Evaluation of The FreezeFree Anti-Icing System

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Final Report

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CERF

Advancing the Design and Construction Industry through Innovation

Evaluation of the FreezeFree Anti-Icing System
Final Report

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Executive Summary

Background

The Highway Innovative Technology Evaluation Center (HITEC) of the Civil Engineering Research Foundation (CERF), with support from the Federal Highway Administration (FHWA), conducted a multiyear study to evaluate the performance of FreezeFree™ fixed automated anti-icing spray system. The study was conducted by documenting the experience of users of the system at six (6) different test sites[1] located in the states of Maryland, Wisconsin (two test sites), Minnesota, North Dakota, and Oregon, and by studying and analyzing the data obtained from these sites.

The FreezeFree system applies calibrated amounts of anti-icing liquids on targeted areas and high-incident locations. To trigger the spraying cycle, highway personnel can either activate the system manually or allow the system to use its pavement sensor and Road Weather Information System (RWIS) to monitor ambient conditions and the road surface, and then automatically activate a pump and a series of high-pressure valves that spray anti-icing liquid over the targeted area in a pre-determined sequence. The system's computer makes a record of the conditions and other information, including the date and time of activation. To supervise and evaluate the system's performance, officials can retrieve data or monitor the system via telephone, fax, or computer.

Limitations of the Study

The FreezeFree systems installed on various sites were for the most part, unique. This uniqueness existed in terms of the type of system such as Basic, Automated, or Nitro, type of sensor (active or passive), types of nozzles, and so forth. This diversity of system features, on the one hand, was useful in representing the various features and possible configurations of the system, but on the other hand, made it difficult to compare system performance from one site to another. In addition, repairs and upgrades of the system on an ongoing basis made it difficult to "lock" the various parameters within a system for the purpose of monitoring performance over time of a given configuration at any given site.

In addition to the evolving nature of the system during the course of the evaluation, the other important limitation of the study is that it attempts to qualitatively summarize the experience of system users at each of the test sites by assigning an anecdotal rating to the system. While such overall qualitative assessment is very useful in providing a snapshot of user experience, it is important to note that the criteria of assignment of such ratings can vary from user to user, depending on the personality, expectations, perception, and understanding of each user. Moreover, outside factors such as the level of cooperation and response received from the local FreezeFree representatives can also impact the assignment of these ratings from one site to another.

Lastly, due to the unavailability of data, an assessment of the safety, environmental, and economic benefits of the system was not possible. Also, while system activation data was

[1] There is a test site in California that was intended for use in this evaluation, but was not included since the installation at that site was not complete at the time of publication of this report.

available from most sites, the ability to confirm an actual spray application was limited. Hence, a deterministic conclusion on system activation errors was made based on limited information.

Key Lessons Learned

The key lessons learned from this evaluation study include:

1. The FreezeFree system is not an off-the-shelf system that can be purchased and installed right away at any given site. It requires customization of the installation at each site after studying the site requirements and conditions, and designing a specific system and its installation to meet those requirements.

2. Selection of the proper site for the installation of the system is key to obtaining the maximum benefit out of the system. The site should have unique characteristics like high crash history, sharp horizontal curve and/or vertical gradient change, remote location away from the regular maintenance routine, etc.

3. The type and quality of the anti-icing liquid used can significantly affect the performance of the system, particularly, the presence and purity of rust inhibitors.

4. The system can be most effective under frost conditions. It should not be expected to enhance safety under moderate to heavy snow conditions.

5. The installation and maintenance of the system is fairly simple. Apart from some isolated problems that have been documented in this report, the installation and maintenance requirements generally met the expectations of the users.

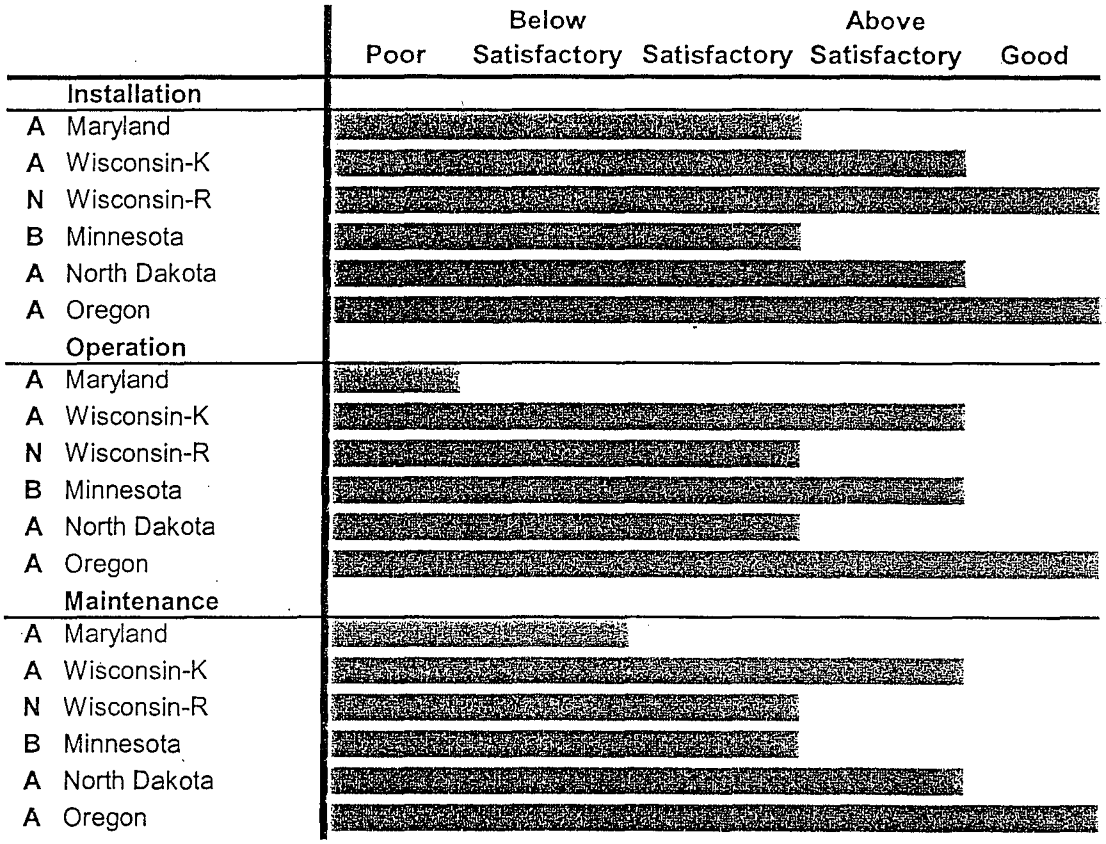
6. There were a number of problems that were experienced in the operation of the system. Some sites reported erratic response to the spray logic, which includes firing of the system when not required (6% of all events), and not firing when required (7% of all events), as observed at the North Dakota test site. There needs to be more work done in order to eliminate or significantly reduce this problem to get maximum safety and economic benefits, and to increase the overall reliability of the system.

Summary of Evaluation

While the comments received from the test sites were spread over a wide range of observations and experiences, it is clear from this evaluation that a number of problems were experienced by the test sites, which in most cases, were resolved over time. Some of the problems related to the command element of the automated systems remain to be resolved. Since the systems evolved over time due to repairs and upgrades, the test sites were not able to achieve a stable/equilibrium state over the past winter seasons to collect data and information that could be compared from one season to another. That being said, there is little doubt that when fully and reliably operational, the system has demonstrated the potential to maintain a high level of service, resulting in only a few cases of ice or snow bonding to the pavement surface, with minimal labor and material used. Consequently, one would expect :

a) Enhanced traffic safety by preventing ice formation on sensitive locations on highways and bridges at all times;
b) Reduced winter maintenance costs by intelligent application of an appropriate amount of anti-icing chemical when and only when necessary, and by providing an alternative to dispatching winter maintenance crews to remote locations; and
c) Reduced environmental impacts that could otherwise result from excessive regular application of winter maintenance materials.

Figure-A shows a summary of overall rating of the system on its installation, operation, and maintenance, as experienced by the representatives at each of the test sites.



A = Automated; B = Basic; N = Nitro

Figure-A: Summary of Overall Rating of the System

Chapter 1: Introduction

1.1 Background

As part of its Highway Innovative Technology Evaluation Center (HITEC) program, CERF has undertaken the evaluation of the FreezeFree system, an anti-icing spray technology that is a product of the Chicago-based Energy Absorption Systems, Inc. The FreezeFree technology consists of an anti-icing system designed for application on bridges, curves, ramps, steep grades and high incident locations. The system features an anti-icing system that provides measured applications of anti-icing liquids on targeted areas at appropriate times. The study was initiated after the Federal Highway Administration (FHWA) received a directive from the U.S. Congress to evaluate the effectiveness of FreezeFree technology.

As part of an earlier phase of this project, CERF had developed guidelines[2] for evaluating the system, and had facilitated the selection of sites for installation of the system on seven (7) test locations in six (6) different states including California, Maryland, Minnesota, North Dakota, Oregon, and Wisconsin. This report is the product of the final phase of this project, and provides a comprehensive documentation of the test sites, the types of systems installed, and the installation, operation, and maintenance of those systems as experienced by the personnel responsible for managing those systems at each of the test sites.

The evaluation was directed by the technical evaluation panel assembled by HITEC to develop the FreezeFree evaluation plan[1] as part of an earlier effort. The evaluation panel includes industry experts, representatives of FHWA, and representatives of state transportation agencies responsible for the test sites.

In summary, the goal of this effort was to conduct an objective, consensus-based assessment of the performance of a system that has potential for improving highway safety and mobility, and reducing winter maintenance costs.

1.2 Anti-Icing of Bridge Decks and Other Problem Locations

1.2.1 The Problem

In any highway maintenance operation, some sites on the system have characteristics that pose a particular challenge to the field forces charged with carrying out the work and require a disproportionate amount of attention and expenditure of resources.

In the particular case of winter maintenance, bridge decks are one such class of problem locations. Because of the difference in the thermal regime of bridges and pavements, bridge decks usually freeze sooner than the adjoining pavement. At stream crossings, this problem can be further aggravated by generally higher levels of available moisture (humidity) near the

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[2] Highway Innovative Technology Evaluation Center, "HITEC Evaluation Plan for Energy Absorption System, Inc. FreezeFree System", March 28, 2002.

bridge. This moisture can condense on the deck and freeze, even while the nearby pavement remains frost or ice-free (so-called "preferential icing"). As a result, bridge decks commonly require anti-icing treatment earlier and more often than pavement.

Providing timely and effective anti-icing operations on bridge decks thus causes the normal operational problems of (a) detecting the need for an anti-icing operation and (b) applying the appropriate strategy to be more acute and costly by, e.g., requiring more frequent emergency or off-hours call-outs of patrol trucks.

A second class of problematic winter maintenance locations are high crash sites: places where sharp curves, steep grades, poor sight distance, a particularly harsh microclimate, or other undesirable conditions contribute to a disproportionate number or rate of crashes during snow and ice events.

Finally, a third situation where providing a prescribed level of service can be particularly costly and inefficient is in servicing critical sites that are difficult to reach due to their distance from the winter maintenance yard or due to traffic congestion. These critical sites — usually, bridge decks or high crash locations — pose the same operational problems described above, but to a more pronounced degree, due to the influence of increased time and/or distance from the maintenance workshop.

