Brine-Making Practices and Considerations

Synthesis Report

CLEAR ROADS

research for winter highway maintenance

CTC & Associates LLC

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16. Abstract

Many state departments of transportation (DOTs) are treating winter roads with salt brine to reduce rock salt use and decrease waste, road maintenance costs and environmental impacts. While winter maintenance managers continue to purchase and take delivery of brine from a manufacturer or vendor, more transportation agencies are making their own brine as brine-making equipment has improved over time and become easier to use.

A survey of winter maintenance professionals and a review of relevant literature gathered information to advance transportation agency understanding of current practices for the in-house production of brine. Nineteen Clear Roads member agencies — nearly half of the DOTs participating in this research program — described their agencies' brine-making programs, the brine makers in operation, brine-making infrastructure and operational considerations, and brine-blending programs.

Respondents offered best practices for in-house brine making in eight topic areas:

- **Equipment**: Use automated equipment, and employ quick-connect flexible piping for tanks to avoid expansion, contraction, leaking and cracking.
- **Maintenance**: Conduct frequent equipment cleaning, consider brine maker service contracts and provide ready access to spare parts.
- **Material**: Use solar salt, keep salt stockpiles clean and ensure ready access to salt.
- **Methods**: Establish practices to ensure product consistency and monitor the brine's salinity level.
- **Staff:** Develop programs or practices to ensure properly trained staff.
- **Storage capacity**: Provide adequate brine storage capacity.
- **Structures**: Ensure adequate indoor space.
- **Water and power**: Ensure adequate water supply and pressure, use properly sized water lines that are suitable for brine making, and retain a backup power supply.

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Table of Contents

List of Tables

List of Figures

Executive Summary

Many state departments of transportation (DOTs) are treating winter roads with salt brine to reduce rock salt use and decrease waste, road maintenance costs and environmental impacts. While winter maintenance managers continue to purchase and take delivery of brine from a manufacturer or vendor, more transportation agencies are making their own brine as brine-making equipment has improved over time and become easier to use.

This synthesis project used a survey of winter maintenance professionals and a review of relevant literature to gather information that will aid transportation agencies implementing in-house brine-making programs. Survey respondents addressed questions related to the range of available brine-making equipment, operational considerations and resource needs, benefits and challenges, and best practices for brine making.

Nineteen Clear Roads member agencies — nearly half of the DOTs participating in this research program — responded to the survey. Three state DOTs — Massachusetts, Nebraska and Texas — provided multiple responses from different districts. All but one of the 19 state transportation agencies, represented by 27 respondents, produce brine in-house to support winter maintenance operations.

Brine-Making Programs

Survey respondents described brine-making practices by location, number and type of brine makers and years of brine-making operations. The longevity of respondents' in-house brine-making programs varied significantly, ranging from one member agency completing its first year of brine-making operations to another member agency with 29 years of experience making brine in-house. More than half of respondents (54%) have been making brine in-house for 11 to 20 years.

The number of brine makers in operation also ranged widely among respondents. While three respondents reported having one brine maker in operation, two state DOTs have over 100 operating brine makers. Most respondents (81%) have one to 20 brine makers in operation.

Eight-five percent of respondents produce brine in maintenance yards throughout the winter season, but responses varied on whether brine is produced in all or select districts.

Brine-Maker Models

Agencies participating in the survey most frequently use brine-making equipment from three manufacturers: VariTech Industries, Inc.; Henderson Products, Inc.; and Cargill, Inc. The table below identifies the primary manufacturers or vendors and brine-maker models respondents described in their survey responses.

Manufacturer or Vendor	Model	State/District
Cargill, Inc.	AccuBrine Automated Brine Maker NXT-Gen	Arizona, Connecticut, Maine, New Jersey, Oregon, Pennsylvania
Dultmeier Sales	BPS3000-SS and BPS5000-SS	Iowa, Kansas, Nebraska Districts 3 and 7
Henderson Products, Inc.	BrineXtreme Advantage and Infinity; other selected older models	Connecticut, Iowa, Maryland, Massachusetts Districts 2 and 5, Montana, Pennsylvania, Vermont, Wyoming

Manufacturer or Vendor	Model	State/District
VariTech Industries, Inc.	HCSB1400-SS, HCSB1400-IA and SB600 Brine Boss (automated salt brine production system)	Arizona; Connecticut; Iowa; Maine; Montana; Pennsylvania; South Dakota; Texas Abilene, Austin, Brownwood, Dallas, Fort Worth and San Angelo districts; Utah
Brine Masters LLC	Brine Masters Continuum BM-6	Massachusetts HQ
Camion	Brine Master 3000	Texas Fort Worth District
GVM Incorporated	EZ Brine System	Pennsylvania

Three respondents described brine makers that their agencies designed or constructed: Texas Brownwood and San Angelo districts and Utah DOT. Utah DOT also uses the VariTech Brine Boss, an automated salt brine production system, in tandem with agency-built brine makers.

Brine-Making Practices

Brine-making operations are affected by the equipment used to produce brine along with other factors. Respondents described their agencies' brine-making infrastructure and operational needs in the following topic areas:

- Site selection.
- Brine system shelters and housing.
- Salt type and storage.
- Power and water supplies for brine making.

Site Selection

A first step in implementing a brine-making program is deciding where to locate the operation. Respondents reported a variety of considerations. The primary drivers of site selection are geographical convenience to districts, routes and winter weather areas, and proximity to salt stockpiles and utilities. Other considerations include logistics, field staff recommendations and staff resources.

Most agencies locate brine-making operations relatively close to salt stockpiles. Five respondents reported locating brine-making operations at maintenance facilities.

Brine System Shelters and Housing

More than three-quarters of respondents reported housing their brine makers in a heated shed, garage, constructed building or other structure. Heat sources include electric, propane, gas, and wall-mounted or portable units. Seven respondents noted that some or all brine makers operate in unheated areas, and five respondents reported that some or all brine makers are located outdoors.

Salt Type and Storage

Agencies use three kinds of salt:

- *Rock or mined salt.* More than three-quarters of responding agencies (14 of 18, or 78%) use rock or mined salt.
- *Solar salt.* Three respondents use solar salt in addition to rock or mined salt; four agencies use solar salt exclusively.

- *DriRox*. In addition to using rock or mined salt, one agency uses DriRox, a kiln-dried solar salt that is known for its low moisture content.

Agencies typically store salt in sheds, barns, or wood or metal structures. Some agencies use a combination of structures.

Power and Water Supplies for Brine Making

Power Supply
Thirteen of the 18 participating agencies (72%) use hard-wired brine-making systems, with several reporting the availability of a backup generator. Five respondents use a plug-in power supply; two agencies use only generator power or a three-phase power supply.

Water Supply
Producing salt brine requires a dependable water source and consideration of other system components, such as water hoses and water lines that may freeze. Water is also needed to clean brine makers, and the water remaining after cleaning must be disposed of or reused.

Respondents use three water sources for brine making, with several using multiple water sources:

- *Municipal water supply.* Most respondents (15 of 18 agencies, or 83%) use municipal water supplies.
- *Groundwater wells.* Two respondents use only well water for brine making; five respondents use well water in addition to municipal water.
- *Reusing water*. Utah DOT reuses pond water, which consists of wash water and stormwater.

Water Hoses
The water hoses used in brine making range in size from 1.5 to 4 inches. Hose material may be flexible or rigid; materials include rubber, PVC and Kanaflex. Respondents use different connections or fittings, with some specifying the hose's purpose or the equipment it connects.

Preventing Water Lines from Freezing
To prevent the water line into the brine maker from freezing, 14 respondents from 12 state DOTs store brine makers in heated storage areas. Additional practices used to winterize equipment and prevent water lines from freezing include:

- Applying heat or thermal tape.
- Cycling the plant periodically during the off-season.
- Draining or blowing out the lines when not in use.
- Ensuring all lines are working, and making any necessary repairs before the winter season begins.
- Freezeproofing hydrants.
- Servicing drains.
- Waterproofing pipe heating cable.

Cleaning Brine-Making Equipment
In addition to the substantial amount of water used to produce brine, cleaning brine-making equipment is also water-intensive. Respondents reported a variety of purposes for cleaning brine makers, with all identifying cleaning as a best practice for protecting or preserving the equipment. The Texas Dallas

District respondent noted that cleaning allows staff to check the components and neutralize the unit to prolong the life of the system.

Twenty-three respondents (88%) cited operational reasons for cleaning brine equipment, primarily because the equipment gets clogged or will not function as efficiently unless it is cleaned. More than two-thirds of respondents identified repairing or maintaining the system as a primary purpose for cleaning brine-making equipment.

Disposition of Water

More than half of responding agencies (58%) do not have requirements for the disposition of water left after brine making or equipment cleaning. Others reported using wash bays or reclamation buildings to clean equipment where the water is captured. Some agencies reuse the water from brine making and cleaning.

Brine-Blending Practices

Agencies may blend other materials, such as corrosion inhibitors or other additives, with the salt brine they produce to enhance the effectiveness of the brine by lowering its freezing point, reducing corrosion and improving its ability to stick to the roadway.

Eleven survey respondents representing nine agencies blend additives into brine; all indicated plans to continue this practice. Six respondents blend brine into a storage tank; another six respondents blend directly into the truck that will apply the material.

Respondents primarily use pumps and tanks for brine blending. Two respondents indicated their AccuBrine systems have blending functions. Respondents use magnesium chloride, agricultural by-products and corrosion inhibitors as additives. Five of the nine agencies blending brine determine blend rates in-house.

Brine Program Assessment

Respondents assessed their brine-making programs by identifying whether their agencies planned to continue brine-making operations, describing the challenges of brine making and offering best practices, including quality assurance and quality control, to assist other agencies considering producing their own brine.

General Program Assessment

All agencies currently engaged in in-house brine production plan to continue the practice. Nearly all survey respondents cited cost-effectiveness and a readily available brine supply as benefits of brine making. Six respondents noted that decreased liquid storage capacity is also beneficial. For 88% of respondents, the in-house brine-making program meets agency demand for brine.

Equipment Reliability

Several respondents shared positive experiences with equipment reliability, with one agency highlighting the beneficial impact of stainless steel system components. Another respondent noted that specialized knowledge and proper maintenance and repairs are key to proper equipment function.

Other respondents identified the brine-maker components that could compromise brine production, including the meters or sensors used to test for salinity or flow, piping or water line capacity or tendency to freeze, and pumps faltering or failing.

Staffing and Other Challenges

Nearly half of the survey respondents reported challenges with brine-making operations other than those related to equipment reliability. Only Kansas and Oregon DOTs had no challenges to report.

Staffing is the primary concern for most respondents. Many cited short-staffing, while others highlighted the need for training, including the training of new employees. Other challenges reported by respondents:

- Availability of commercial brine.
- Difficultly making or hauling brine during storm events.
- Educating the public about the use of brine and its benefits.
- Ensuring the availability of tankers to disperse product before winter events.
- Obtaining the funding to replace equipment and storage tanks past their useful life.
- Quality of rock salt, salt shortages or restocking material after events.
- Timely contracting for equipment or materials.

Quality Assurance and Quality Control

While nine respondents reported that their agencies have no quality assurance or quality control processes for brine production processes, others described procedures for measuring or monitoring brine concentrations for salinity levels, testing materials throughout the brine-making process, and monitoring and maintaining the equipment.

Several respondents stressed the importance of monitoring brine concentration levels to ensure product consistency, with some providing target salinity percentages and describing the use of a hydrometer to conduct the testing. Other reported methods of monitoring salinity:

- Automated salinity controller.
- External meters.
- Handheld devices.
- Manual salinity checks to verify a sensor.

Best Practices

Respondents offered best practices for in-house brine making in eight topic areas:

- **Equipment**: Use automated equipment, and employ quick-connect flexible piping for tanks to avoid expansion, contraction, leaking and cracking.
- **Maintenance**: Conduct frequent equipment cleaning, consider brine-maker service contracts and provide ready access to spare parts.
- **Material**: Use solar salt, keep salt stockpiles clean and ensure ready access to salt.
- **Methods**: Establish practices to ensure product consistency and monitor the brine's salinity level.
- **Staff:** Develop programs or practices to ensure properly trained staff.
- **Storage capacity**: Provide adequate brine storage capacity.

- **Structures**: Ensure adequate indoor space.
- **Water and power**: Ensure adequate water supply and pressure, use properly sized water lines that are suitable for brine making, and retain a backup power supply.

New Practices to Explore

Several respondents reported agency interest in exploring mobile brine making and quantifying energy saved by making brine in-house.

Examining the Literature

A literature search that sought in-process and published research addressing in-house brine production identified relatively little formal research. Presented below are selected highlights from the publications cited:

- A December 2021 evaluation of winter maintenance brine applications in Wisconsin examining the cost of salt brine production considered costs related to acquisition of the brine maker, storage tanks, related production equipment and the brine-making facility.
- Ohio DOT's evaluation of the cost of brine, documented in a September 2017 report, includes a calculation of the cost of the brine produced at an Ohio DOT county garage.
- In a September 2015 research project, Clear Roads researchers addressed the costs and benefits of winter maintenance strategies, including making salt brine and blended products.
- An in-house brine-making system established in 2011 in a Texas DOT district is described in a September 2017 report that offers guidelines for evaluating the brine used in winter maintenance operations.
- A May 2008 Virginia DOT research study examined the use of recycled stormwater runoff to meet the majority of the agency's in-house brine production needs.

1 Introduction

1.1 Background

State departments of transportation (DOTs) are turning to salt brine to reduce the use of rock salt on winter roads. Using less rock salt will not only decrease waste, it will also lower road maintenance costs and impacts to the environment. Winter maintenance managers had been purchasing brine from manufacturers or vendors. But as brine-making equipment has improved over time and become easier to use, more transportation agencies are making their own brine for winter maintenance operations.

Clear Roads members requested this synthesis to explore transportation agency practices for making brine to better understand the range of available brine-making equipment and other resource needs, the operational considerations for producing brine in-house, and the benefits and challenges of brine making.

1.2 Project Description

A three-part strategy gathered information for this synthesis:

- *Survey of winter maintenance professionals*. A survey of Clear Roads member states sought information about brine-making practices, including:
    - Equipment and infrastructure needed to make or blend brine.
    - Operational and maintenance considerations and practices.
    - Costs, benefits and best practices for producing brine in-house.

  Respondents could describe up to three different brine makers their agencies use.
- *Literature search*. An examination of publicly available domestic and in-progress research supplemented survey findings.
- *Sampling of available brine-making equipment*. A review of commercial manufacturer or vendor websites and literature provided additional details of the brine-making equipment used by member agencies.

