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Use of Dashboards for Winter Operations Case Study: Iowa Department of Transportation

Clear Roads Project 22-05: Use of Dashboards for Winter Operations

December 2024

Technical Report Documentation Page

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16. Abstract Public works agencies at state and municipal levels have invested a large amount of personnel and funding resources in dashboards to improve winter maintenance operations. This document is one of the five case studies conducted for the Clear Roads project entitled *Use of Dashboards for Winter Operations*. This case study report summarizes the Iowa Department of Transportation's experiences and lessons learned in using dashboards to support winter maintenance. The case study identifies the purpose of each Iowa DOT dashboard, the performance measures tracked, the data sources, how the dashboards are maintained, difficulties encountered, and key lessons learned.			
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1. Overview of Iowa DOT Dashboards for Winter Operations

This section provides an overview of this Case Study report detailing how the Iowa Department of Transportation (Iowa DOT) has used dashboards for winter operations. The data for this case study was gathered from an interview conducted with the Iowa DOT. The Iowa DOT was selected based on preliminary data gathered from a project survey with approval from the Clear Road's committee for this project.

1.1 Case Study Background

This research project is being funded through the Clear Roads pooled fund program to develop Case Study Reports documenting how multiple State DOTs and public works agencies use dashboards for winter operations. The goal is to share knowledge on current and/or innovative practices to see how agencies can leverage dashboards for best decision making and management of operations.

1.2 Agency Characteristics

The Iowa DOT consists of six districts as shown in Figure 1. Each district contains a maintenance superintendent and a maintenance supervisor responsible for winter maintenance operations.

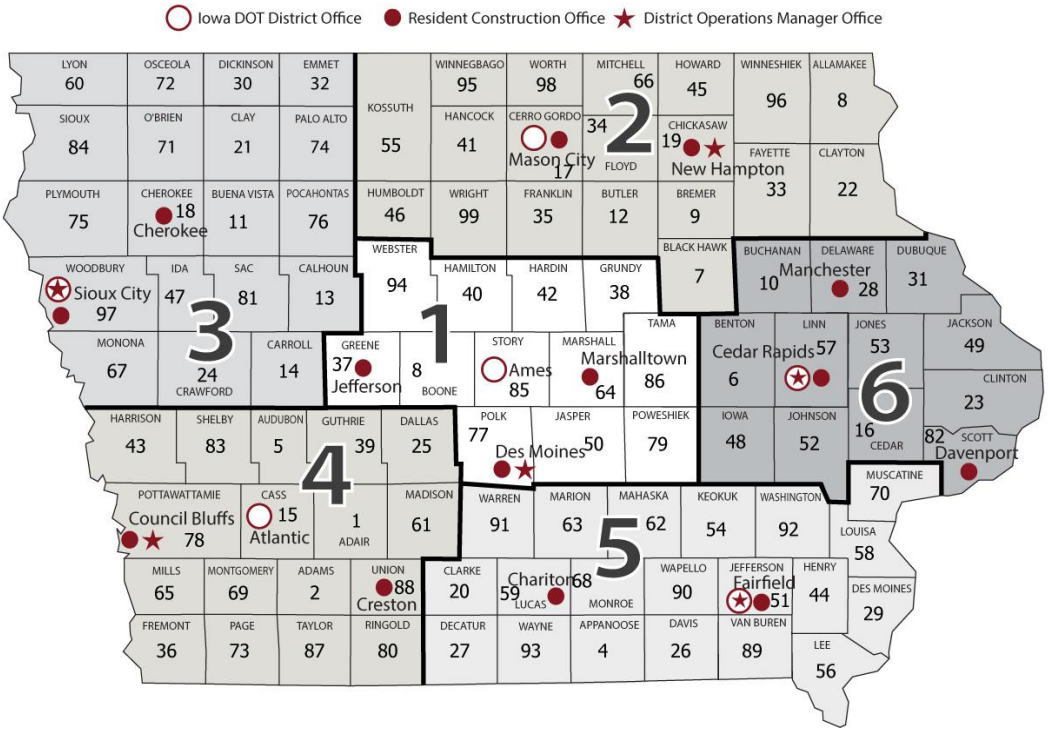


Figure 1 Iowa DOT Districts

Iowa DOT manages 24,592 total lane miles with 920 state-owned plow trucks with over 1,000 state employees and 425 seasonal workers. Iowa DOT maintains 99% of the state-owned roadways. In the 2022-2023 winter season, Iowa DOT applied approximately 129,000 tons of sodium chloride, 17,000 tons of abrasives, and 31,700,000 gallons of liquids (sodium chloride brine and calcium chloride brine). The cost of salt last season was $83.11 per ton resulting in $17.8 million dollars in material cost. The average accumulated winter season index was 653[1]. These data were reported to Clear Roads Winter Data Survey.

1.3 Agency Interviews

An interview was conducted virtually with Iowa DOT staff on Monday November 27th, 2023, at 9 AM CST on use of dashboards for winter operations. Table 1 contains a listing of the staff interviewed and the subjects discussed. Appendix B to this report contains meeting minutes from the interview.

Table 1 Details of Agency Interview

Staff Interviewed	Date / Time	Subjects Discussed
Tina Greenfield Huitt, Iowa Department of Transportation Road Weather Information Systems (RWIS) Coordinator **Craig Bargfrede,** Winter Operations Administrator	Nov. 27th, 2023 / 9:00 AM	Dashboard objectives Description of each dashboard Limitations of each dashboard Process for developing a new dashboard Data accuracy Data storage and management Dashboard maintenance Costs Benefits of dashboards Recommendations and lessons learned Future enhancements

2. General Overview of Winter Dashboards

The Iowa DOT began using dashboards to visualize winter maintenance operation data around the Fiscal Year (FY) 2012. The driving force to start using dashboards was to monitor and track salt usage. It started with an Excel workbook dashboard. By FY 2013, Iowa DOT moved from the Excel workbook to Dundas BI for more enterprise-level business intelligence and to further automate the Excel workbook. Iowa DOT has been using PowerBI for about 5 years as their primary dashboard for winter maintenance operations from previously using Excel and later DunceBI as their primary dashboard.

[1] https://mrcc.purdue.edu/research/awssi/indexAwssi.jsp

Most of the dashboards are centered around material and salt usage tracking. Iowa DOT has several winter dashboards:

- A salt dashboard,
- A salt ledger dashboard,
- A material usage and storm reporting dashboard,
- A public dashboard that provides salt usage chart, salt accumulation and weather severity index, and
- Salt budget dashboard overview.

The following sections will discuss each of these dashboards in more details

2.1 The Salt Dashboard General Overview

The Salt Dashboard tracks and monitors salt usage, it is a tool for calculating and comparing anticipated versus actual salt usage rates. It operates by forecasting the expected salt usage and then cross-referencing it with real-time data. This comparison provides essential insights into the efficiency and accuracy of salt usage throughout operations. Its primary function is to offer a clear overview of anticipated versus actual usage, enabling more informed decisions based on these insights. Figure 2 shows the example of the salt dashboard. Table 2 provides details of the Salt Dashboard.

As shown in Table 2, the purpose of the salt dashboard is to track and monitor salt usage and the performance measures includes calculation of anticipated salt usage rate (predictive analytics) and then comparing anticipated usage versus actual usage. This dashboard is refreshed daily. The software used for the dashboard is PowerBI. The field staff reports salt usage manually. Garage managers and field staff then review salt usage gathered by the AVL and adjust as needed. Field staff report weather information manually as well. Weather data was gathered from RWIS. Weather is important since it is used to calculate target ideal salt usage. The salt target uses miles for garage responsibility routes (not miles driven), LOS priority, and weather. Data are entered and pulled from Iowa DOT's MMS and RMS. The users of the data are mainly Garage supervisor, district managers, and field division manager utilize the dashboard. Data Management Analyst and Winter Operations Administrator use to assist with administration even though their roles are not included in Field Operations. Data Management Analyst and the Winter Operations Administrator use to review budget and monitor salt requests. Garages and district supervisors review for managing their resources. The Winter Operations Administrator procures the salt, so they use the dashboard to guide procurement needs.

It was noted that the prediction helps but is not always prefect. Fortunately, Iowa DOT has been using the Salt Dashboard for 11 years and the garage managers are used to the model. These insights facilitate conversations between managers on best practices to hit target salt usage. The dashboard is a tool to

help education and start conversations with maintenance staff, which helps alleviate concerns regarding staff turnover, particularly at the supervisor level.

Iowa DOT is currently working on a storm or daily weather index instead of a monthly/seasonal index. Current mobility data is not added to prediction/targeted salt usage. Iowa DOT attempted to integrate speed but fell apart because of inaccurate speed data (note that was 10 years ago, so data might be better now). Iowa DOT is currently not using any road surface friction sensor data within their storm index calculations or within their dashboard.

Future enhancements are to explore filling data gaps with crowdsource data. Also, Iowa DOT has already calculated time to bare pavement but has not integrated into the dashboard yet.

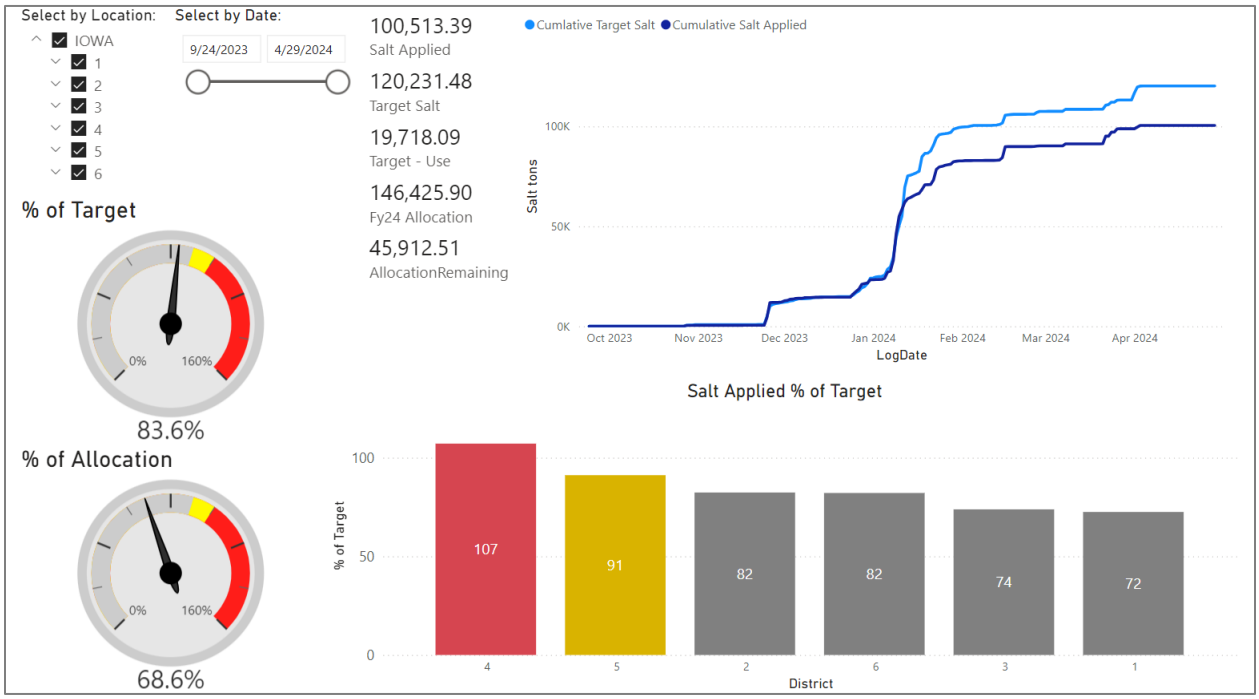


Figure 2 Salt Dashboard

Table 2 Salt Dashboard Overview

Purpose	Track and monitor salt usage.
Performance Measures	Calculates an anticipated salt usage rate (predictive analytics) and then compares anticipated usage versus actual usage.
Data Sources	Field staff report salt usage manually. Garage managers and field staff then review salt usage gathered by the Automatic Vehicle Location (AVL) and adjust as needed. Field staff report weather information manually as well. Weather data was gathered from Road Weather Information System

