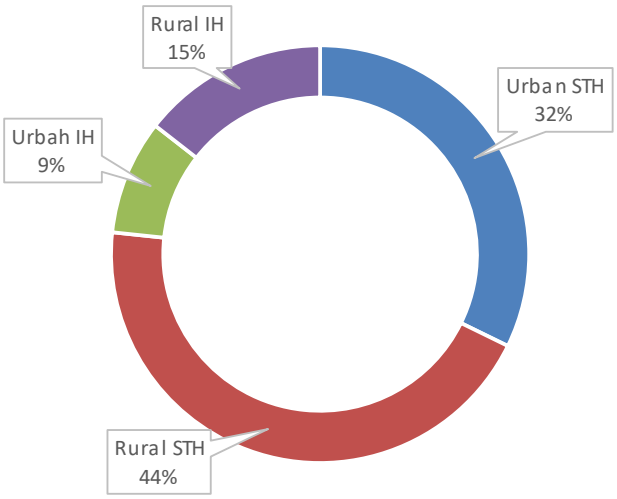
Source: WisDOT Bureau of Transportation Safety

How VMT Is Calculated

WisDOT's Traffic Forecasting Section uses a number of factors to estimate Vehicle Miles of Travel for the state's roads. Annual average daily traffic counts are taken in about one-third of Wisconsin's counties every year, and estimates are made for the counties not counted. In addition, forecasters factor in gallons of gas sold, fuel tax collected, and average vehicle miles per gallon.

Total winter VMT for all counties is shown in Table 4.12. This winter, total VMT ranged from a low of 18.1 million in Menominee County to a high of 3.3 billion in Milwaukee County. VMT estimates at the county level tend to be less reliable than at the statewide level, because current traffic counts are not available for all counties, and more variability exists in the data at finer levels of resolution.

Figure 4.9. Winter Crashes by Highway Type, Bureau of Transportation Safety Data 2018-2019



COUNTY-BY-COUNTY TABLES AND FIGURE FOR SECTION 4: PERFORMANCE

WISCONSIN
DEPARTMENT OF TRANSPORTATION

Table 4.8. Winter Maintenance Sections

NC Region

County	Lane Miles	Winter Patrol Sections 2019	Lane Miles per Patrol Section	Winter Service Group
Adams	193.20	5	38.6	F
Florence	141.07	3	47.0	F
Forest	312.38	6	52.1	E
Green Lake	158.44	3	52.8	E
Iron	249.56	6	41.6	E
Langlade	299.21	6	49.9	E
Lincoln	405.55	10	40.6	C
Marathon	874.81	19	46.0	B
Marquette	245.75	5	49.2	D
Menominee	90.26	2	45.1	F
Oneida	396.79	10	39.7	D
Portage	569.76	14	40.7	B
Price	320.19	6	53.4	E
Shawano	524.17	14	37.4	C
Vilas	305.24	7	43.6	E
Waupaca	546.52	12	45.5	B
Waushara	345.01	6	57.5	D
Wood	429.28	10	42.9	C
Region Average			**45.8**	

NW Region

County	Lane Miles	Winter Patrol Sections 2019	Lane Miles per Patrol Section	Winter Service Group
Ashland	245.35	5	49.1	E
Barron	428.77	12	35.7	C
Bayfield	316.42	6	52.7	D
Buffalo	317.02	7	45.3	D
Burnett	237.93	5	47.6	E
Chippewa	654.65	16	40.9	B
Clark	402.56	10	40.3	C
Douglas	451.40	9	50.2	C
Dunn	519.24	9	57.7	C
Eau Claire	540.70	9	60.1	B
Jackson	515.44	9	57.3	C
Pepin	112.38	3	37.5	E
Pierce	369.46	7	52.8	C
Polk	385.81	6	64.3	D
Rusk	213.47	5	42.7	E
Saint Croix	646.54	12	53.9	B
Sawyer	367.44	6	61.2	E
Taylor	233.90	4	58.5	E
Trempeleau	443.67	11	40.3	D
Washburn	372.14	7	53.2	D
Region Average			**50.1**	

NE Region

County	Lane Miles	Winter Patrol Sections 2019	Lane Miles per Patrol Section	Winter Service Group
Brown	902.70	20	45.1	B
Calumet	202.44	6	33.7	E
Door	271.80	9	30.2	D
Fond du Lac	608.36	10	60.8	B
Kewaunee	111.35	3	37.1	F
Manitowoc	426.63	9	47.4	C
Marinette	436.66	9	48.5	D
Oconto	469.52	10	47.0	C
Outagamie	538.99	11	49.0	B
Sheboygan	528.68	13	40.7	C
Winnebago	634.28	18	35.2	B
Region Average			**43.2**	

SW Region

County	Lane Miles	Winter Patrol Sections 2019	Lane Miles per Patrol Section	Winter Service Group
Columbia	788.10	16	49.3	B
Crawford	397.19	8	49.6	C
Dane	1545.15	29	53.3	A
Dodge	637.85	17	37.5	B
Grant	624.93	11	56.8	B
Green	314.64	5	62.9	D
Iowa	473.13	10	47.3	C
Jefferson	549.67	11	50.0	B
Juneau	496.27	10	49.6	C
LaCrosse	500.84	13	38.5	C
Lafayette	299.38	6	49.9	D
Monroe	666.31	13	51.3	B
Richland	327.64	7	46.8	D
Rock	690.06	17	40.6	B
Sauk	625.18	13	48.1	B
Vernon	477.82	11	43.4	C
Region Average			**48.4**	

SE Region

County	Lane Miles	Winter Patrol Sections 2019	Lane Miles per Patrol Section	Winter Service Group
Kenosha	664.20	17	39.1	B
Milwaukee	1973.24	33	59.8	A
Ozaukee	309.54	6	51.6	D
Racine	691.78	17	40.7	B
Walworth	707.92	23	30.8	B
Washington	612.97	11	55.7	B
Waukesha	1087.33	32	34.0	A
Region Average			**44.5**	

	Lane Miles	Winter Patrol Sections 2019	Lane Miles per Patrol Section
Statewide Totals	34,774.0	756.0	46.0
Statewide Averages	483.0	10.5	46.0
Group A Averages	1,535.2	31.3	49.0
Group B Averages	656.0	14.6	46.5
Group C Averages	459.8	10.2	45.8
Group D Averages	341.6	7.1	49.4
Group E Averages	250.6	5.2	48.0
Group F Averages	134.0	3.3	42.0

Table 4.9. Storm Start vs. Crew Out by Precipitation Type, Group A

From Winter Storm Reports, 2018-2019

Note: 1) A negative number indicates that the crews were on the road when the storm started. 2) A discrepancy is inherent in these calculation because an individual storm may have several precipitation types but when calculating the average time difference for a particular precipitation type this is not taken into account.

County	Region	Precipitation Type					Severity Index	Cost per LM per Severity Index
		Dry Snow	Wet Snow	Freezing Rain	Sleet	All Precip. Types		
		(Average Time in Hours)						
DANE	SW	-0.75	-0.38	0.14	-0.17	-0.31	110.58	4.02
WAUKESHA	SE	1.68	1.85	1.21	1.06	1.74	86.34	2.17
MILWAUKEE	SE	0.00	0.00	0.00	0.00	0.00	94.36	1.45
Group A Averages		0.31	0.49	0.45	0.30	0.48	97.09	2.55

Table 4.9. Storm Start vs. Crew Out by Precipitation Type, Group B

From Winter Storm Reports, 2018-2019

Note: 1) A negative number indicates that the crews were on the road when the storm started. 2) A discrepancy is inherent in these calculation because an individual storm may have several precipitation types but when calculating the average time difference for a particular precipitation type this is not taken into account.