Clearly, the operational difficulties associated with providing effective anti-icing at problem locations have significant economic implications not only in terms of direct agency costs, but also in terms of crash costs. When the very substantial benefits accruing from providing improved motorist safety during winter storms is factored in, significant capital investments in improved technology may – in appropriate cases – be warranted. Indeed, the potential payoff of early intervention in snow removal and ice control in terms of improved quality-of-service (motorist convenience, mobility, and safety) was a major factor in the decision by transportation agencies in recent years to make substantial investments in advanced technology to permit anti-icing to be more systematically and effectively applied. Those investments in advanced technology–collectively referred to as the "new generation of snow and ice control"[3] and "a revolution in winter maintenance"[4] – include specially equipped applicator trucks, sophisticated management information systems, and innovative ice control materials.

1.2.2 FAST- The Proposed Solution

Studies in the US[5] and Canada[6] indicate that a technology first used in Europe — generically referred to as Fixed Anti-icing Spray Technology (FAST) — can be a cost-effective means for improving motorist safety on bridge decks during winter storms. Unlike the traditional

[3] "*The New Generation of Snow and Ice Control: Anti-icing and RWIS*," a brochure developed by the Iowa DOT as part of the AASHTO Lead States Program (1998).

[4] Chollar, B. "A Revolution in Winter Maintenance," *Public Roads On-Line*, FHWA (Winter 1996).

[5] Decker, R., "Automated Bridge Deck Anti- and Deicing System," NCHRP-IDEA Project 27 Report (November 1998).

[6] Pinet, M. et al, "Anti-Icing on Structures Using Fixed Automated Spray Technology (FAST)," presented at the 2001 Annual Conference of the Transportation Association of Canada, Halifax, Nova Scotia (May 1, 2001).

mobile (truck-mounted) equipment for applying anti-icing chemicals, the mechanical sprayer in a FAST system is permanently installed on the site.

The FreezeFree™ system is a proprietary FAST system. First installed in Wisconsin in January 2000, it consists of two major subsystems: a control system and a hydraulic system. The control system consists of sensors that detect the need for an application of anti-icing chemical, and a remote processing unit (RPU), which collects and stores the sensor data and activates and deactivates the spray cycle. The hydraulic system consists of a storage tank and pump that dispenses the anti-icing fluids through a series of solenoid-controlled nozzles along a length of steel piping. The nozzles may be side-mounted on a parapet or guardrail, or flush-mounted in the pavement or bridge deck.

The sensors used in the FreezeFree control system are available in a range of options, the choice of which will affect the accuracy of the detection, the flexibility and reliability of the overall operation, as well as the system cost. For example, detection may be based solely on data from a pavement sensor (i.e., surface temperature, surface condition, brine freezing point) or upon the full panoply of pavement and atmospheric data from an on-site Environmental Sensor Station (i.e., wind speed, air temperature, humidity, etc.) as part of a Road Weather Information System (RWIS). Further, pavement sensors are available as either active or passive units. A passive sensor estimates the freezing point of any brine present on the pavement surface from measurements of conductivity; an active sensor measures freezing point directly by freezing a sample of the liquid.

A range of options is also available for activating the FreezeFree system. The spray cycle can be manually activated — either on-site or remotely by telephone — or the system can be operated fully automatically, based on the programmable logic incorporated in a proprietary FreezeFree computer algorithm. (Among other things, the choice between manual and fully automatic activation may be influenced by the relative sophistication of the detection system selected by the user.)

The FreezeFree system is designed to be used as a "first response," anti-icing system, not as a snow removal tool. For some winter events (e.g., the classic early morning transient frosting of a bridge deck), timely applications by the FreezeFree system may be the only action necessary to effectively deal with the incident. Prolonged heavy snowfalls will still require plowing. In such cases, the FreezeFree system ideally will cycle only long enough to perform its basic anti-icing function — i.e., supplying enough freezing point depressant to prevent a tight ice/pavement bond from forming or developing — and then deactivate until any accumulated snow is removed. Depending on the sophistication of the installed detection equipment, such deactivation may require intervention by maintenance staff.

1.2.3 Potential Benefits of FAST

Including FAST as part of the winter operations infrastructure can result in numerous benefits. These benefits, depending on the type of system and the ability of the system to perform as designed, include:

- Proactive approach to snow and ice control;
- Automated control over timeliness of activation, resulting in the application of chemical only when it is most effective;
- Potential for reduction in winter weather-related crashes at high-crash locations;
- Reduced/minimal staffing needs, resulting in a direct impact on reducing operating costs;
- Ability to apply chemical at any time of the day, every day of the year, regardless of holidays, public closings, and staff availability;
- Ability to instantly apply chemical on sites at remote locations with distant and difficult access to winter maintenance vehicles, especially in bad weather conditions;
- Efficient use of the chemical due to need-based application, resulting in economic benefits and reduced environmental impact;
- Flexibility in setting and modifying spray logic based on site conditions;
- Flexibility in using alternative chemicals at the site, including chemicals that are less corrosive to structures;
- Ability to accurately monitor the amount of chemical being used per mile per structure; and
- Generation and collection of extensive data that can be used to develop models on spray requirements.

1.3 Organization of the Report

This report is organized in seven (7) different chapters. Following the first chapter that introduces the evaluation, Chapter 2 provides an overview of the different types of FreezeFree systems, and the various components that are part of each of these systems. Chapter 3 provides a description of the seven (7) test sites located in six (6) different states from the East Coast to the West Coast. Chapter 4 provides a description of the experience of the State DOT personnel with the installation of the system at the test sites. Chapter 5 describes the Operation and Maintenance of the system, while Chapter 6 provides a brief summary of the findings from the analysis of data collected at the test sites. Chapter-7 presents the key highlights of the findings and conclusions from the system evaluation process.

Chapter 2: System Information

This chapter discusses the generic version of the FreezeFree Anti-Icing System as it is typically presented in Product and Installation Manuals. The actual system deployed at each site is specifically designed to meet the needs and requirements at the site, and may vary from site to site as seen in the following chapters. The FreezeFree System is designed and manufactured by Energy Absorption Systems, Inc., of Chicago, Illinois. It is available in three different types:

- FreezeFree™ Basic
- FreezeFree™ Automated
- FreezeFree™ Nitro

2.1 FreezeFree™ Basic[7]

The FreezeFree Basic is a fixed anti-icing system that provides treatment of a bridge, ramp, or other problem location. The FreezeFree Basic dispenses a liquid anti-icing agent by pumping the chemical through a series of high-pressure spray nozzles, individually controlled by solenoid valves. Upon activation, the system energizes a motorized pump and automatically sequences the solenoid valves to spray the anti-icing liquid over the targeted area.

A programmable controller activates the motorized pump to bring the system to its operating pressure. An anti-icing chemical is circulated by the pump through an overpressure relief valve back to the storage tank to provide agitation of the solution. A series of solenoid valves is then sequentially opened and closed to purge air from the system and dispense the anti-icing chemical. The anti-icing cycle can be initiated remotely via a means of communication medium such as telephone, cell phone, pager, computer, etc., or by manually pushing a button at the controller assembly.

The FreezeFree Basic pump house assembly consists of a prefabricated pump house, a stainless steel pump assembly, a polyethylene storage tank, a controller assembly, and miscellaneous hardware (Figure 2.1).

[7] Source: Product/Installation Manual, FreezeFree Basic Anti-Icing System, Energy Absorption Systems, Inc.

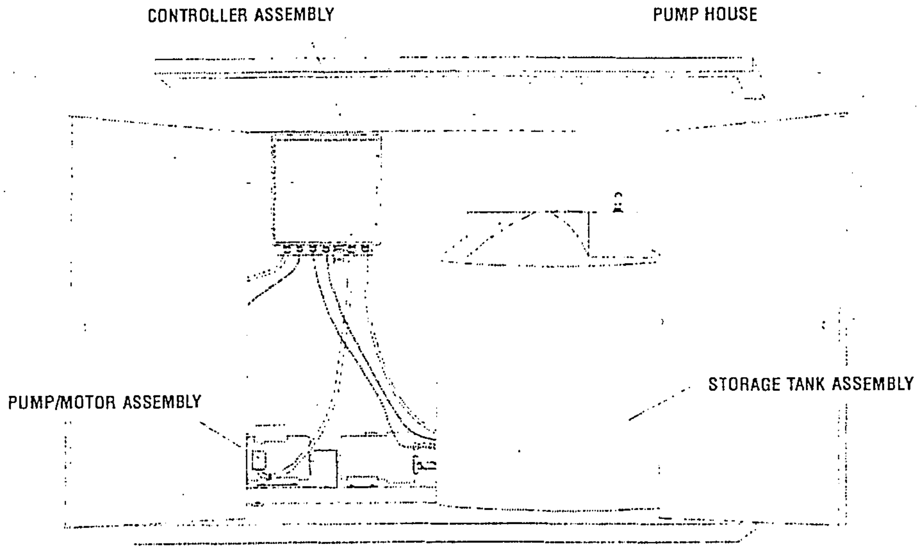


Figure 2.1: Pump House Assembly

The pump house is constructed of high-impact vinyl wall and roof panels. For most applications, the insulation provided by the double-wall construction is sufficient, although the wall and roof panels may be filled with Polystyrene pellets or strips of rigid Polystyrene sheeting.

The completed pump house is heated by a thermostatically controlled electric heater, and electric heating cable is wrapped around the pump discharge and suction lines for added thermal protection. The pump assembly consists of a positive displacement pump directly coupled to a totally enclosed, fan-cooled, single phase, electric motor (Figure 2.2).

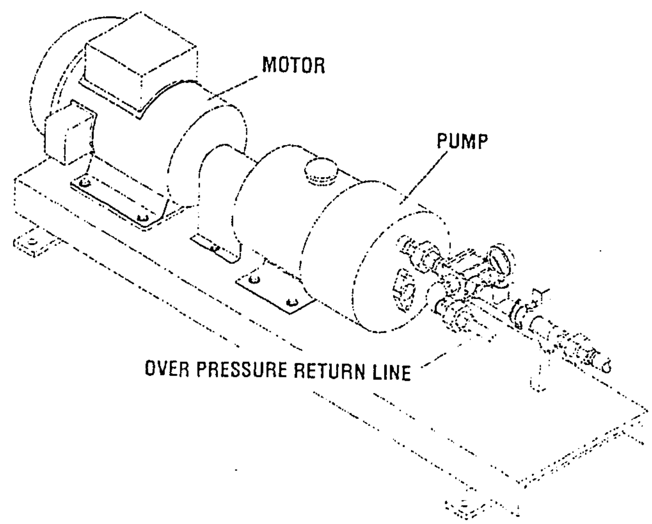


Figure 2.2: Pump Assembly

A variable pressure relief-valve is attached to the pump discharge, with an over pressure return line connected to the storage tank. The pump and relief valve are constructed of stainless steel, and the internal valve components are made of chromium alloys. The storage tank is molded polyethylene. Standard tank sizes typically range from 375 to 700 gallons. Other sizes are provided depending on the specific needs at the site. The tank assembly consists of the tank with a vented lid, two level switches, and PVC fittings for the suction line, return line, and drain.