1.3 Survey Response

The survey received 27 responses from 19 state DOT Clear Roads members:

- Arizona
- Connecticut
- Idaho
- Illinois
- Iowa
- Kansas
- Maine
- Maryland
- Massachusetts (3 responses)
- Montana
- Nebraska (2 responses)
- New Jersey
- Oregon
- Pennsylvania
- South Dakota
- Texas (6 responses)
- Utah
- Vermont
- Wyoming

Survey questions are provided in Appendix E. The full text of survey responses, including respondent contact information, is available as a supplement to this report.

1.4 Organization of This Synthesis Report

Survey findings that describe respondents' brine-making programs are summarized in Chapter 2 along with brief descriptions of the brine makers used by these agencies. Chapter 3 highlights members' brine-

making practices, including an examination of brine-making infrastructure and operational considerations for making brine. Member agency practices for blending brine are reviewed in Chapter 4. In Chapter 5, respondents' assessment of their brine-making programs considers equipment reliability, staffing and other challenges, quality assurance and quality control, best practices for making brine, and new practices for exploration.

Appendices A through D provide individual agency survey responses describing experiences with commercial equipment provided by four brine-maker manufacturers or vendors; Appendix E provides the survey questions.

While the survey conducted for this synthesis received responses from nearly half of the Clear Roads membership, the survey findings do not serve as a representative sampling of all public transportation agencies. These results will, however, inform the practices of winter maintenance managers when considering whether and how to produce or blend brine in-house to support winter maintenance operations.

2 Brine-Making Programs and Equipment

2.1 Introduction

Nineteen Clear Roads member agencies — nearly half of the DOTs participating in this research program — responded to the survey. All but one of the 19 agencies produce brine in-house to support winter maintenance operations. Only Illinois DOT does not make its own brine and has no immediate plans to do so.

Survey respondents described brine-making practices by location, number and type of brine makers, and years of brine-making operations. This chapter presents a general description of respondents' brine-making programs and the brine makers used by the responding agencies, followed by summaries of brine-maker performance.

2.2 Brine-Making Programs

The longevity of respondents' in-house brine-making programs varied significantly, ranging from Oregon DOT, which is completing its first year of brine-making operations, to Kansas DOT, with 29 years of experience making brine in-house. More than half of respondents (54%) have been making brine in-house for 11 to 20 years. Table 1 summarizes the years in operation for respondents' brine-making programs.

Table 1. Years in Operation for Respondents' Brine-Making Programs

Range of Years	Number of Respondents
1 to 10	9
11 to 15	8
16 to 20	6
21 to 30	3

The number of brine makers in operation also ranged widely among respondents. While three respondents reported having one brine maker in operation (*Massachusetts District 5*, *Oregon* and *Wyoming*), two state DOTs operate more than 100 brine makers (*Iowa* and *Kansas*). Most respondents (81%) have one to 20 brine makers in operation. Table 2 summarizes the number of respondents' brine makers in operation.

Table 2. Number of Respondents' Brine Makers in Operation

Number of Brine Makers	Number of Respondents
1 to 5	9
6 to 10	6
11 to 20	6
21 to 100	6
More than 100	2

Eight-five percent of respondents produce brine in maintenance yards throughout the winter season, but responses varied on whether brine is produced in all or select districts. Survey responses regarding brine-making scope, the number of brine makers and locations for brine production are summarized in Table 3.

Table 3. Responding Agencies' Brine-Making Programs

State	Years Making Brine	Number of Brine Makers in Operation	Produced in All Districts	Produced in Select Districts	Produced in Maintenance Yards	Produced at Select Times of the Year	Produced Throughout Winter Season
Arizona	9	5		X	X	X	X
Connecticut	10+	13	X				X
Idaho	15+	6		X	X		X
Iowa	25	119	X		X		X
Kansas	29	107	X		X		X
Maine	15 to 20	8 (in operation) 13 (total)	X		X	X	X
Maryland	15	15	X		X	X	X
Massachusetts HQ	~10	2 (in operation) 1 (recently purchased)		X	X	X	X
Massachusetts District 5	22	1		X			X
Massachusetts District 2	4+	2		X			
Montana	14	5		X	X	X	X
Nebraska District 3	20+	13			X		X
Nebraska District 7	25	12			X		
New Jersey	20+	29			X		X
Oregon	1	1		X	X		X
Pennsylvania	28	70	X		X		X
South Dakota	15	21		X	X		X
Texas Abilene District	11	8			X		
Texas Austin District	8+	4			X	X	X
Texas Brownwood District	15	10			X		X
Texas Dallas District	10 to 15	8			X		X
Texas San Angelo District	10	2 (in operation) 2 (recently purchased)		X	X		X
Texas Fort Worth District	~5	11			X		
Utah	27	~20	X		X		X

State	Years Making Brine	Number of Brine Makers in Operation	Produced in All Districts	Produced in Select Districts	Produced in Maintenance Yards	Produced at Select Times of the Year	Produced Throughout Winter Season
Vermont	14	7		X			
Wyoming	10	1		X	X	X	
Total			**7**	**11**	**22**	**7**	**20**

Two respondents offered more detailed information about brine production practices:

Massachusetts DOT. Until a few years ago, Massachusetts District 5 brine makers produced brine for all state roads. District 5 was home to Massachusetts' first brine plant, a more complex unit as compared to newer brine-making equipment. Massachusetts District 2 was the second district to take delivery of a brine plant and now maintains two plants. Massachusetts Districts 3 and 4 recently received brine makers that will be operational over the next two seasons. While District 5 still supports three districts without brine-making capacity, most districts are responsible for producing their own brine. All districts provide support across district lines to address storm events or equipment failures.

Texas DOT. Abilene and Dallas districts produce brine as needed during the winter season. The Brownwood District produces brine in each of the district's nine counties, typically during each winter event, to keep the storage tanks full.

Brine makers in the Texas San Angelo District proved to be inefficient and were little used, leading to the purchase of brine and an increase in storage capacity. This practice has adequately addressed the district's relatively few winter storms. The San Angelo District is planning to make more brine with new brine makers.

2.3 Brine-Maker Models

Agencies participating in the survey most frequently use brine-making equipment from three manufacturers: VariTech Industries, Inc.; Henderson Products, Inc.; and Cargill, Inc. Table 4 identifies the primary manufacturers or vendors and brine-maker models respondents described in their survey responses.

Table 4. Respondents' Brine-Maker Manufacturers/Vendors and Models

Manufacturer or Vendor	Model
Cargill, Inc.	AccuBrine Automated Brine Maker NXT-Gen
Henderson Products, Inc.	BrineXtreme Advantage and Infinity
Dultmeier Sales	BPS3000-SS and BPS5000-SS
VariTech Industries Inc.	HCSB1400-SS, HCSB1400-IA and SB600
Brine Masters LLC	Brine Masters Continuum BM-6
Camion	Brine Master 3000
GVM Incorporated	EZ Brine System

Below are summaries of product features, as described by the brine-maker manufacturer or vendor, links to product information, and highlights of agency experiences with the brine makers identified in Table 4. General descriptions of agency-built brine makers follow the commercial products. More details of agency use of selected commercial brine makers appear in Appendices A through D of this report.

AccuBrine Automated Brine Maker NXT-Gen

Offered by Cargill, Inc.

Figure 1. AccuBrine Automated Brine Maker
(*Source*: Cargill, Inc.)

Product Features

- Brine production capacity up to 6,000 gallons per hour.
- *Programmable logic controller (PLC)*: The PLC initiates the production process while a patented sensing system monitors salinity levels.
- *Accurate data tracking*: The PLC tracks daily and seasonal data, including production volume, water, salt and additives usage.

Other Features

- Modular system allows users to add a truck filling and additive blending system.
- Remote access allows customer to remotely monitor and operate via Apple or Android mobile device or desktop.
- Air purge automatically purges fresh water supply lines to salt mixing tank to avoid freezing.
- The brine maker is available in single- or three-phase motor options.
- A custom blend can be made in real time as it is being sent directly to a liquid application truck, eliminating the need to store blended product in storage tanks.

Product Information

Product website: https://www.cargill.com/industrial/winter-road-maintenance/accubrine-nxt-gen

Product fact sheet: https://www.cargill.com/doc/1432075977317/abss-1101-ab-sell-sheet.pdf

Agency Use

Six state DOTs use AccuBrine brine makers:

- Arizona
- Connecticut
- Maine
- New Jersey
- Oregon
- Pennsylvania

Arizona, Connecticut, Maine and Pennsylvania DOTs use AccuBrine brine makers in addition to other brine-maker makes and models. New Jersey DOT maintains 29 AccuBrine brine makers, and Oregon uses one AccuBrine brine maker, exclusively. Respondents reported brine production that ranged from 700 to 6,000 gallons per hour.

All respondents noted that the AccuBrine needed manual cleaning by up to two staff people and requires from 30 minutes to up to six hours to clean. Respondents specifying a cleaning cost reported $1,000 per cleaning event (*Arizona*) and cost of labor (*Maine* and *Oregon*). Arizona DOT's brine maker will produce 25,000 gallons before cleaning is required; the New Jersey DOT respondent noted that cleaning requirements vary "based on brine quantity and salt quality."

The frequency of AccuBrine brine-maker cleaning ranged from multiple times during the season (*Arizona*) to the end of the season (*Connecticut* and *Maine*). Oregon DOT cleaned its brine maker at the end of the season, in part because a light winter required relatively little brine production and the solar salt used in brine production was very clean. In New Jersey, depending on salt quality, some brine makers are cleaned after every storm and others are cleaned once a season.

See Appendix A for further details of each agency's use of Cargill, Inc.'s brine-making system.

Dultmeier Brine Makers

Offered by Dultmeier Sales

Dultmeier Brine-Maker Models (see Figure 2)

- DU BPS3000-SS
- DU BPS5000-SS

Figure 2. Dultmeier Brine Maker
(*Source*: Dultmeier Sales.)

Product Features

- Brine production capacity between 4,000 and 6,000 gallons per hour.
- Stainless steel construction.
- No augers or conveyors are required; salt is loaded into the top of the hopper with a front-end loader.
- One master panel controls brine production and hydraulic cleanout.
- Units use 2-inch water inlet plumbing that includes 24-volt automatic control valve, with polypropylene and stainless fittings for "excellent corrosion resistance."
- Pump the produced brine to storage, recirculate the material to the hopper from storage, and make salinity adjustments as needed.
- BPS5000-SS has the same dimensions and speed as the BPS3000-SS model but also includes an internal overflow weir inside the top salt hopper. This provides for simultaneous upward and downward flow.
- Both models are available in *Easy Clean Out* or *Stainless Steel Hopper and Tank and Skid Frame* versions.

Product Information

Product website: https://www.dultmeier.com/salt-brine-production-systems

Product fact sheet: https://assets.dultmeier.com/assets/catpages/E0623.pdf

Agency Use

Three state DOTs use Dultmeier brine makers:

- Iowa (BPS3000 and BPS5000)
- Kansas (BPS3000)
- Nebraska Districts 3 and 7 (BPS3000)

Iowa DOT and Nebraska District 3 use Dultmeier brine makers in addition to other brine-maker makes and models. Kansas DOT and Nebraska District 7 use Dultmeier brine makers exclusively.

Reported production capacity ranged from between 1,000 to 3,000 gallons per hour (*Nebraska District 7*) to 3,000 to 5,000 gallons per hour (*Iowa*).

All respondents reported the Dultmeier brine makers require manual cleaning by one staff person and described a cleaning time from 15 to 30 minutes. Kansas DOT is the only agency to address cleaning cost and reports that it is minimal. All respondents noted that the quantity of brine produced before a required cleaning depends on the quality or cleanliness of the salt, with Iowa estimating 50,000 gallons; Nebraska District 3 estimating between 10,000 and 20,000 gallons; and 2,000 gallons estimated by Nebraska District 7.

Both Iowa and Kansas DOTs clean their Dultmeier brine makers multiple times per season; Nebraska Districts 3 and 7 clean their units after making each batch.

See Appendix B for further details of each agency's use of Dultmeier Sales brine-making models.

BrineXtreme (Advantage and Infinity)

Offered by Henderson Products, Inc.

Product Features

BrineXtreme Advantage (Figure 3)

Basic brine making with high-volume salt brine production combined with an unobstructed large cleanout.

- Brine production capacity up to 7,500 gallons per hour.
- Stainless steel tank construction.
- Cleanout features:
  - Large solids cleanout door.
  - Fines cleanout using a 3-inch butterfly valve.
  - Sloped floor to aid cleanout.
- Treated or untreated rock salt allowed.

Figure 3. BrineXtreme Advantage Brine Maker
(*Source:* Henderson Products, Inc.)

BrineXtreme Infinity (Figure 4)

- Brine production capacity up to 7,500 gallons per hour.
- Stainless steel tank construction.
- Fully automated, continuous brine production that uses the vendor's auto-clean technology for continuous, fully automated self-cleaning.
- Triple-filtered brine.
- Automated salinity management.
- Treated or untreated rock salt allowed.

Figure 4. BrineXtreme Infinity Brine Maker
(*Source:* Henderson Products, Inc.)

Product Information

Product website:	Advantage: http://www.hendersonproducts.com/brinextreme-advantage.html
	Infinity: http://www.hendersonproducts.com/brinextreme-infinity.html
Product fact sheet:	Advantage: http://www.hendersonproducts.com/assets/hp-201_brinextreme_advantage.pdf
	Infinity: http://www.hendersonproducts.com/assets/hp-200_brinextreme_infinity.pdf

Agency Use

Nine respondents from eight state DOTs use BrineXtreme brine-maker models:

- Connecticut (model not specified)
- Iowa (Advantage)
- Maryland (Infinity)
- Massachusetts District 2 (Advantage)
- Massachusetts District 5 (Ultimate)
- Montana (Advantage and Infinity)
- Pennsylvania (model not specified)
- Vermont (1200)
- Wyoming (Mobile Advantage)

Connecticut, Iowa, Montana and Pennsylvania DOTs use BrineXtreme brine makers in addition to other brine-maker makes and models. Respondents from Maryland, Massachusetts Districts 2 and 5, Vermont and Wyoming use only BrineXtreme brine makers.

Reported brine production ranged from 2,500 to 7,000 gallons per hour.

Most respondents noted that BrineXtreme brine makers require manual cleaning by one to two staff people. For Montana DOT, cleaning may take up to three people; Maryland's BrineXtreme Infinity model was described as having an automatic cleaning function. Cleaning times ranged from 10 minutes to five hours. The Massachusetts District 5 respondent reported a cost of $250 per cleaning event; the Montana DOT respondent described the cost as "equipment and man hours." Other respondents did not address cleaning costs or have access to that data.

Respondents reported a wide range of quantity of brine produced before the brine maker needed to be cleaned, from 6,000 gallons (*Vermont*) to 60,000 gallons (*Montana*). For Massachusetts District 5, "a season's worth" of brine can be produced before a cleaning.