County	Region	Precipitation Type (Average Time in Hours)					Severity Index	Cost per LM per Severity Index
		Dry Snow	Wet Snow	Freezing Rain	Sleet	All Precip. Types		
WASHINGTON	SE	0.73	0.85	0.50	0.20	0.76	122.72	4.73
EAU CLAIRE	NW	1.00	1.71	0.90	1.00	1.18	104.02	4.64
OUTAGAMIE	NE	1.23	0.98	1.87	1.33	1.19	109.91	4.59
PORTAGE	NC	2.00	2.30	0.94	0.00	2.03	145.57	4.54
WAUPACA	NC	1.81	1.19	0.87	0.90	1.41	113.42	4.43
COLUMBIA	SW	0.03	0.96	1.25	-0.12	0.48	122.46	4.07
FOND DU LAC	NE	1.35	1.95	0.93	0.75	1.65	91.32	3.85
WINNEBAGO	NE	1.50	1.45	0.72	1.25	1.40	87.92	3.78
KENOSHA	SE	0.35	0.13	0.22	-0.50	0.20	97.61	3.71
DODGE	SW	0.40	2.69	2.64	0.79	2.00	78.72	3.56
MONROE	SW	1.10	0.22	0.23	0.30	0.52	130.92	3.55
RACINE	SE	1.30	1.85	1.36	0.25	1.42	90.67	3.51
SAINT CROIX	NW	0.70	0.14	0.50	-0.75	0.74	105.86	3.50
JEFFERSON	SW	0.50	0.60	-0.13	-0.33	0.48	104.51	3.44
WALWORTH	SE	3.05	0.88	1.22	0.83	1.55	118.18	3.30
SAUK	SW	0.32	0.34	2.40	1.00	0.67	100.33	3.16
ROCK	SW	0.42	0.14	0.09		0.39	90.11	3.16
MARATHON	NC	2.85	4.07	4.37	4.92	3.22	160.89	2.91
BROWN	NE	1.06	0.23	0.86	0.06	0.79	97.40	2.88
GRANT	SW	1.33	1.07	0.95	0.71	1.17	109.39	2.87
Group B Averages		1.15	1.19	1.13	0.66	1.16	109.10	3.71

Final totals as of Monday, September 23, 2019 **Page 1 of 1**

Table 4.9. Storm Start vs. Crew Out by Precipitation Type, Group C

From Winter Storm Reports, 2018-2019

Note: 1) A negative number indicates that the crews were on the road when the storm started. 2) A discrepancy is inherent in these calculation because an individual storm may have several precipitation types but when calculating the average time difference for a particular precipitation type this is not taken into account.

County	Region	Precipitation Type (Average Time in Hours)					Severity Index	Cost per LM per Severity Index
		Dry Snow	Wet Snow	Freezing Rain	Sleet	All Precip. Types		
JACKSON	NW	1.55	1.46	1.85	1.90	1.48	96.50	7.70
LINCOLN	NC	5.36	4.50	5.61	3.85	5.35	166.80	5.64
WOOD	NC	3.95	3.46	2.72	1.60	3.20	143.74	5.55
PIERCE	NW	3.05	2.81	3.59	3.00	3.04	117.63	5.37
CLARK	NW	3.13	3.92	2.06	4.17	3.46	139.59	5.35
BARRON	NW	2.13	2.38	2.28	2.22	2.21	142.10	5.13
LA CROSSE	SW	1.17	1.25	0.94	1.25	1.17	90.56	5.04
DOUGLAS	NW	1.56	3.67	2.86	6.00	2.10	140.72	4.95
JUNEAU	SW	-0.23	-0.13	-0.37	-0.29	-0.15	84.43	4.74
DUNN	NW	0.86	0.54	-0.05	0.50	0.61	134.50	4.73
MANITOWOC	NE	0.95	0.92	0.72	1.25	0.89	98.50	4.68
SHAWANO	NC	3.34	2.25	1.25	1.40	2.86	121.93	4.30
CRAWFORD	SW	3.97	1.95	1.40	1.00	2.62	139.89	4.17
SHEBOYGAN	NE	0.89	2.45	0.75	0.80	1.41	120.45	4.15
VERNON	SW	1.30	0.38	0.63	2.00	0.71	134.16	4.09
IOWA	SW	1.00	1.26	1.67	0.80	1.56	110.57	3.80
OCONTO	NE	4.56	5.06	4.19	5.33	4.26	135.39	3.41
Group C Averages		2.27	2.24	1.89	2.16	2.16	124.56	4.87

Final totals as of Monday, September 23, 2019 **Page 1 of 1**

Table 4.9. Storm Start vs. Crew Out by Precipitation Type, Group D

From Winter Storm Reports, 2018-2019

Note: 1) A negative number indicates that the crews were on the road when the storm started. 2) A discrepancy is inherent in these calculation because an individual storm may have several precipitation types but when calculating the average time difference for a particular precipitation type this is not taken into account.

County	Region	Precipitation Type					Severity Index	Cost per LM per Severity Index
		Dry Snow	Wet Snow	Freezing Rain	Sleet	All Precip. Types		
		(Average Time in Hours)						
MARQUETTE	NC	2.05	0.70	1.45	1.13	1.80	94.13	9.90
GREEN LAKE	NC	5.75	2.60	3.62	3.30	4.72	102.13	9.41
BAYFIELD	NW	4.67	3.71	5.14	3.71	4.47	131.16	8.22
DOOR	NE	3.00	2.67	2.17	2.34	2.68	127.39	7.98
ONEIDA	NC	4.90	6.86	5.75	6.25	5.66	141.70	6.21
POLK	NW	1.81	2.06	2.33	0.00	1.94	138.00	6.00
WASHBURN	NW	3.23	4.22	5.81	3.81	3.85	125.73	5.87
OZAUKEE	SE	0.89	1.50	1.10	1.29	1.07	96.22	5.62
MARINETTE	NE	0.35	0.32	0.19		0.30	139.47	5.30
RICHLAND	SW	3.56	2.29	3.62	0.75	2.46	95.53	5.25
BUFFALO	NW	0.00	0.00	0.00	0.00	0.00	148.79	5.12
GREEN	SW	6.79	4.18	4.44	7.20	4.91	102.08	4.74
WAUSHARA	NC	2.33	2.39	1.91	1.79	2.40	93.02	4.62
TREMPEALEAU	NW	1.20	1.04	0.84	1.04	1.06	135.97	4.47
LAFAYETTE	SW	4.25	1.57	1.06	1.29	1.77	94.96	3.96
Group D Averages		2.99	2.41	2.63	2.42	2.61	117.75	6.18

Final totals as of Monday, September 23, 2019 **Page 1 of 1**

Table 4.9. Storm Start vs. Crew Out by Precipitation Type, Group E

From Winter Storm Reports, 2018-2019

Note: 1) A negative number indicates that the crews were on the road when the storm started. 2) A discrepancy is inherent in these calculation because an individual storm may have several precipitation types but when calculating the average time difference for a particular precipitation type this is not taken into account.