	(RWIS). Weather is important since it is used to calculate target ideal salt usage. The salt target uses miles for garage responsibility routes (not miles driven), Level of Service (LOS) priority, and weather. Data are entered and pulled from Iowa DOT's Maintenance Management System (MMS) and Roadway Management System (RMS).
Refresh Rate	Daily refresh
Users/Access	Garage supervisor, district managers, and field division manager utilize the dashboard. Data Management Analyst and Winter Operations Administrator use to assist with administration even though their roles are not included in Field Operations. Data Management Analyst and the Winter Operations Administrator use to review budget and monitor salt requests. Garages and district supervisors review for managing their resources. The Winter Operations Administrator procures the salt, so they use the dashboard to guide procurement needs.
Platform/Software	Microsoft PowerBI

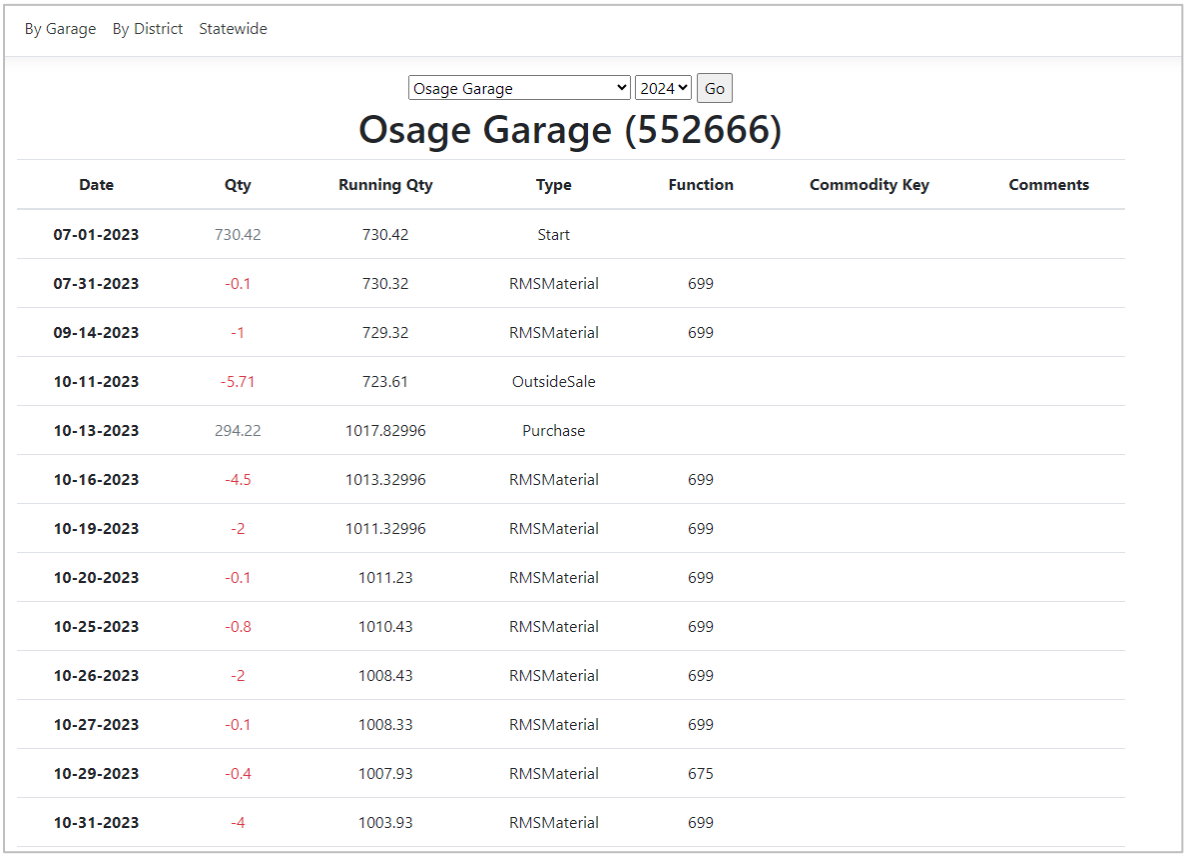
2.2 The Salt Ledger Dashboard General Overview:

The Salt Ledger dashboard serves as a comprehensive record-keeping system for salt-related transactions. It keeps a running total of salt on hand by garage and salt usages. This dashboard provides opportunities to manage in a more real-time for better tracking. It tracks salt quantities across garages, documenting daily usage, receipts, sales, transfers, and contracts with the city. This ledger ensures a real-time assessment of salt quantities, allowing garages to manage their inventories more effectively. This information is given to the dashboards. The users started with a few offices and IT, but then continued to grow into other bureaus and districts. Table 3 provides details of the Salt ledger Dashboard.

As shown in Table 3, the purpose of the salt ledger dashboard is keeping a running total of salt on hand by garage and salt usages. The performance measures show daily usage as reported in the garage daily logs, plus it shows when they receive salt and when they sell or transfer salt. The data sources include Field staff report salt usage manually and review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Data are added and pulled from Iowa DOT's MMS, RMS. This dashboard is also refreshed daily, and the system software is Power BI. The users for the dashboard are generally garage/district managers for the purpose of actively manage resources. Figure 3 shows the Salt Ledger Dashboard.

Table 3 Salt Ledger Dashboard Overview

Purpose	Keeps a running total of salt on hand by garage and salt usages. Opportunities to manage in a more real-time, better tracking. Helps with garage tracking when making brine. Not used for ordering future salt.
Performance Measures	Shows daily usage as reported in the garage daily logs, plus it shows when they receive salt and when they sell or transfer salt.
Data Sources	Field staff report salt usage manually and review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Data are added and pulled from Iowa DOT's MMS, RMS.
Refresh Rate	Daily refresh
Users/Access	Garage/district managers use to actively manage resources
Platform/Software	Microsoft PowerBI



Date	Qty	Running Qty	Type	Function	Commodity Key	Comments
07-01-2023	730.42	730.42	Start			
07-31-2023	-0.1	730.32	RMSMaterial	699		
09-14-2023	-1	729.32	RMSMaterial	699		
10-11-2023	-5.71	723.61	OutsideSale			
10-13-2023	294.22	1017.82996	Purchase			
10-16-2023	-4.5	1013.32996	RMSMaterial	699		
10-19-2023	-2	1011.32996	RMSMaterial	699		
10-20-2023	-0.1	1011.23	RMSMaterial	699		
10-25-2023	-0.8	1010.43	RMSMaterial	699		
10-26-2023	-2	1008.43	RMSMaterial	699		
10-27-2023	-0.1	1008.33	RMSMaterial	699		
10-29-2023	-0.4	1007.93	RMSMaterial	675		
10-31-2023	-4	1003.93	RMSMaterial	699		

Figure 3 Salt Ledger Dashboard

2.3 The Material Usage and Storm Reporting Dashboard General Overview

The Material Usage and Storm Reporting dashboard provides a detailed breakdown of material usage across different garages throughout the current season. It correlates these data with weather information sourced from daily logs, offering a comprehensive overview of how materials are utilized in varying weather conditions. Acting as a complementary tool to the Salt Dashboard, it uses the same data reports to enable comparative analysis and aid in decision-making processes. Figure 4 shows the example of the material usage dashboard. Table 4 provides details of the Material Usage and Storm Reporting Dashboard.

As shown in Table 4, the main purpose of the Material Usage and Storm Reporting Dashboard is to focus on weather variables as reported by garages on daily logs, to help garages see what data were logged. Garage managers can use to self-regulate and make sure the data are as accurate as possible. Internal only, allows for full picture and used at district post-season meetings for discussion on what was reported. The performance measures in the dashboard shows all material usage by garage for the current season plus it displays weather data as reported by the garage field staff through their daily logs. This dashboard has no analytics. Data sources include manually filled reports of salt usage by field staff. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Field staff report weather information manually as well. Can use RWIS sites as a comparison to field reports, and central office can check for any outliers in the data based on RWIS data. Data are added and pulled from Iowa DOT's MMS and RMS. The dashboard is refreshed daily, and the main users are internal and garage managers and field staff.