The controller assembly (Figure 2.3) employs a programmable controller to cycle the system, and a remote touch-tone controller used for telephone activation.

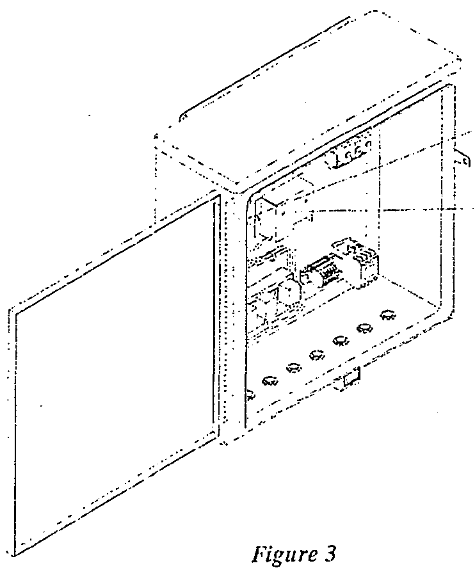


Figure 3
Controller Assembly

Figure 2.3: Controller Assembly

The controller is capable of addressing up to 256 individual solenoid valves with a single pair of AC power lines. A low level warning switch sets an alarm, which warns the customer via telephone of low fluid level in the storage tank. When the low level alarm is set, the controller dials the programmed number up to three times, in quick succession, or until halted by the attendant, and signals an alert tone every five seconds for two minutes. This is repeated every 8 hours until halted. A second low-level shut-off switch prevents pump damage if the fluid level becomes dangerously low.

The piping system consists of synthetic rubber hose, used from the pump discharge to the solenoid valves, and nylon tubing from the solenoid valves to the nozzle assemblies. The fluid carrying hose and electrical wiring are contained in galvanized steel pipe.

Piloted, two-way solenoid valves are used to control the spraying sequence. The valves have brass bodies, and stainless steel internal components. All valve controls are installed in electrical enclosures. The spray nozzle assemblies are constructed of a reinforced nylon block with brass fittings and stainless steel attachment hardware. Nozzle assembly designs are available for concrete barrier and wood or steel post guardrail installations (Figures 2.4 and 2.5). Flush-mounted pavement nozzles are also available (Figure 2.6).

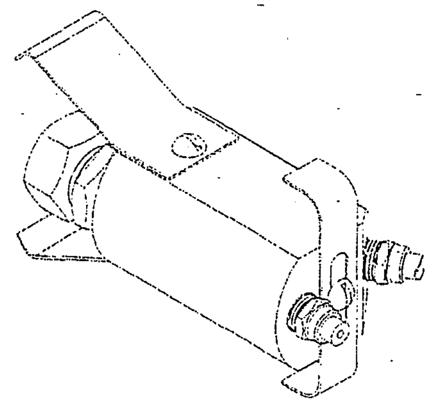


Figure 2.4: Spray Nozzle Assembly – Concrete Mount

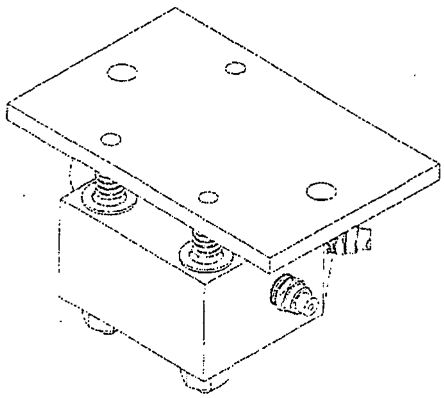


Figure 2.5: Spray Nozzle Assembly – Guardrail Mount

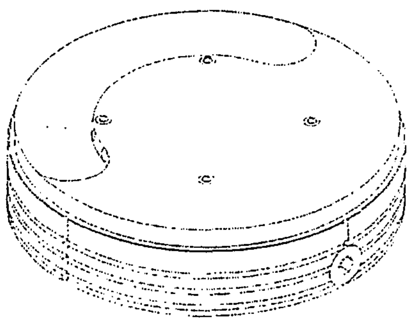


Figure 2.6: Flush-Mounted Pavement Nozzle

2.2 FreezeFree™ Automated[8]

The FreezeFree™ Automated system offers intelligence to the FreezeFree Basic System, which enables it to be activated automatically. Automatic activation of the FreezeFree Automated system is provided with an ice prediction system to accurately measure pavement surface conditions. The ice prediction system utilizes a pavement sensor that uses electrical conductivity measurements, surface temperature, and optical measurements to determine the surface state. Depending on the particular system design, atmospheric sensors may also be employed.

A brief description of the various components that detect and report conditions for automatic activation of the FreezeFree Automated system is provided below.

2.2.1 Pavement Sensors

Pavement sensors use electrical conductivity measurements, surface temperature, and optical measurements to monitor roadway surface conditions. From the measured data, water-layer thickness, depression of freezing point, and chemical concentration are calculated in order to detect ice and frost warning conditions. A computer algorithm uses the data to calculate when icing conditions will occur and activates the system before the road ices. A computer logs the event conditions, date, and time.

2.2.2 Road/Runway Weather Information Systems (RWIS)

Weather affects all modes of transportation, be it on the ground or in the air. RWIS technology provides vital information on pavement and weather conditions for both highway and airport maintenance and operations. RWIS has proven to provide increased safety for the traveling public by enabling maintenance and operations personnel to monitor changing weather conditions in real time and make informed and timely decisions in response to the effects of nature. RWIS information also enables maintenance and operations personnel to effectively plan for and appropriately respond to the weather's effects on pavements, resulting in more efficient operations and thus cost savings.

Each RWIS site can contain surface sensors embedded in the pavement that determine temperature, freeze point, moisture, form of moisture (snow/ice), and amount of de-icing chemical present, as well as atmospheric sensors that determine air temperature, relative humidity, wind speed and direction, precipitation and visibility.

All sensors are connected to a remote processing unit (RPU), which is positioned adjacent to the road/runway. The RPU transmits the sensor data to the Server located in the main agency office, which collects and stores it. Agency personnel access the data via computer workstations at the office or from remote locations.

[8] Source: Product/Installation Manual, FreezeFree Automated Anti-Icing System, Energy Absorption Systems, Inc.

An integral component of RWIS is pavement-specific weather forecasting. While the RWIS sensors provide timely information on current and historical conditions, it is the pavement-specific weather forecasts that serve as the predictor of the future. Knowing what type of weather will occur is key to being and staying one step ahead of the storm. Accurate pavement-specific weather forecasts are a necessity for any efficient and effective anti-icing program.

2.2.3 ScanWeb

ScanWeb is the latest Road/Runway Weather Information Systems (RWIS) user interface from Surface System's, Inc. (SSI). ScanWeb uses standard Internet technologies to display data from the RWIS. These technologies include the Transmission Control Protocol/Internet Protocol (TCP/IP), the Hypertext Transfer Protocol (HTTP), the Hypertext Markup Language (HTML), and Active Server Pages (ASPs). These standards form the foundation of what has become commonly known as the World Wide Web (WWW). ScanWeb makes use of these standards technologies to display SCAN RWIS data using widely available HTML browsers such as Netscape Navigator and Microsoft Internet Explorer.

ScanWeb provides powerful graphical data display pages. Users can easily select various data views to display and produce either concise summary views or detailed RWIS data. Site Summary, Site Status, and historical data pages are available to enhance operational effectiveness. In addition, ScanWeb integrates current video images when sites are configured with video cameras.

2.3 FreezeFree™ Nitro[9]

The FreezeFree™ Nitro Anti-Icing System is a variation of the FreezeFree Basic system. It is a solar-charged, battery-powered system in which a pressurized nitrogen tank propels anti-icing fluid sprayed on a bridge, ramp or other problem location, without the need for external electrical power or telephone communication lines. Upon actuation, anti-icing chemical is gravity fed on demand to a pressure vessel, which is then pressurized with gaseous nitrogen, regulated to maintain the design operating pressure throughout the System. A programmable logic controller (PLC) monitors and controls System fluid levels and pressure, and energizes a sequence of solenoid valves to dispense the anti-icing liquid over the targeted area.

The FreezeFree Nitro System pump house assembly (Figure 2.7) consists of a prefabricated pump house kit, a stainless steel and brass pressure tank assembly, a polyethylene storage tank, a controller assembly, and miscellaneous hardware. The pump house is made up of high-impact vinyl wall and roof panels of reinforced double-wall construction.

[9] Source: Product/Installation Manual, FreezeFree Nitro Anti-Icing System, Energy Absorption Systems, Inc.

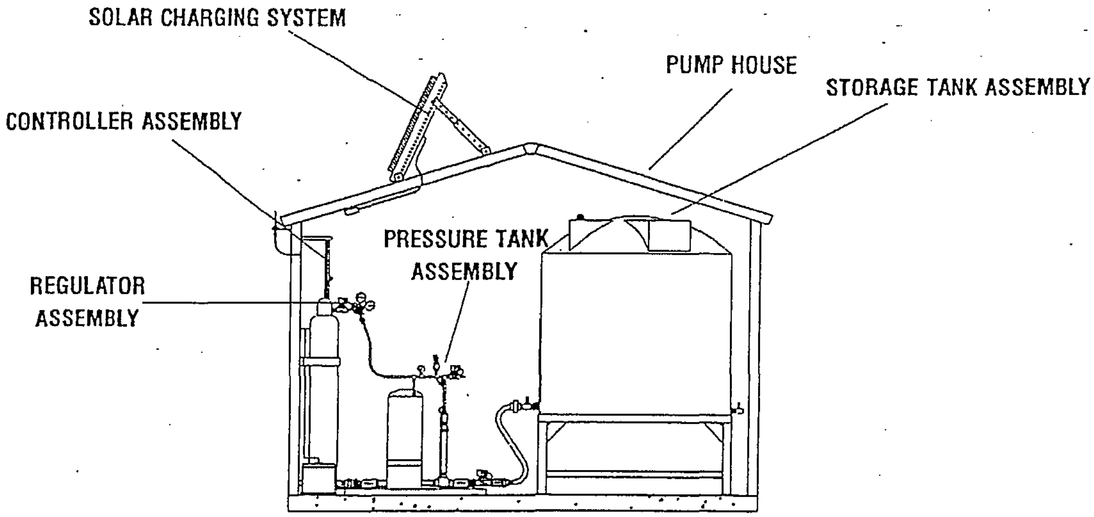


Figure 2.7: Pump House (Nitro)

The pressure tank assembly (Figure 2.8) consists of a stainless steel pressure vessel equipped with solenoid valves, check valves, level and pressure switches and a strainer. The complete assembly is mounted on a painted steel platform for easy installation.

The storage tank is molded polyethylene. The typical standard tank size is 375 gallons. Other sizes are provided depending on the specific needs at the site. The tank assembly consists of the tank with a vented lid, a level switch, a shut-off valve and PVC fittings for the chemical supply line and drain. The storage tank assembly is elevated to allow the anti-icing chemical to be gravity fed to the pressure tank.