County	Region	Precipitation Type (Average Time in Hours)					Severity Index	Cost per LM per Severity Index
		Dry Snow	Wet Snow	Freezing Rain	Sleet	All Precip. Types		
PEPIN	NW	4.56	4.75	3.43	3.40	4.70	98.37	16.23
IRON	NC	5.87	4.60	2.95	4.64	5.19	193.23	11.21
RUSK	NW	5.81	4.98	4.85	6.75	5.03	128.32	9.19
ASHLAND	NW	5.08	4.18	3.35	2.50	4.46	160.75	9.14
CALUMET	NE	4.85	6.13	1.63		4.97	97.27	9.00
TAYLOR	NW	1.71	2.24	1.50	0.75	1.99	156.98	8.80
FOREST	NC	5.12	5.17	5.47		5.39	141.60	8.40
BURNETT	NW	3.67	4.22	3.00	7.00	3.70	102.14	7.13
PRICE	NC	3.13	2.79	1.75	2.87	2.64	168.78	6.85
VILAS	NC	7.31	4.89	4.62	2.50	5.77	172.06	6.79
LANGLADE	NC	3.85	4.32	3.64	5.50	3.99	139.91	6.71
SAWYER	NW	6.39	4.79	5.15	6.42	5.00	126.05	4.84
Group E Averages		4.78	4.42	3.44	4.23	4.40	140.46	8.69

Final totals as of Monday, September 23, 2019 **Page 1 of 1**

Table 4.9. Storm Start vs. Crew Out by Precipitation Type, Group F

From Winter Storm Reports, 2018-2019

Note: 1) A negative number indicates that the crews were on the road when the storm started. 2) A discrepancy is inherent in these calculation because an individual storm may have several precipitation types but when calculating the average time difference for a particular precipitation type this is not taken into account.

County	Region	Precipitation Type (Average Time in Hours)					Severity Index	Cost per LM per Severity Index
		Dry Snow	Wet Snow	Freezing Rain	Sleet	All Precip. Types		
MENOMINEE	NC	4.33	2.54	1.50		3.55	117.59	22.95
KEWAUNEE	NE	2.12	3.18	3.89	0.33	2.81	116.83	18.24
FLORENCE	NC	4.54	4.48	5.73	6.28	4.87	141.53	17.73
ADAMS	NC	5.87	3.58	3.36	4.19	4.39	108.96	15.21
Group F Averages		4.22	3.44	3.62	3.60	3.91	121.23	18.53

Final totals as of Monday, September 23, 2019

Table 4.10. Winter Maintenance Costs per Lane Mile

County #		Total Labor	Labor $'s per Lane Mile	Total Equipment	Equip $'s per Lane Mile	Total Materials	Materials $'s Lane Mile	Total Admin	Cost of Salt Used	Tons of Salt Used	Total FY 2019 Winter Costs	2019 LOS Lane Miles	Winter Costs Per Lane Mile
	Southwest Region												
11	**Columbia**	$580,017	$736	$801,863	$1,017	$34,577	$44	$119,405	$1,556,037	19,130	$3,091,899	788.10	$3,923
12	**Crawford**	$182,304	$459	$292,828	$737	$24,858	$63	$25,140	$344,560	4,816	$869,690	397.19	$2,190
13	**Dane**	$1,893,877	$1,226	$2,030,801	$1,314	$168,076	$109	$237,141	$3,007,705	40,634	$7,337,600	1,545.15	$4,749
14	**Dodge**	$400,434	$628	$606,995	$952	$18,966	$30	$63,951	$759,985	11,296	$1,850,331	637.85	$2,901
22	**Grant**	$318,515	$510	$474,906	$760	$55,414	$89	$40,555	$552,804	8,273	$1,442,194	624.93	$2,308
23	**Green**	$161,044	$512	$206,904	$658	$45,217	$144	$20,717	$266,616	3,233	$700,498	314.64	$2,226
25	**Iowa**	$343,936	$727	$409,314	$865	$39,347	$83	$57,573	$376,129	5,429	$1,226,299	473.13	$2,592
28	**Jefferson**	$315,762	$574	$497,190	$905	$225,736	$411	$42,969	$381,278	5,116	$1,462,935	549.67	$2,661
29	**Juneau**	$301,422	$607	$532,680	$1,073	$86,540	$174	$82,309	$706,658	9,256	$1,709,609	496.27	$3,445
32	**La Crosse**	$352,503	$704	$624,444	$1,247	$37,650	$75	$48,231	$538,593	8,300	$1,601,421	500.84	$3,197
33	**Lafayette**	$130,806	$437	$221,804	$741	$98,991	$331	$22,226	$142,578	2,055	$616,405	299.38	$2,059
41	**Monroe**	$326,380	$490	$678,247	$1,018	$17,342	$26	$49,694	$849,110	11,652	$1,920,773	666.31	$2,883
52	**Richland**	$163,202	$498	$238,251	$727	$22,652	$69	$22,824	$271,488	3,584	$718,417	327.64	$2,193
53	**Rock**	$386,451	$560	$570,256	$826	$35,788	$52	$57,831	$912,340	11,363	$1,962,666	690.06	$2,844
56	**Sauk**	$433,455	$693	$585,906	$937	$9,839	$16	$51,872	$1,027,830	11,498	$2,108,902	625.18	$3,373
62	**Vernon**	$250,367	$524	$439,830	$920	$61,564	$129	$51,761	$423,484	6,217	$1,227,006	477.82	$2,568
	SWR Totals	**$6,540,475**	**$695**	**$9,212,219**	**$979**	**$982,557**	**$104**	**$994,199**	**$12,117,195**	**161,851**	**$29,846,645**	**9,414.16**	**$3,170**

Table 4.10. Winter Maintenance Costs per Lane Mile

County #		Total Labor	Labor $'s per Lane Mile	Total Equipment	Equip $'s per Lane Mile	Total Materials	Materials $'s Lane Mile	Total Admin	Cost of Salt Used	Tons of Salt Used	Total FY 2019 Winter Costs	2019 LOS Lane Miles	Winter Costs Per Lane Mile
	Southeast Region												
30	**Kenosha**	$488,878	$736	$680,368	$1,024	$18,382	$28	$54,765	$693,325	11,629	$1,935,718	664.20	$2,914
40	**Milwaukee**	$4,203,980	$2,130	$2,077,622	$1,053	$24,953	$13	$1	$2,403,961	35,105	$8,710,517	1,973.24	$4,414
45	**Ozaukee**	$332,723	$1,075	$338,197	$1,093	$24,100	$78	$34,727	$248,468	4,023	$978,215	309.54	$3,160
51	**Racine**	$547,129	$791	$629,872	$911	$17,871	$26	$55,434	$902,686	13,001	$2,152,992	691.78	$3,112
64	**Walworth**	$357,661	$505	$626,052	$884	$27,420	$39	$73,113	$1,000,363	15,505	$2,084,609	707.92	$2,945
66	**Washington**	$472,449	$771	$643,753	$1,050	$25,608	$42	$98,715	$1,004,642	13,779	$2,245,167	612.97	$3,663
67	**Waukesha**	$708,880	$652	$1,040,912	$957	$85,195	$78	$85,183	$1,536,678	21,990	$3,456,848	1,087.33	$3,179
	SER Totals	**$7,111,700**	**$1,176**	**$6,036,776**	**$998**	**$223,529**	**$37**	**$401,938**	**$7,790,123**	**115,032**	**$21,564,066**	**6,046.98**	**$3,566**
	Northeast Region												
5	**Brown**	$718,676	$796	$1,269,667	$1,407	$713	$1	$118,851	$1,105,847	16,251	$3,213,754	902.70	$3,560
8	**Calumet**	$138,039	$682	$204,720	$1,011	($3,249)	($16)	$14,923	$139,713	2,215	$494,146	202.44	$2,441
15	**Door**	$236,591	$870	$326,640	$1,202	$22,339	$82	$30,880	$224,021	3,465	$840,471	271.80	$3,092
20	**Fond du Lac**	$461,863	$759	$628,591	$1,033	$42,427	$70	$53,591	$698,762	9,031	$1,885,234	608.36	$3,099
31	**Kewaunee**	$83,170	$747	$135,480	$1,217	$36,410	$327	$13,050	$102,978	1,494	$371,088	111.35	$3,333
36	**Manitowoc**	$351,437	$824	$465,968	$1,092	$58,997	$138	$44,673	$403,442	6,872	$1,324,517	426.63	$3,105
38	**Marinette**	$354,344	$811	$445,711	$1,021	$18,295	$42	$39,803	$448,796	7,065	$1,306,949	436.66	$2,993
42	**Oconto**	$287,890	$613	$387,113	$824	$15,785	$34	$33,886	$337,233	5,114	$1,061,907	469.52	$2,262
44	**Outagamie**	$639,484	$1,186	$734,443	$1,363	$95,957	$178	$76,265	$480,185	8,111	$2,026,334	538.99	$3,760
59	**Sheboygan**	$471,768	$892	$461,001	$872	$206,988	$392	$62,212	$620,529	8,125	$1,822,498	528.68	$3,447
70	**Winnebago**	$488,210	$770	$727,117	$1,146	$119,284	$188	$61,259	$665,192	9,512	$2,061,062	634.28	$3,249
	NER Totals	**$4,231,472**	**$825**	**$5,786,451**	**$1,128**	**$613,946**	**$120**	**$549,393**	**$5,226,697**	**77,255**	**$16,407,959**	**5,131.41**	**$3,198**