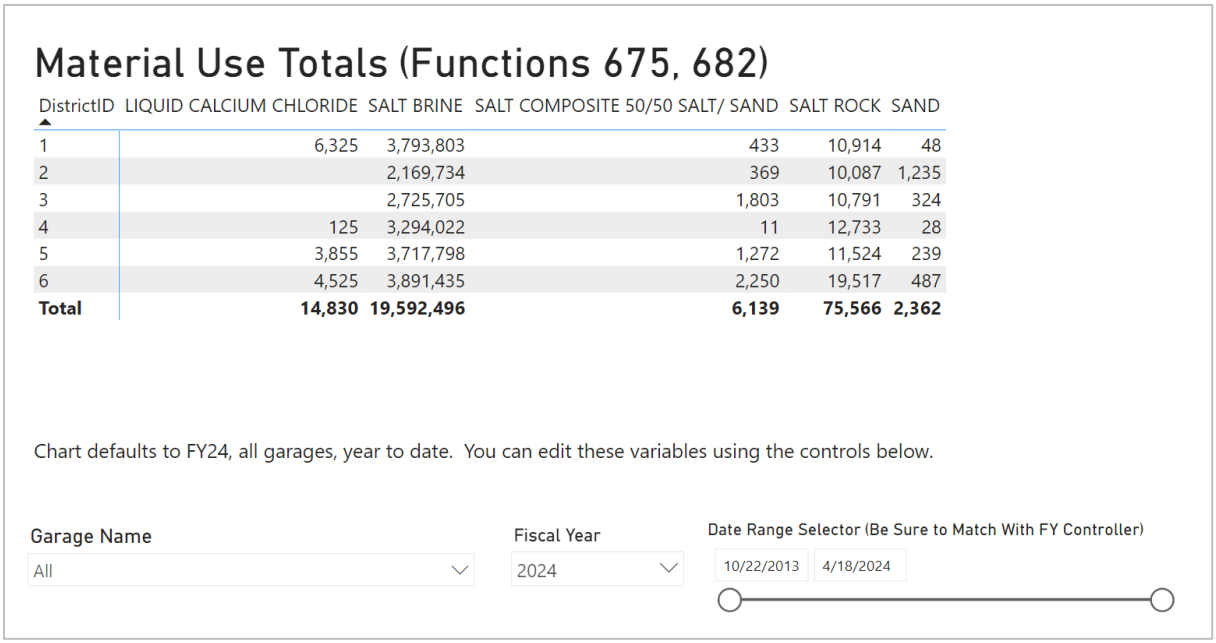


Figure 4 Material Usage Dashboard

Table 4 Material Usage and Storm Reporting Dashboard Overview

Purpose	Like the first dashboard but focuses on weather variables used in dashboard #1 as reported by garages on daily logs. Helps garages see what data were logged. Garage managers can use to self-regulate and make sure the data are as accurate as possible. Internal only, allows for full picture and used at district post-season meetings for discussion on what was reported
Performance Measures	This dashboard shows all material usage by garage for the current season plus it displays weather data as reported by the garage field staff through their daily logs. No analytics. Summarizes inputs for dashboard #1. Can see where storms were more active based on daily logs.
Data Sources	Field staff reports salt usage manually and will review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Field staff report weather information manually as well. Can use RWIS sites as a comparison to field reports, and central office can check for any outliers in the data based on RWIS data. Data are added and pulled from Iowa DOT's MMS, RMS.
Refresh Rate	Daily refresh

Users/Access	Internal, garage managers and field staff
Platform/Software	Microsoft PowerBI

2.4 Public Dashboard General Overview

The public dashboard is a high-level summary from multiple dashboards including data of the Winter Severity Index (WSI) dashboard, which offers a visual representation of winter severity based on data entered by garage staff. Publicly accessible, this dashboard provides a comparison of the current winter season with the past five years. It's used not only internally but also by management and legislators who have become familiar with interpreting and utilizing the data presented. While the public site showcases an overview, the internal version contains more detailed garage specific WSI data.

Additionally, there are charts from the Salt Usage Dashboard on the public dashboard that tracks salt usage over a five-year period and is simply meant to be a public performance page. The Materials Uses and Storm Reporting Dashboard is used for more thorough analysis.

Snow Accumulation Dashboard is dedicated to presenting yearly snowfall data over the last five years, and similar to the Salt Usage Chart Dashboard is simply meant for public performance with the Materials Uses and Storm Reporting Dashboard being the more comprehensive data source.

The Salt Budget Dashboard is specifically designed to monitor the $15 million salt budget, this dashboard is primarily used internally for executive-level analysis statewide. It encompasses various aspects of winter operations funding, including snow fence contracts, overhead garage budgets, training, AVL, winter forecasting services, temp worker job postings, and winter administration. Notably, it excludes labor and fuel, which are budgeted separately under district charges. The tool is utilized to manage the salt budget strategically and it aids in planning for restocking salt sheds before the end of the season. Table 5 provides details of the Public Dashboard.

As shown in Table 5, the purpose of the public dashboard is to present the public with Iowa DOT's performance. The performance measures include weather severity index, total snow accumulation, precipitation events, salt usage, and valuable salt and capacity. Year to year comparisons for all but the on-hand salt and capacity is also done. The measures can be reviewed statewide. The data sources include are same as previously mentioned dashboards. This dashboard is refreshed daily as well. This dashboard is open to public. Figure 5 shows the example of the winter severity index dashboard which displays the average winter weather severity score for the state based on storm duration, storm frequency, snowfall amount and temperature.

Figure 6 shows the yearly total snow accumulation and Figure 7 shows the total precipitation events.

Table 5 Public Dashboard Overview

Purpose	To present the public with Iowa DOT's performance. Helpful for discussions with management and legislators, especially mid-season when projections show that more salt is needed.
Performance Measures	Weather severity index, total snow accumulation, precipitation events, salt usage, and valuable salt and capacity. Year to year comparisons for all but the on-hand salt and capacity. Statewide review.
Data Sources	Field staff reports salt usage manually and will review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Field staff report weather information manually as well. Data are added and pulled from Iowa DOT's MMS and RMS.
Refresh Rate	Daily refresh
Users/Access	Public
Platform/Software	Microsoft PowerBI Widgets
Source	https://www.arcgis.com/apps/dashboards/8fa8eb99dc164f879a96db717c15356e

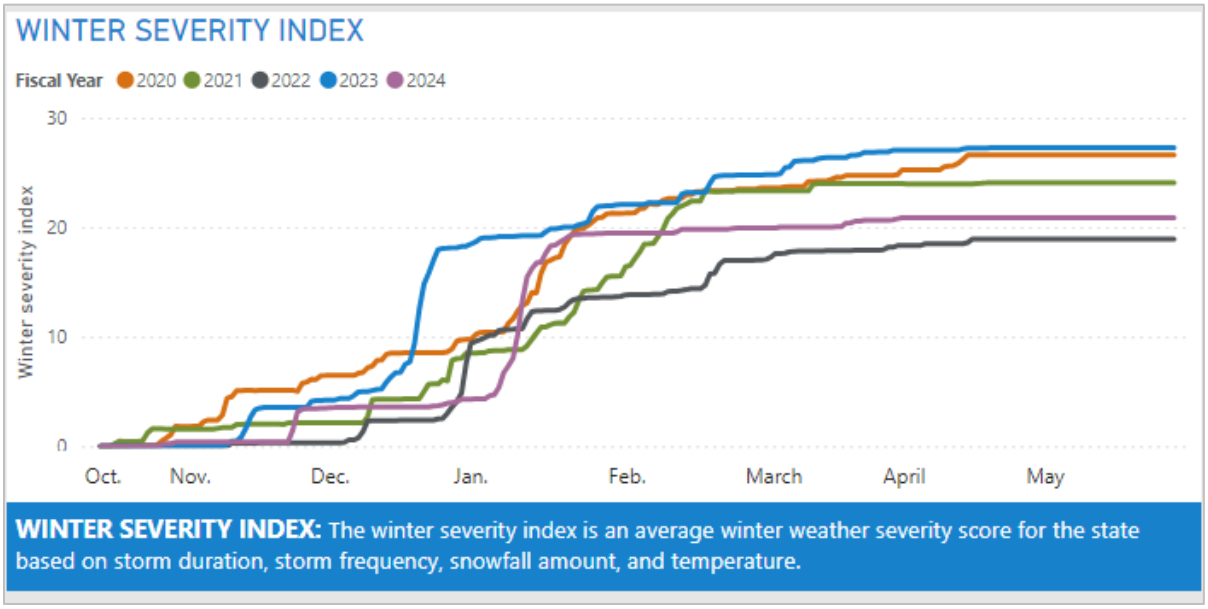


Figure 5 Winter Severity Index

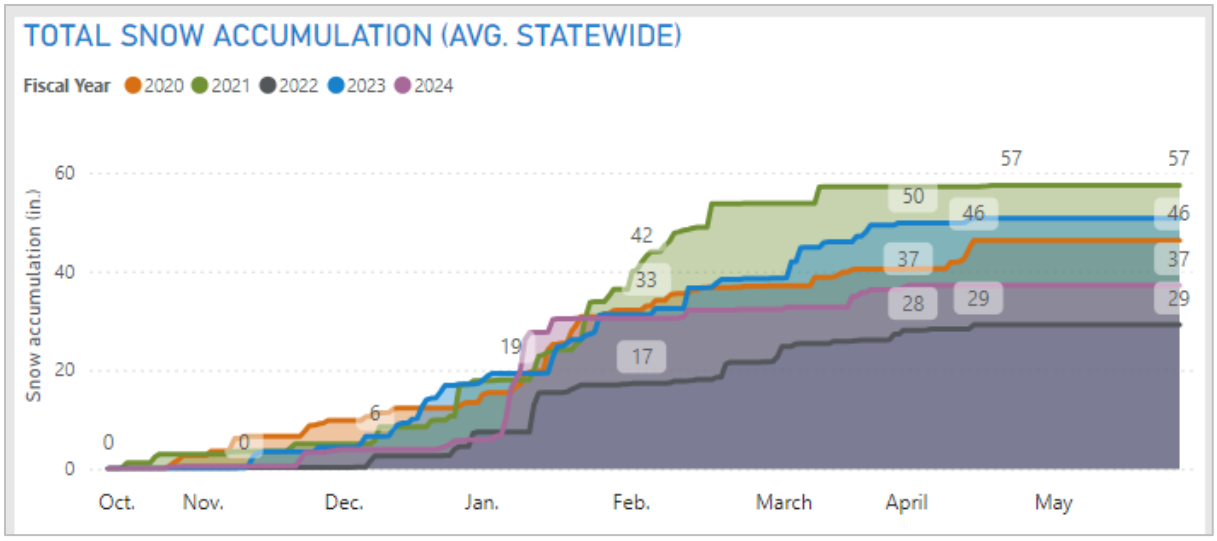


Figure 6 Total Snow Accumulation

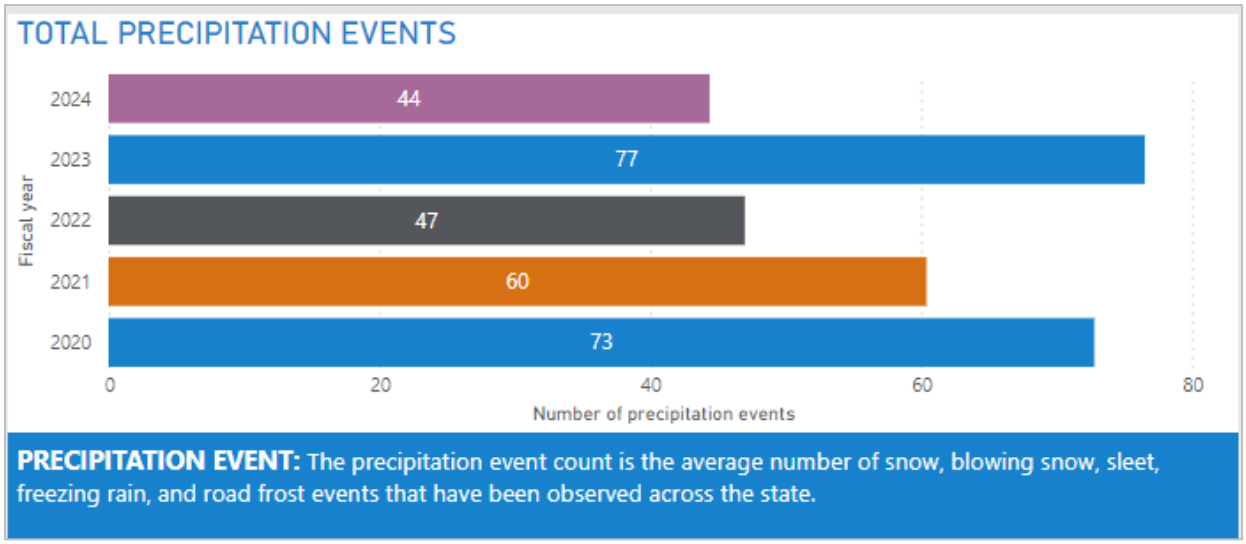


Figure 7 Total Precipitation Events

2.5 Salt Budget Dashboard General Overview

The salt budget dashboard is used to track the status of our $15 million salt budget. Salt budget is heavily monitored for potential to use in other places. This dashboard helps manage expectations for what is “available” in this line item. The average amount of salt is used to set the upcoming salt contract amounts, so this dashboard helps with understanding these historical averages. Used for end of season re-fill to help use up budget and get this done in winter season. and Table 6 provides details of the Salt Budget Dashboard.