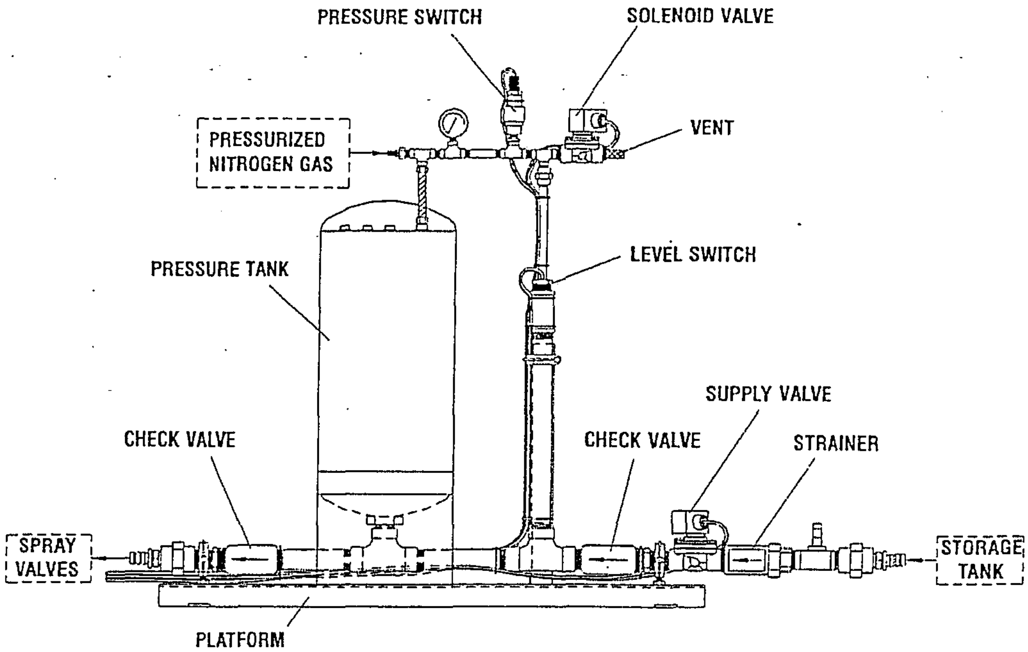


Figure 2.8: Pressure Tank (Nitro)

The controller assembly employs a programmable logic controller (PLC) to cycle the System, and a remote control paging device for remote activation.

Chapter 3: Test Sites

In order to conduct an evaluation of the FreezeFree system, seven (7) test sites were selected nationwide in six different states, including Maryland, Wisconsin, Minnesota, North Dakota, Oregon, and California. Five of these sites consist of system installation on bridges, while the other two consist of system installation on sloping, curved pavements.

The FreezeFree systems installed on various sites were for the most part, unique. This uniqueness existed in terms of the type of system such as Basic, Automated, or Nitro, type of sensor (active or passive), types of nozzles, and so forth. This variety of system features, on the one hand, was useful in representing the various features and possible configurations of the system, but on the other hand, made it difficult to compare system performance from one site to another. In addition, repairs and upgrades of the system on an ongoing basis made it difficult to "lock" the various parameters within a system for the purpose of monitoring performance over time at any given site.

The following sections discuss each of the test sites, and the type of system installed on those sites:

3.1 Maryland

3.1.1 Site Information

This installation is located on two separate spans of Clarysville Bridge that carry eastbound and westbound traffic on Interstate 68 in Clarysville, Maryland (Figure 3.1). The Clarysville bridges were excellent candidates to install the FreezeFree anti-icing spray technology because of the uniqueness of their location. The I-68 Clarysville bridges are located in one of the coldest regions in Maryland. The high elevation of the bridges in the valley causes a significant traffic hazard when cold weather is accompanied by precipitation. The bridge surface freezes while the roadway surface next to the bridges remains wet. These circumstances cause a number of crashes each year when vehicles leave the wet approach roadway and drive onto the frozen bridge surface unaware of the hazardous conditions.

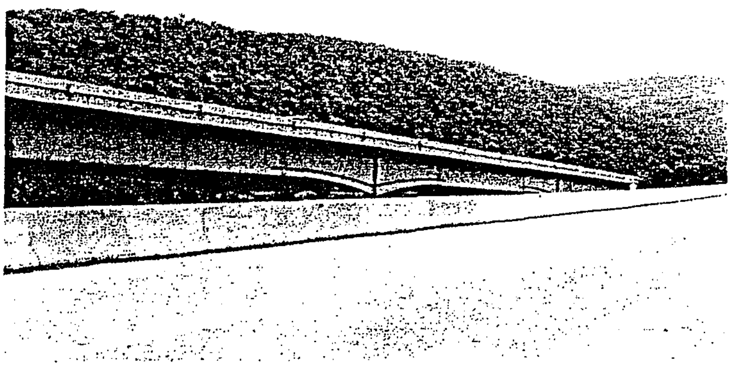


Figure 3.1: FreezeFree Automated System Installation Site, Clarysville, Maryland

[13] The quality of the chemical used affects the performance of the FreezeFree system

The site is located 3.5 miles west of Maryland State Highway Administration's (MDSHA's) District 6 LaVale Maintenance Shop. The eastbound span has a width of 39.6 feet and consists of 2 travel lanes (1.6% cross slope), a 10-foot outside shoulder with a 6% cross-slope and a 4-foot inside shoulder with a 4% cross-slope. The length of the bridge is 708 feet and it has a longitudinal slope of 1.5%. The westbound span has a width of 51.6 feet and consists of 3 travel lanes, a 4-foot inside shoulder and 10-foot outside shoulder. Cross slopes are the same as the eastbound structure. The length of this bridge is 744 feet and it has a longitudinal slope of 5%. The bridge is at an elevation of 1,800'. At the highest point, the westbound span is approximately 100' above MD 55 and Braddock Run. The Average Annual Daily Traffic (AADT) on the bridge is 27,000 vehicles per day (VPD).

3.1.2 System Information

The FreezeFree Automated System in Maryland was fully commissioned in April 2002. The Maryland Freeze Free System consists of 77 parapet-mounted nozzles (spaced every 40') and 8 guardrail-mounted nozzles (spaced every 20' at the approaches). The liquid deicer (50% solution potassium acetate) is stored in a 1,000 gallon tank located in a 7.5'X 9.0' pump house. The control system is a Surface Systems Inc. (SSI) RWIS. Originally, there was one FP 2000 pavement sensor located in the eastbound #2 lane. In March 2003, two active sensors and one additional FP 2000 were added. The RWIS also includes a remote processing unit, a 10' tower, precipitation sensor, relative humidity/air temp sensor, a wind speed/direction sensor, and one sub-surface temperature probe.

When the RPU determines that a frost or freeze condition exists, the nozzles begin spraying in a sequence. The total activation time for a spray cycle is 8 minutes and 30 seconds. A volume of 44 gallons of deicer is sprayed during one spray cycle. The pavement and atmospheric data along with the spray device history are displayed by a ScanWeb 3.3 user interface.

3.2 Wisconsin-K

3.2.1 Site Information

This installation is located on the eastbound lanes of a bridge on STH-50 in Kenosha County, Wisconsin, and is therefore referred to as Wisconsin-K site. The bridge is made up of concrete girders, railing, and deck, and spans 137 feet over the Des Plaines River in the township of Bristol (Figure 3.2). It is located at about 1.4 miles from the County Shop. Table 3.1 provides information on the Wisconsin-K installation site.

Table 3.1: General Information on Kenosha Site

County	Kenosha
Highway/Direction	S.T.H. 50 – E.B.L.
Over	Des Plaines River
Township	Bristol
Distance from County Shop	1.40 Miles
Average Daily Traffic (2001)	8,900 vehicles
Bridge Number	B-30-54
Year Constructed	1989
Type of Construction	Concrete Girders Railing & Deck
Bridge Deck Size (W' X L')	40' X 137'

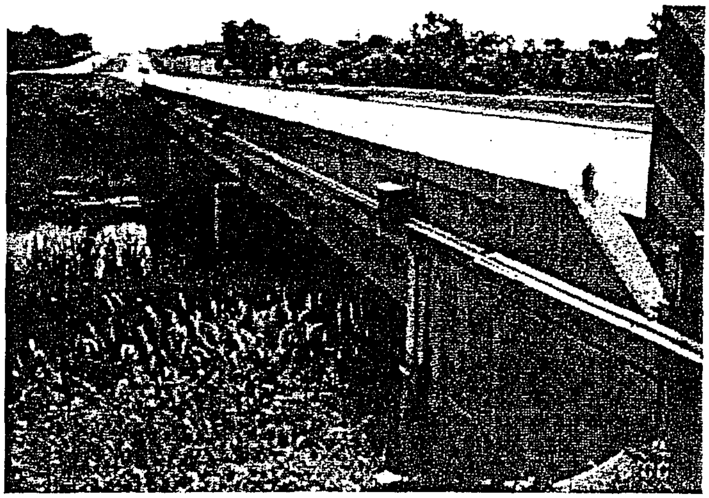


Figure 3.2: FreezeFree Automated System Installation Site, Kenosha County, WI

3.2.2 System Information

The FreezeFree Automated System in Kenosha County became operational in January 2000. It is self-activated based on real-time data provided by a Vaisala DRS 511 fiber optic pavement sensor (bridge deck surface temperature, surface conditions, and predicted freezing point), manually operated at the site, or activated by a remote call-in to the system controls by the Kenosha County Highway Department. The site also has a Road Weather Information System (RWIS) installed, but it is not part of the FreezeFree system.

When the system is activated, each of the six nozzles spray out a total of 0.5 gallons/nozzle through two complete cycles of spraying or a total of three gallons per activation. Each nozzle covers an area approximately 24' x 40' or 960 sq. ft. The system application rate for the two complete cycles is calculated to be a total of 33 gallons per lane-mile, which is consistent with Wisconsin DOT anti-icing guidelines. The anti-icing liquid used in the system is a 26% solution of magnesium chloride ($MgCl_2$).

3.3 Wisconsin-R

3.3.1 Site Information

This installation is located on the northbound lanes of a bridge on STH-36 in Racine County, Wisconsin, and is therefore referred to as Wisconsin-R in this report. The bridge is made up of concrete girders, railing, and deck, and spans 313 feet over the Fox River in the township of Rochester (Figure 3.3). It is located at about 2.3 miles from the County Shop. Table 3.2 provides information on the Wisconsin-R installation site.

Table 3.2: General Information on Racine Site

County	Racine
Highway/Direction	S.T.H. 36 – N.B.L.
Over	Fox River
Township	Rochester
Distance from County Shop	2.25 Miles
Average Daily Traffic (2001)	6,750 vehicles
Bridge Number	B-51-78
Year Constructed	1993
Type of Construction	Concrete Girders Railing & Deck
Bridge Deck Size (W' X L')	40' X 313'

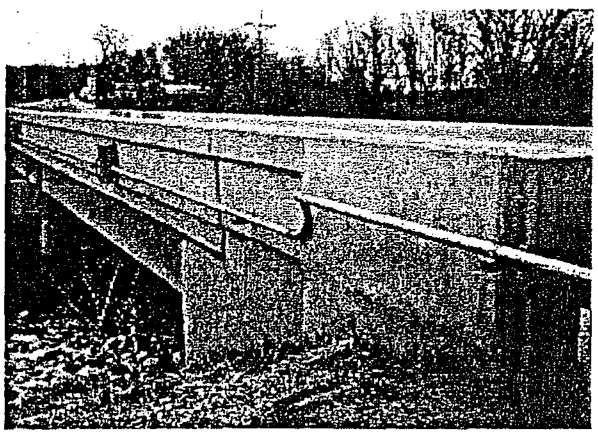


Figure 3.3: FreezeFree Nitro System Installation Site, Racine County, WI

3.3.2 System Information

The FreezeFree Nitro System in Racine County became operational in January 2001. It is activated by the Racine County Highway Department via a pager call-in number, or manually activated at the site. Pressurized nitrogen gas provides the pressure to discharge the anti-icing liquid agent through the distribution and spray system. A solar charging system provides adequate battery charge for operation of the system controller. The total amount of liquid sprayed from the seven bridge parapet-mounted nozzles and the one surface mounted bridge approach nozzle is approximately 4.2 gallons for two complete cycles of the eight nozzles (0.5 gallon/parapet nozzle/application and 0.7 gallon/surface nozzle/application). The application rate for this system is similar to that of the Kenosha County installation, which is 33 gallons per lane mile. The anti-icing material used in the system is a 26% solution of magnesium chloride, the same as the liquid agent used at the Kenosha County site.