Table 4.10. Winter Maintenance Costs per Lane Mile

County #		Total Labor	Labor $'s per Lane Mile	Total Equipment	Equip $'s per Lane Mile	Total Materials	Materials $'s Lane Mile	Total Admin	Cost of Salt Used	Tons of Salt Used	Total FY 2019 Winter Costs	2019 LOS Lane Miles	Winter Costs Per Lane Mile
	North Central Region												
1	**Adams**	$106,216	$550	$197,897	$1,024	$19,349	$100	$19,667	$377,624	4,263	$720,753	193.20	$3,731
19	**Florence**	$65,313	$463	$160,183	$1,135	$7,318	$52	$23,327	$209,927	2,544	$466,068	141.07	$3,304
21	**Forest**	$144,830	$464	$354,949	$1,136	$14,287	$46	$34,575	$494,153	6,008	$1,042,794	312.38	$3,338
24	**Green Lake**	$94,910	$599	$111,306	$703	$4,206	$27	$10,234	$121,032	1,624	$341,688	158.44	$2,157
26	**Iron**	$242,390	$971	$344,567	$1,381	$11,169	$45	$30,938	$373,725	4,435	$1,002,789	249.56	$4,018
34	**Langlade**	$188,101	$629	$279,590	$934	$14,963	$50	$31,456	$314,129	4,161	$828,239	299.21	$2,768
35	**Lincoln**	$303,577	$749	$475,487	$1,172	$26,352	$65	$39,766	$356,212	4,123	$1,201,394	405.55	$2,962
37	**Marathon**	$563,905	$645	$1,064,650	$1,217	$444,525	$508	$99,176	$797,476	9,399	$2,969,732	874.81	$3,395
39	**Marquette**	$184,159	$749	$239,718	$975	$11,042	$45	$23,074	$361,179	4,172	$819,172	245.75	$3,333
73	**Menominee**	$31,808	$352	$74,292	$823	$7,482	$83	$5,202	$139,541	2,005	$258,325	90.26	$2,862
43	**Oneida**	$285,616	$720	$423,417	$1,067	$21,657	$55	$33,345	$555,598	6,511	$1,319,633	396.79	$3,326
49	**Portage**	$491,561	$863	$761,253	$1,336	$57,881	$102	$61,235	$517,737	6,269	$1,889,667	569.76	$3,317
50	**Price**	$211,164	$659	$369,504	$1,154	$161,422	$504	$33,236	$309,334	3,541	$1,084,660	320.19	$3,388
58	**Shawano**	$407,839	$778	$639,764	$1,221	$20,415	$39	$50,976	$441,394	6,376	$1,560,388	524.17	$2,977
63	**Vilas**	$162,811	$533	$373,998	$1,225	$24,681	$81	$27,983	$376,476	3,935	$965,949	305.24	$3,165
68	**Waupaca**	$415,956	$761	$651,447	$1,192	$22,164	$41	$53,153	$725,365	9,705	$1,868,085	546.52	$3,418
69	**Waushara**	$158,118	$458	$217,487	$630	$929	$3	$24,303	$317,158	3,987	$717,995	345.01	$2,081
71	**Wood**	$253,015	$589	$390,493	$910	$22,880	$53	$30,509	$504,149	5,755	$1,201,046	429.28	$2,798
	NCR Totals	**$4,311,289**	**$673**	**$7,130,002**	**$1,113**	**$892,722**	**$139**	**$632,155**	**$7,292,209**	**88,814**	**$20,258,377**	**6,407.19**	**$3,162**

Table 4.10. Winter Maintenance Costs per Lane Mile

County #		Total Labor	Labor $'s per Lane Mile	Total Equipment	Equip $'s per Lane Mile	Total Materials	Materials $'s Lane Mile	Total Admin	Cost of Salt Used	Tons of Salt Used	Total FY 2019 Winter Costs	2019 LOS Lane Miles	Winter Costs Per Lane Mile
	Northwest												
2	**Ashland**	$146,877	$599	$267,576	$1,091	$76,437	$312	$41,817	$242,721	3,048	$775,428	245.35	$3,160
3	**Barron**	$388,797	$907	$490,343	$1,144	$40,827	$95	$52,098	$316,139	4,006	$1,288,204	428.77	$3,004
4	**Bayfield**	$235,324	$744	$371,513	$1,174	$48,367	$153	$36,988	$357,851	5,477	$1,050,043	316.42	$3,319
6	**Buffalo**	$171,021	$539	$261,218	$824	$2,222	$7	$22,148	$234,628	3,049	$691,237	317.02	$2,180
7	**Burnett**	$135,379	$569	$211,644	$890	$37,177	$156	$19,541	$178,845	2,674	$582,586	237.93	$2,449
9	**Chippewa**	$597,244	$912	$730,050	$1,115	$1,751	$3	$114,282	$755,924	9,676	$2,199,251	654.65	$3,359
10	**Clark**	$260,899	$648	$384,782	$956	$904	$2	$30,711	$444,294	5,064	$1,121,590	402.56	$2,786
16	**Douglas**	$334,869	$742	$573,979	$1,272	$64,525	$143	$49,743	$455,431	7,636	$1,478,547	451.40	$3,275
17	**Dunn**	$388,601	$748	$516,165	$994	$26,708	$51	$46,480	$651,318	9,031	$1,629,272	519.24	$3,138
18	**Eau Claire**	$510,093	$943	$773,906	$1,431	$42,927	$79	$69,038	$657,077	8,501	$2,053,041	540.70	$3,797
27	**Jackson**	$257,706	$500	$486,666	$944	$114,640	$222	$80,151	$686,165	8,758	$1,625,328	515.44	$3,153
46	**Pepin**	$106,412	$947	$96,286	$857	$1,074	$10	$9,454	$72,200	961	$285,426	112.38	$2,540
47	**Pierce**	$280,393	$759	$395,874	$1,071	$20,945	$57	$39,941	$329,493	4,674	$1,066,646	369.46	$2,887
48	**Polk**	$229,386	$595	$369,437	$958	$62,959	$163	$35,885	$432,317	5,394	$1,129,984	385.81	$2,929
54	**Rusk**	$103,674	$486	$170,401	$798	$5,573	$26	$29,303	$223,378	2,639	$532,329	213.47	$2,494
55	**Saint Croix**	$583,022	$902	$616,039	$953	$115,515	$179	$68,113	$723,688	10,715	$2,106,377	646.54	$3,258
57	**Sawyer**	$171,580	$467	$234,296	$638	$14,505	$39	$20,183	$392,359	4,836	$832,923	367.44	$2,267
60	**Taylor**	$205,891	$880	$313,460	$1,340	$17,000	$73	$27,912	$203,589	2,232	$767,852	233.90	$3,283
61	**Trempealeau**	$295,941	$667	$432,505	$975	$21,448	$48	$37,079	$460,192	6,058	$1,247,165	443.67	$2,811
65	**Washburn**	$237,834	$639	$441,180	$1,186	$21,993	$59	$39,630	$400,562	6,059	$1,141,199	372.14	$3,067
	NWR Totals	**$5,640,943**	**$726**	**$8,137,320**	**$1,047**	**$737,497**	**$95**	**$870,497**	**$8,218,172**	**110,490**	**$23,604,429**	**7,774.29**	**$3,036**