As shown in Table 6, the purpose of the salt budget dashboard is to track the status of Iowa DOT's $15 million salt budget. Salt budget is heavily monitored for potential to use in other places. The average amount of salt is used to set the upcoming salt contract amounts, so this dashboard helps with understanding these historical averages. Used for end of season re-fill to help use up budget and get this done in winter season. The performance measures include cost displays broken down to garage level, track orders, fees for various purposes and estimated range to get to the end of the winter season (based on a 5-year average). Provides previous average, minimum, and maximum costs. The data sources for this dashboard involves salt data usage obtained from Iowa DOT's MMS and RMS. The dashboard is refreshed daily, and the users include Winter Operations Administrator, Internal and administrative users only. Figure 8 and 9 shows an example of on hand salt and capacity budget along with the salt usage.

Table 6 Salt Budget Dashboard Overview

Purpose	This dashboard is used to track the status of our $15 million salt budget. Salt budget is heavily monitored for potential to use in other places. This helps manage expectations for what is "available" in this line item. The average amount of salt is used to set the upcoming salt contract amounts, so this dashboard helps with understanding these historical averages. Used for end of season re-fill to help use up budget and get this done in winter season.
Performance Measures	Cost broken down to garage level. Track orders, paid, delivered, administration fees, along with an estimated range to get to the end of the winter season (based on a 5-year average). Provides previous average, minimum, and maximum costs.
Data Sources	Salt data usage is added and pulled from Iowa DOT's MMS; RMS. RMS has data on shed salt capacity. Includes all materials.
Refresh Rate	Daily refresh
Users/Access	Winter Operations Administrator; Internal and administrative users only
Platform/Software	Microsoft PowerBI

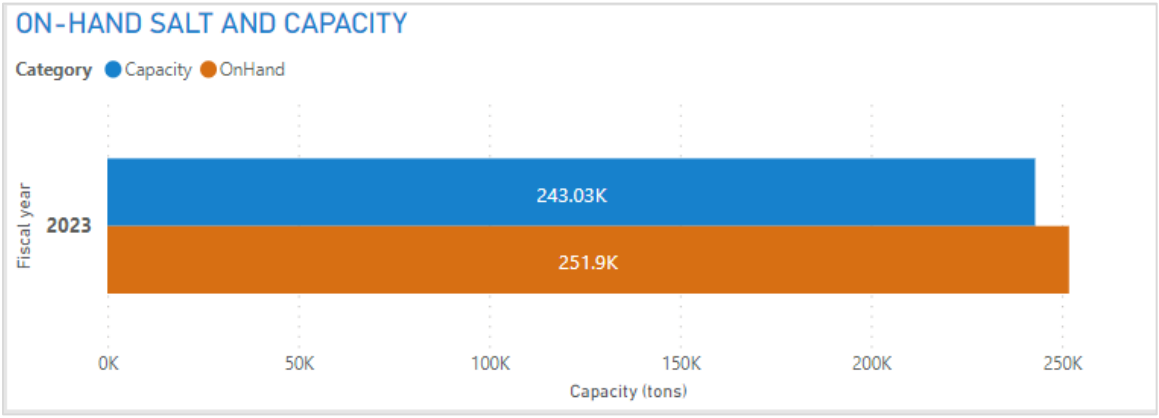


Figure 8 On Hand Salt and Capacity

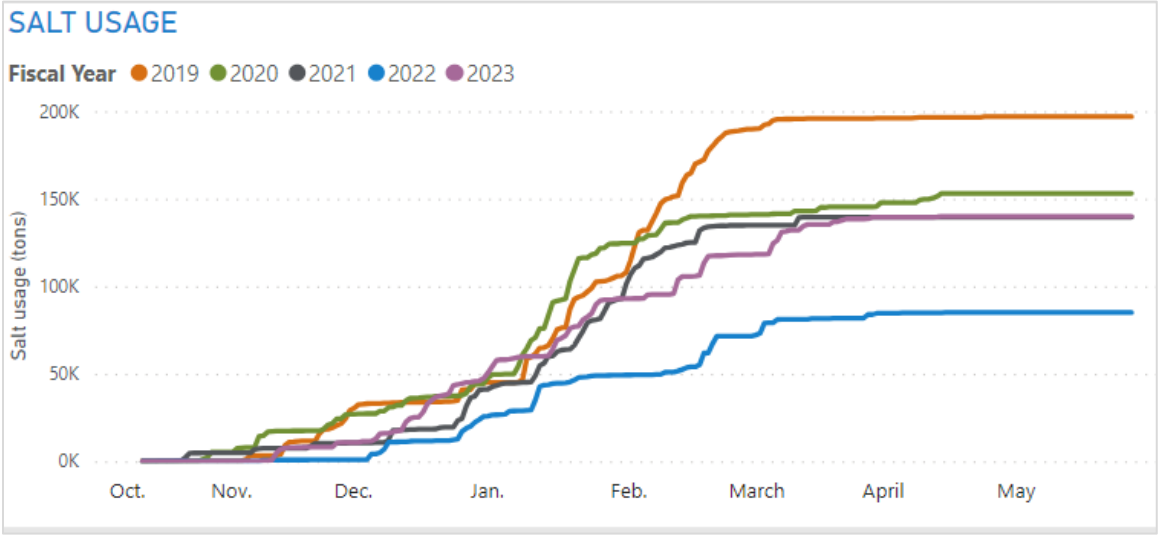


Figure 9 Salt Usage Dashboard

3. Other General Dashboard Information

This section of the report outlines the purpose, performance measures, data sources, refresh rate, users, access, platform and software related to the winter dashboards.

The data provided to these dashboards involving the salt used and weather conditions comes from field staff, and it's compared against the AVL data and can be adjusted as needed to ensure accuracy. When data is being collected the field staff are responsible for their own plan with how they will be treating the roads they are assigned. They are provided parameters and targets to stay within so that they are in line with how the central office wants the roads to be treated. The MMS is used to track maintenance actions

taken as well as road and weather conditions. The data for the dashboards is refreshed daily by the RMS system. The dashboards are all created using PowerBI and the public uses widgets from PowerBI plus.

Some improvements the Iowa DOT is looking to make to their winter dashboards include working with a different AVL provider in 2024. Internally, a storm or daily weather index is being worked on that will help predict weather severity.

4. Development of Dashboards

In the development of winter dashboards, the need for a dashboard typically arises when central figures in dashboard management, notice repeated requests for specific data or when higher management seeks specific information. Their involvement streamlines data management, reducing their workload, and although field staff rarely request dashboards directly, there is a desire for more accessible data representation.

When designing dashboards, collaboration with end-users is key. Examples are shared, and if managers are the intended users, all six primary dashboards are incorporated. There's a winter steering group available, if necessary, though it hasn't been actively involved for some time. Winter Operations Administrator along with the Data Management Analyst take charge of dashboard development, with the Data Management Analyst overseeing the Extract, Transform, Load (ETL) process, particularly data cleaning from RWIS via Structured Query Language (SQL) database, handled by the IT team. The process prioritizes the use of unfiltered data from the legally logged RMS to enable error identification in input, primarily benefiting garage operations. Data storage primarily occurs within SQL databases, with the oldest available data for certain dashboards dating back to 2013, while others are typically focused on five-year trends or single fiscal year insights, like the Salt Dashboard. The main data source for these dashboards is the MMS and RMS, which is a legal log. No formal process is required to verify accuracy. The dashboard does allow for field personnel to review data quickly and determine if there was a data entry error in RMS, which can then be mitigated. The data within the dashboards are developed to present the previous five years or just the current seasonal year.

Challenges during development involved limitations arising from calculations and data constraints, leading to ongoing refinements as user interaction increased. Technical issues led to the exclusion of a speed dashboard due to data processing challenges, and RWIS sensor unreliability prevented its inclusion in analyses.

The development of new dashboards in Iowa DOT are initiated by the Winter Operations Administrator along with the Data Management Analyst. Dashboards are typically developed based on requests from other management, field operations, and/or public requesting the same data insights; leading the development of a dashboard to manage these requests. Rare for any field personnel to specifically request a dashboard but might wish to review data in an easy manner, which leads to a dashboard.

During development, the team may reach out to end users for feedback and share draft dashboards. If the dashboard is for garage management, they will include all district managers in this feedback. When necessary, a steering committee may be implemented during the design phase but not very often.

The lead developers of these dashboards are the Winter Operations Administrator and the Data Management Analyst. Once developed, IT maintains the dashboard. IT will assist with the cleaning processes for the data loaded into the dashboard. All data are stored in a SQL database and many of the analytics are done within the SQL database, not in the dashboard platform.

It is important to have a complete understanding of the data being used and know the audience that will use the dashboard is the key advice Iowa DOT provided to other agencies.

5. System Operations and Maintenance

This section describes the Iowa DOT's system operations and maintenance procedures for the winter dashboards.

The hosting of these dashboards for viewing occurs through three distinct methods:

- Publicly accessible sites on the website,
- Technically public but not openly shared, and
- Those requiring a PowerBI pro license for viewing, allocated to a small group.

The dashboards are technically accessible publicly, the material usage and weather dashboards are not advertised but can be accessed through the DOT site with dedicated links. This removes the need for password access to dashboards that are shared with partner agencies.

The Data Management Analyst maintains the frontend of the dashboards and IT maintains the database side of the dashboards. Data updates are varied, with the RMS updated manually while the dashboards refresh automatically. Responsibility for data updates falls on IT, particularly if any issues arise on the database side, although Tina oversees the PowerBI side and reviews aspects external to the database. Maintenance for both the dashboards system and databases is handled jointly by the Data Management Analyst for PowerBI and IT for the database.