3.4 Minnesota

3.4.1 Site Information

The Freeze Free Basic System in Minnesota is installed on 2nd Avenue West, a southbound one-way collector street in the City of Duluth. This section of the street is 1,200 feet long and 18 feet wide. The grade on this street is extremely steep. The downhill slope ranges from 15% to 18.5%, along with a sharp 200 feet radius horizontal curve located within the study area. The roadway also passes under a bridge, which shades the roadway.

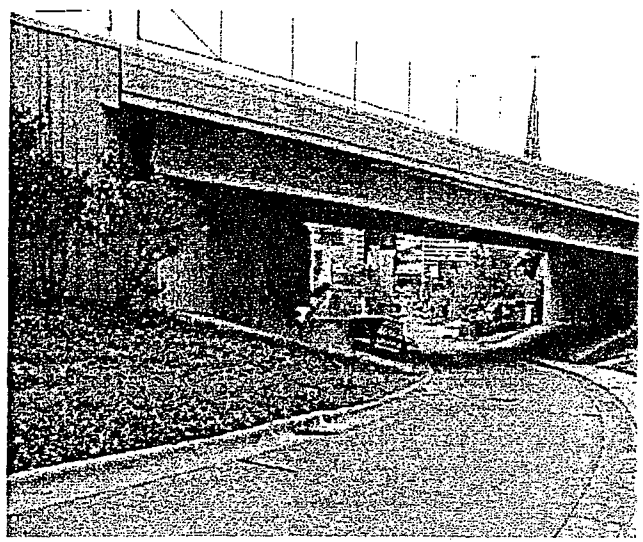


Figure 3.4: FreezeFree Basic System Installation Site, City of Duluth, Minnesota

The nearest city maintenance facility is located at about 0.65 miles from the site. This section of the street has an annual average daily traffic (AADT) of 2,500 vehicles per day (VPD), and has had 24 crashes from 1998 to 2003. The crash reports in this area are prepared by City of Duluth Police Records Bureau, State of Minnesota. Winter weather at the site is monitored by Road Weather Information System (RWIS). The average snowfall in this area is 80 inches, which normally falls from November through March. There are snow fences located on the upward prevailing wind side of the bridges towards the north of the bridge structures. Flashing beacons and signs are also located adjacent to the southbound and northbound roadways prior to approaching the bridge structures.

3.4.2 System Information

The FreezeFree Basic System installed in Minnesota includes a 700-gallon tank that holds magnesium chloride anti-icing liquid. Currently, there is no system such as a flow switch or flow meter in place to detect the flow from the tank. The system sprays once through each of the 12 flush-mounted nozzles, using approximately 15 gallons of anti-icing liquid per activation.

The Duluth system can be manually activated at the site or by telephone. There are no pavement sensors or other means of knowing what the pavement conditions are prior to activation. The decision on when to fire the system is based on the judgment of the maintenance foreman. For that reason, it may not function as a true automated anti-icing system.

3.5 North Dakota

3.5.1 Site Information

The FreezeFree Automated System in North Dakota is installed on an interstate bridge in the North-South direction on I-29 in Trail County near reference point 114. The northbound and southbound traffic is carried on two separate structures, each with a span of 330 feet, and width of 37 feet. The nearest maintenance section building is located in Hillsboro at about 10 miles from the bridge. This section of the interstate has an annual average daily traffic (AADT) of 10,210 vehicles per day (VPD), and is considered as an area with high crash rate. Winter weather at the site is monitored by a Road Weather Information System (RWIS). Typical winter conditions normally consist of 50 to 60 inches of snow, with frequent blowing snow and freezing temperatures from November through March. There are snow fences located on the upward prevailing wind side of the bridges towards the north of the bridge structures. Flashing beacons and signs are also located adjacent to the southbound and northbound roadways prior to approaching the bridge structures.

Figure 3.5: FreezeFree Automated System Installation Site, Trail County, ND

3.5.2 System Information

The FreezeFree Automated System installed in North Dakota consists of a total of eight flush mount spray nozzles installed at 40 feet spacing on each bridge, along with two (2) additional side-mounted nozzles on the w-beam guardrail on the entrance end of each bridge. The system has a 500-gallon storage tank, and it disperses approximately 0.6 gallons per nozzle or about 12 gallons per activation cycle. A flow switch was added to confirm flow through the pump due to system activation. The anti-icing liquid used is a potassium acetate based product with corrosion inhibitors. The system is automated with a manual override capability by phone, cell phone, computer, or manual switch in the pump house. The monitoring software initially used was ScanWeb 3.1, which was later upgraded to ScanWeb 3.3. An FP-2000 passive sensor was installed to provide the automatic sensing for the system.

3.6 Oregon

3.6.1 Site Information

The project site is located on US Highway 26 in the Cascade Range Mountains. This highway is designated as a Statewide Highway, which runs from the Pacific Ocean through the Coast Range Mountains east to the center of the state. The site is approximately 25 miles inland from the Pacific Ocean, with an elevation of 1,147 feet, and 24 miles from the Manning Maintenance station.

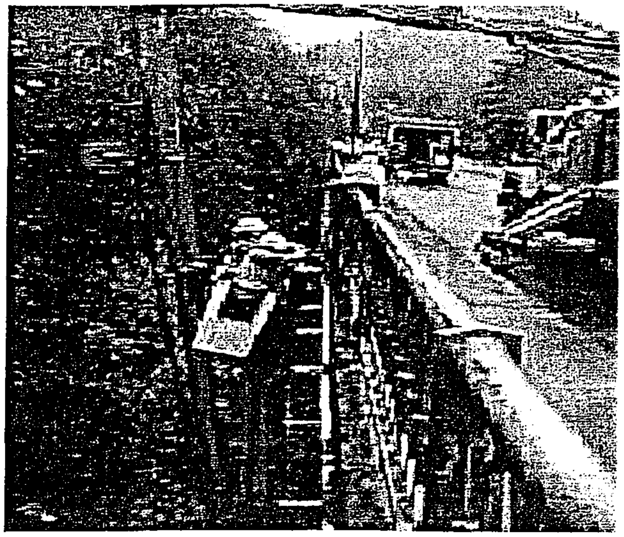


Figure 3.6: FreezeFree Automated System Installation Site, Quartz Creek Bridge, OR

The FreezeFree Automated System is installed on an 835 foot long, 26 foot wide steel girder bridge that crosses over Quartz Creek which is fifty feet below. The structure has a 4.4% longitudinal profile with a 7% cross slope and is on a 2½ degree curve. The Quartz Creek structure crosses between two tall ridges that are heavily wooded combined with the trees adjacent to the structure, which have grown well above the structure. The structure is well shaded during the winter months. The presence of moisture or precipitation is a common occurrence, and it will typically freeze in the early and late hours of the day when the temperatures have dropped to the 32°F range.

During the months of November through March this structure has a tendency to ice up well before the adjacent roadway. This portion of the highway has an average daily traffic count of around 6,800 vehicles per day. The crash data shows there have been nine injury crashes on the structure from February 2001 through March 2003.

3.6.2 System Information

The FreezeFree System installed at this location consists of twenty-five side spray nozzles and valve boxes, spaced on forty foot centers, and an in-ground concrete vault for the electronic components. Magnesium chloride is the selected anti-icing material to be used and is stored in a 750-gallon tank within the concrete vault.

This system is self-activated and is interconnected with an existing RWIS system and also utilizes the pre-existing in-deck sensors for activation. When the system is activated, each of the twenty-five nozzles will apply 0.5 gallons/nozzle or 12.5 gallons of a 30% solution of magnesium chloride through two complete cycles. This is equivalent to a rate of 33 gallons per lane-mile.

3.7 California

3.7.1 Site Information

The installation site is located on State Route 2 in the East-West segment outside of Los Angeles, California. The length of the test section is 1,200 feet, with a width of 24 feet for travel. The nearest maintenance station is located at about 15 miles from the test site. This section of the highway has an annual average daily traffic (AADT) of 1,300 vehicles per day (VPD). The California Highway Patrol (CHP) is the agency responsible for processing collision reports for this location.

Figure 3.7: FreezeFree Automated System Installation Site, Los Angeles, CA

3.7.2 System Information

The installation of the system began in August 2003. The construction has not yet been completed. The primary reason for this delay in installation is related to getting the necessary permits for utilities (electrical power and telephone service) to serve the installation. Also, since the site falls within Angeles National Forest, a construction permit was required from the U.S. Forest Service.

The system under installation in California consists of 13 side-mounted nozzles on guardrail, spaced 37.5 feet apart, and 18 flush-mounted nozzles spaced 40 feet apart. A pavement sensor is installed at approximately 50 feet from the pumping station. The system includes a 400-gallon storage tank that holds Cryotech CF7, a potassium acetate-based anti-icing liquid. The software that will be used for collecting and viewing the data is ScanWeb.

It is important to note that since the installation of the system at the site in California was not complete at the time of preparation of this report, data and observations from that site could not be included as part of this evaluation.

3.8 Summary of Test Site Characteristics

Table 3.3 summarizes the characteristics of each of the test sites and installations.

Table 3.3: Summary of Test Site Characteristics

State	Location	Installation Type	Length (ft)	System Type	Type of Pavement Sensor	On-Site RWIS	Number of Nozzles	Nozzle Type	Anti-Icing Chemical [13]
MD	I-68 over S.R. 55, Clarysville, MD	Bridge	708 EB 744 WB	Auto	Passive & Active	Yes	85	Side	KAc
WI	S.R. 50 EB over Des Plaines River, Kenosha County, WI	Bridge	138	Auto	Passive & Active	No[14]	6	Side	$MgCl_2$
WI	S.R. 36 NB over Fox River, Racine County, WI	Bridge	313	Nitro	N/A	No	8	Flush & Side	$MgCl_2$
MN	2nd Avenue West, Duluth, MN	Pavement	400	Basic	N/A[15]	No	12	Flush	$MgCl_2$
ND	I-29 over Burlington Northern R.R., Buxton, ND	Bridge	300	Auto	Passive & Active	Yes	10	Flush & Side	KAc
OR	I-84 EB, M.P. 41.5, Cascade Lakes, OR	Bridge	800	Auto	Passive	Yes	25	Side	$MgCl_2$
CA	Angeles Crest Hwy. S.R. 2, Ladybug Curve, Los Angeles, CA	Pavement	1,250	Auto	Passive & Active	Yes	13	Flush & Side	KAc

[14] Kenosha County site in Wisconsin has an RWIS installed, but it is not a part of the FreezeFree system
[15] Minnesota site has a pavement sensor installed, but it is not a part of the FreezeFree system

Chapter 4: Installation

This chapter documents the system installation at various sites, along with *anecdotal ratings* representing the views of personnel responsible for managing and installing the system at each of the sites. The installation of storage, delivery, command, and reporting elements of the system was rated by the test site representatives by selecting from a list of five (5) choices, as shown in Figure 4.1 below.