The frequency of BrineXtreme brine-maker cleaning ranged from after each use (*Wyoming*) to at the end of the season (*Connecticut*). Some agencies clean multiple times a season (*Iowa*, *Maryland* and *Vermont*) or after every 30,000 gallons of brine production (*Massachusetts District 2*). For other agencies, cleaning practices depend on brine production (*Massachusetts District 5*) and salt quality (*Montana*).

See Appendix C for further details of each agency's use of Henderson Products, Inc. brine-making models.

VariTech Brine Makers

Offered by VariTech Industries, Inc.

Figure 5. Brine Boss Automated Salt Brine Production System
(*Source*: VariTech Industries, Inc.)

VariTech Brine-Maker Models

- High Capacity Salt Brine Production System (HCSB1400-SS)
- Salt Brine Production System (SB600)
- Brine Boss Automated Salt Brine Production System (stand-alone cabinet used in conjunction with a brine-making system; see Figure 5)

Product Features

High Capacity Salt Brine Production System (HCSB1400-SS)

- Brine production capacity of up to 5,000 gallons per hour.
- On-board brine storage capacity of 1,400 gallons.
- *Up-flow design*: Single-pass saturation ensures consistent salinity, purer brine and less sediment.
- *Full range salinity adjustments*: Permits production of salt brine to exact salinity needed.
- *Tethered remote control*: Controls unloading system on/off from a distance of up to 15 feet.
- *Integrated ground fault protection*: Provides electric shock and overload protection.
- *On-board storage overflow protection*: Provides an automated full switch for shut-off when the storage is full in continuous throughput production.

Salt Brine Production System (SB600)

- Brine production capacity of up to 3,600 gallons per hour.
- Salinity controlled manually by the operator.
- *Up-flow design*: Ensures consistent salinity and purer brine.
- *Full range salinity adjustments*: Permits production of salt brine to exact salinity needed.
- *110% secondary containment system*: Provides a standard, double-wall containment that complies with environmental storage and production regulations.
- *Tethered remote control*: Controls unloading system on/off from a distance of up to 15 feet.
- *On-board storage overflow protection*: Provides an automated full switch for shut-off when the storage is full in continuous throughput production.

Brine Boss Automated Salt Brine Production System

- Stand-alone cabinet that houses an automated, touch-screen controller unit. Used in conjunction with a brine maker.
- *Multiple group user options*: Allows multiple users to use the same system while tracking usage per group.
- *Advanced data tracking and transfer capabilities*: Allows the administrator to view and transfer data such as salt used, gallons of brine produced, truck ID numbers, date and time. Offers capability to download information.
- *Truck loading and off-loading*: Allows for loading and off-loading of mobile truck tanks while tracking truck ID, date, time and gallons loaded/off-loaded.
- *Temperature-compensated brine production*: Monitors water temperature to ensure consistency in the brine produced.
- *Multiple tank monitoring system*: Permits the production and pumping of brine to multiple storage tanks with add-on valve and hose packages.

Product Information

Product website: https://VariTech-industries.com/

Product fact sheets: HCSB1400-SS: https://VariTech-industries.com/products/brine-production-equipment/hcsb1400-ss

SB600: https://VariTech-industries.com/products/brine-production-equipment/sb600

Brine Boss: https://VariTech-industries.com/products/brine-production-equipment/brine-boss

Agency Use

Fourteen respondents from nine state DOTs use VariTech brine-maker models:

- Arizona (HCSB1400-SS and SB600)
- Connecticut (SB600)
- Iowa (HCSB1400-SS, HCSB1400-IA and SB600)
- Maine (SB600)
- Montana (SB600)
- Pennsylvania (model not specified)
- South Dakota (SB600)
- Texas Abilene District (SB600)
- Texas Austin District (SB600)
- Texas Brownwood District (SB600)
- Texas Dallas District (SB600)
- Texas Fort Worth District (SB600 and Brine Boss)
- Texas San Angelo District (SB600)
- Utah (Brine Boss)

Most agencies using VariTech brine makers also use other brine-maker makes and models. South Dakota DOT and Texas Abilene, Austin, Dallas and San Angelo districts use VariTech brine makers exclusively.

Reported brine production ranged from 500 to 5,000 gallons per hour. Most respondents noted that the VariTech brine makers require manual cleaning by one to three staff people. Cleaning times ranged from 30 minutes (*Iowa*) to one day (*Texas Brownwood District*). For most respondents, cleaning the brine maker requires two to five hours. Costs of cleaning ranged from $30 (*Texas Austin District*) to $2,000 (*Texas Abilene District*). Respondents also reported costs associated with labor (*Maine* and *Texas Dallas District*) or labor and equipment (*Montana*). The South Dakota DOT respondent noted that local vacuum trucks cost an average of $35 per ton.

Several respondents noted that the quantity of brine produced before cleaning was necessary depended on the cleanliness of salt and water supply. Estimated quantities that can be produced before cleaning ranged from 10,000 gallons (*Arizona*) to 150,000 gallons (*Texas Abilene District*).

Two respondents clean VariTech brine makers after each batch (*Arizona* and *Texas Austin District*). For the Texas Brownwood and Fort Worth districts, cleaning frequency depends on the cleanliness of the salt. The remaining VariTech brine-maker users were split between cleaning the machines multiple times during the season and only at the end of the season.

See Appendix D for further details of each agency's use of VariTech Industries, Inc. brine-making models.

Other Brine-Making Models

The brine makers described below are used by relatively few respondents. Details for each user are provided after a brief product description for three brine-maker manufacturers or vendors:

- Brine Masters LLC
- Camion
- GVM Incorporated

Brine Masters Continuum BM-6 (see Figure 6)

Offered by Brine Masters LLC

Product Features

- Brine production capacity of up to 6,000 gallons per hour
- Streamlined, self-calibrating controls
- Automatic salinity management
- Compatible with treated or plain salt
- Automated continuous self-cleaning
- Optional cellular remote access, storage tank level monitoring, hopper extensions and outdoor installation package with relocated controls

Figure 6. Brine Masters Continuum BM-6 Brine Maker
(*Source*: Brine Masters LLC.)

Product Information

Product website: https://brinemasters.com/products/#BM-6

Massachusetts Department of Transportation (HQ)

The Massachusetts DOT HQ respondent described a Brine Masters Continuum BM-6 brine maker with integrated controls. Agency responses are summarized below.

Topic	Description
Brine storage	5,000- or 10,000-gallon polyethylene tanks
Brine mixing	TF-XR real-time blending system
Pumps	Not addressed
Loading practice	Loader
Brine production	5,000 to maximum of 7,000 gallons per hour; three-phase power and 2-inch water line required The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 to 2 staff needed to operate the cleaning cycle **Time**: 1 hour or less **Gallons produced before cleaning**: 50,000 **Cost**: Not addressed **Frequency**: Not addressed

Brine Master 3000 (see Figure 7)

Offered by Camion

Product Description

- Brine production capacity of up to 2,600 gallons per hour
- Stainless steel frame with one-piece high-density polyethylene hopper and mixing tank
- Central control station keeps valves all in one place
- Complete unit with all the components, including a mixing tank
- Built-in fork points make the unit easy to move in and out of storage; unit must be empty while being moved
- Comes standard with a flow meter to easily monitor flow rate
- Electronic salinity reader
- Fully drainable hopper

Figure 7. Brine Master Brine Maker
(*Source*: Camion.)

Product Information

Product website: https://www.camionsystems.com/product/brine-master/

Product owner manual: https://www.camionsystems.com/wp-content/uploads/2024/10/Brine_Master%C2%AE_LG_Owners_Manual_v1.8.pdf

Texas Department of Transportation (Fort Worth District)

This Texas DOT district uses an automatic Brine Master 3000 brine maker in addition to a manual VariTech SB600 brine maker with the Brine Boss automated controller. The respondent noted that the information provided below generally applies to all district brine makers; differences in brine-making practices and brine-maker performance are associated salt quality and how the salt is delivered.

Topic	Description
Brine storage	Mostly fiberglass; some poly 12,000-gallon tanks
Brine mixing	10,000 to 20,000
Pumps	Not specified
Loading practice	Skid steer and auger system
Brine production	1,000 to 3,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: Minimum of 2 staff needed to operate the cleaning cycle **Time**: 2 to 5 hours, depending on buildup **Gallons produced before cleaning**: Depends on the quality of salt **Cost**: $200 per hour **Frequency**: Depends on the quality of salt; sometimes every few hours

GVM EZ Brine System (see Figure 8)

Offered by GVM Incorporated

Product Description

Figure 8. GVM EZ Brine System Brine Maker
(*Source*: GVM Incorporated.)

- Brine production capacity of up to 6,000 gallons per hour (depending on water source)
- Stainless steel automated batch system
- Used as a batch system to produce blends on an as-needed basis or as a continuous manufacturing system
- Blends up to three different micro-ingredients, allowing users to produce custom blends
- Constantly monitors salinity and pump performance in addition to logging brine production data
- Built-in Wi-Fi allows for easy remote monitoring
- Built-in printer can quickly print logged data
- Top-mounted spray bars for rapid saturation of salt and easy tank cleanout

Product Information

Product website: https://www.gvminc.com/brine-production-systems

Pennsylvania Department of Transportation

Pennsylvania DOT uses a GVM brine maker in addition to VariTech, AccuBrine and BrineXtreme brine makers. As the respondent did not specify to which brine-maker model the information provided applied, this information is reproduced for each brine maker.

Topic	Description
Brine storage	2,300- to-10,000-gallon tanks provided at all stockpiles
Brine mixing	Not addressed
Pumps	Primarily 2-inch pumps operating at 250 to 500 gallons per minute
Loading practice	Primarily loaders; also backhoe and skid steer
Brine production	1,000 to 7,500 gallons per hour, depending on system type and water supply Brine makers do not produce at the rate the agency anticipated (the brine maker's maximum capacity) if the water supply line is not large enough.
Cleaning	**Type**: Manual; some systems have automated option **Staff**: 2 staff needed to operate manual cleaning cycle **Time**: Unknown; depends on the salt and cleaning frequency **Gallons produced before cleaning**: Unknown; depends on the salt and cleaning frequency **Cost**: Unknown; depends on the salt and cleaning frequency **Frequency**: Multiple times during the season

More Survey Feedback Brine Production in Wisconsin Counties

In Wisconsin, winter maintenance is conducted by the state's 72 counties. To learn more about concerns about the increased frequency of cleanout of the counties' brine makers, Wisconsin DOT conducted a survey that examined how each county deals with the cleanout process. The survey also gathered information about the types of brine makers in operation throughout Wisconsin.

Fifty of the state's counties responded to the survey, with 36 counties reporting on the high-capacity brine maker each county owns and operates. ("High capacity" was defined as a brine maker that is capable of producing at least 5,000 gallons per hour.) Eighty-one percent of the brine makers used by these Wisconsin counties are manufactured by VariTech Industries or Henderson Products, Inc.

- VariTech Industries, Inc.: 17 units (includes HCSB1400-SS, HCSB700-SS, HCSDI-400-SS and Brine Boss).
- Henderson Products, Inc.: 12 BrineXtreme units.
- Cargill, Inc.: 6 AccuBrine units.
- Brine Masters: 1 unit.

Agency-Built Brine Makers

Note: Respondents describing brine makers built in-house provided general information about agency use but did not provide specifications for each unit. The summary of agency-built units below is followed by a tabular presentation of agency responses.

Three respondents described brine makers their agencies designed and/or constructed:

- **Texas Brownwood District** uses one brine maker that was previously designed and built by the agency's fleet division years ago and will be replaced in the near future. The district also uses VariTech brine makers.
- **Texas San Angelo District** has used two district-built brine makers with manual valves for more than 10 years. The district also uses VariTech brine makers.
- **Utah DOT** uses an estimated 20 agency-designed brine makers in conjunction with a VariTech Brine Boss, an automated controller system.

Texas Brownwood and San Angelo districts reported a brine production capacity of 1,500 to 2,000 gallons per hour, while the Utah DOT shop-made brine makers produce 5,000 gallons per hour. Texas San Angelo District and Utah DOT require two to four staff for brine maker cleaning, with cleaning completed in three to five hours; the Texas Brownwood District requires one day to clean its brine maker.

Utah DOT produces at least 110,000 gallons of brine between cleanings. All three respondents noted that cleaning is required multiple times a season and depends on cleanliness of the salt.

Texas Department of Transportation (Brownwood District)

Topic	Description
Brine storage	Two 12,500-gallon fiberglass tanks; $17,000 each
Brine mixing	Batch mixing system
Pumps	Hard-wired electric motor with pacer pump; also PVC plumbing lines and transfer hoses
Loading practice	Skid steer
Brine production	1,500 to 2,000 gallons per hour, depending on solubility and water pressure The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 to 3 staff needed to operate manual cleaning cycle **Time**: 1 day **Gallons produced before cleaning**: Not addressed **Cost**: Approximately $600 per day **Frequency**: Depends on the cleanliness of the salt. With clean salt, cleanouts are rare; dirty salt may require cleanout after every event.

Texas Department of Transportation (San Angelo District)

Topic	Description
Brine storage	10,500-gallon water storage tanks
Brine mixing	Batch style
Pumps	Cast iron
Loading practice	Loader
Brine production	1,500 gallons per hour The brine makers are not producing brine at the rate the agency anticipated. The equipment is considered “very inefficient” and only used as backup in emergency situations.
Cleaning	**Type**: Manual **Staff**: 4 staff needed to operate manual cleaning cycle **Time**: 3 to 4 hours **Gallons produced before cleaning**: Not addressed **Cost**: $4,000 **Frequency**: Require frequent cleaning due to the setup and inefficient style; cleaned each time after making a batch

Utah Department of Transportation

Topic	Description
Brine storage	5,000-gallon polyethylene tanks
Brine mixing	Not specified
Pumps	Many different types of pumps; most common is a polypropylene plastic pump
Loading practice	Loader
Brine production	5,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 to 3 staff needed to operate manual cleaning cycle **Time**: 4 to 5 hours **Gallons produced before cleaning**: At least 110,000 gallons **Cost**: $690 per cleaning **Frequency**: Multiple times during the season; at least 1 to 2 times per year, depending on contaminants in the salt

3 Brine-Making Practices

3.1 Introduction

The equipment used to produce brine is one of several factors that affect brine-making operations. Respondents described their agencies' brine-making infrastructure and operational needs in the following topic areas:

- Site selection.
- Brine system shelters and housing.
- Salt type and storage.
- Power and water supplies for brine making.