Table 4.10. Winter Maintenance Costs per Lane Mile

	Total Labor	Labor $'s per Lane Mile	Total Equipment	Equip $'s per Lane Mile	Total Materials	Materials $'s Lane Mile	Total Admin	Cost of Salt Used	Tons of Salt Used	Total FY 2019 Winter Costs	2019 LOS Lane Miles	Winter Costs Per Lane Mile
STATEWIDE SUMMARY												
SW Region	$6,540,475	$695	$9,212,219	$979	$982,557	$104	$994,199	$12,117,195	161,851	$29,846,645	9,414.16	$3,170
SE Region	$7,111,700	$1,176	$6,036,776	$998	$223,529	$37	$401,938	$7,790,123	115,032	$21,564,066	6,046.98	$3,566
NE Region	$4,231,472	$825	$5,786,451	$1,128	$613,946	$120	$549,393	$5,226,697	77,255	$16,407,959	5,131.41	$3,198
NC Region	$4,311,289	$673	$7,130,002	$1,113	$892,722	$139	$632,155	$7,292,209	88,814	$20,258,377	6,407.19	$3,162
NW Region	$5,640,943	$726	$8,137,320	$1,047	$737,497	$95	$870,497	$8,218,172	110,490	$23,604,429	7,774.29	$3,036
Statewide Totals	$27,835,879	$800	$36,302,768	$1,044	$3,450,251	$99	$3,448,182	$40,644,396	553,443	$111,681,476	34,774.03	$3,212

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Figure 4.10. 2018-2019 Winter Costs vs. 5-Year Average

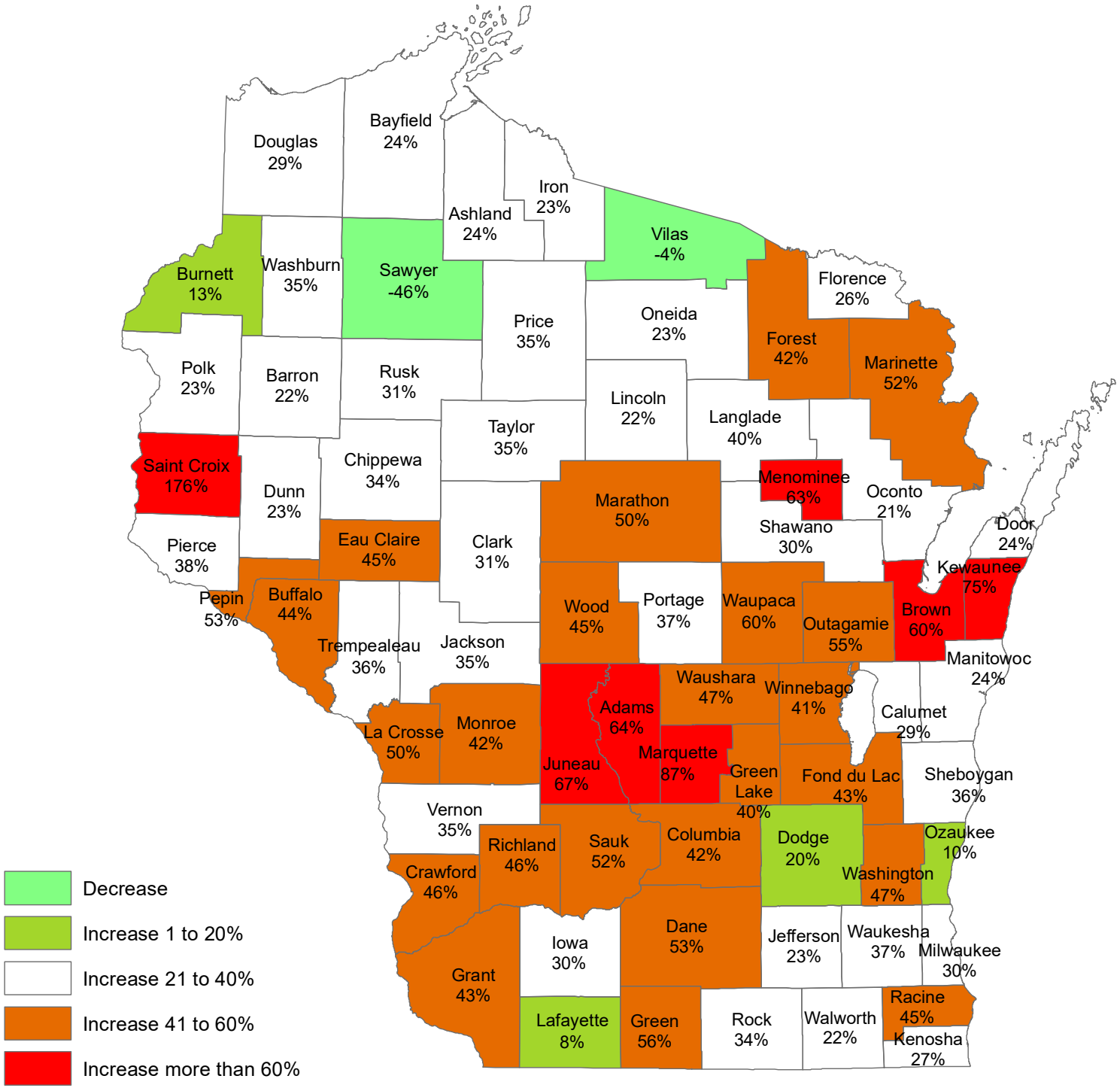

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group A)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
DANE	SW	1,545.15	110.58	53.2	40634	26.30	0.24	$9,547,000	$6,211	4.02
WAUKESHA	SE	1,087.33	86.34	75.9	21990	20.22	0.23	$2,566,000	$2,363	2.17
MILWAUKEE	SE	1,973.24	94.36	55.6	35105	17.79	0.19	$5,596,000	$2,870	1.45
Group A Averages		1,535.24	97.09	61.6	32576	21.44	0.22	$5,903,000	$3,814	2.55