Hydraulic System	*Storage Element (such as storage tank, pump-house, etc.)*	✓ Good ✓ Above Satisfactory ✓ Satisfactory ✓ Below Satisfactory ✓ Poor
	Delivery Element (such as pump, pipes, solenoids, nozzles, etc.)	
Control System	*Command Element (RPU)*	
	Reporting Element (Web-based reporting software)	
Overall		

Figure 4.1: Anecdotal Rating of System Components

4.1 Maryland

In August 2001, the Maryland State Highway Administration (MDSHA) applied to the Highway Innovative Technology Evaluation Center (HITEC) for consideration of federal funding to install and evaluate the effectiveness of FreezeFree System on the Clarysville bridges located on Interstate 68 in Clarysville, Maryland. The application was approved in December, 2001, for a fully automated FreezeFree System. The system was purchased from National Capital Industries of Bladensburg, Maryland. The vendor was given a "Notice to Proceed" on December 3, 2001.

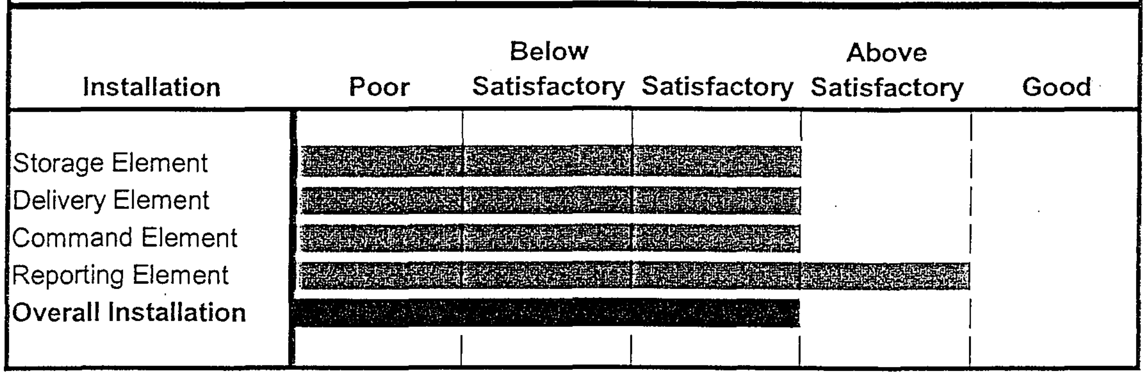
The system was installed by H&W Contracting of Raleigh, NC between January 28, 2002 and March 25, 2002. A total of 18 working days were required to install the various components of the System. The Road Weather Information System (RWIS) was installed by Global Specialties of St. Louis, MO on March 21-25, 2002. The RWIS was commissioned by Surface Systems Inc. (SSI) on April 2, 2002 and the spray system was commissioned by Energy Absorption on April 17, 2002.

The total cost of the system was approximately $265,000. Details on the system are provided in Section 3.1.2.

Based on the overall experience at the Maryland site, the MDSHA representative(s) rated the installation of the FreezeFree Automated System as follows:

Summary of Experience in System Installation

State: Maryland | **System Type:** Automated | **Number of Nozzles:** 85



Comments on Ratings from Site Representative(s)

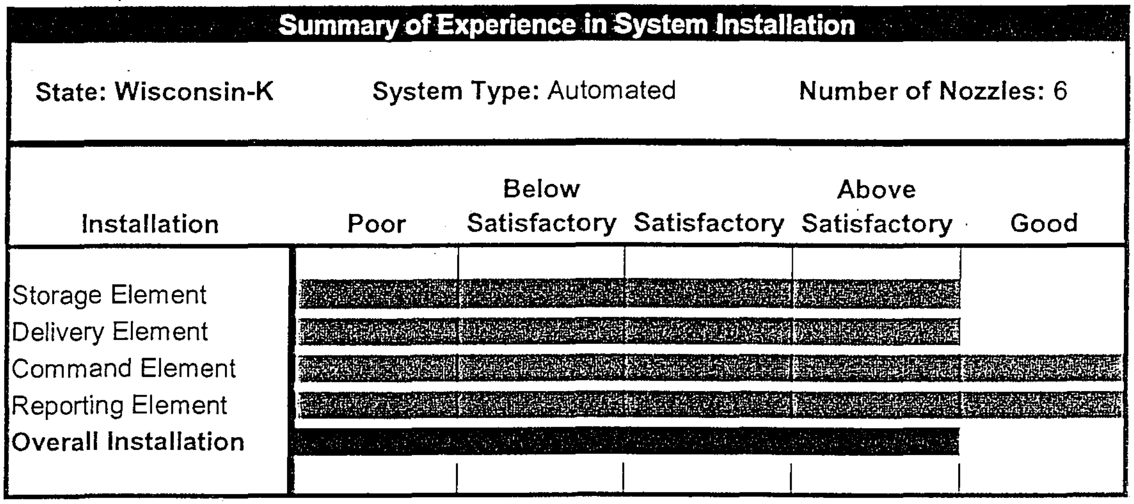
- Lack of site-specific plans caused the ordering of the incorrect amount of material which in turn caused a delay in the completion of the project.
- It took from 1-28-02 to 4-17-02 for complete installation and commissioning

4.2 Wisconsin-K

In October 1999, a representative of Energy Absorption Systems, Inc. approached the Wisconsin DOT with a proposal to form a partnership for the installation of a FreezeFree bridge deck anti-icing system on a selected bridge deck on the state highway system in southeastern Wisconsin. An agreement was reached whereby Energy Absorption Systems, Inc. would provide the materials and labor for this pilot installation and Wisconsin DOT, with assistance from the Kenosha County Highway Department, would provide site preparation work, electrical and telephone utility installations, and a supply of anti-icing material for the system. The installation began in October 1999 and the system was completely operational in January, 2000. The estimated installed cost of this system was approximately $50,000. Site work and utility installations provided by the Kenosha County

Highway Department and Wisconsin DOT were estimated to be less than $3,500. Details on the system are provided in Section 3.2.2.

Based on the overall experience at the Wisconsin-K site, the WisDOT representative(s) rated the installation of the FreezeFree Automated System as:



Comments on Ratings from Site Representative(s)

- Had to span bridge deck expansion joints with flexible conduit during installation.
- There was always live power on the bridge during installation. Had to install a relay switch so that the valve circuit was only energized when the pump was running.
- Had to address WisDOT P.C. firewall issues in order to get access to the system computer and data. WisDOT IT unit does not support PC Anywhere software.

4.3 Wisconsin-R

In November 2000, Energy Absorption Systems, Inc. approached Wisconsin DOT with a proposal to install a FreezeFree Nitro bridge deck anti-icing system on a selected Wisconsin state highway system bridge deck. As with the Kenosha County installation, an agreement was developed whereby Energy Absorption Systems, Inc. provided the materials and labor for this installation and Wisconsin DOT, with assistance from the Racine County Highway Department, provided site preparation work, bottled nitrogen gas, and a supply of anti-icing liquid material for use in the system.

Installation of this system began in November, 2000 and the system was operational in January, 2001. The estimated installed cost of this system was approximately $21,000. Site work performed by the Racine County Highway Department amounted to less than $500. Details on the system are provided in Section 3.3.2.

Based on the overall experience at the Wisconsin-R site, the WisDOT representative(s) rated the installation of the FreezeFree Nitro System as:

Summary of Experience in System Installation					
State: Wisconsin-R	System Type: Nitro			Number of Nozzles: 8	
Installation	**Poor**	**Below Satisfactory**	**Satisfactory**	**Above Satisfactory**	**Good**
Storage Element	■	■	■	■	■
Delivery Element	■	■	■	■	■
Command Element	■	■	■	■	■
Reporting Element			N/A		
Overall Installation	■	■	■	■	■

Comments on Ratings from Site Representative(s)

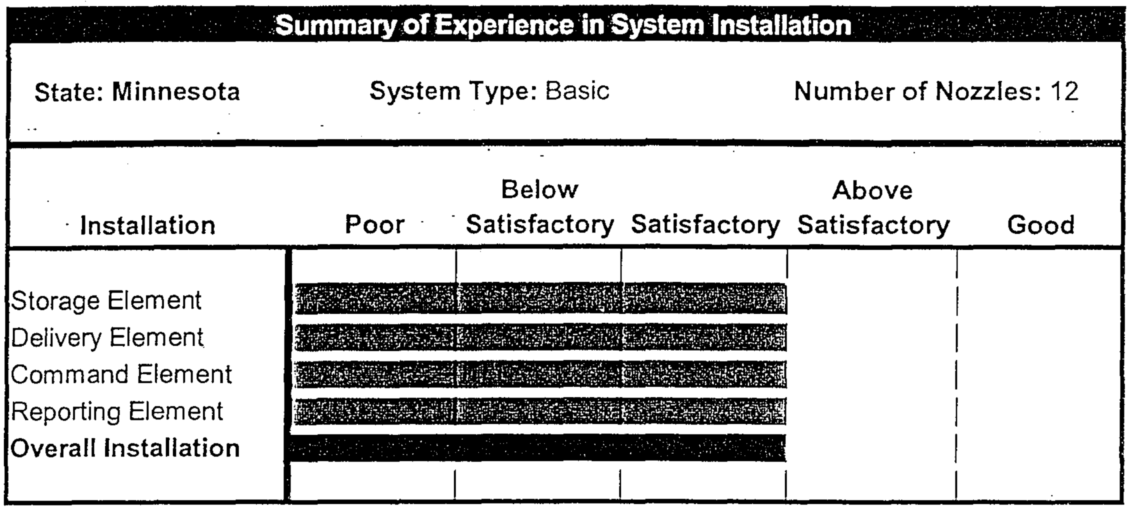
- No reporting system at this site due to lack of power source.

4.4 Minnesota

The FreezeFree System in Minnesota was installed in October 2001, and became operational in 30 days. Polyphase Electric Inc. of Duluth, Minnesota served as the prime contractor for installation. Concrete work for the pump house was done by their laborers. Saw cutting of the concrete pavement for the flush nozzles was sublet. Permits for electrical work were issued by the City of Duluth. Traffic Technologies of Minneapolis, Minnesota were the suppliers of anti-icing components.

The total installation cost was $77,335. Out of this amount, $39,750 was spent on hardware, and $37,585 was spent on labor. The annual costs for electricity and telephone are $93 and $82 respectively. It would cost the city more than the monthly billing costs to deactivate the power and telephone each season. Details on the system are provided in Section 3.4.2.