3.2 Site Selection

A first step in implementing a brine-making program is deciding where to locate the operation. Respondents reported a variety of considerations, summarized in Table 5. The primary drivers of site selection are geographical convenience to districts, routes and winter weather areas, and proximity to salt stockpiles and utilities.

Table 5. Considerations for Brine-Making Site Selection

Consideration	State/District	Description
Geographical Convenience	Idaho, Massachusetts District 2, Massachusetts HQ, Pennsylvania, Texas Fort Worth District, Vermont	*Idaho.* Located to assist selected districts with hauling brine from the production site to storage tanks. *Massachusetts District 2, Massachusetts HQ, Vermont.* Centralized location. *Texas Fort Worth District.* Most accessible locations.
Proximity to Salt Stockpiles	Nebraska District 7, Pennsylvania, Texas Dallas and San Angelo districts, Utah, Wyoming	None
Proximity to Utilities	Maryland, Oregon, Pennsylvania, Texas Brownwood and Dallas districts, Vermont, Wyoming	*Maryland, Oregon, Pennsylvania, Wyoming.* Access to water. *Texas Brownwood* and *Dallas districts.* Access to water and electricity. *Vermont.* Access to municipal water supply.
Salt Storage	Oregon	Adequate salt storage for direct application and brine production.
Sufficient Indoor Space	Massachusetts District 5, Oregon	*Oregon.* Adequate cover and maneuverability inside shed to load hopper.
Sufficient Outdoor Space	Massachusetts District 2, Vermont	*Vermont.* Adequate size for additional sheds and tank storage.
Winter Weather Areas	Arizona, Montana, South Dakota, Texas Dallas District	*Arizona.* Centralized maintenance yards that receive significant snow.

Consideration	State/District	Description
Other Factors	South Dakota, Texas Austin and San Angelo districts	*South Dakota.* Route average daily traffic and population. *Texas Austin and San Angelo districts.* Tiered highways and maintenance section needs.

Five respondents produce brine at maintenance facilities (*Iowa, Kansas, Nebraska District 3*, *Texas Abilene District* and *Wyoming*).

Other siting considerations:

- Ability to produce and haul brine (*Montana*).
- Availability of a Texas DOT inspector that can operate the brine makers (*Texas San Angelo District*).
- Logistics (*Connecticut*).
- Request of field staff (*Idaho*).
- Staff resources (*Montana* and *Texas San Angelo District*).

Agencies locate brine-making operations relatively close to salt stockpiles, with locations ranging from on-site to two miles away (see Table 6).

Table 6. Brine-Maker Proximity to Salt Stockpiles

Distance	State/District and Description
On-Site or Close Proximity	*Connecticut, Iowa* *Kansas.* Most are next to each other. *Oregon.* Hopper is inside salt shed; adjacent shed houses brine-maker electronics.
30 to 100 Feet	*Idaho; Maine; Massachusetts Districts 2, 5 and HQ; Montana; Nebraska District 7; New Jersey; Utah; Vermont; Wyoming*
100 to 300 Feet	*Maryland; Massachusetts District 2; Nebraska District 7; Pennsylvania; South Dakota; Texas Austin, Brownwood, Dallas and Fort Worth districts*
Over 300 Feet	*Arizona, Texas Abilene District* *Texas San Angelo District.* One brine maker is located in the same yard as the salt shed. Super sacks are used to transport brine salt to the second brine maker located about two miles away.

3.3 Brine System Shelters and Housing

Survey respondents described where their brine makers and related equipment are housed and the sources of heat, if any.

Heated Brine System Shelters

More than three-quarters of respondents reported housing agency brine makers in a heated shed, garage, constructed building or other structure. Respondents' descriptions of these shelters and their uses are presented in Table 7.

Table 7. Respondents' Heated Brine-Making System Shelters

Shelter Type	State/District and Description
Shed	*Maryland*. Houses compressor used for winterizing the unit in a shed; heaters are also located in the control shed. *Nebraska District 7*. Uses existing wooden salt sheds in some locations; the agency constructed 20' x 20' buildings in others. *Oregon*. Purchased a commercial outdoor shed kit.
Garage	*Connecticut*. Installed automatic brine makers and hoppers in a maintenance garage; older, nonautomated systems are located outdoors in a shed. *Massachusetts District 5*
Constructed Building	*Idaho.* Varies, from small in-house-built buildings to large contractor-constructed buildings. *Iowa*. Houses system in standard wood frame buildings; storage tanks are located outside the buildings. *Maine.* Houses AccuBrine system in 50' x 60' building and VariTech system in 8' x 10' plastic insulated building. *Massachusetts District 2.* Constructed a building for brine-making equipment; a concrete pad holds six 10,000-gallon tanks. *Montana.* Includes storage and containment pads in new or retrofitted buildings; corrosion inhibitor must be kept indoors under climate-controlled conditions. *Pennsylvania*. Varies; some brine makers are in heated buildings, some are outside. *South Dakota*. Uses a pole barn building. *Wyoming*. Constructed a 20' x 30' steel building.
Various Structures	*New Jersey.* Provides indoor control panel storage (heated); shed or garage (heat unspecified). *Texas Abilene District*. Retrofitted all shops to house brine makers (heated). One stand-alone brine maker shed is in progress; 12 more are needed. *Texas Dallas District*. Includes a concrete foundation with a three-sided metal-treated shed to prevent corrosion and an open front for loading; a modular shelter with contractible rooftop for loading. *Texas Fort Worth District*. Stores some brine makers in covered buildings; covers others with tarps. More permanent structures with concrete floors are needed. *Utah.* Houses brine makers in pump houses.
Unspecified	*Arizona, Massachusetts HQ*

Heat Sources

Some respondents commented on the heat source:

- Electric (*Maine*, *Montana*, *Oregon*, *South Dakota*, *Utah*).
- Gas (*Montana*).
- Propane (*Massachusetts District 2*, *Montana*, *Texas Dallas District*, *Wyoming*).
- Wall-mounted and portable unspecified heat source (*Texas Dallas District*).

Tips and Techniques Product Experience Surveys Offer More Insights

Clear Roads encourages ongoing evaluation of products related to winter maintenance through an informal Product Experience Survey conducted at the end of each winter season. Member states are invited to share the results of pilot-testing of winter maintenance products and materials conducted that year. Clear Roads has compiled all survey responses received, beginning in 2006 through the current winter season. This informal survey serves as a tool for states to share experiences with winter maintenance products and is not intended to be a scientific evaluation of product performance.

The brine makers below are among the products assessed in these surveys:

- AccuBrine automated brine maker (Cargill, Inc.).
- Dultmeier brine generator (Dultmeier Sales).
- BrineXtreme blending unit (Henderson Products, Inc.).
- Brine Boss automated monitoring system (VariTech Industries, Inc.).
- Salt brine maker (Reed Systems LTD).
- Salt blending station (JWB Manufacturing).

Review the combined survey results from the 2006-2023 surveys to learn more about this product experience feedback. Discussion of brine makers and blenders begins on page 20.

Clear Roads does not endorse any of the products evaluated in the Product Experience Surveys or examined in this synthesis report.

Unheated Brine-Maker System Shelters

Of the seven respondents reporting that some or all brine makers operate in unheated areas, four described their unheated brine-making system shelters:

- *Kansas.* Houses brine makers in three-sided sheds with or without roofs.
- *Texas Austin District.* Uses small enclosures currently, with plans to build 20-by-20-foot structures.
- *Texas Brownwood District*. Uses six new brine sheds and three older metal structures for brine making and material storage. New sheds constructed of metal and wood have concrete pads and a 4-foot concrete wall.
- *Vermont*. Houses brine makers in former salt sheds.

Some or all brine makers operated by five respondents are located outdoors (*Kansas, Nebraska District 3*, *Pennsylvania* and *Texas Austin and San Angelo districts*). The Texas San Angelo District respondent noted that the district hopes to "keep them out of the weather and make [them] more accessible. The heat in west Texas tends to take a toll on the units since they are out in the open elements and not protected from the sun."

3.4 Salt Type and Storage

Agencies use three kinds of salt:

- *Rock or mined salt.* More than three-quarters of responding agencies (14 of 18, or 78%) use rock or mined salt.
- *Solar salt.* Three respondents use solar salt in addition to rock or mined salt (*Iowa*, *Massachusetts HQ* and *New Jersey*); four agencies use solar salt exclusively (*Maryland*, *Oregon*, *Pennsylvania* and *Utah*).
- *DriRox*. In addition to using rock or mined salt, Wyoming DOT uses DriRox, a kiln-dried solar salt that is known for its low moisture content.

Agencies typically store salt in sheds and barns or in wood, metal or other types of structures, as summarized in Table 8. Some agencies use a combination of structures (*Nebraska*, *Pennsylvania*, *South Dakota* and *Texas Dallas District*).

Table 8. Agency Practices or Plans for Salt Stockpile Storage

Shelter Type	State/District and Description
Barn	*Massachusetts HQ*. Covered barn. *Pennsylvania.* Barn-style structure. *South Dakota*. Hoop barn-style structure with concrete walls.
Dome	*Nebraska, Pennsylvania, South Dakota*
Shed	*Texas Austin District*. Plans to build 30' x 60' sheds. *Texas Dallas District*. Includes: • 300-cubic-yard salt shed with concrete foundation and wood and treated metal walls • 300-cubic-yard salt shed with concrete foundation, half-walls and weatherproof canvas-type covering
Other Structure	*Maine.* Many structures that range in size from 42' x 44' to 130' x 60'. *Montana*. Transitioning to covered wood-framed structures after experiencing rapid corrosion of tents used for storage. *Nebraska*. Tent. *Oregon*. Metal building with concrete bunker to store salt that did not require retrofitting to store hopper. *Pennsylvania.* Three-sided buildings. *Texas Dallas District*. Shipping containers for storing 2,000-pound super sacks. *Texas Fort Worth District*. Covered buildings and tarps.

3.5 Power and Water Supplies for Brine Making

Described below are agency practices for managing infrastructure components of the brine-making system in two topic areas:

- Power supply.
- Water supply and other considerations for water use.

Power Supply

Thirteen of the 18 participating agencies (72%) use hardwired brine-making systems, with some noting the availability of a backup generator (*Iowa* and *Texas Dallas and Fort Worth districts*). Five respondents use a plug-in power supply (*Connecticut*, *Kansas*, *Nebraska Districts 3 and 7,* and *Texas Abilene District*). Wyoming DOT uses only generator power, and Massachusetts HQ uses a three-phase power supply.

Water Supply and Other Considerations for Water Use

Producing salt brine requires a dependable water source and consideration of other system components, such as water hoses and water lines that may freeze. Water is also needed to clean brine makers, and the water remaining after cleaning must be disposed of or reused. Each of these issues is addressed below.

Water Supply

Respondents use three water sources for brine making, with several agencies using multiple water sources:

- *Municipal water supply.* Most respondents (15 of 18 agencies, or 83%) use municipal water supplies. Iowa DOT accesses both municipal and rural water entities. Oregon DOT required the addition of a municipal water line that connects the main water supply to the salt shed.
- *Groundwater wells.* Two respondents use only well water for brine making (*Nebraska District 7* and *Montana*); a few of Maryland DOT's brine-making locations have well water. Five respondents use well water and municipal water (*Idaho*, *New Jersey*, *Pennsylvania*, and *Texas Brownwood and Fort Worth districts*).
- *Reusing water*. Utah DOT reuses pond water, which consists of wash water and stormwater.

Water Hoses

The water hoses used in brine making range in size from 1.5 to 4 inches. Hose material may be flexible or rigid, and materials include rubber, PVC and Kanaflex. Respondents use different connections or fittings, and some specified the hose's purpose or the equipment it connects. Table 9 summarizes survey responses.

Table 9. Characteristics of Brine-Making Water Hoses

Characteristic	Description and State/District
Size	1.5- and 2-inch: *Maine*, *Texas Dallas District.* 1.5- and 2-inch suction and 2-inch discharge: *Texas Dallas District.* 2-inch: *Nebraska Districts 3 and 7; Pennsylvania; South Dakota; Texas Abilene, Austin and San Angelo districts; Utah.* 2- to 3-inch: *Arizona.* 3-inch: *Massachusetts District 2, Wyoming.* 2-, 3- and 4-inch: *Montana.*

Characteristic	Description and State/District
Material	Flexible: *Maryland, Pennsylvania.* Flexible for brine maker; rigid line for inhibitor delivery: *Oregon.* Kanaflex: *Texas Abilene District*. Polyethylene: *South Dakota*. PVC piping: *Iowa.* Rubber: *Maine*, *Nebraska District* 7, *Texas Brownwood District*.
Connections	Banjo fittings: *Maryland*. Cam lock: *Montana*. Metal braids: *Texas Brownwood District*. Quick connect: *Massachusetts District 2*.
Purpose	Connects brine maker to storage tanks: *Iowa*, *Texas San Angelo District*. Connects hopper to brine-mixing station: *Massachusetts District 2*.

Preventing Water Lines from Freezing

To prevent the water line into the brine maker from freezing, 14 respondents from 12 state DOTs store the brine makers in heated storage areas (*Arizona; Connecticut; Idaho; Iowa; Maine; Massachusetts District 5 and HQ; Montana; Nebraska District 7; Pennsylvania; South Dakota; Texas Abilene, Dallas and Fort Worth districts;* and *Wyoming*).

In Oregon, the water line comes from the ground into the heated shed housing the electronics, then into the hopper on the other side of the wall. The New Jersey DOT respondent described an indoor control panel storage and winterization mode that keeps the water line from freezing.

Respondents described additional practices to winterize equipment and prevent water lines from freezing:

- Applying heat or thermal tape (*Texas Austin and Brownwood districts*).
- Draining or blowing out the lines when not in use (*Kansa*s, *Maryland, Nebraska District 3*, *Oregon*, *Texas Dallas District* and *Utah*).

Other winterizing techniques:

- Checking equipment before each winter to ensure all lines are working properly and make any necessary repairs (*Texas San Angelo District*).
- Cycling the plant for an hour twice a week throughout the off-season to keep the equipment active (*Massachusetts District 2*).
- Freezeproofing hydrants (*Kansas*).
- Servicing drains *(Vermont*).
- Waterproofing pipe heating cable (*Texas Dallas District*).

Cleaning Brine-Making Equipment

In addition to the substantial amount of water used to produce brine, cleaning brine-making equipment is also water-intensive. Respondents reported a variety of purposes for cleaning brine makers, with all identifying cleaning as a best practice for protecting or preserving the equipment. The Texas Dallas

District respondent noted that cleaning allows staff to check the components and neutralize the unit to prolong the life of the system.

Twenty-three respondents (88%) cited operational reasons for cleaning brine equipment, primarily because the equipment gets clogged or will not function as efficiently unless it is cleaned. More than two-thirds of respondents identified repairing or maintaining the system as a primary purpose for cleaning brine-making equipment. For Oregon DOT, equipment cleaning depends on the amount of brine produced and how dirty the hopper becomes during the winter maintenance season.