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group B)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
WASHINGTON	SE	612.97	122.72	74.1	13779	22.48	0.18	$1,743,000	$2,902	4.73
EAU CLAIRE	NW	540.70	104.02	89.7	8501	15.72	0.15	$1,343,000	$2,512	4.64
OUTAGAMIE	NE	538.99	109.91	93.1	8111	15.05	0.14	$1,224,000	$2,473	4.59
PORTAGE	NC	569.76	145.57	105.8	6269	11.00	0.08	$1,467,000	$2,584	4.54
WAUPACA	NC	546.52	113.42	96.3	9705	17.76	0.16	$1,316,000	$2,418	4.43
COLUMBIA	SW	788.10	122.46	62.0	19130	24.27	0.20	$2,529,000	$3,209	4.07
FOND DU LAC	NE	608.36	91.32	90.0	9031	14.84	0.16	$1,397,000	$2,342	3.85
WINNEBAGO	NE	634.28	87.92	83.5	9512	15.00	0.17	$1,496,000	$2,396	3.78
KENOSHA	SE	664.20	97.61	42.9	11629	17.51	0.18	$1,637,000	$2,464	3.71
DODGE	SW	637.85	78.72	68.0	11296	17.71	0.22	$1,434,000	$2,272	3.56
MONROE	SW	666.31	130.92	87.6	11652	17.49	0.13	$1,573,000	$2,366	3.55
RACINE	SE	691.78	90.67	53.1	13001	18.79	0.21	$1,672,000	$2,428	3.51
SAINT CROIX	NW	646.54	105.86	103.5	10715	16.57	0.16	$1,462,000	$2,261	3.50
JEFFERSON	SW	549.67	104.51	63.4	5116	9.31	0.09	$977,000	$1,891	3.44
WALWORTH	SE	707.92	118.18	65.1	15403	21.76	0.18	$1,648,000	$2,334	3.30
SAUK	SW	709.92	100.33	82.9	11498	16.20	0.16	$1,587,000	$2,244	3.16
ROCK	SW	690.06	90.11	56.1	11363	16.47	0.18	$1,505,000	$2,181	3.16
CHIPPEWA	NW	654.65	93.85	85.3	9676	14.78	0.16	$1,352,000	$2,066	3.16

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group B)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
MARATHON	NC	874.81	160.89	108.1	9399	10.74	0.07	$2,140,000	$2,542	2.91
BROWN	NE	902.70	97.40	70.4	16251	18.00	0.18	$2,317,000	$2,600	2.88
GRANT	SW	624.93	109.39	76.4	8273	13.24	0.12	$1,115,000	$1,793	2.87
Group B Averages		660.05	108.37	78.9	10920	16.41	0.16	$1,568,286	$2,394	3.68

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group C)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
JACKSON	NW	515.44	96.50	106.9	8758	16.99	0.18	$2,046,000	$3,970	7.70
LINCOLN	NC	405.55	166.80	133.7	4123	10.17	0.06	$910,000	$2,286	5.64
WOOD	NC	429.28	143.74	100.3	5755	13.41	0.09	$986,000	$2,381	5.55
PIERCE	NW	369.46	117.63	83.5	4674	12.65	0.11	$727,000	$1,985	5.37
CLARK	NW	402.56	139.59	108.7	5064	12.58	0.09	$866,000	$2,152	5.35
BARRON	NW	428.77	142.10	117.2	4006	9.34	0.07	$943,000	$2,200	5.13
LA CROSSE	SW	500.84	90.56	94.0	8300	16.57	0.18	$1,241,000	$2,523	5.04
DOUGLAS	NW	451.40	140.72	134.6	7636	16.92	0.12	$1,009,000	$2,236	4.95
JUNEAU	SW	496.27	84.43	75.0	9256	18.65	0.22	$1,166,000	$2,350	4.74
DUNN	NW	519.24	134.50	108.9	9031	17.39	0.13	$1,269,000	$2,453	4.73
MANITOWOC	NE	426.63	98.50	61.3	6872	16.11	0.16	$853,000	$1,998	4.68
SHAWANO	NC	524.17	121.93	112.1	6376	12.16	0.10	$1,175,000	$2,255	4.30
CRAWFORD	SW	397.19	139.89	77.1	4816	12.13	0.09	$658,000	$1,656	4.17
SHEBOYGAN	NE	528.68	120.45	83.4	8125	15.37	0.13	$1,142,000	$2,192	4.15
VERNON	SW	477.82	134.16	80.7	6217	13.01	0.10	$913,000	$1,953	4.09
IOWA	SW	473.13	110.57	76.3	5429	11.47	0.10	$852,000	$1,800	3.80
OCONTO	NE	469.52	135.39	96.9	5114	10.89	0.08	$753,000	$1,603	3.41

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group C)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
Group C Averages		459.76	124.56	97.1	6444	13.87	0.12	$1,029,941	$2,235	4.87

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group D)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
MARQUETTE	NC	245.75	94.13	67.6	4172	16.98	0.18	$598,000	$2,433	9.90
GREEN LAKE	NC	158.44	102.13	73.1	1624	10.25	0.10	$235,000	$1,491	9.41
BAYFIELD	NW	316.42	131.16	138.2	5477	17.31	0.13	$807,000	$2,602	8.22
DOOR	NE	271.80	127.39	98.4	3465	12.75	0.10	$585,000	$2,168	7.98
ONEIDA	NC	396.79	141.70	121.0	6511	16.41	0.12	$978,000	$2,466	6.21
POLK	NW	385.81	138.00	74.1	5394	13.98	0.10	$883,000	$2,316	6.00
WASHBURN	NW	372.14	125.73	86.4	6059	16.28	0.13	$807,000	$2,186	5.87
OZAUKEE	SE	309.54	96.22	72.4	4023	13.00	0.14	$532,000	$1,739	5.62
MARINETTE	NE	436.66	139.47	112.2	7065	16.18	0.12	$1,008,000	$2,313	5.30
RICHLAND	SW	327.64	95.53	73.0	3584	10.94	0.11	$564,000	$1,721	5.25
BUFFALO	NW	317.02	148.79	127.1	3049	9.62	0.06	$515,000	$1,624	5.12
GREEN	SW	314.64	102.08	54.5	3233	10.28	0.10	$469,000	$1,490	4.74
WAUSHARA	NC	345.01	93.02	93.9	3987	11.56	0.12	$549,000	$1,593	4.62
TREMPEALEAU	NW	443.67	135.97	106.8	6058	13.65	0.10	$881,000	$1,985	4.47
LAFAYETTE	SW	299.38	94.96	57.3	2055	6.86	0.07	$355,000	$1,187	3.96
Group D Averages		329.38	117.75	90.4	4384	13.07	0.11	$651,067	$1,954	6.18

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group E)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
PEPIN	NW	112.38	98.37	89.7	961	8.55	0.09	$205,000	$1,824	16.23
IRON	NC	249.56	193.23	215.6	4435	17.77	0.09	$694,000	$2,799	11.21
RUSK	NW	213.47	128.32	97.2	2639	12.36	0.10	$419,000	$1,963	9.19
ASHLAND	NW	245.35	160.75	172.2	3048	12.42	0.08	$544,000	$2,243	9.14
CALUMET	NE	202.44	97.27	80.6	2214	10.94	0.11	$366,000	$1,822	9.00
TAYLOR	NW	233.90	156.98	99.4	2232	9.54	0.06	$470,000	$2,058	8.80
FOREST	NC	312.38	141.60	104.2	6008	19.23	0.14	$809,000	$2,625	8.40
BURNETT	NW	237.93	102.14	86.1	2674	11.24	0.11	$404,000	$1,698	7.13
PRICE	NC	320.19	168.78	126.0	3541	11.06	0.07	$690,000	$2,194	6.85
VILAS	NC	305.24	172.06	143.2	3935	12.89	0.07	$631,000	$2,072	6.79
LANGLADE	NC	299.21	139.91	115.0	4161	13.91	0.10	$601,000	$2,008	6.71
SAWYER	NW	367.44	126.05	115.5	4836	13.16	0.10	$653,000	$1,778	4.84
Group E Averages		258.29	140.46	120.4	3390	12.76	0.09	$540,500	$2,090	8.69