The costs and resources involved in the development, implementation, maintenance, and enhancement of these dashboards aren't meticulously tracked, but minimal efforts are needed for ongoing maintenance, especially for updates in new seasons. The costs primarily lie in the development phase, with ongoing maintenance and storage costs being comparatively lower and less rigorously tracked.

The initial development involves more significant efforts, requiring collaboration with IT and users, prioritizing these operations over others due to their significance. The Data Management Analyst and the Winter Operations Administrator focus on refining analytic methodologies within SQL, aligning with

policies and guidelines such as salt prediction, and any policy changes prompt collaboration between the Data Management Analyst and IT to recalibrate calculations within SQL.

The costs primarily lie in the development phase, with ongoing maintenance and storage costs being comparatively lower and less rigorously tracked.

6. Benefits and Lessons Learned

This section goes over the benefits and lessons learned from developing the winter dashboards. The winter dashboards are very useful because it helps everyone from the management level to the garage level understand and measure how resources are being used during winter maintenance operations. The dashboards also create a form of healthy competition between garages as they can compare, but also work together to meet target resource usage.

One lesson learned from the development of these winter dashboards was that it is best to keep them simple and easy to understand for users. The data should start out small and grow over time. The staff should not be forced to use it and the data should be presented as it is. Some difficulties that had to be overcome when developing the dashboards was the cost it would take to develop the first dashboard. However, with the pressure to save money on salt expenses, the benefits far outweighed the costs.

7. Plans for the Future and Potential Enhancements

This section goes over future plans for the winter dashboards and possible enhancements that could be made. A tool for comparing individual storms as projected and what actually occurred, is also being developed. Beyond that there are no plans for the future besides potentially adding more dashboards.

Some potential dashboards that would be useful for development include, a speed based data dashboard, a dashboard using friction sensors, using weather information to compute road conditions, and image analysis using dashcam data.

Overall, there are many ideas for potential dashboards in the future, but it is difficult to see the benefits of them if the use cases are not fully understood and outweigh the cost of development.

8. Key Point

- The salt prediction is calculating and comparing anticipated versus actual salt usage rates. It operates by forecasting the expected salt usage and then cross-referencing it with real-time data. This comparison provides essential insights into the efficiency and accuracy of salt usage throughout operations. Its primary function is to offer a clear overview of anticipated versus actual usage, enabling more informed decisions based on these insights. This helps facilitate conversations between garage managers on ways to help keep salt usage on target.

- The main source of the data for these dashboards are pulled from Iowa DOT's MMS and RMS. Which is their legal log, ensuring that the data quality is high. Other data sources have been tested such as speed and RWIS data; however, the data was not trusted resulting in it not being used.
- The best advice for developing a dashboard is to have a complete understanding of the data being used and to know the audience that is going to be using the dashboard. The data should start out small and grow over time. The staff should not be forced to use it and the data should be presented as it is.
- Some difficulties that had to be overcome when developing the dashboards was the cost it would take to develop the first dashboard. However, with the pressure to save money on salt expenses, the benefits far outweighed the costs.
- Future enhancements are to explore filling data gaps with crowdsource data. Potential dashboards that would be useful for development include a speed-based data dashboard, a dashboard using friction sensors, using weather information to compute road conditions, and image analysis using dashcam data.

Appendix A Survey Response

Contact Information	
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Agency	Iowa DOT
Email	craig.bargfrede@iowadot.us
Phone	515-290-2713
Survey Information	
1. Do you have any dashboards (with interactive performance measures) using data of winter maintenance operations?	Yes
If yes, how many?	7
1A. If you answered yes to the previous question (you do have dashboards) please briefly describe how each on is used.	1. Salt Dashboard- calculates an anticipated salt usage rate and then compares anticipated usage versus actual usage. 2. Salt Ledger- Keeps a running total of salt on hand by garage. Shows daily usage as reported in the garage daily logs plus it shows when they receive salt and when they sell or transfer salt. 3. Material Usage and Storm Reporting Dashboard. This dashboard shows all material usage by garage for the current season plus it displays weather data as reported by the garages through their daily logs. 4. Winter Severity Index. This dashboard shows a graph of winter severity based on the winter weather data entered by the garage staff into their daily logs 5. Salt usage chart. This dashboard shows salt usage for the past five years. 6. Snow Accumulation. This dashboard shows the amount of snowfall per year for the last five years. 7. Salt Budget Dashboard. This Dashboard is used to track the status of our $15millon salt budget.
2. Do you find these dashboards useful during an event in real-time?	No
3. Do you find these dashboards useful after an event, such as after action reports?	Yes
4. Do you use the dashboards to inform beneficial / best practices?	Yes
5. What data are you using in your dashboard(s)? (Select all that apply)	5
Automatic Vehicle Location/Global Positioning System (AVL/GPS)	X
Material Usage total	X

Material Usage Rates	X
Weather Data (For example: Road Weather Information System (RWIS))	X
Cycle Time	
Plow Position	
Traffic Data (Speed and/or Volumes)	
Connected Vehicle (CV) data	
Incident Data	
Finance data	X
Other (please specify)	
6. What are the sources of the data in the dashboards? (Select all that apply)	5
Automatic Vehicle Location/Global Positioning System (AVL/GPS)	X
Spreader/Sprayer Controller	X
Plow Position Sensor	
Mobile Weather Sensors, etc.	X
Maintenance Decision Support Systems (MDSS)	
RWIS Stations	X
Advance Traffic Management System (ATMS)	
Maintenance Management System	
Probe Traffic Data	
Connected Vehicles (CVs)	
Crowd Sourced data (e.g. Waze)	
Other (please specify)	our internal Resource Management System (RMS)
7. How are the data ingested into the dashboard? (Select all that apply)	
Application Programming Interface (API) from data source	
SQL database updated	
Excel spreadsheets	
CSV/Text File	
Access Database	
Other (please specify)	Power Bi
8. What is the frequency of the data refresh? (Select all that apply)	5
Minutes / Close to real-time (5)	X

Hourly (4)	
Daily (3)	X
Weekly (2)	
Monthly (1)	
Other (please specify)	
9. How are data stored? (Select all that apply)	
Cloud-based	
Client-Owned Server	X
Third-Party Server	
Enterprise Content Management System (For example: SharePoint)	
Other (please specify)	
10. What dashboarding platforms are used? (Select all that apply)	
PowerBi	X
Tableau	
ArcGIS	
Internally custom created or other platform (please describe)	
11. What metrics/performance measures presented on the dashboard(s) do you find most helpful for operations? And describe why they are the most helpful.	1. Salt usage information- You cannot manage your operation properly if you cannot measure your usage properly. Winter Severity - This has helped us paint the picture with DOT Leadership, the Governor's office and our Legislature on the overall winter severity. We have used this dashboard twice in the last 8 years to go to the legislature and ask for additional funding for salt due to the severity of the winter. Both times we were successful in our request.
12. Are you able to generate static reports / outputs from the dashboard?	No
13. Who has access to view the dashboards? (Select all that apply)	3
Internal agency	X
Partner Agencies	X
Contractors	
Public	X
Other (please specify)	
14. Who developed the dashboard(s)? (Select all that apply)	
Internal agency	X
Consultant	

AVL / GPS Vendor	
Other Third-Party vendor	
Unversity	
Other (please specify)	
15. If an external entity developed any of your dashboards, were you a part of the design process?	No
15A. Is your dashboard customizable to fit your needs?	Yes
16. Who maintains the dashboard and data used?	We maintain our own dashboards.
17. How are the data checked for accuracy and who is responsible for checking?	We provide our own QA/QC.
18. What data do you wish you had within a dashboard? And why?	We are happy with the data we currently have right now.
19. What are the limitations of your current dashboard(s)?	Unsure
20. Do you have any enhancements to current dashboards, or new dashboards, you want to develop or are in the process of developing?	No
If yes, please describe:	
21. Has your agency deployed or planned to deploy connected vehicle technology that may assist with winter operations?	No
22. Has your agency used or planned to use connected vehicle data for winter maintenance dashboards?	No
23. What issues has your agency experienced with developing the dashboard(s)?	Typical issues that one has when working with big data. It is always a concern that the data quality is a good as possible.
24. What issues has your agency experienced with using the dashboard(s)?	Educating those who are using the dashboards- Making sure that they understand what the dashboard is telling them....
25. What practical advice and/or lessons learned can be offered to others interested in developing and implementing dashboards to support winter maintenance operations?	Dashboards are an effective way to display big data. They are very useful in painting a picture or telling the story of what happened during the winter season.
26. May we contact you with follow-up questions?	Yes

Appendix B Virtual Interview Meeting Minutes

PROJECT 22-05: USE OF DASHBOARDS FOR WINTER OPERATIONS

SUMMARY OF IOWA DOT VIRTUAL INTERVIEW

Overview

Virtual interviews were conducted by Ming-Shiun Lee, Mallory Crow, and Allison Balogh of AECOM and coordinated with the assistance of Tina Greenfield Huitt and Craig Bargfrede with the Iowa Department of Transportation (Iowa DOT) on Monday November 27th, 2023 at 9 AM CST.

Iowa DOT Staff Interviews

Meeting attendees on Monday November 27th included the following individuals:

Introduction

The Iowa DOT began using dashboards to visualize winter maintenance operation data around the Fiscal Year (FY) 2012. The driving force to start using dashboard was to monitor and track salt usage. It started with an Excel workbook dashboards. By FY 2013, Iowa DOT moved from the Excel workbook to Dundas BI for more enterprise-level business intelligence and to further automate the Excel workbook. The users started with a few offices and IT, but then continued to grow into other departments.

General

All dashboards are used for after-action analyses. Iowa DOT is using a new AVL provider next season, so internally reviewing these new datasets for future dashboarding.