Other purposes for brine-maker cleaning:

- Effects from using mined salt (*Massachusetts HQ*).
- Aesthetics (*Connecticut, Massachusetts Districts 2 and 5, South Dakota, and Texas Austin and Fort Worth districts*).
- Consistent salinity (*South Dakota*).

Disposition of Water

More than half of responding agencies (58%) do not have requirements for the disposition of water left after brine making or equipment cleaning. Others reported using wash bays or reclamation buildings to clean equipment where the water is captured (*Arizona, Iowa* and *Texas San Angelo District*). Massachusetts District 5 has an interior containment drain, and Idaho Transportation Department keeps all water for washing on the property.

Respondents offered additional comments on the disposition of leftover water from brine making and equipment cleaning:

- Berms and wash pits prevent runoff, and vacuum trucks are used to clean out wash pits (*Texas Brownwood District*).
- Water is managed to meet stormwater runoff control requirements (*Utah*).
- Water used for cleaning is placed on sand or salt piles (*Oregon*), aggregate stockpiles (*Texas Dallas District*) or in storage tanks (*Texas Fort Worth District*).
- Water used for making brine (*Oregon*) or cleaning *(Iowa*) is reused for brine making.

Tips and Techniques Maintaining the Brine-Making Infrastructure

Ensuring that the brine maker can produce brine when it's needed means that agencies must consider brine-making operations before, during and after the brine-making season. Respondents' top tips:

- Drain or blow out the lines when not in use to keep water lines from freezing.
- Apply heat or thermal tape to the water lines.
- Freezeproof water hydrants.
- Service the drains and check the lines before powering up the equipment.
- Cycle the brine maker for a short time a couple of times each week during the off-season.

4 Brine-Blending Practices

4.1 Introduction

Agencies may blend other materials, such as corrosion inhibitors or other additives, with the salt brine they produce. Brine additives can enhance the effectiveness of salt by lowering its freezing point, reducing corrosion and improving its ability to stick to the roadway.

Eleven survey respondents representing nine agencies blend additives into brine; all indicated plans to continue this practice. The remaining nine responding agencies do not blend brine. Below is a summary of the blending practices described by survey respondents, followed by a tabular presentation of survey responses.

4.2 Response Summary

Six respondents blend brine into a storage tank (*Arizona*, *Maine*, *Massachusetts HQ*, *Montana, New Jersey* and *South Dakota*); six respondents blend directly into the truck that will apply the material (*Kansas*, *Massachusetts District 2*, *Montana*, *Nebraska Districts 3 and 7,* and *Oregon*). Montana DOT blends brine in a storage tank or truck, depending on the brine maker.

Respondents described the equipment used for brine blending — primarily pumps and tanks. Two respondents indicated their AccuBrine systems have blending functions (*New Jersey* and *Oregon*). Agencies use magnesium chloride, agricultural by-products and corrosion inhibitors as additives. Five of the nine agencies blending brine determine blend rates in-house.

Presented below are summaries of the brine-blending practices of nine state DOTs:

- Arizona
- Kansas
- Maine
- Massachusetts (District 2 and HQ)
- Montana
- Nebraska (Districts 3 and 7)
- New Jersey
- Oregon
- South Dakota

Arizona Department of Transportation

Topic	Description
Brine-blending practice	Into a storage tank
Brine-blending equipment	Pumps, hoses and tanks
Additives or other materials blended	AMP additive for liquid deicer
How blend rates are determined	Purchased from a vendor
Gallons blended per hour	4,000

Kansas Department of Transportation

Topic	Description
Brine-blending practice	Directly into the truck that will apply it

Topic	Description
Brine-blending equipment	Truck
Additives or other materials blended	Agricultural by-products
How blend rates are determined	Developed in-house
Gallons blended per hour	Not addressed

Maine Department of Transportation

Topic	Description
Brine-blending practice	Into a storage tank
Brine-blending equipment	Pumps, tanks and brine computers
Additives or other materials blended	30% Ice B'Gone (magnesium chloride and molasses) mixed with 70% salt brine
How blend rates are determined	Developed in-house
Gallons blended per hour	Not addressed

Massachusetts Department of Transportation (District 2)

Topic	Description
Brine-blending practice	From pump station directly into the truck that will apply it
Brine-blending equipment	Same equipment used to make brine
Additives or other materials blended	15% magnesium chloride
How blend rates are determined	Developed in-house
Gallons blended per hour	7,000

Massachusetts Department of Transportation (HQ)

Topic	Description
Brine-blending practice	Into a storage tank
Brine-blending equipment	Additional tanks
Additives or other materials blended	28% magnesium chloride with corrosion inhibitor
How blend rates are determined	Developed in-house
Gallons blended per hour	Not addressed

Montana Department of Transportation

Topic	Description
Brine-blending practice	Into a storage tank and directly into truck that will apply it

Topic	Description
Brine-blending equipment	Storage tanks; external pumps for blending into brine
Additives or other materials blended	Corrosion inhibitor
How blend rates are determined	Purchased from a vendor and developed in-house
Gallons blended per hour	Approximately 3,000

Nebraska Department of Transportation (District 3)

Topic	Description
Brine-blending practice	Directly into the truck that will apply it
Brine-blending equipment	Gas and electric pumps; tanks for material shortage
Additives or other materials blended	Not addressed
How blend rates are determined	Developed in-house
Gallons blended per hour	Not addressed
Other comments	Based on weather conditions

Nebraska Department of Transportation (District 7)

Topic	Description
Brine-blending practice	Directly into the truck that will apply it
Brine-blending equipment	2-inch pump; truck tanks
Additives or other materials blended	Magnesium chloride
How blend rates are determined	Developed in-house
Gallons blended per hour	Not addressed

New Jersey Department of Transportation

Topic	Description
Brine-blending practice	Into a storage tank
Brine-blending equipment	AccuBrine system
Additives or other materials blended	Calcium and Ice Bite
How blend rates are determined	Blend ratio: 85% brine, 15% calcium, 5% Ice Bite (Cargill)
Gallons blended per hour	5,000

Oregon Department of Transportation

Topic	Description
Brine-blending practice	Directly into the truck that will apply it

Topic	Description
Brine-blending equipment	AccuBrine Blend V2 truck loading and blending system
Additives or other materials blended	Corrosion inhibitor
How blend rates are determined	Vendor-recommended rate based on Clear Roads Qualified Products List category and corrosion inhibition performance target of 70% less corrosive than salt
Gallons blended per hour	Unknown but adequate
Other comments	We love it.

South Dakota Department of Transportation

Topic	Description
Brine-blending practice	Into a storage tank
Brine-blending equipment	Agitating mixing tank with nozzles on the bottom and toward the top
Additives or other materials blended	AMP, Beet Heat and Ice B'Gone Magic 80% salt brine, 20% additive
How blend rates are determined	Borrowed from another agency
Gallons blended per hour	1,500 on average
Other comments	Brine only blended and used if temperatures are too warm for magnesium chloride but too cold for straight salt brine.

5 Brine-Making Program Assessment

5.1 Introduction

Respondents assessed their brine-making programs and operations in the following topic areas:

- General program assessment.
- Equipment reliability.
- Staffing and other challenges.
- Quality assurance and quality control.
- Best practices.

Several agencies also identified new brine-related practices to explore.

5.2 General Program Assessment

All agencies currently engaged in in-house brine production plan to continue the practice. Nearly all survey respondents cited cost-effectiveness and a readily available brine supply as benefits of brine making. Six respondents noted that decreased liquid storage capacity is also beneficial (*Arizona, Kansas, Maryland, Oregon, Texas San Angelo District* and *Utah*).

For 88% of respondents, the in-house brine-making program meets agency demand for brine. In Idaho, vendor-supplied brine is used when in-house supplies cannot meet demand during more challenging winter events or seasons. Texas DOT's Dallas District respondent noted that prolonged winter events with near zero temperatures can be problematic.

Specific challenges for Massachusetts DOT include extensive repairs required for the brine-making system in District 5. While current capacity does not quite meet demand, a third brine-making plant is coming online and should help meet most of the state's brine needs.

5.3 Equipment Reliability

Several respondents shared positive experiences with equipment reliability, with the Kansas DOT respondent highlighting the beneficial impact of stainless steel system components. The New Jersey DOT respondent noted that specialized knowledge and proper maintenance and repairs are key to proper equipment function. In Vermont, a new brine-making system seems to require less maintenance and is more easily cleaned than the older system it replaced.

Other respondents described reliability issues with brine-making system components or accessories. The brine-making system in Massachusetts District 5, for example, is aged and currently requires approximately $28,000 in repairs. Other equipment reliability issues are summarized in Table 10.

Table 10. Brine-Making Equipment Reliability Issues

Component or Challenge	State/District and Description
Electronics or Information Technology	*Maine*. Minor problems with computerized system calibration. *Maryland*. Information technology-related issues. *Pennsylvania.* Controller issues.

Component or Challenge	State/District and Description
Meters or Sensors	*Idaho*. Sensor accuracy. *Maine*. Tank sensor minor issues. *Maryland.* Salinity meter issues. *Montana*. Flow meters, floats in the brine maker and salinity meters occasionally fail.
Piping or Water Lines	*Massachusetts District 2.* The current tank farm piping is rigid PVC but should be flexible quick-connect piping. *Oregon*. Frozen water lines led to shed modifications to prevent wind penetrating the walls and floor; exposed water pipes were insulated. *Pennsylvania.* Water supply line size and infrastructure can be problematic. *Texas Brownwood District.* Water lines freeze and hoses burst. *Texas Dallas District*. Water pipes freeze even after wrapping and/or burying. *Texas Fort Worth District*. Pipes burst.
Pumps	*Iowa*. Normal wear and tear, especially pumps. *Maine.* Pump and motor issues. *South Dakota.* Parts availability. Maintain an inventory of spare pumps and flushing and servicing pumps, hoses, couplings and seals at season's beginning and end to reduce production downtime. *Texas Austin District.* Pumps that mix and transfer brine require replacement every few years. *Texas Dallas District*. Corrosion from salt has caused pump issues. *Utah.* Pumps are not reliable and frequently fail.
Other	*New Jersey.* Sourcing parts can be a challenge. *Texas Abilene District*. Corrosion on wiring and equipment. *Texas Brownwood District.* Skid steers that break down.

5.4 Staffing and Other Challenges

Nearly half of the survey respondents reported having some resource issues. Only Kansas and Oregon DOTs had no challenges to report.

Most respondents reporting challenges indicated staffing was the issue. Many cited being short-staffed as the primary problem, in general or due to retention issues (*Idaho, Nebraska District 3, Pennsylvania,* and *Texas Brownwood and Fort Worth districts*).

Others specified staff training, including the training of new employees, as a primary challenge (*Texas Dallas District*, *Utah, Vermont* and *Wyoming*). Massachusetts District 5, for example, cited the need for staff capable of performing duties associated with computers, tracking data, performing minor equipment repairs and addressing leaks, cleaning out brink makers, loading salt and other tasks. The Wyoming DOT respondent noted, however, that while the agency's old brine-making system was not intuitive and retraining trained employees was challenging, a new brine-making unit should mitigate those challenges. Similarly, the Massachusetts HQ respondent noted that the state's first brine plant is very complex. The agency is considering decommissioning it and salvaging parts.

Tips and Techniques Don't Forget to Educate the Public

Iowa DOT has been producing brine in-house for years as part of the agency's winter maintenance strategy. Unlike respondents reporting challenges with staffing, Iowa DOT staff is well-trained.

The primary challenge for Iowa DOT is educating the public — ensuring that it understands how and why brine is used.

Other challenges reported by respondents:

- Availability of commercial brine (*Texas Austin District*).
- Difficultly making or hauling brine during storm events (*Idaho* and *Montana*).
- Funding for replacement equipment and storage tanks past their useful life (*Iowa*).
- Quality of rock salt (*New Jersey* and *Texas Brownwood and San Angelo districts*), salt shortages (*New Jersey*) or restocking material after events (*Texas Dallas District*).
- Timely contracting for equipment or materials (*Utah*).
- Trucking and need for tanks (*Vermont*) and the availability of tankers to disperse product before winter events (*Massachusetts District 5*).

5.5 Quality Assurance and Quality Control

While nine respondents reported that their agencies have no quality assurance or quality control processes for brine production processes, others described procedures for measuring or monitoring brine concentrations for salinity levels, testing materials throughout the brine-making process, and monitoring and maintaining the equipment.

Monitoring Brine Concentrations

The Iowa DOT respondent stressed the importance of monitoring brine concentration levels to ensure product consistency. Several respondents noted the use of a hydrometer to test salinity (*Kansas*, *Massachusetts District 2*, *Pennsylvania* and *Utah*). Massachusetts District 2 confirms that 24.5% salinity is achieved in the brine; Pennsylvania DOT's target salinity is 23.3%.

Other reported methods of monitoring salinity:

- Automated salinity controller (*Wyoming*).
- External meters (*Montana*).
- Handheld devices (*Texas Fort Worth District*).
- Manual salinity check to verify the sensor (*Idaho*).

Testing Materials

Two Texas DOT districts offered further details of testing practices:

- Winter maintenance materials obtained for the Texas Dallas District must be lab-tested and agency-approved and meet all other agency standards before purchase. Brine samples taken during production verify salinity levels before brine is transferred to storage tanks. Samples are taken from brine storage tanks when the brine is transferred for roadway application.
- The Texas DOT Brownwood District uses refractometers to test the salinity of the brine mixture throughout the brine-making process. The salt material is also tested for insolubles (solid particles that did not dissolve in the brine) at an in-house lab.

Monitoring and Maintaining Equipment

Two respondents described other processes to ensure brine quality standards are met:

- Massachusetts District 5 ensures products are well-circulated during production, safety procedures are followed and routine maintenance is performed.
- New Jersey DOT's maintenance team has specialized experience and the tools needed to service and repair brine-making equipment.

5.6 Best Practices

Respondents offered best practices for in-house brine making in eight topic areas:

- **Equipment**: Use automated equipment, and employ quick-connect flexible piping for tanks to avoid expansion, contraction, leaking and cracking.
- **Maintenance**: Conduct frequent equipment cleaning, consider brine-maker service contracts and provide ready access to spare parts.
- **Material**: Use solar salt, keep salt stockpiles clean and ensure ready access to salt.
- **Methods**: Establish practices to ensure product consistency and monitor the brine's salinity level.
- **Staff:** Develop programs or practices to ensure properly trained staff.
- **Storage capacity**: Provide adequate brine storage capacity.
- **Structures**: Ensure adequate indoor space.
- **Water and power**: Ensure adequate water supply and pressure, use properly sized water lines that are suitable for brine making, and retain a backup power supply.