Table 4.11. Cost per Lane Mile per Severity Index Ranking (Group F)

From Winter Storm Reports, 2018-2019

County	Region	Lane Miles	Severity Index	Snow Depth (in)	Salt (ton)	Salt per LM	Salt per LM per Severity Index	Total Cost	Total $/LM	Cost per LM per Severity Index
MENOMINEE	NC	90.26	117.59	98.2	2005	22.21	0.19	$187,000	$2,071	22.95
KEWAUNEE	NE	111.35	116.83	101.7	1494	13.42	0.11	$218,000	$2,031	18.24
FLORENCE	NC	141.07	141.53	110.3	2544	18.03	0.13	$353,000	$2,501	17.73
ADAMS	NC	193.20	108.96	87.1	4263	22.07	0.20	$567,000	$2,940	15.21
Group F Averages		133.97	121.23	99.3	2577	18.93	0.16	$331,250	$2,386	18.53

Table 4.12. Winter Crashes per 100 Million Vehicle Miles of Travel

Bureau of transportation Safety data, Nov. 1, 2018 - April 30, 2019 State, U.S. and Interstate Highways only

WisDOT REGION / COUNTY	2018-19 WINTER VEHICLE MILES OF TRAVEL (VMT)	2018-19 WINTER CRASHES	CRASH RATE PER 100M VMT
NORTH CENTRAL			
ADAMS	119,700,000	25	21
FLORENCE	40,900,000	7	17
FOREST	71,100,000	21	30
GREEN LAKE	108,200,000	21	19
IRON	58,800,000	27	46
LANGLADE	117,500,000	33	28
LINCOLN	238,500,000	52	22
MARATHON	821,200,000	442	54
MARQUETTE	146,000,000	50	34
MENOMINEE	18,100,000	2	11
ONEIDA	239,300,000	76	32
PORTAGE	447,900,000	184	41
PRICE	109,700,000	20	18
SHAWANO	308,400,000	89	29
VILAS	179,700,000	70	39
WAUPACA	287,200,000	118	41
WAUSHARA	186,400,000	55	30
WOOD	317,600,000	142	45
Region Total	**3,816,200,000**	**1,434**	**38**
NORTHEAST			
BROWN	1,178,500,000	477	40
CALUMET	205,000,000	73	36
DOOR	220,100,000	49	22
FOND DU LAC	569,700,000	187	33
KEWAUNEE	110,700,000	17	15
MANITOWOC	405,500,000	164	40
MARINETTE	356,600,000	68	19
OCONTO	305,600,000	80	26
OUTAGAMIE	754,400,000	337	45
SHEBOYGAN	499,900,000	142	28
WINNEBAGO	843,100,000	464	55
Region Total	**5,449,100,000**	**2,058**	**38**

Table 4.12. Winter Crashes per 100 Million Vehicle Miles of Travel

Bureau of transportation Safety data, Nov. 1, 2018 - April 30, 2019 State, U.S. and Interstate Highways only

WisDOT REGION / COUNTY	2018-19 WINTER VEHICLE MILES OF TRAVEL (VMT)	2018-19 WINTER CRASHES	CRASH RATE PER 100M VMT
NORTHWEST			
ASHLAND	108,900,000	20	18
BARRON	318,500,000	57	18
BAYFIELD	174,600,000	25	14
BUFFALO	110,400,000	22	20
BURNETT	121,700,000	23	19
CHIPPEWA	451,800,000	129	29
CLARK	261,200,000	72	28
DOUGLAS	280,900,000	73	26
DUNN	352,100,000	138	39
EAU CLAIRE	512,600,000	309	60
JACKSON	318,400,000	111	35
PEPIN	44,900,000	13	29
PIERCE	178,900,000	75	42
POLK	256,300,000	36	14
RUSK	113,400,000	9	8
ST.CROIX	623,200,000	192	31
SAWYER	147,000,000	20	14
TAYLOR	117,200,000	22	19
TREMPEALEAU	221,400,000	80	36
WASHBURN	173,300,000	49	28
Region Total	**4,886,700,000**	**1,475**	**30**
SOUTHEAST			
KENOSHA	752,900,000	173	23
MILWAUKEE	3,258,800,000	749	23
OZAUKEE	502,800,000	84	17
RACINE	787,500,000	204	26
WALWORTH	581,200,000	139	24
WASHINGTON	762,000,000	160	21
WAUKESHA	1,950,300,000	329	17
Region Total	**8,595,500,000**	**1,838**	**21**

Table 4.12. Winter Crashes per 100 Million Vehicle Miles of Travel

Bureau of transportation Safety data, Nov. 1, 2018 - April 30, 2019 State, U.S. and Interstate Highways only

WisDOT REGION / COUNTY	2018-19 WINTER VEHICLE MILES OF TRAVEL (VMT)	2018-19 WINTER CRASHES	CRASH RATE PER 100M VMT
SOUTHWEST			
COLUMBIA	497,100,000	192	39
CRAWFORD	125,700,000	16	13
DANE	2,412,100,000	473	20
DODGE	498,000,000	104	21
GRANT	284,200,000	106	37
GREEN	166,700,000	49	29
IOWA	209,900,000	69	33
JEFFERSON	481,400,000	169	35
JUNEAU	350,500,000	100	29
LA CROSSE	495,400,000	365	74
LAFAYETTE	122,000,000	22	18
MONROE	382,800,000	171	45
RICHLAND	113,800,000	31	27
ROCK	757,300,000	255	34
SAUK	411,400,000	199	48
VERNON	166,700,000	56	34
Region Total	**7,475,000,000**	**2,377**	**32**
STATEWIDE TOTAL	**30,222,500,000**	**9,182**	**30**

Table 4.13 Motor Vehicle Crashes on Roads with Snow/Ice/Slush

Bureau of transportation Safety data, Nov. 1, 2018 - April 30, 2019 State, U.S. and Interstate Highways only

NC Region

COUNTY	TOTAL	Urban STH	Rural STH	Urban IH	Rural IH	Urban State Highway			Rural State Highway		
						Non-div	Divided	Unkn	Non-div	Divided	Unkn
ADAMS	25	0	25	0	0	0	0	0	23	1	1
FLORENCE	7	0	7	0	0	0	0	0	7	0	0
FOREST	21	0	21	0	0	0	0	0	16	1	4
GREEN LAKE	21	4	17	0	0	4	0	0	17	0	0
IRON	27	0	27	0	0	0	0	0	25	2	0
LANGLADE	33	3	30	0	0	3	0	0	29	1	0
LINCOLN	52	12	40	0	0	10	1	1	15	25	0
MARATHON	442	145	233	20	44	44	97	4	59	172	2
MARQUETTE	50	0	23	0	27	0	0	0	23	0	0
MENOMINEE	2	0	2	0	0	0	0	0	2	0	0
ONEIDA	76	2	74	0	0	0	2	0	68	3	3
PORTAGE	184	42	71	15	56	23	18	1	23	47	1
PRICE	20	0	20	0	0	0	0	0	19	0	1
SHAWANO	89	7	82	0	0	7	0	0	29	53	0
VILAS	70	0	70	0	0	0	0	0	61	4	5
WAUPACA	118	8	110	0	0	5	3	0	58	52	0
WAUSHARA	55	0	39	0	16	0	0	0	34	4	1
WOOD	142	86	56	0	0	43	41	2	36	18	2
TOTAL	1,434	309	947	35	143	139	162	8	544	383	20