Salt Dashboard

Salt Dashboard Overview

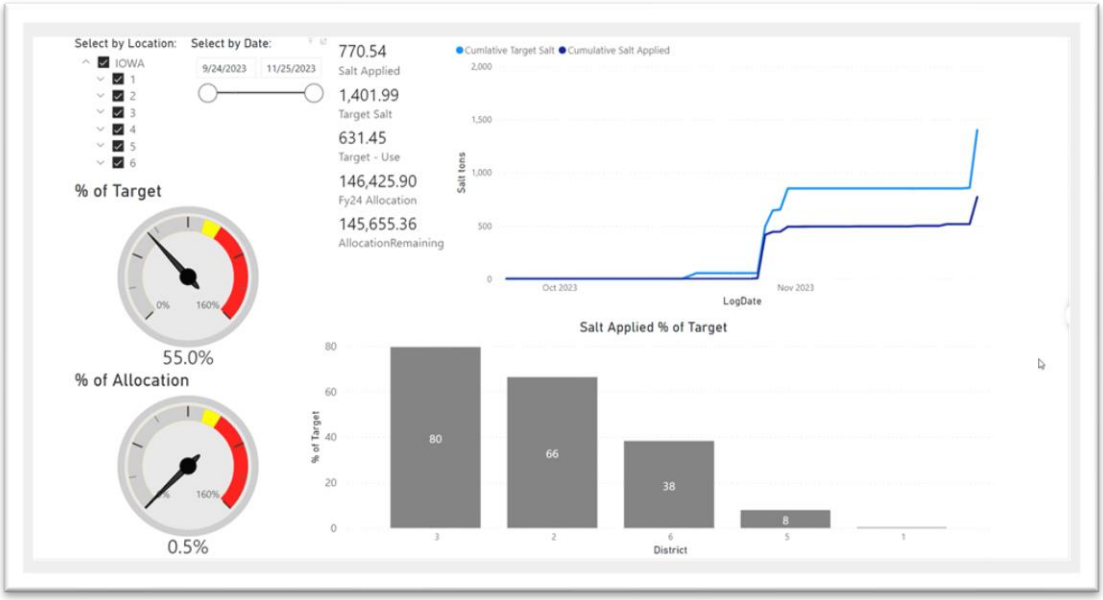
Purpose	Track and monitor salt usage.
Performance Measures	Calculates an anticipated salt usage rate (predictive analytics) and then compares anticipated usage versus actual usage.
Data Sources	Field staff reports salt usage manually and will review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Field staff report weather information manually as well. Weather is important since it uses to calculate target ideal salt usage. The salt target uses miles for garage responsibility routes (not miles driven), Level of Service (LOS) priority, and weather. Data are added and pulled from Iowa DOT's Maintenance Management System (MMS), RMS Omega Technologies.
Refresh Rate	Daily refresh

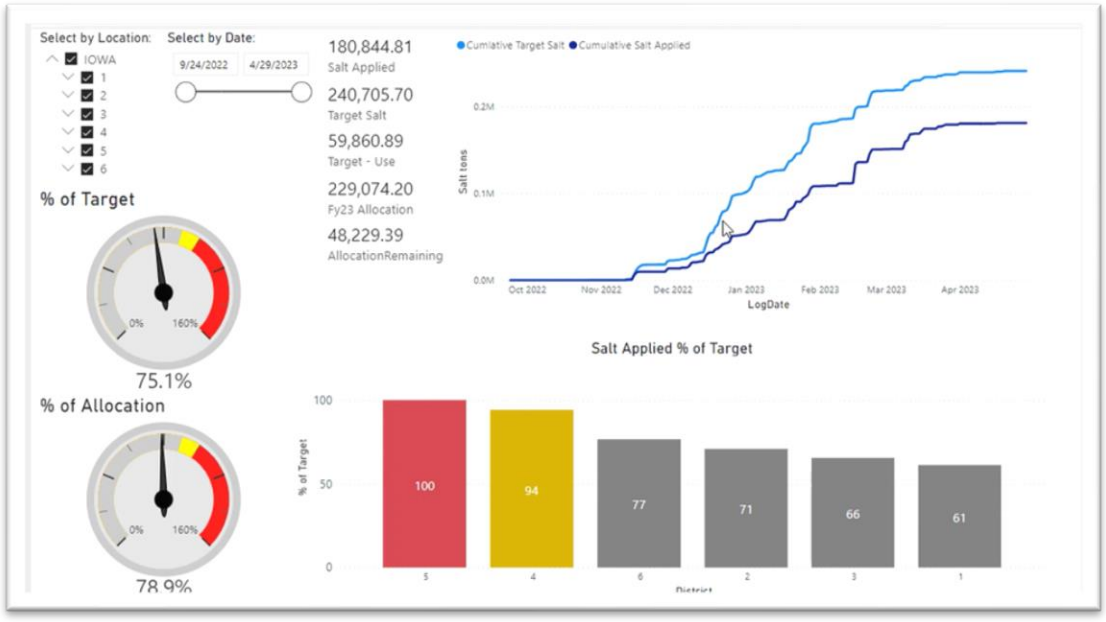
Users/Access	Garage supervisor, district managers up to field division manager utilize the dashboard. Management Analyst and Winter Operations Administrator use to assist with administration even though their roles are not included in Field Operations. Management Analyst and the Winter Operations Administrator, use to review budget and monitor salt requests. Garages and district supervisors review for managing their resources. The Winter Operations Administrator procures the salt so uses to guide procurement needs.
Platform/Software	Microsoft PowerBI

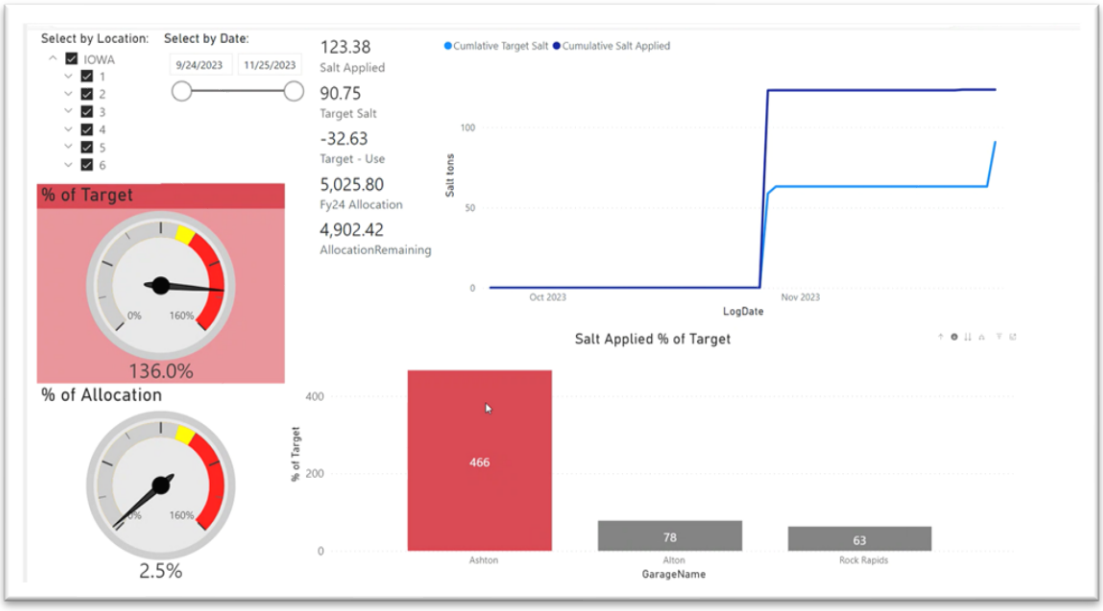
It was noted that the prediction helps but is not always prefect, fortunately Iowa DOT has been using for 11 years and the garage managers are used to the model. These insights facilitate conversations between managers on best practices to hit target salt usage. Large turnover of staff supervisors, so this is a tool to help education and start conversations. No contract fleets.

Currently working on a storm or daily weather index instead of current monthly/seasonal. Current mobility data does not get added to prediction/targeted salt usage. Attempted to integrate speed but fell apart because of inaccurate speed data (note that was 10 years ago, so might be better now). No friction sensor based.

Future enhancements are to explore filling data gaps with crowdsource data. Also, Iowa DOT has already calculated time to bare pavement but hasn't integrated into dashboard yet.







Salt Ledger Dashboard

Salt Ledger Dashboard Overview

Purpose	Keeps a running total of salt on hand by garage and salt usages. Opportunities to manage in a more real-time, better tracking. Helps with tracking when making brine.

Performance Measures	Shows daily usage as reported in the garage daily logs plus it shows when they receive salt and when they sell or transfer salt.
Data Sources	Field staff reports salt usage manually and will review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Data are added and pulled from Iowa DOT's Maintenance Management System (MMS), RMS Omega Technologies.
Refresh Rate	Daily refresh
Users/Access	Garage/district managers use to manage resources
Platform/Software	Microsoft PowerBI

Material Usage and Storm Reporting Dashboard

Material Usage and Storm Reporting Dashboard Overview

Purpose	Similar to first one but focus on weather variables used in dashboard 1 as reported by garages on daily logs. Helps garages see what data were logged. Garage managers can use to self-regulate and make sure the data are as accurate as possible. Internally only, allows for full picture.
Performance Measures	This dashboard shows all material usage by garage for the current season plus it displays weather data as reported by the garage field staff through their daily logs. No analytics. Summarizes inputs for dashboard 1. Can see where storms were more active based on daily logs.
Data Sources	Field staff reports salt usage manually and will review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Field staff report weather information manually as well. Data are added and pulled from Iowa DOT's Maintenance Management System (MMS), RMS Omega Technologies.
Refresh Rate	Daily refresh
Users/Access	Internal, garage managers and field staff
Platform/Software	Microsoft PowerBI

Material Use Totals (Functions 675, 682)

DistrictID	SALT BRINE	SALT ROCK	SAND
1	45		
2	21,066	74	4
3	56,062	319	
4	1,714		
5	1,967		
6	3,071	10	
Total	**83,925**	**402**	**4**

Chart defaults to FY24, all garages, year to date. You can edit these variables using the controls below.

Garage Name: All

Fiscal Year: 2024

Date Range Selector (Be Sure to Match With FY Controller): 10/22/2013 11/9/2023

Material Use Totals (Functions 675, 682)

DistrictID	LIQUID CALCIUM CHLORIDE	SALT BRINE	SALT COMPOSITE 50/50 SALT/ SAND	SALT ROCK	SAND
1	4,778	6,462,913	1,133	21,843	397
2		4,287,764	1,367	23,386	7,601
3		4,445,462	4,405	18,203	2,127
4	200	5,166,365	312	19,275	461
5	10,577	4,871,524	1,482	14,711	835
6		6,454,703	1,546	31,831	875
Total	**15,555**	**31,688,732**	**10,245**	**129,248**	**12,296**

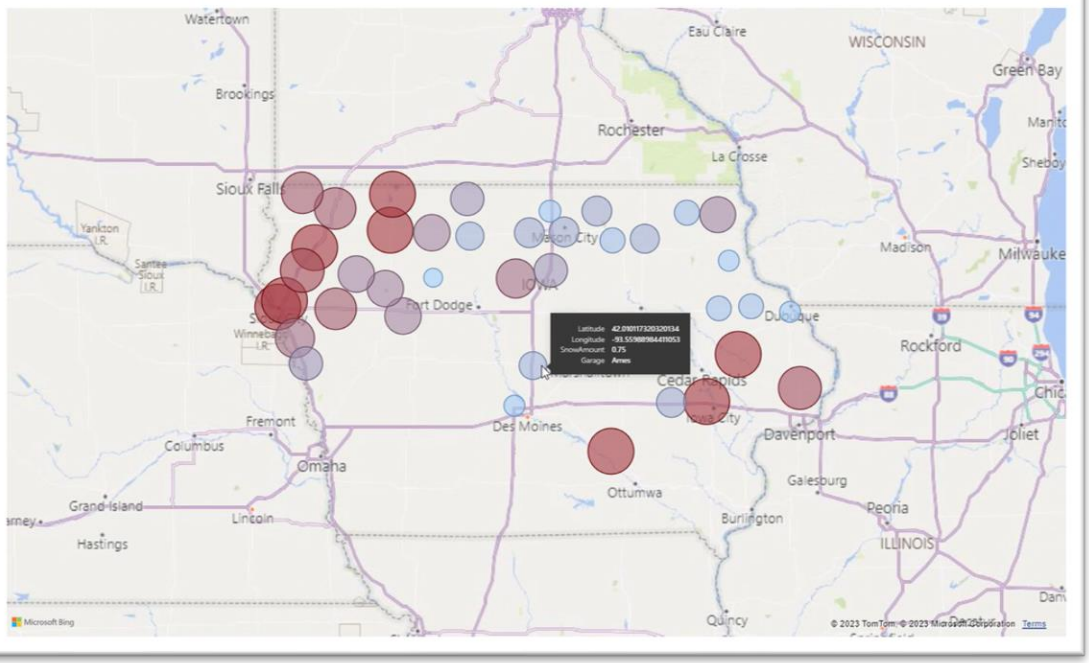
Chart defaults to FY24, all garages, year to date. You can edit these variables using the controls below.