> Use solar salt instead of mined rock salt. Solar salt dissolves better and is a much cleaner product. Although [solar salt is] more expensive, the number of cleanouts is reduced, and the amount of foreign material (sand, dirt) is significantly reduced.
>
> — *Massachusetts DOT District 2 respondent*

Survey responses describing best practices are summarized in Table 11 and the accompanying *Tips and Techniques*.

Table 11. Best Practices for Brine Production

Practice Area	State/District and Description
Equipment	*Arizona.* Use automated systems. *Kansas.* Use stainless steel equipment. *Massachusetts District 2*. Use quick-connect flexible piping for tanks to avoid expansion, contraction, leaking and cracking of rigid PVC as seasons change. *Texas Austin District*. Face brine-maker doors south to avoid the north wind. *Texas Brownwood District.* Use tankers to more quickly disperse brine with less reloading time.
Maintenance	*Kansas.* Clean and maintain pumps; store hoses and pumps inside during off-season. *Maryland.* Consider a standing contract for specialized repairs; identify a brine-maker expert to keep the unit operational. *Pennsylvania.* Clean equipment frequently. *South Dakota, Texas Dallas District*. Retain spare plumbing parts and pumps. *Texas Austin District.* Keep equipment clean and use corrosion inhibitor. *Texas Fort Worth District.* Clean equipment after each storm and as frequently as possible. *Utah.* Keep brine maker and other equipment clean and winterize at season's end. *Vermont.* Establish a service contract for the brine maker.
Material	*Massachusetts District 2 and HQ.* Use only solar salt; store only blended brine in cold temperatures (outside). *Montana, Texas San Angelo District, Utah.* Store clean salt to decrease need to clean the brine maker. *Pennsylvania.* Use solar salt. *Texas Abilene District.* Ensure salt availability. *Texas Brownwood District.* Ensure clean salt is available to avoid downtime and costly repairs. *Texas Dallas District.* Use good salt neutralizer for cleaning equipment and parts during operations; maintain an adequate salt stockpile to last a minimum of three winter events.

Tips and Techniques Methods to Ensure Effective Brine Production

As the Iowa DOT respondent noted, "A consistent product will produce consistent results on the highway." Responding agencies offered a range of recommended methods and practices that can contribute to the production of a consistent product and more effective brine production:

- Check consistency of the brine regularly — every 15 minutes, if necessary (*South Dakota*).
- Circulate brine in storage tanks throughout the year for proper mixing (*Texas Dallas District*).
- Consider workflow of truck reloading needs and salt transfer from sheds to brine maker; stress consistency (*Iowa*).
- Perform manual quality assurance and quality testing (*Idaho*).
- Test brine for correct concentration before storing (*Utah*).
- Use a color-coded system to distinguish between brine and magnesium chloride (*Idaho*).

Table 11. Best Practices for Brine Production (Continued)

Practice Area	State/District and Description
Staff	*Arizona.* Train staff on production and application. *Maryland.* Keep staff trained to manage turnover. *South Dakota.* Retain core staff to ensure brine operations are consistent, accurate and well-monitored. *Texas Dallas District.* Properly train employees. *Texas San Angelo District*. Provide annual in-house training on brine making. *Vermont*. Engage with staff operating brine makers regarding maintenance needs.
Storage Capacity	*Texas Abilene and Brownwood Districts*. Ensure adequate brine storage capacity; consider the use of fiberglass tanks, which last longer than poly tanks.
Structures	*Maine.* Ensure adequate indoor space. *Nebraska District 7*. House brine makers in appropriate structures. *Pennsylvania.* Provide indoor storage.
Water and Power	*Iowa*. Ensure water lines into the brine building or brine maker are large enough and electrical service is sufficient for brine equipment. *Maine, Texas Abilene District, Vermont*. Ensure adequate water supply. (Vermont is unable to make brine in two districts because of an inadequate water supply.) *Massachusetts District 2*. Confirm water pressure to brine maker meets equipment recommendation for optimal production rates. *Nebraska District 7*. Consider water source and available gallons per minute. *Texas Dallas District*. Retain backup power supply.
General Practices	*Arizona.* Pretreat roadways before snow events; ensure brine is appropriate for the temperature. *Texas Fort Worth District*. Start early with winter operations.

5.7 New Practices to Explore

Several respondents reported agency interest in exploring these brine-related practices:

- *Mobile brine making.* Massachusetts District 5, some districts and maintenance yards in Oregon, and Pennsylvania DOT are interested in mobile brine making. Texas San Angelo District is discussing purchasing a mobile unit. (Wyoming DOT's brine maker is a BrineXtreme Mobile Advantage unit.)
- *Quantifying carbon footprint or energy savings.* Respondents from Massachusetts District 5 and Pennsylvania DOT reported interest in quantifying energy saved by making brine in-house. Iowa DOT is always looking for ways to be more efficient and save on energy costs.

6 Examining the Literature

A literature search that sought in-process and published domestic research addressing brine production in-house identified relatively little formal research, cited below.

6.1 Previous Clear Roads Research

Benefit–Cost of Various Winter Maintenance Strategies, Laura Fay, David Veneziano, Anburaj Muthumani, Xianming Shi, Ashley Kroon, Cortney Falero, Michael Janson and Scott Petersen, Clear Roads Pooled Fund Study, Minnesota Department of Transportation, September 2015. https://www.clearroads.org/download/final-report-19/?tmstv=1735135793
This report addresses the costs and benefits of winter maintenance strategies, including making salt brine and blended products. A survey of transportation agencies across the United States sought information about in-house brine production. The following report excerpt, from page B-18 of the report (page 134 of the PDF), summarizes survey findings:

> A total of 18 respondents indicated that their agency produced its own salt brine. In line with this, the different costs associated with the production of brine were of interest. Therefore, follow-up questions were posed that sought information on the costs of brine-making such as the cost of equipment, transport, materials, maintenance, labor, etc. Unfortunately, only a limited number of respondents provided feedback to these questions, and in most cases, responses indicated that the information being sought was not available or tracked. In light of this, the following information that is presented should be considered as a supplemental point of reference and may or may not represent the true costs associated with a particular aspect of brine-making.
>
> The average cost of brine-making equipment was $89,273, with reported costs ranging from $7,000 to $250,000. Only one response was provided regarding the cost to transport brine from a production location to another site. The respondent indicated that the cost of transport was "16[%]-31% of haul cost (haul cost is labor to haul, brine production cost and the cost of the transport to haul)." Input materials used in making the brine were reported by one respondent as "51[%]-56% of haul cost" and a second respondent as $1,563,901. Fuel costs associated with the transport of brine were indicated as being included in the equipment cost by two respondents, while a third indicated a cost of $0.035 per gallon. Similarly, two respondents indicated that transport truck maintenance was included under equipment costs, while a third indicated a cost of $80.00. Finally, labor costs were cited as $50.00 (units such as per hour or season not specified), $256,245 (units not specified, but assumed to be the annual cost for all production in the respective state) and "13[%]-18% of haul cost." As these collective values indicate, there appear to be different approaches to tracking and reporting the costs of brine-making, when values themselves are tracked. In light of these responses, it is difficult to assign a specific cost to the production of brine.
>
> The final question sought feedback on the benefits of brine-making. The results of this question are presented in Figure 17. As the figure indicates, all aspects of brine making were rated by respondents as being very or somewhat important. The ability to make brine on an as-needed basis was the benefit most widely indicated as important by respondents. [**Note**: Other benefits included quality control, whether the unit can control the amount produced and cost savings.] Information provided by one respondent indicated that the cost of brine per gallon was $0.10 when produced by the agency and $0.30 when purchased from a vendor. Another respondent indicated that their agency had reduced the use of salt by 30 percent when using brine.

6.2 Other Research

Evaluation of Winter Maintenance with Salt Brine Applications in Wisconsin, Boris Claros, Madhav Chitturi, Andrea Bill and David Noyce, Wisconsin Department of Transportation, December 2021.
https://wisconsindot.gov/documents2/research/0092-20-53-final-report.pdf
Section 2.3.4.2., Cost, which begins on page 7 of the report (page 14 of the PDF), addresses the cost of salt brine production, including acquisition of the brine maker, storage tanks, related equipment and the facility. *From the report:*

> Investment was defined as the cost associated with introducing salt brine to existing and established solid salt applications. Three main components were considered for investment cost to introduce salt brine: salt brine production, trucks and maintenance.
>
> Salt brine production requires the acquisition of a brine maker, storage tanks, and related production/storage/loading equipment and facility (pumps, pipeline, etc.). In terms of trucks, counties regularly upgrade and purchase trucks based on life cycle, residual value and other requirements. Thus, investment costs associated with trucks were the difference between the purchase of salt brine equipped trucks and solid salt trucks. Also, counties may not necessarily need to purchase new trucks[;] existing solid salt trucks may be retrofitted with salt brine add-ons which were considered as an investment. Maintenance is crucial for production and application of salt brine. Maintenance cost estimates were provided by counties which ranged from $15,000 to $31,484 per year, which included maintenance of brine maker, production/storage/loading system, and trucks. The benefit–cost analysis was conducted for a period of 10 years, so maintenance cost was also included for 10 years of analysis.

Table 8 (see page 15 of the report, page 22 of the PDF) identifies the cost of investment across multiple Wisconsin counties. Brine-maker costs ranged from $150,000 to $191,000 at the time of publication for the six counties evaluated.

Evaluation and Analysis of Liquid Deicers for Winter Maintenance, William Schneider, Teresa Cutright, Mallory Crow and Andrew Pelfrey, Ohio Department of Transportation, September 2017.
https://rosap.ntl.bts.gov/view/dot/32841/dot_32841_DS1.pdf
Chapter 9 of this report provides a cost analysis that includes an exercise to calculate the cost of the brine made by Ohio DOT at its garages. Researchers based their determination of brine cost using the brine-making setup at the Summit County, Ohio DOT garage.

Section 9.1.1, Calculating the Cost of Brine, begins on page 138 of the report (page 154 of the PDF). Table 9.1, Variables Used to Calculate Summit County's Brine Cost, includes the following:

- Capital cost of brine maker capable of producing 3,000 gallons per hour.
- Life span of brine maker.
- Labor rate.
- Labor efficiency for brine maker.
- Costs for electricity, water and salt.

Guidelines to Facilitate the Evaluation of Brines for Winter Roadway Maintenance Operations, William Lawson, W. Andrew Jackson, Kenneth Rainwater, Sanjaya Senadheera and Daan Liang, Texas Department of Transportation, September 2017.
https://rosap.ntl.bts.gov/view/dot/34261
These guidelines offer descriptions, impacts and operational best practices of different types of preapproved brines, including homemade salt brine. The report summarizes the Childress District's brine manufacturing system, which began making brine in Texas in 2011. *From page 13 of the report:*

> **HOMEMADE SALT BRINE**
> Salt brine (NaCl) is the liquid form of sodium chloride (NaCl). Salt brines may be manufactured for roadway applications in commercially-available brine production units.
>
> In 2011, the TxDOT [Texas DOT] Childress District invested in a salt brine manufacturing system (Figure 5) where they now make their own salt brine at proper concentration for anti-icing applications (23 percent salt), in a dedicated mixing tank. The raw materials for salt brine are water and brining-quality road salt. Because the parent chemical — in this case, brining salt — is an approved product, the brine resulting from this salt is also approved.

Recycling of Salt-Contaminated Stormwater Runoff for Brine Production at Virginia Department of Transportation Road-Salt Storage Facilities, G. Michael Fitch, Vinka Craver and James Smith, Virginia Transportation Research Council, May 2008.
http://www.virginiadot.org/vtrc/main/online_reports/pdf/08-r17.pdf
From the abstract: Although VDOT [Virginia DOT] is implementing recommended management options to reduce the quantity of salt water captured, this research was undertaken to determine the possibility of recycling salt-contaminated stormwater runoff for the purpose of producing brine that can be used for pre-wetting of granular NaCl and direct application. Laboratory and field tests were conducted using bench-scale brine generation equipment. … VDOT appears to capture sufficient volumes of water to meet the majority of its potential brine production needs. Further, significant economic benefits can be obtained by applying this recycling strategy, with the greatest benefits resulting from generating brine for both direct application and pre-wetting. Assuming average stormwater volume collection and average total NaCl application, VDOT can save approximately $3 million each year by generating brine for pre-wetting only versus approximately $6.5 million each year by generating brine for the combination of pre-wetting and direct application.

Appendix A: Agency Use of Cargill, Inc. Brine Makers

Presented below are the survey responses that address equipment specifications and brine-making practices of six state DOTs using an AccuBrine Automated Brine Maker NXT-Gen brine maker:

- Arizona
- Connecticut
- Maine
- New Jersey
- Oregon
- Pennsylvania

Arizona Department of Transportation

Arizona DOT uses AccuBrine brine makers in addition to VariTech units.

Topic	Description
Brine storage	7 plastic 10,000-gallon tanks
Brine mixing	Not addressed
Pumps	Unspecified number of submersible trash pumps
Loading practice	Loader and auger system
Brine production	4,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 to 2 staff needed to operate the cleaning cycle **Time**: 4 to 6 hours **Gallons produced before cleaning**: 25,000 gallons **Cost**: $1,000 per cleaning event **Equipment:** Loader and wash bay **Frequency**: Multiple times during the season

Connecticut Department of Transportation

Connecticut DOT uses three AccuBrine brine makers. The agency also uses Henderson BrineXtreme and VariTech brine makers.

Topic	Description
Brine storage	6,500-gallon tanks
Brine mixing	Yes
Pumps	Not known
Loading practice	Loader

Topic	Description
Brine production	Up to 6,000 gallons per hour (per manufacturer) The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 2 to 5 hours **Gallons produced before cleaning**: Unknown **Cost**: Unknown **Frequency**: At the end of the season

Maine Department of Transportation

Maine DOT uses two AccuBrine salt brine makers controlled with a computerized dashboard. The agency also uses VariTech brine makers.

Topic	Description
Brine storage	Assmann 5,500-gallon tanks
Brine mixing	Mixed manually by computerized settings
Pumps	2- and 5-horsepower motors with pedestal Dayton pumps
Loading practice	Loader
Brine production	700 to 1,500 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 to 2 staff needed to operate the cleaning cycle **Time**: 2 to 4 hours **Gallons produced before cleaning**: Not addressed **Cost:** Only the labor cost of the employees **Frequency**: At the end of season

New Jersey Department of Transportation

New Jersey DOT uses 29 AccuBrine stationary brine makers.