Based on the overall experience at the Minnesota site, the MNDOT representative(s) rated the installation of the FreezeFree Basic System as:



Comments on Ratings from Site Representative(s)

- There were problems with the solenoid boxes filling with water and freezing. The problem was later resolved, however, thorough site evaluation is required in this area before installation.
- Some mechanical and electrical problems were experienced with the installation of the new active sensor.

4.5 North Dakota

The FreezeFree System was installed at the test site in North Dakota in the fall of 2002, and put into operation on December 17, 2002. A contract was established between NDDOT and Traffic Technologies for the installation of the system. Other parties involved included Global Specialties, SSI, Quixote, and Qwest Communications. The contractor was required to get a permit from Burlington Northern Railroad to get clearance while working over the railroad tracks, which are located under the bridge.

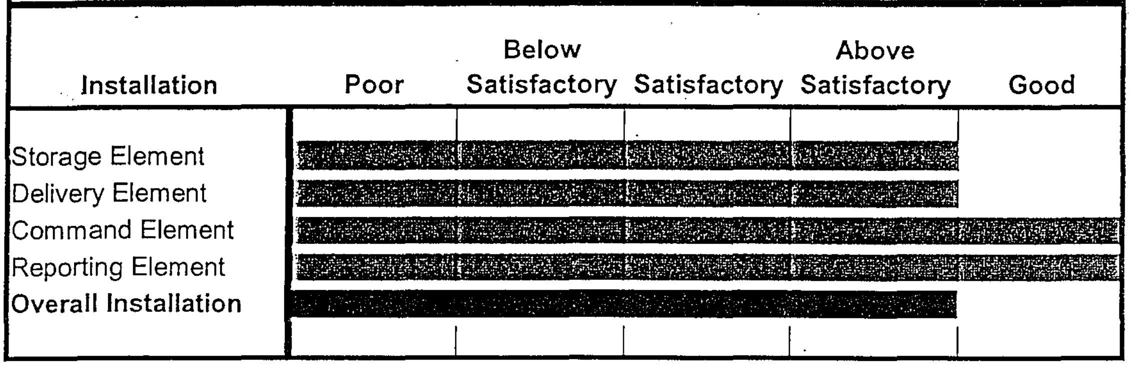
The system took approximately two months to install and put into operation. NDDOT was required to upgrade its ScanWeb software to Version 3.1 as part of the project. A flow switch was installed to verify that liquid actually flowed through the pump. A voice dialer was also added which gave a recorded message to a designated phone number that provided notification of when the system fired.

The initial cost of the system was approximately $169,000. The final installation costs totaled about $173,000. Additional costs included an RPU enclosure, railroad insurance, and phone line costs. Details on the system are provided in Section 3.5.2.

Based on the overall experience at the North Dakota site, the NDDOT representative(s) rated the installation of the FreezeFree Automated System as:

Summary of Experience in System Installation

State: North Dakota | **System Type:** Automated | **Number of Nozzles:** 10



Comments on Ratings from Site Representatives

- The pump house installation is fairly easy. It consists of pouring a flat slab and setting a building on top.
- The installation of the delivery equipment is fairly easy.
- The RWIS and sensor installation is fairly simple.
- The installation of the ScanWeb software is easy.
- Installation of the system was done by a contractor and appeared to be fairly simple.

4.6 Oregon

The FreezeFree System in Oregon was installed utilizing Oregon Department of Transportation work forces. ODOT's Region 1 Electrical Crew, West Region 1 Bridge Maintenance Crew and District 2A Manning Maintenance Crew began installation at the beginning of November 2002 and the system was completed in late November.

Figure 4.2: Working Conditions During System Installation

The Manning Crew excavated and installed the concrete vault, provided the common trench for the communication lines, liquid line and power line, and provided one-way traffic control for work on the structure (Figure 4.2).

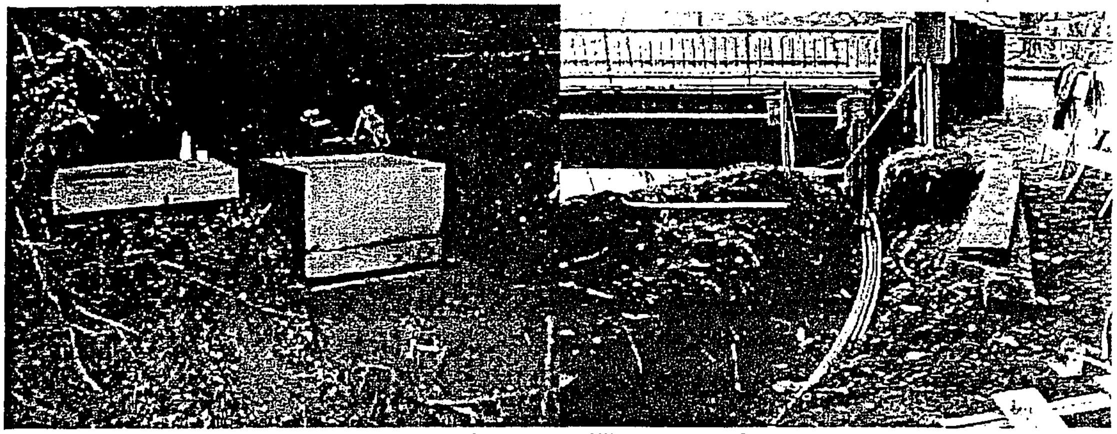


Figure 4.3: Installation of Concrete Vault and Communication Lines

The Region 1 Electrical Crew in conjunction with the Bridge Crew mounted and installed the conduits and valve boxes along the north edge of the structure overhang. This work was accomplished using two Snooper Crane trucks. Two bridge crew members, working out of a snooper-crane truck basket, led the way by mounting the support brackets for the conduits to the side of the overhang.

Figure 4.4: Mounting of Support Brackets for the Conduits to the Side of the Overhang

Two electricians followed in the other Snooper Crane truck installing the conduits, mounting the valve boxes, installing the communication wire and liquid line and completing the assembly inside the box before moving on toward the next valve box location. All parts were installed at the same time in an attempt to save time with only one crossing of the structure with the slow moving Snooper cranes and cause the least disruption to traffic.

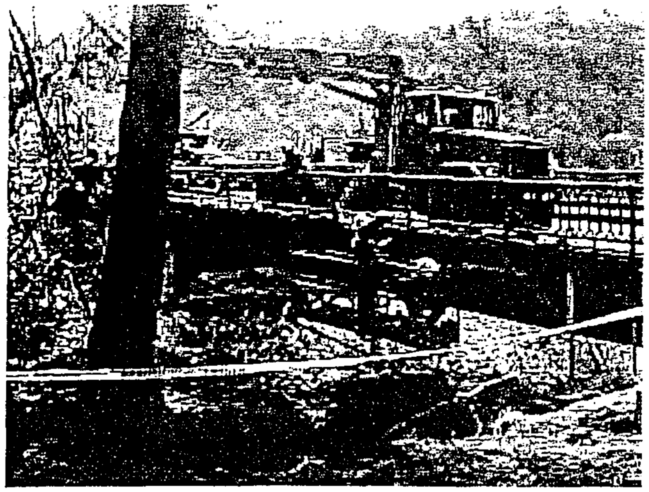


Figure 4.5: Another View of Installation Using a Snooper Crane

The installation of the conduit supports, the twenty-three valve boxes, conduits, hoses and wiring, on the north side of the structure, took a total of four days to complete. An additional nine days were needed to finish installing the two remaining valve boxes, on the south side, laying the underground conduits, modifying the existing power service and installing the components inside the vault. An additional box was added on the west end as a junction box to supply liquid to the south side nozzles in lieu of running the liquid line to the first valve box on the west end and piping back to the third nozzle. This design change eliminated the need for the approximately one hundred feet length of additional liquid line, conduits and communication wire, and the corresponding support brackets. The ODOT Electrical Crew installed all the components within the vault along with the necessary conduits and wiring.

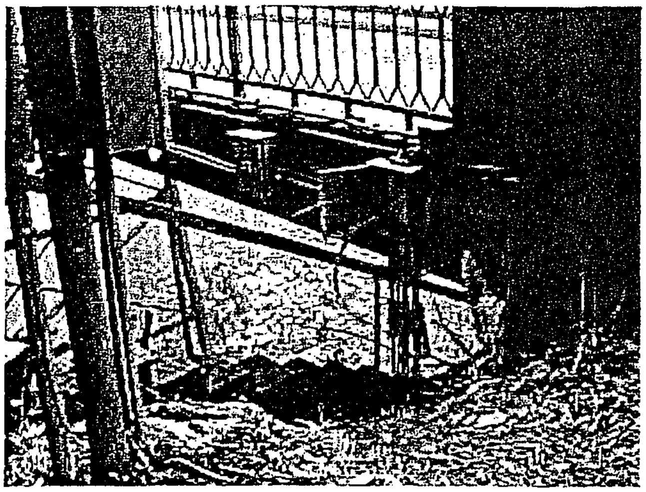


Figure 4.6: Solenoid Valve Boxes Installed at the Side of the Bridge

The estimated cost of this system was approximately $165,000. Details on the system are provided in Section 3.6.2.

Based on the overall experience at the Oregon site, the ODOT representative(s) rated the installation of the FreezeFree Automated System as:

Summary of Experience in System Installation

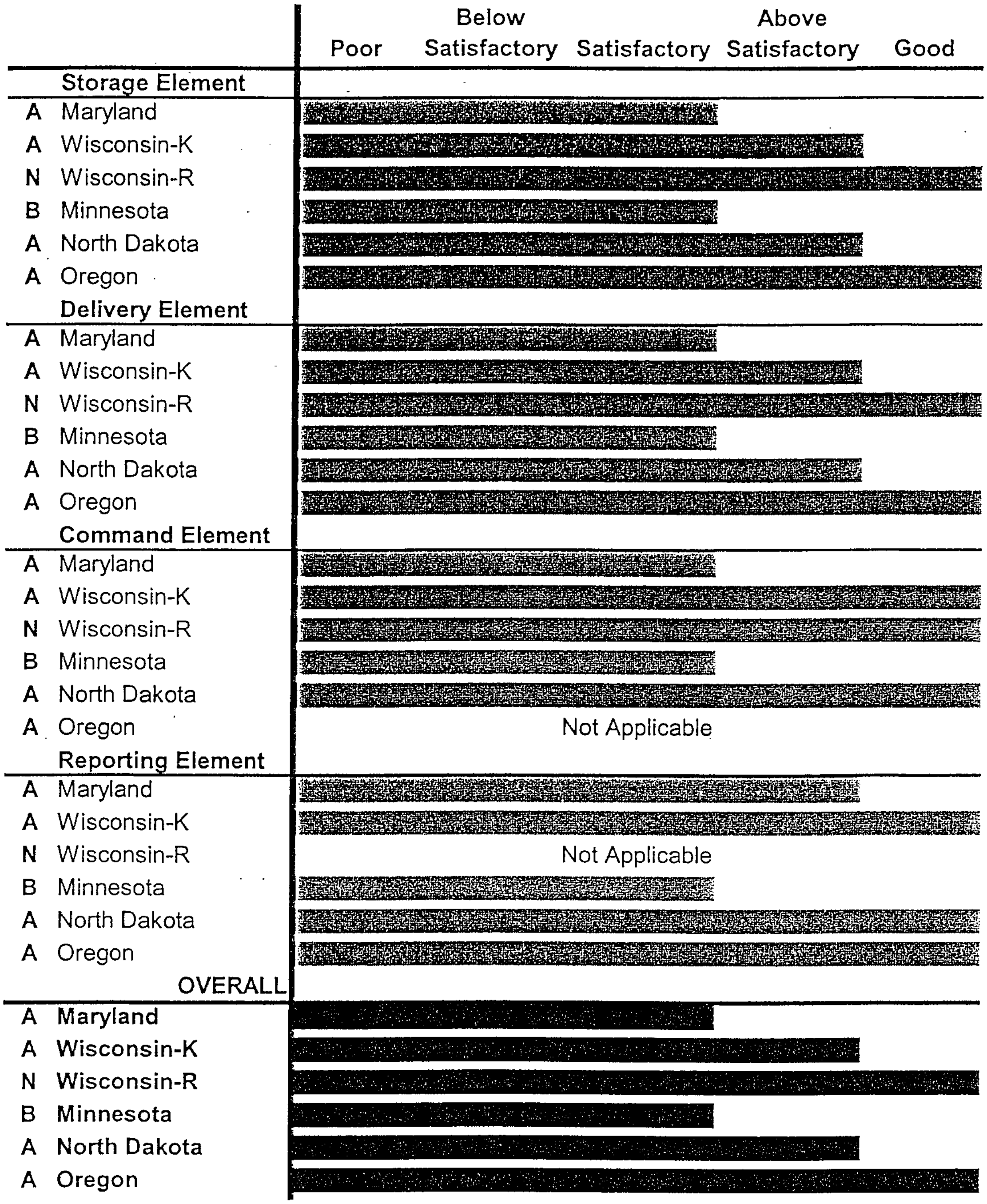
State: Oregon | **System Type:** Automated | **Number of Nozzles:** 25