Garage Name: All

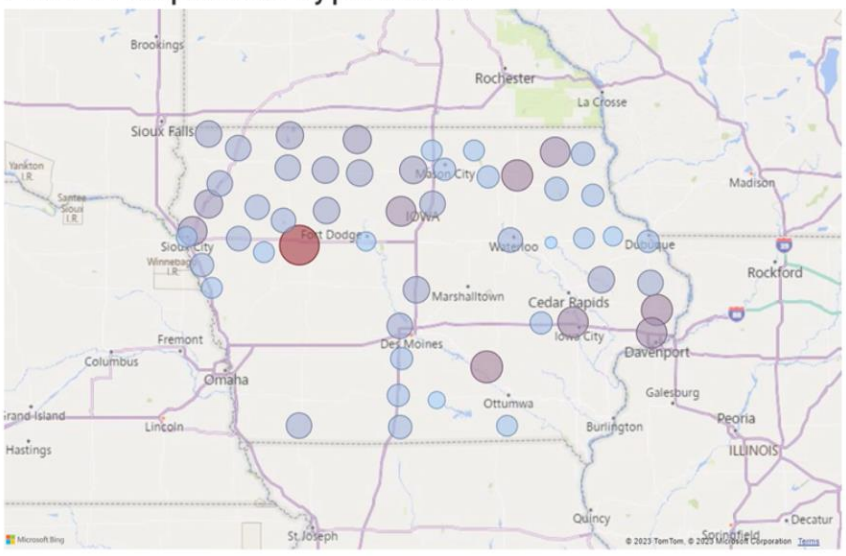
Fiscal Year: 2023

Date Range Selector (Be Sure to Match With FY Controller): 10/22/2013 11/9/2023

FY24 Snow Amount (Inches)

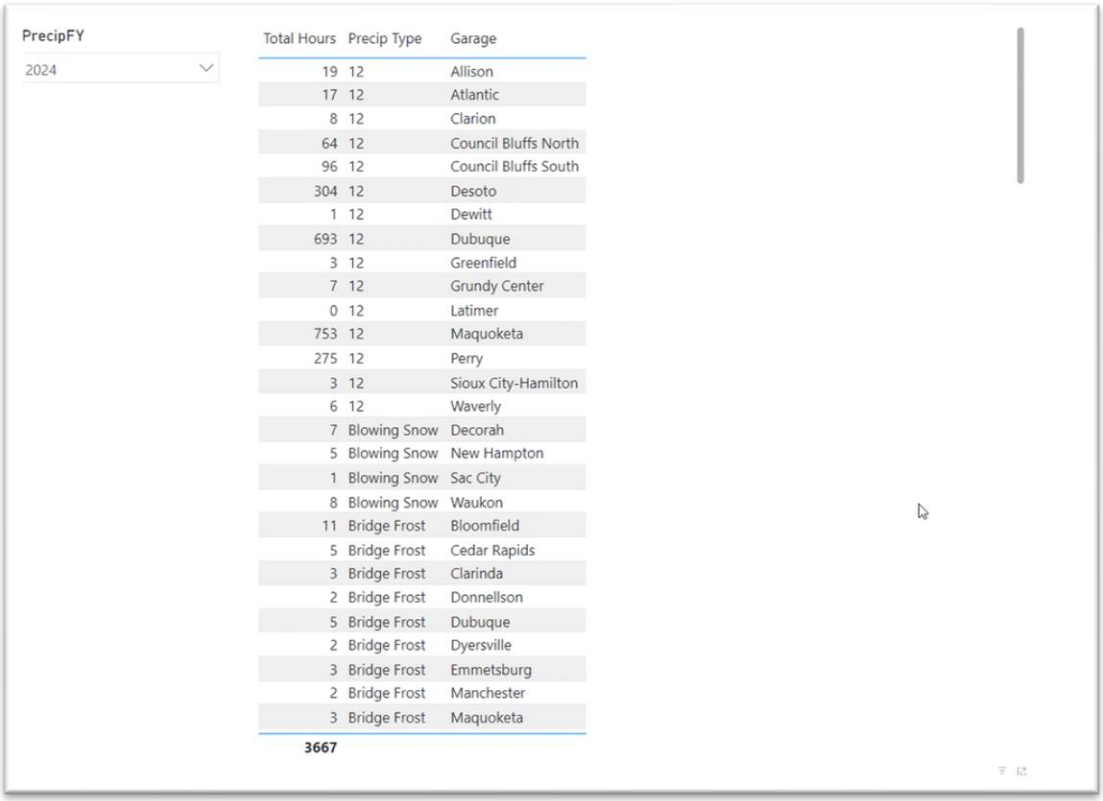


FY24 Precipitation Type Hours



Precip Type

- Blowing Snow
- Bridge Frost
- Mixed Precip
- Refreeze
- Road Frost
- Sleet
- Snow

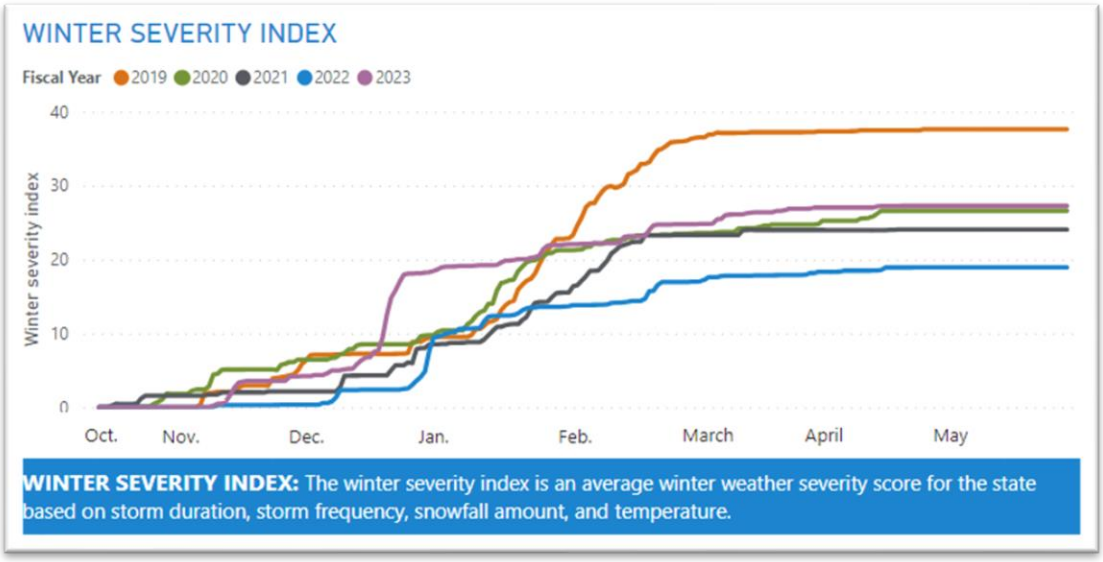


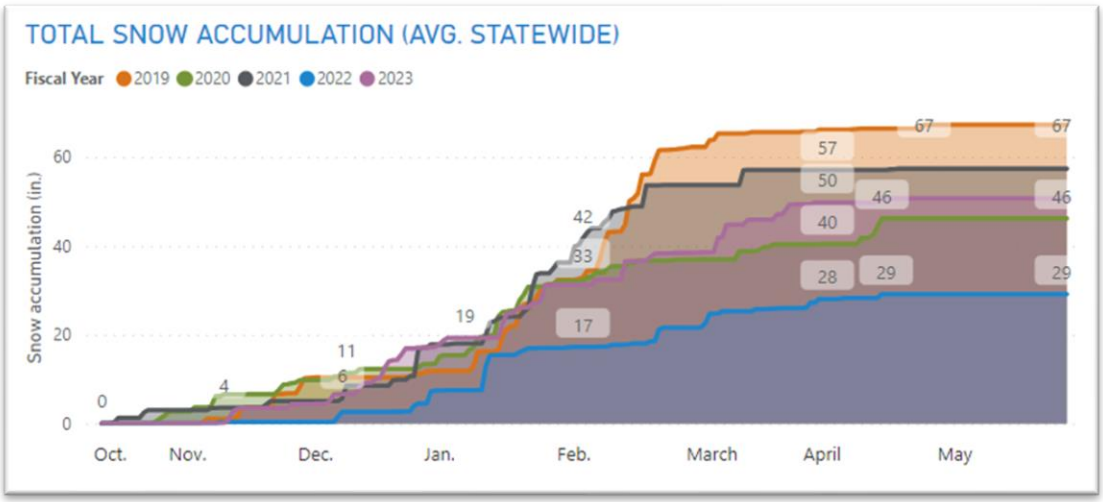
Public Dashboard - Salt Usage Chart, Salt Accumulation, & Weather Severity Index

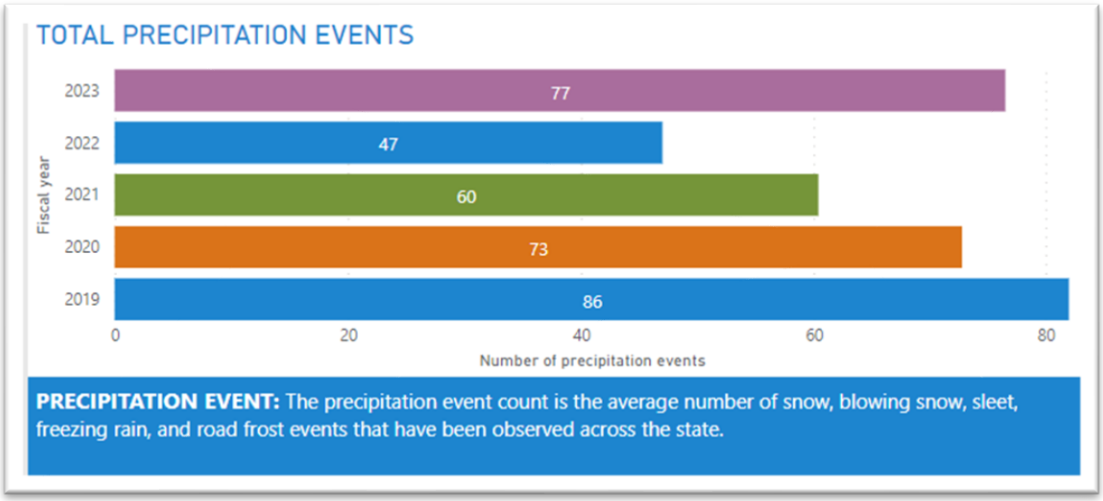
https://iowadot.gov/performance/winter-operations