Topic	Description
Brine storage	4 to 5 product tanks, depending on system; 2 brine tanks for every system
Brine mixing	Brine is mixed “on the fly” using one holding tank.
Pumps	1 to 2 pumps used, depending on system
Loading practice	Loader

Topic	Description
Brine production	5,000 to 6,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: At least 2 staff needed to operate the cleaning cycle **Time**: 30 minutes to 2 hours (depends on level of cleaning) **Gallons produced before cleaning**: Varies based on brine quantity and salt quality **Cost:** Not addressed **Frequency**: Some brine makers are cleaned after every storm; others are cleaned once a season, depending on salt quality.

Oregon Department of Transportation

Oregon DOT uses one AccuBrine brine maker with an automated controller.

Topic	Description
Brine storage	10,000-gallon poly tanks
Brine mixing	AccuBrine Blend V2 truck loading and blending system
Pumps	Built into the system
Loading practice	Loader
Brine production	4,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 3 hours **Gallons produced before cleaning**: Last winter was light; unit was cleaned because it was the end of the season. **Cost**: 6 hours of labor; cost varies based on pay rate **Frequency**: In the past year the brine maker was only cleaned at the end of the season given a light winter and limited production. Also, the solar salt used in the unit is very clean. **Other comments:** The hopper is also rinsed and a loader scoops up the water and small amount of residual dirt to place on the sand pile.

Pennsylvania Department of Transportation

Pennsylvania DOT uses AccuBrine brine makers in addition to Henderson BrineXtreme, VariTech and GVM brine makers. As the respondent did not specify to which brine-maker model the information provided applied, the information below is reproduced for each brine maker.

Topic	Description
Brine storage	2,300- to 10,000-gallon tanks provided at all stockpiles
Brine mixing	Not addressed
Pumps	Primarily 2-inch pumps operating at 250 to 500 gallons per minute
Loading practice	Primarily loaders; also backhoe and skid steer
Brine production	1,000 to 7,500 gallons per hour, depending on system type and water supply Brine makers do not produce at the rate the agency anticipated (the brine maker's maximum capacity) if the water supply line is not large enough.
Cleaning	**Type**: Manual; some systems have automated option **Staff**: 2 staff needed to operate manual cleaning cycle **Time**: Unknown; depends on the salt and cleaning frequency **Gallons produced before cleaning**: Unknown; depends on the salt and cleaning frequency **Cost**: Unknown; depends on the salt and cleaning frequency **Frequency**: Multiple times during the season

Appendix B: Agency Use of Dultmeier Sales Brine Makers

Presented below are the survey responses that address equipment specifications and brine-making practices of three state DOTs using a Dultmeier brine maker:

- Iowa
- Kansas
- Nebraska (Districts 3 and 7)

Iowa Department of Transportation

Iowa DOT uses two models of Dultmeier brine makers: BPS3000-SS (21 units) and BPS5000-SS (2 units). The respondent did not indicate to which model the information below applies. Iowa DOT also uses Henderson BrineXtreme and VariTech brine makers.

Topic	Description
Brine storage	Ice Master and Norwesco poly storage tanks range from 7,800- to 9,000-gallon capacity.
Brine mixing	None
Pumps	Majority are Pacer electric pumps ranging from 5 to 7.5 horsepower
Loading practice	Loader
Brine production	3,000 to 5,000 gallons per hour, depending on the size of the water line feeding the system The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 15 to 20 minutes **Gallons produced before cleaning**: 50,000 gallons on average, depending on cleanliness of the salt **Cost**: Unknown **Frequency**: Multiple times during the season **Other comments**: Cleanout trays are used as catch trays mounted on loaders to catch debris collected from the brine maker during cleaning.

Kansas Department of Transportation

Kansas DOT uses a BPS3000-SS brine maker.

Topic	Description
Brine storage	10,000- and 20,000-gallon fiberglass tanks
Brine mixing	Not addressed
Pumps	Part of system

Topic	Description
Loading practice	Skid steer
Brine production	Depends on the water line The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 15 minutes **Gallons produced before cleaning**: Depends on salt quality **Cost**: Minimal **Frequency**: Multiple times during the season

Nebraska Department of Transportation (District 3)

Nebraska DOT District 3 uses three Dultmeier BPS3000-SS brine makers, in addition to three Etnyre ET2324 and seven Brehmer BPU-05-A brine makers. The respondent noted that the three brine-maker models are similar with regard to storage, capacity and cleaning, and provided the information below for all district brine makers.

Topic	Description
Brine storage	Harvestore 100,000+-gallon tank; 10,000- and 20,000-gallon tanks
Brine mixing	Not addressed
Pumps	Electric
Loading practice	Loader
Brine production	Dependent on the water source The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 30 minutes **Gallons produced before cleaning**: 10,000 to 20,000 gallons, depending on the salt **Cost**: Not addressed **Frequency**: Each time after making a batch

Nebraska Department of Transportation (District 7)

Nebraska DOT District 7 uses 12 BPS3000-SS brine makers.

Topic	Description
Brine storage	10,000- and 20,000-gallon fiberglass tanks

Topic	Description
Brine mixing	Not addressed
Pumps	Not addressed
Loading practice	Loader
Brine production	1,000 to 3,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 15 minutes **Gallons produced before cleaning**: 2,000 gallons, depending on the cleanliness of the salt **Cost**: Not addressed **Frequency**: Each time after making a batch

Appendix C: Agency Use of Henderson Products, Inc. Brine Makers

Presented below are the survey responses that address equipment specifications and brine-making practices of eight state DOTs using a BrineXtreme brine maker:

- Connecticut
- Iowa
- Maryland
- Massachusetts (Districts 2 and 5)
- Montana
- Pennsylvania
- Vermont
- Wyoming

Connecticut Department of Transportation

Connecticut DOT uses two BrineXtreme Pro brine makers in addition to Cargill AccuBrine and VariTech brine makers. The respondent noted that the Pro model predates the Advantage and Infinity platforms; the Pro model is equivalent to the current Advantage model.

Topic	Description
Brine storage	6,500-gallon tanks
Brine mixing	None
Pumps	Not addressed
Loading practice	Loader
Brine production	Up to 6,000 gallons per hour (per manufacturer) The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 2 to 5 hours **Gallons produced before cleaning**: Unknown **Cost**: Unknown **Frequency**: At the end of the season

Iowa Department of Transportation

Iowa DOT uses two BrineXtreme Advantage brine makers with the Pro Control system. The agency also uses Dultmeier and VariTech brine makers.

Topic	Description
Brine storage	Combination of Ice Master and Norwesco poly storage tanks ranging from 7,800- to 9,000-gallon capacity
Brine mixing	None
Pumps	Majority are Pacer electric pumps ranging from 5 to 7.5 horsepower
Loading practice	Loader

Topic	Description
Brine production	5,000 gallons per hour with a 3-inch water service The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 10 to 15 minutes **Gallons produced before cleaning**: Over 50,000 gallons **Cost**: Unknown. **Frequency**: Multiple times during the season **Other comments:** Cleanout hole is on the end of the maker. We attached a large hose to the maker to flush out debris into a loader bucket, which is then hauled away.

Maryland Department of Transportation

Maryland DOT uses 15 BrineXtreme Infinity brine makers without separate controls.

Topic	Description
Brine storage	Norwesco single wall 6,000- and 10,000-gallon tanks
Brine mixing	Henderson integrated controls and hopper
Pumps	Henderson
Loading practice	Loader
Brine production	Up to 5,000 gallons per hour with the proper 2-inch water supply and solar salt, depending on the location The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Automatic **Staff**: Not applicable **Time**: 30 minutes **Gallons produced before cleaning**: 20,000 gallons **Cost**: Unknown. The unit has an auger that removes all insolubles, which are then disposed of properly. **Equipment:** Loader and wash bay **Frequency**: Multiple times during the season

Massachusetts Department of Transportation (District 2)

Massachusetts DOT District 2 uses the BrineXtreme Advantage brine maker with Ultimate Salinity Control. Massachusetts DOT HQ also uses a BrineXtreme brine maker and deferred to the District 2 and District 5 respondents to provide detailed information about that unit.

Topic	Description
Brine storage	Four 10,000-gallon tanks to hold brine; two 10,000-gallon tanks to hold magnesium chloride
Brine mixing	Ultimate Salinity Control
Pumps	Three pumps
Loading practice	Loader
Brine production	Up to 7,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 2 hours **Gallons produced before cleaning**: 30,000 gallons **Cost**: Not specified **Frequency**: Typically after 30,000 gallons

Massachusetts Department of Transportation (District 5)

Massachusetts DOT District 5 uses one BrineXtreme Ultimate. The survey respondent noted this machine is currently in need of extensive repairs and not likely to be in operation in the coming season.

Topic	Description
Brine storage	Three 10,000-gallon tanks at the brine facility supplemented by 10 5,000-gallon tanks throughout the district
Brine mixing	To be determined
Pumps	To be determined
Loading practice	Loader
Brine production	2,500 gallons per hour of brine; 20,000 gallons per hour of blended brine The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 5 hours **Gallons produced before cleaning**: A season's worth **Cost**: Approximately $250 per cleaning event **Frequency**: Depends. District 5 requires very little brine compared to other districts due to warmer rainy weather patterns at the onset of a winter event.

Montana Department of Transportation

Montana DOT uses one BrineXtreme Advantage and one BrineXtreme Infinity brine maker, in addition to three VariTech brine makers. The respondent did not distinguish between the BrineXtreme Advantage and Infinity brine makers in the information provided below.

Topic	Description
Brine storage	10,000-gallon poly tanks
Brine mixing	Direct water injection mixing
Pumps	Pumps that support production of 6,000 gallons per hour
Loading practice	Loader
Brine production	Up to 6,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 to 3 staff needed to operate the cleaning cycle **Time**: 1 to 2 hours **Gallons produced before cleaning**: Up to 60,000 gallons **Cost**: Equipment and man hours **Frequency**: Usually 1 to 2 times per season, depending on salt contamination upon delivery

Pennsylvania Department of Transportation

Pennsylvania DOT uses BrineXtreme brine makers, in addition to Cargill AccuBrine, VariTech and GVM brine makers. As the respondent did not specify to which brine maker-model the information provided applied, this information is reproduced for each brine maker.

Topic	Description
Brine storage	2,300- to 10,000-gallon tanks provided at all stockpiles
Brine mixing	Henderson's Ultimate Controls has mixing capability though the agency has not utilized it. **Note**: Ultimate Controls is a "complete brine mixing/blending/truck and tank filling system."
Pumps	Primarily 2-inch pumps operating at 250 to 500 gallons per minute
Loading practice	Primarily loaders; also backhoe and skid steer
Brine production	1,000 to 7,500 gallons per hour, depending on system type and water supply Brine makers do not produce at the rate the agency anticipated (the brine maker's maximum capacity) if the water supply line is not large enough.

Topic	Description
Cleaning	**Type**: Manual; some systems have automated option **Staff**: 2 staff needed to operate manual cleaning cycle **Time**: Unknown, depends on the salt and cleaning frequency **Gallons produced before cleaning**: Unknown, depends on the salt and cleaning frequency **Cost**: Unknown, depends on the salt and cleaning frequency **Frequency**: Multiple times during the season

Vermont Department of Transportation

Vermont DOT uses seven BrineXtreme 1200 brine makers with controllers included.

Topic	Description
Brine storage	Tenco 6,000-gallon tanks
Brine mixing	Included
Pumps	Included
Loading practice	Loader
Brine production	6,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 1 to 2 hours, depending on the amount of debris and cleanliness of salt **Gallons produced before cleaning**: 6,000 gallons **Cost**: Unknown **Frequency**: Multiple times during the season

Wyoming Department of Transportation

Wyoming DOT uses one BrineXtreme Mobile Advantage brine maker with Pro Controls.

Topic	Description
Brine storage	Large storage tanks at most maintenance locations
Brine mixing	Within the unit
Pumps	EV-X
Loading practice	Loader
Brine production	6,000 gallons per hour The brine maker is producing brine at the rate the agency anticipated.

Topic	Description
Cleaning	**Type**: Manual **Staff**: 1 staff person needed to operate the cleaning cycle **Time**: 30 minutes **Gallons produced before cleaning**: Every day or 50,000 gallons **Cost**: Not addressed **Frequency**: Each time after making a batch

Appendix D: Agency Use of VariTech Industries, Inc. Brine Makers

Presented below are the survey responses that address equipment specifications and brine-making practices of nine state DOTs using a VariTech brine maker:

- Arizona
- Connecticut
- Iowa
- Maine
- Montana
- Pennsylvania
- South Dakota
- Texas (Abilene, Austin, Brownwood, Dallas, Fort Worth and San Angelo districts)
- Utah

Arizona Department of Transportation

Arizona DOT uses two VariTech models (HCSB1400-SS and SB600) in addition to Cargill AccuBrine brine makers.

Topic	Description
Brine storage	9 plastic 10,000-gallon tanks (HCSB 1400S) Multiple 10,000-gallon plastic tanks (SB600)
Brine mixing	Not addressed
Pumps	Unspecified number of submersible trash pumps
Loading practice	Loader (HCSB 1400S) Skid steer (SB600)
Brine production	1,000 gallons per hour (HCSB 1400S) 500 gallons per hour (SB600) The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 to 3 staff needed to operate the cleaning cycle **Time**: 5 hours **Gallons produced before cleaning**: 10,000 gallons **Cost**: $1,000 per cleaning event **Equipment:** Loader and wash bay **Frequency**: Each time after making a batch

Connecticut Department of Transportation

Connecticut DOT uses two SB600 brine makers, in addition to Cargill AccuBrine and Henderson BrineXtreme brine makers. The agency also uses older VariTech and agency-built systems.

Topic	Description
Brine storage	6,500-gallon tanks
Brine mixing	None
Pumps	Not specified
Loading practice	Loader
Brine production	Up to 3,600 gallons per hour (per manufacturer) The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 needed to operate the cleaning cycle **Time**: 2 to 5 hours **Gallons produced before cleaning**: Unknown **Cost**: Unknown **Frequency**: At the end of a season

Iowa Department of Transportation

Iowa DOT uses HCSB1400-SS (67 units), HCSB1400-IA (22 units) and SB600 (1 unit) brine makers. The agency also uses Dultmeier and Henderson BrineXtreme brine makers.

Topic	Description
Brine storage	Combination of Ice Master and Norwesco poly storage tanks ranging from 7,800- to 9,000-gallon capacity
Brine mixing	None
Pumps	Majority are Pacer electric pumps ranging from 5 to 7.5 horsepower
Loading practice	Loader
Brine production	2,000 to 5,000 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: Minimum of 2 **Time**: 30 minutes **Gallons produced before cleaning**: 20,000 to 40,000 gallons, depending on cleanliness of the salt **Cost**: Unknown **Frequency**: Multiple times during the season **Other comments:** To clean out this system, staff has to disconnect the maker, attach it to a loader and pull it from the building to remove debris and rinse out the maker. Once cleaning is complete, the maker has to be reconnected.