NE Region

COUNTY	TOTAL	Urban STH	Rural STH	Urban IH	Rural IH	Urban State Highway			Rural State Highway		
						Non-div	Divided	Unkn	Non-div	Divided	Unkn
BROWN	477	312	82	63	20	93	216	3	22	59	1
CALUMET	73	18	49	6	0	11	7	0	46	3	0
DOOR	49	8	41	0	0	4	4	0	29	12	0
FOND DU LAC	187	47	116	4	20	23	21	3	38	78	0
KEWAUNEE	17	0	17	0	0	0	0	0	15	2	0
MANITOWOC	164	42	43	2	77	30	11	1	28	13	2
MARINETTE	68	19	49	0	0	14	5	0	31	16	2
OCONTO	80	0	80	0	0	0	0	0	26	53	1
OUTAGAMIE	337	147	158	13	19	78	67	2	78	77	3
SHEBOYGAN	142	34	57	1	50	24	9	1	31	25	1
WINNEBAGO	464	172	175	88	29	65	102	5	52	118	5
TOTAL	2,058	799	867	177	215	342	442	15	396	456	15

Bureau of transportation Safety data, Nov. 1, 2018 - April 30, 2019 State, U.S. and Interstate Highways only

NW Region

COUNTY	TOTAL	Urban STH	Rural STH	Urban IH	Rural IH	Urban State Highway			Rural State Highway		
						Non-div	Divided	Unkn	Non-div	Divided	Unkn
ASHLAND	20	17	3	0	0	9	3	5	3	0	0
BARRON	57	5	52	0	0	5	0	0	24	28	0
BAYFIELD	25	0	25	0	0	0	0	0	24	0	1
BUFFALO	22	0	22	0	0	0	0	0	21	1	0
BURNETT	23	0	23	0	0	0	0	0	20	0	3
CHIPPEWA	129	17	112	0	0	3	13	1	31	81	0
CLARK	72	0	72	0	0	0	0	0	32	40	0
DOUGLAS	73	41	18	14	0	17	19	5	6	12	0
DUNN	138	24	37	22	55	15	9	0	32	5	0
EAU CLAIRE	309	139	56	18	96	26	110	3	28	26	2
JACKSON	111	0	35	0	76	0	0	0	27	6	2
PEPIN	13	0	13	0	0	0	0	0	11	1	1
PIERCE	75	6	69	0	0	6	0	0	65	4	0
POLK	36	0	36	0	0	0	0	0	31	3	2
RUSK	9	0	9	0	0	0	0	0	6	0	3
ST. CROIX	192	19	97	13	63	11	7	1	56	38	3
SAWYER	20	0	20	0	0	0	0	0	16	4	0
TAYLOR	22	0	22	0	0	0	0	0	21	1	0
TREMPEALEAU	80	0	69	0	11	0	0	0	67	1	1
WASHBURN	49	0	49	0	0	0	0	0	23	24	2
TOTAL	1,475	268	839	67	301	92	161	15	544	275	20

SE Region

COUNTY	TOTAL	Urban STH	Rural STH	Urban IH	Rural IH	Urban State Highway			Rural State Highway		
						Non-div	Divided	Unkn	Non-div	Divided	Unkn
KENOSHA	173	81	51	32	9	35	43	3	17	34	0
MILWAUKEE	749	520	0	229	0	183	322	15	0	0	0
OZAUKEE	84	20	15	28	21	10	9	1	4	11	0
RACINE	204	133	66	0	5	52	72	9	30	36	0
WALWORTH	139	17	86	6	30	11	4	2	51	33	2
WASHINGTON	160	71	66	11	12	31	38	2	27	39	0
WAUKESHA	329	92	68	103	66	15	74	3	27	41	0
TOTAL	1,838	934	352	409	143	337	562	35	156	194	2

SW Region

COUNTY	TOTAL	Urban STH	Rural STH	Urban IH	Rural IH	Urban State Highway			Rural State Highway		
						Non-div	Divided	Unkn	Non-div	Divided	Unkn
COLUMBIA	192	20	73	4	95	14	6	0	60	9	4
CRAWFORD	16	6	10	0	0	5	1	0	8	2	0
DANE	473	233	142	39	59	51	178	4	62	76	4
DODGE	104	7	90	0	7	3	3	1	37	51	2
GRANT	106	6	100	0	0	4	1	1	54	46	0
GREEN	49	5	44	0	0	0	5	0	40	4	0
IOWA	69	0	69	0	0	0	0	0	20	48	1
JEFFERSON	169	15	90	0	64	11	4	0	36	53	1
JUNEAU	100	0	33	1	66	0	0	0	29	2	2
LA CROSSE	365	227	59	40	39	127	87	13	36	23	0
LAFAYETTE	22	0	22	0	0	0	0	0	13	8	1
MONROE	171	35	49	8	79	16	18	1	43	6	0
RICHLAND	31	0	31	0	0	0	0	0	26	5	0
ROCK	255	71	104	35	45	45	24	2	73	25	6
SAUK	199	26	102	0	71	20	5	1	61	40	1
VERNON	56	0	56	0	0	0	0	0	52	3	1
TOTAL	2,377	651	1,074	127	525	296	332	23	650	401	23

5 Looking Ahead

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The Wisconsin Department of Transportation (WisDOT) Bureau of Highway Maintenance continues to look toward efficiencies that reduce winter maintenance costs. Using brine during winter storm events helps reduce salt use and can result in a significant reduction of material costs. Additionally, the reduction in salt can reduce impacts to roadside vegetation and the state's water resources.

WisDOT hired the University of Wisconsin – Madison Traffic Operations and Safety (TOPS) Laboratory in 2018 to collect data from these DLA routes and to research the effectiveness of different brine mixtures in varying weather conditions. The department will continue this effort with the UW TOPS Lab during the winter of 2019-20 with the goal to collect more data relating to these liquid routes. These results are expected to promote statewide use of liquids, as equipment is upgraded and personnel adapt to changes in winter maintenance practices. As part of similar research being performed by a Clear Roads Technical Advisory Committee led by WisDOT, the UW TOPS Lab has also been contracted to perform a nationwide analysis of this technique. This will allow for synergy between WisDOT's efforts and those occurring on a national level.

WisDOT will continue to explore other methods of reducing rock salt usage on the state highway system. Through our partnership with the counties, we will continue to implement route optimization, which has proven to enhance efficiency. The Maintenance Decision Support System (MDSS) continues to be refined, including the option of having treatment recommendations sent directly to plow drivers. This winter, MDSS will also include recommendations for DLA routes. Through the Wisconsin County Highway Association, winter maintenance training at all levels will be implemented using materials and methods created by Clear Roads and other expert sources.

All these efforts are aimed at providing users of Wisconsin's highways the safest possible experience despite harsh winter weather while WisDOT safeguards the state's natural environment by implementing sustainable practices.sustainable practices.

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