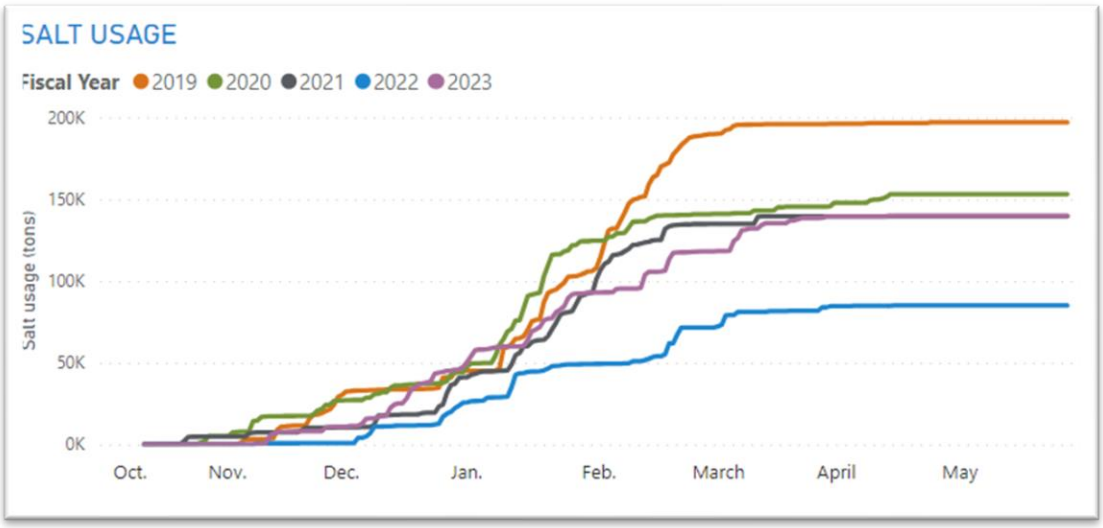
Public Dashboard Overview

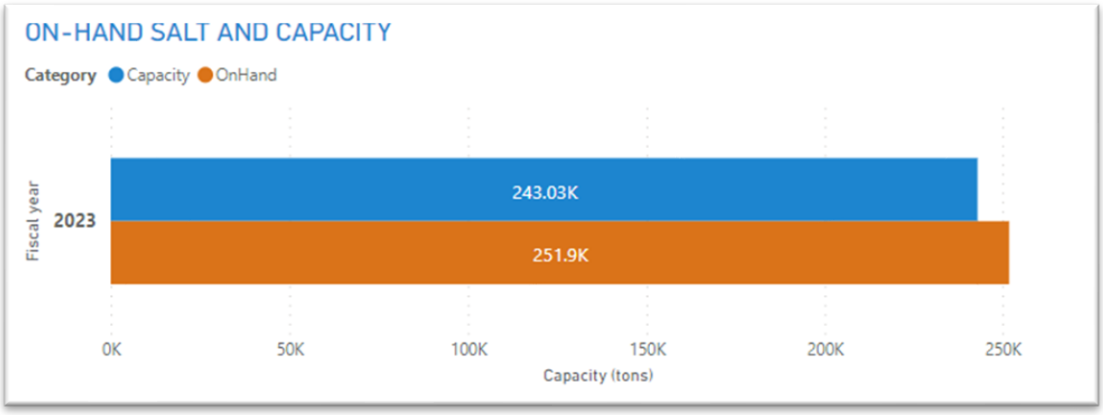
Purpose	To present the public with Iowa DOT's performance
Performance Measures	Weather severity index, total snow accumulation, precipitation events, salt usage, and valuable salt and capacity. Year to year comparisons for all but the on-hand salt and capacity. Statewide review.
Data Sources	Field staff reports salt usage manually and will review their AVL data to report salt usage. Garage managers and field staff can edit if salt usage gathered by the AVL seems incorrect. Field staff report weather information manually as well. Data are added and pulled from Iowa DOT's Maintenance Management System (MMS), RMS Omega Technologies.
Refresh Rate	Daily refresh
Users/Access	Public
Platform/Software	Microsoft PowerBI Widgets


WINTER SEVERITY INDEX
Fiscal Year 2019 2020 2021 2022 2023
Winter severity index
40
30
20
10
0
Oct.
Nov.
Dec.
Jan.
Feb.
March
April
May
WINTER SEVERITY INDEX: The winter severity index is an average winter weather severity score for the state based on storm duration, storm frequency, snowfall amount, and temperature.


TOTAL SNOW ACCUMULATION (AVG. STATEWIDE)
Fiscal Year 2019 2020 2021 2022 2023
Snow accumulation (in.)
60
40
20
0
0
4
6
11
19
17
33
42
28
40
29
50
46
57
67
67
46
29
Oct.
Nov.
Dec.
Jan.
Feb.
March
April
May


TOTAL PRECIPITATION EVENTS
2023
2022
2021
2020
2019
77
47
60
73
86
Fiscal year
0
20
40
60
80
Number of precipitation events
PRECIPITATION EVENT: The precipitation event count is the average number of snow, blowing snow, sleet, freezing rain, and road frost events that have been observed across the state.


SALT USAGE
Fiscal Year 2019 2020 2021 2022 2023
200K
150K
100K
50K
0K
Salt usage (tons)
Oct.
Nov.
Dec.
Jan.
Feb.
March
April
May


ON-HAND SALT AND CAPACITY
Category Capacity OnHand
Fiscal year
2023
243.03K
251.9K
0K
50K
100K
150K
200K
250K
Capacity (tons)

Salt Budget Dashboard

Salt Budget Dashboard Overview

Purpose	This Dashboard is used to track the status of our $15 million salt budget. Salt budget is heavily monitored for potential to use in other places. This helps manages expectations for what is “available” in this line item. Set salt contracts by an average, so this helps track historical. And uses for end of season re-fill to help use up budget and get this done in winter season.
Performance Measures	Cost down to garage level. Track orders, paid, delivered, admin fees, etc. Along with an estimation for (based on 5 years) here is range for end of season. Provides previous average, minimum and maximum costs.
Data Sources	Salt data usage is added and pulled from Iowa DOT’s Maintenance Management System (MMS), RMS Omega Technologies. RMS has data on shed salt capacity. Includes all materials.
Refresh Rate	Daily refresh
Users/Access	Winter Operations Administrator; Internal and administrative users only
Platform/Software	Microsoft PowerBI

Note that there is a winter operations budget dashboard for all areas in winter operates, like snow fence, office, third party weather data, AVL, some equipment, temp-advertising, office winter admin, etc. They do not track labor and fuel at this level.

Development of Dashboards

In the development of winter dashboards, the need for a dashboard typically arises when central figures in dashboard management, notice repeated requests for specific data or when higher management seeks specific information. Their involvement streamlines data management, reducing their workload, and although field staff rarely request dashboards directly, there is a desire for more accessible data representation.

When designing dashboards, collaboration with end-users is key. Examples are shared, and if managers are the intended users, all six primary dashboards are incorporated. There's a winter steering group available, if necessary, though it hasn't been actively involved for some time. Craig and Tina take charge of dashboard development, with Tina overseeing the Extract, Transform, Load (ETL) process, particularly data cleaning from RWIS via SQL database, handled by the IT team. The process prioritizes the use of unfiltered data from the legally logged RMS to enable error identification in input, primarily benefiting garage operations. Data storage primarily occurs within SQL databases, with the oldest available data for

certain dashboards dating back to 2013, while others are typically focused on five-year trends or single fiscal year insights, like the Salt Dashboard.

Challenges during development involved limitations arising from calculations and data constraints, leading to ongoing refinements as user interaction increased. Technical issues led to the exclusion of a speed dashboard due to data processing challenges, and RWIS sensor unreliability prevented its inclusion in analyses.

System Operations and Maintenance Questions

The hosting of these dashboards for viewing occurs through three distinct methods: publicly accessible sites on the website, technically public but not openly shared, and those requiring a PowerBI pro license for viewing, allocated to a small group. The technically public material usage and weather dashboards can be accessed via email links, while internally, they're available through the DOT site with dedicated links.

Data updates vary, with the RMS updated manually while the dashboards refresh automatically. Responsibility for data updates falls on IT, particularly if any issues arise on the database side, although Tina oversees the PowerBI side and reviews aspects external to the database. Maintenance for both the dashboards system and databases is handled jointly by Tina for PowerBI and IT for the database.

The costs and resources involved in the development, implementation, maintenance, and enhancement of these dashboards aren't meticulously tracked, but minimal efforts are needed for ongoing maintenance, especially for updates in new seasons.

The initial development involves more significant efforts, requiring collaboration with IT and users, prioritizing these operations over others due to their significance. Tina and Craig focus on refining analytic methodologies within SQL, aligning with policies and guidelines such as salt prediction, and any policy changes prompt collaboration between Tina and IT to recalibrate calculations within SQL.

The costs primarily lie in the development phase, with ongoing maintenance and storage costs being comparatively lower and less rigorously tracked.

Benefits / Lessons Learned

The winter dashboards are very useful because it helps everyone from the management level to the garage level understand and measure how resources are being used during winter maintenance operations. The dashboards also create a form of healthy competition between garages as they can compare, but also work together to meet target resource usage.

One lesson learned from the development of these winter dashboards was that it is best to keep them simple and easy to understand for users. The data should start out small and grow over time. The staff should not be forced to use it and the data should be presented as it is. Some difficulties that had to be overcome when developing the dashboards was the cost it would take to develop the first dashboard. However, with the pressure to save money on salt expenses, the benefits far outweighed the costs.

Future / Enhancements

A tool for comparing individual storms as projected and what actually occurred, is also being developed. Beyond that there are no plans for the future besides potentially adding more dashboards.

Some potential dashboards that would be useful for development include, a speed based data dashboard, a dashboard using friction sensors, using weather information to compute road conditions, and image analysis using dashcam data.

Overall, there are many ideas for potential dashboards in the future, but it is difficult to see the benefits of them if the use cases are not fully understood and outweigh the cost of development.