Maine Department of Transportation

Maine DOT has 11 SB600 brine makers, with six of them currently operational. The agency also uses Cargill AccuBrine brine makers.

Topic	Description
Brine storage	Assmann 5,500-gallon tanks
Brine mixing	Water is added to salt hopper at a rate necessary for a 23.3% eutectic mix of salt brine, which is then pumped off to a holding tank.
Pumps	2 and 5 horsepower motors with Dayton pedestal pumps
Loading practice	Loader
Brine production	500 to 1,000 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 to 2 staff needed to operate the cleaning cycle **Time**: 2 to 4 hours **Gallons produced before cleaning**: Not specified **Cost**: Labor cost of the employees **Frequency**: At the end of the season

Montana Department of Transportation

Montana DOT uses SB600 brine makers in addition to a Henderson BrineXtreme brine maker.

Topic	Description
Brine storage	10,000-gallon poly tanks
Brine mixing	Up-flow design
Pumps	External 2-inch to 3-inch 240-volt pumps
Loading practice	Auger system
Brine production	Up to 3,600 gallons per hour The brine makers are producing brine at the rate the agency anticipated.

Topic	Description
Cleaning	**Type**: Manual **Staff**: 2 to 3 staff needed to operate the cleaning cycle **Time**: 2 to 3 hours **Gallons produced before cleaning**: Upwards of 50,0000 gallons, depending on salt contamination **Cost**: Equipment and man hours **Equipment:** Loader and wash bay **Frequency**: Usually 2 to 3 times per season, depending on salt contamination

Pennsylvania Department of Transportation

Pennsylvania DOT uses VariTech brine makers in addition to Cargill AccuBrine, Henderson BrineXtreme and GVM brine makers. The respondent did not indicate to which model the information below applies.

Topic	Description
Brine storage	2,300- to-10,000-gallon tanks provided at all stockpiles
Brine mixing	Not addressed
Pumps	Primarily 2-inch pumps operating at 250 to 500 gallons per minute
Loading practice	Primarily loaders; also backhoe and skid steer
Brine production	1,000 to 7,500 gallons per hour, depending on system type and water supply Brine makers do not produce at the rate the agency anticipated (the brine maker's maximum capacity) if the water supply line is not large enough.
Cleaning	**Type**: Manual; some systems have automated option **Staff**: 2 staff needed to operate manual cleaning cycle **Time**: Unknown, depends on the salt and cleaning frequency **Gallons produced before cleaning**: Unknown, depends on the salt and cleaning frequency **Cost**: Unknown, depends on the salt and cleaning frequency **Frequency**: Multiple times during the season

South Dakota Department of Transportation

South Dakota DOT uses 21 SB600 brine makers. Salinity is controlled manually.

Topic	Description
Brine storage	Vertical polyethylene tanks
Brine mixing	Not applicable
Pumps	John Blue and Banjo
Loading practice	Loader
Brine production	3,600 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 1 to 2 staff needed to operate the cleaning cycle **Time**: 2 to 4 hours **Gallons produced before cleaning**: 20,000 to 30,000 gallons **Cost**: Local vacuum trucks cost an average of $35 per ton. **Frequency**: Multiple times during the season

Texas Department of Transportation (Abilene District)

Texas DOT Abilene District uses eight SB600 brine makers with manual controllers.

Topic	Description
Brine storage	Two 12,500-gallon tanks
Brine mixing	Not addressed
Pumps	Transfer pump
Loading practice	Skid steer
Brine production	2,500 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 2 hours **Gallons produced before cleaning**: 150,000 gallons **Cost**: $2,000 at each location **Frequency**: At the end of the season

Texas Department of Transportation (Austin District)

Texas DOT Austin District uses four SB600 brine makers.

Topic	Description
Brine storage	10,000-gallon poly tanks
Brine mixing	Manual mixing with valves using a hydrometer refractometer
Pumps	12-horsepower Liberty pump
Loading practice	Loaders, skid steer and forklift
Brine production	1,000 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 1 hour **Gallons produced before cleaning**: Depends on the quality of material used **Cost**: $30 **Other comments:** All parts must be washed with water before applying Salt-B-Gone salt neutralizer for protection. **Frequency**: Each time after making a batch

Texas Department of Transportation (Brownwood District)

Texas DOT Brownwood District uses nine SB600 brine makers in addition to a brine maker built by Texas DOT's Fleet Division years ago.

Topic	Description
Brine storage	20 fiberglass 12,500-gallon storage tanks with catwalks; approximately $17,000 each
Brine mixing	Batch mixing system
Pumps	Electric motors with pacer pumps; Predator and Honda brand gas-powered pumps and motors
Loading practice	Skid steer
Brine production	1,500 to 2,000 gallons per hour, depending on material solubility and water pressure The brine makers are producing brine at the rate the agency anticipated.

Topic	Description
Cleaning	**Type**: Manual **Staff**: 2 to 3 staff needed to operate the cleaning cycle **Time**: Approximately one day **Gallons produced before cleaning**: Depends on the cleanliness of the material **Cost**: Approximately $600 per day **Equipment**: PVC pipes and transfer hoses **Frequency**: Depends on the cleanliness of material. Cleaning is rarely needed with clean material; dirty material may prompt cleaning as often as once per weather event.

Texas Department of Transportation (Dallas District)

Texas DOT Dallas District uses eight SB600 brine makers at the cost of $14,000 each.

Topic	Description
Brine storage	10,000-gallon upright poly tank at $9,000; 12,600-gallon fiberglass upright tank at $17,000; 21,000-gallon frac tank at $43,000
Brine mixing	Agitation
Pumps	3-horsepower Pentair pool pump; 5-horsepower gas-powered water pump; Honda trash pump
Loading practice	Skid steer
Brine production	Approximately 3,600 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 4 to 6 hours **Gallons produced before cleaning**: 60,000 to 90,000 gallons **Cost**: Labor cost **Frequency**: Only at the end of the season given a light winter that required relatively little brine production **Other comments**: Leftover material is drained from the brine maker, and the unit is rinsed three to four times with a salt neutralizer. All liquids are drained from the lines and machine, and pumps are cleaned and lubricated to prevent lockups.

Texas Department of Transportation (Fort Worth District)

Texas DOT Fort Worth District uses a manual SB600 and an automated Brine Boss controller in addition to automatic Brine Master 3000 brine maker. The respondent noted that the information provided

below generally applies to all district brine makers; differences in brine-making practices and brine-maker performance are associated with salt quality and how the salt is delivered.

Topic	Description
Brine storage	Mostly fiberglass; some poly 12,000-gallon tanks
Brine mixing	10,000 to 20,000
Pumps	Not specified
Loading practice	Skid steer and auger system
Brine production	1,000 to 3,000 gallons per hour The brine makers are producing brine at the rate the agency anticipated.
Cleaning	**Type**: Manual **Staff**: Minimum of 2 staff needed to operate the cleaning cycle **Time**: 2 to 5 hours, depending on buildup **Gallons produced before cleaning**: Depends on salt quality **Cost**: $200 per hour **Frequency**: Depends on the quality of brine salt; sometimes every few hours

Texas Department of Transportation (San Angelo District)

Texas DOT's San Angelo District recently purchased two SB600 brine makers at about $16,500 each; the district also uses two district-built brine makers. While the VariTech systems come with manual valves, the district is considering the purchase of a Brine Boss automated salt brine production system to use in tandem with the brine makers. The district will begin using the new units for the upcoming winter season.

Topic	Description
Brine storage	2 fiberglass 12,500-gallon tanks in maintenance section yards, including catwalks and platforms
Brine mixing	Batch-style brine makers
Pumps	Cast iron
Loading practice	Loader
Brine production	3,600 gallons per hour when using clean salt and with access to a good water supply The brine makers are producing brine at the rate the agency anticipated.

Topic	Description
Cleaning	**Type**: Manual **Staff**: 2 staff needed to operate the cleaning cycle **Time**: 1 hour **Gallons produced before cleaning**: Not addressed **Cost**: $1,000 per cleaning event (estimated) **Equipment:** Loader and wash bay **Frequency**: Multiple times during season, depending on cleanliness of the salt

Utah Department of Transportation

Utah DOT uses a VariTech Brine Boss automated production system in conjunction with agency-designed brine makers.

Appendix E: Survey Questions

The survey questions below were provided in an online format to Clear Roads members.

(Required) Does your agency currently produce salt brine in-house?

- Yes (Directed the respondent to **Equipment, Infrastructure and Material Requirements for Brine Production** and the remaining survey questions, if applicable**.**)
- No, but we have an interest in or plans for producing brine in-house. (Directed the respondent to **Considering Producing Brine In-House** and **Wrap-Up**.)
- No, and we have no immediate interest in or plans to produce brine in-house. (Directed the respondent to **Wrap-Up**.)

Considering Producing Brine In-House

1. Please describe your agency's interest in or plans to begin in-house brine production.
2. What are the actual or perceived barriers to producing brine in-house?
3. When does your agency anticipate beginning brine production?

Equipment, Infrastructure and Material Requirements for Brine Production

1. How long has your agency been making brine?
2. Is the brine maker portable (e.g., trailer-mounted) or stationary?
    - Portable
    - Stationary
3. When and where is brine produced across your agency? Please select all that apply.
    - Produced in all districts
    - Produced in select districts
    - Produced at select times of the year
    - Produced throughout the winter season
    - Other (Please describe.)
4. Please describe the brine-making equipment your agency uses for winter road maintenance, including costs (if known).

    Brine production system make and model:
    Brine production system controller, if separate from system:
    Brine storage tanks:
    Brine mixing system:
    Pumps:
    Other (Please describe other equipment required for brine making.)
5. What type of equipment is used to load the brine maker's hopper?
    - Loader
    - Skid steer
    - Auger system
    - Other (Please describe.)
6. Please describe your agency's infrastructure needs for brine making, including constructing or retrofitting existing infrastructure to accommodate brine making.

    Brine system shelter:
    Salt shed:

Water supply:

- Groundwater well
- Municipal water supply
- Driving a water tank to the brine-making site
- Reusing wash water
- Other (Please describe.)

Power supply:

- Hard-wired
- Plug-in
- Generator
- Other (Please describe.)

Hoses:

Heat:

Proximity of brine-making equipment to salt stockpile:

Other (Please briefly describe other infrastructure needs specific to brine making.)

7. How does your agency keep the water line into the brine maker from freezing?
    - House the brine maker in a heated storage area
    - Winterize equipment regularly (Please describe the winterizing process.)
8. Please describe how your agency selects a site for brine making.
9. What kind of salt do you use to produce brine? Please select all that apply.
    - Rock/mined salt
    - Solar/fine salt
    - Other (Please describe.)

Operational and Maintenance Considerations for Brine Production

1. How many gallons per hour does your brine maker produce?
2. Is the brine maker producing at the rate your agency anticipated?
    - Yes
    - No (Please describe the difference between the vendor's stated brine production capacity and the brine maker's actual operation. Include in your description an assessment of why the brine maker is not producing as expected.)
3. Are there any quality assurance (QA) or quality control (QC) processes involved in your agency's brine production process?
    - No
    - Yes (Please describe the QA and/or QC processes in your agency's brine production.)
4. Please describe the process for cleaning the brine-making equipment by addressing each topic area below.

    Manual or automatic cleaning:

    If manual cleaning, number of staff needed to operate the cleaning cycle:

    Time to complete the cleaning cycle:

    How many gallons of brine can be produced before cleaning is required:

    Cost for each cleaning event:

    Other (Please describe other aspects of cleaning the brine-making equipment.):
5. How often does the brine-making equipment need to be cleaned out to remove residual or leftover salt/water mix?
    - Each time after making a batch
    - Multiple times during the season

- At the end of the season
- Depends on use (Please describe how the amount of use relates to cleaning frequency.)

6. What is the purpose of cleaning out the brine-making equipment? Please select all that apply.
    - Aesthetics
    - Best practice for protecting or preserving the equipment
    - Operational (equipment gets clogged or won't function as efficiently unless cleaned out)
    - To repair or maintain the system
    - Other (Please describe.)
7. Does your agency have any requirements related to the disposition of the water used in brine production or equipment cleaning?
    - No
    - Yes (Please describe the requirements related to water used in brine production or equipment cleaning.)
8. Please describe any equipment reliability issues in your brine-making process.
9. Has your agency's brine-making program experienced staffing challenges or other resourcing issues?
    - No
    - Yes (Please describe these resource-related challenges.)
10. Is the brine-making program able to meet your agency's demand for this material?
    - Yes
    - No (Please describe what is needed to be able to keep up with demand.)
11. Please describe any of the aspects of brine making below that your agency does not currently engage in but would like to explore.
    - Blending brine:
    - Mobile brine making:
    - Quantifying carbon footprint or energy savings:
    - Other (Please describe other aspects of brine making that your agency would like to explore.):

(Required) 12. Does your agency blend other liquid materials, such as corrosion inhibitors or other additives, with the salt brine your agency produces or purchases?
    - No (Skipped the respondent to **Assessment** and **Wrap-Up.**)
    - Yes (Skipped the respondent to **Brine-Blending Practices** and the remaining survey questions.)

Brine-Blending Practices

1. Please describe the equipment your agency uses for brine blending.
2. How is the brine blended?
    - Into a storage tank
    - Directly into the truck that will apply the material
    - Other (Please describe.)
3. What additives or other materials does your agency blend into the salt brine?
4. How does your agency determine blend rates? Please select all that apply.
    - Developed in-house
    - Purchased from a vendor
    - Borrowed from another agency
    - Other source (Please describe.)
5. How many gallons of brine are blended per hour?
6. Please provide any other comments regarding your agency's brine-blending practices.

Assessment

1. Does your agency plan to continue making brine in-house?
    - Yes
    - No (Please explain why you plan to discontinue making brine.)
2. What are the benefits for your agency of in-house brine making? Please select all that apply.
    - More cost-effective than other alternatives
    - Ready availability when needed
    - Decreased liquid storage capacity
    - Other (Please describe.)
3. Please describe any challenges, other than equipment reliability issues, your agency has faced in brine-making or blending operations.
4. What are the top three best practices or lessons learned your agency would offer to an agency considering producing its own brine?
    - Best Practice or Lesson 1:
    - Best Practice or Lesson 2:
    - Best Practice or Lesson 3:
5. Please provide links to documents associated with your agency's brine-making practices. These might include brine-making equipment specifications or operating procedures. Send any files not available online to susan.johnson@ctcandassociates.com.

Wrap Up

Please use this space to provide any comments or additional information about your previous responses.

research for winter highway maintenance

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