Installation	Poor	Below Satisfactory	Satisfactory	Above Satisfactory	Good
Storage Element					
Delivery Element					
Command Element	Installation performed by outside representative. Rating information not available				
Reporting Element					
Overall Installation					

**No comments on ratings from site representative(s)*

4.7 Summary of Ratings for System Installation

Figure 4.6 shows a summary rating of system installation based on the input received from the representatives and personnel responsible for the test sites.



A = Automated; B = Basic; N = Nitro

Figure 4.7: Summary of System Installation Ratings

Chapter 5: Operation & Maintenance

This chapter briefly introduces the operation of the FreezeFree system as described by the manufacturer, followed by the recommended periodic maintenance of the various components of the system. It then documents a summary of experience with operation and maintenance of the system at the test sites for the past winter seasons, highlighting any operational and maintenance issues that were encountered, and the corrective actions that were taken. As mentioned earlier in this report, each test site is unique in terms of the type of installation. Moreover, at each site, the system has evolved over time due to various repairs, replacements, adjustments, and upgrades. That is why, in addition to presenting a summary of experience with operating and maintaining the system at each of the sites, *anecdotal ratings* representing the views of personnel responsible for operating, and maintaining the system at each of the sites are presented at the end of this chapter.

5.1 Operation

The FreezeFree System operates under a simple sequence of events from the point of activation. It dispenses a liquid anti-icing agent by pumping the chemical through a series of high-pressure spray nozzles, individually controlled by a series of solenoid valves. Upon activation, the system energizes a motorized pump and automatically sequences the solenoid valves to spray the anti-icing liquid over the targeted area. A programmable controller activates the motorized pump to bring the system to its operating pressure. An anti-icing chemical is circulated by the pump through an overpressure relief valve back to the storage tank to provide agitation of the solution. A series of solenoid valves is then sequentially opened and closed to purge air from the system and dispense the anti-icing chemical. The anti-icing cycle is automatically activated, and can also be initiated remotely via telephone, or by manually pushing a button at the controller assembly.

Automatic activation of the FreezeFree Automated system is provided with an ice prediction system employed to accurately measure pavement surface conditions. The ice prediction system utilizes a pavement sensor that uses electrical conductivity measurements, surface temperature, and optical measurements to determine the surface state. Depending on the particular system design, atmospheric sensors may also be employed. From the measured data, water-layer thickness, depression of the freezing point, and chemical concentration are calculated to provide ice and frost warning conditions. A computer algorithm uses the measured and calculated data to automatically activate the FreezeFree Automated system when icing conditions are predicted.

In the case of the FreezeFree Nitro System, upon activation by manual push-button or remote pager, the fluid levels in the pressure tank and storage tank are checked. If the storage tank level is adequate, a vent opens on the pressure tank assembly to bleed off any system pressure. After 2 ½ minutes, a supply valve opens to allow anti-icing chemical to flow by gravity from the storage tank to the pressure tank. When the pressure tank is filled, a solenoid valve on the gas regulator assembly opens and nitrogen pressurizes the system until the system operating pressure (150 psi) is reached. The spray valves are sequentially opened for one second each, one second apart. Upon completion of the spraying cycle, the system re-pressurizes to 150 psi and completes a second spray cycle.

5.2 Maintenance

Periodic maintenance of various components of the FreezeFree System is recommended by the system manufacturer for smooth operation of the system. These include pump, solenoid, spray nozzles, storage tank, strainer, and other key components. Table 5.1 shows the recommended maintenance schedule for FreezeFree Basic and Automated Systems, followed by Table 5.2 showing the recommended maintenance schedule for the FreezeFree Nitro System. It is important to note that the information provided in Table 5.1 and 5.2 is a representative listing of typical maintenance requirements. For detailed information on maintenance requirements, the reader is recommended to refer to the FreezeFree user manual, and also to the manufacturer recommendations for maintenance of various command element components such as RWIS and active and passive pavement sensors.

Table 5.1: Preventative Maintenance Schedule for FreezeFree Basic and Automated Systems

	Monthly	Decommission	Commission	Upon Occurrence of an Incident[17]
Confirm Operation	X	X	X	X
Inspect Pump	X	X	X	
Inspect Solenoid Valves		X	X	X
Inspect Spray Nozzles	X		X	X
Inspect Storage Tank	X		X	
Inspect/Clean Strainer	X		X	
Flush System		X		

Table 5.2: Preventative Maintenance Schedule for FreezeFree Nitro Systems

	Monthly	Decommission	Commission	Upon Occurrence of an Incident
Confirm Operation	X	X	X	X
Inspect Pump	X	X	X	
Inspect Solenoid Valves		X	X	X
Inspect Spray Nozzles	X		X	X
Inspect Storage Tank	X		X	
Inspect/Clean Strainer	X		X	
Nitrogen Bottles	X		X	
Charge Controller	X		X	
Solar Panel			X	
Inspect Solar Charging System		X		
Flush System			X	

[17] Upon occurrence of an incident resulting in system damage

5.3 Summary of Experience at the Test Sites

This section summarizes the experience of the personnel at the test sites in operating and maintaining the system. The information presented, for the most part, was summarized from the documents submitted directly by the site representatives, and from information gathered from electronic and telephonic communication with the site representatives and field personnel.

5.3.1 Maryland

The Maryland State Highway Agency (MDSHA) representative(s), who are responsible for the operation and maintenance of the FreezeFree system, provided the following comments and observations:

a) Winter 2002 – 2003

October 18, 2002 to December 27, 2002

The system activated a total of 22 times during this time period. Several mechanical problems were experienced during this time period. MDSHA also had some difficulty understanding why the system was activating (or not activating) when certain weather conditions existed as indicated by the data that was being reported by the ScanWeb interface. Problems during this time period included:

- An activation on October 18, 2002 did not log into the Device History. The RPU was monitoring the wrong analog input channel. This problem was corrected by SSI from their St. Louis office.
- The system sprayed the westbound span only and would not shut off. The problem was identified as excessive voltage between the RPU and the spray controller. SSI installed a new Viking 2000 dialer and a 5 Volt power supply to correct the problem. The system was down from October 22, 2002 until October 31, 2002 because of this problem.
- On November 4, 2002, it was discovered that the tank was losing fluid. The tank level had dropped by 44 gallons between November 1, 2002 and November 4, 2002 and the system had not activated according to the Device History. SSI personnel came to the site on November 8, 2002 after MDSHA personnel had found the leak at nozzle D7. The leak was stopped by disassembling and cleaning the solenoid assembly.
- On November 15, 2002, MDSHA manually activated the system. Nozzle B12 began spraying continuously. The problem was identified as a bad address module in the valve control box. The system was down from November 15, 2002 until November 22, 2002, waiting for a new address module to be installed.
- It was observed that some side-mounted nozzles had rotated, resulting in misdirected spray. This problem was fixed by grouting in the holes drilled to install the nozzles.

Some of the questions raised by MDSHA when they looked at the data being reported from the ScanWeb site included:

- Why was the system not activating in a "Snow Ice Warning" surface status?
- Why was the data indicating an activation when there was none?
- Why was the system activating when the surface status was "Wet" or "Chemical Wet"?

During this time period, there were two significant storms. From December 4, 2002 through December 6, 2002, a total of 7 inches of snow was received (the system activated 3 times). On December 24, 2002 and December 25, 2002, a total of 7 inches of snow was received (the system activated 2 times).

December 27, 2002 to March 4, 2003

The Freeze Free System did not function properly during this time period. The RPU called for the sprayer to activate a total of 77 times but there was no response. At the January 8, 2003 meeting SSI could not give a definitive answer as to why the system was not working. They proposed to improve the system by installing new ESS software along with active sensors. These improvements would hopefully allow MDSHA staff to have a better understanding of the spray logic when the system activates. SSI advised that it may be the summer of 2003 before these improvements could be implemented.

- On January 17, 2003, Energy Absorption advised that they believed the existing problem with the system was being caused by a faulty Relay 8 module. On January 21, 2003, a new Relay 8 module was installed. MDSHA advised that the system should now function properly.
- On January 22, 2003, the system activated automatically 4 times during late morning. It was discovered that nozzle E6 was spraying continuously and the system was spraying a dry bridge deck. The precipitation sensor was indicating precipitation although it was sunny and clear. The system was shut down and SSI was advised.
- On January 28, 2003, Contracting Technology Inc. of Imperial, Missouri installed two Frensor active sensors and one FP 2000 passive sensor. SSI installed a new address module at nozzle E6. The system was test-fired prior to installing the active sensors so the spray pattern could be viewed. This allowed the contractor to properly position the sensors. Upon activation, deicer fluid gushed from valve control box B7 (the ¾" supply line had come off the solenoid assembly). After repairs were made at B7, the system was activated again. Nozzle E5 sprayed continuously. It was disabled by removing the fuse in the valve control box, and the system was activated again. This time Nozzle B8 sprayed continuously. The system was shut down. There was no further action taken at the site by the vendors until March 4, 2003.

During this time period (December 27, 2002 to March 4, 2003) a total of 78 inches of snow was received, and the RPU called for the sprayer to activate 77 times.

March 4, 2003 to April 9, 2003

On March 4-7, 2003, representatives from Energy Absorption, SSI, National Capital Industries and H& W Contracting were on site. They performed the following:

- Inspected all valve control boxes for leaks.
- Placed hose clamps on all ¾" connections at the solenoid assemblies.
- Installed new address modules at E5 and B8.
- Caulked around spray nozzles to prevent rotation. Calibrated the active sensors.
- Updated the RPU code to ESS 1.6.
- Installed new processor board and power supply.

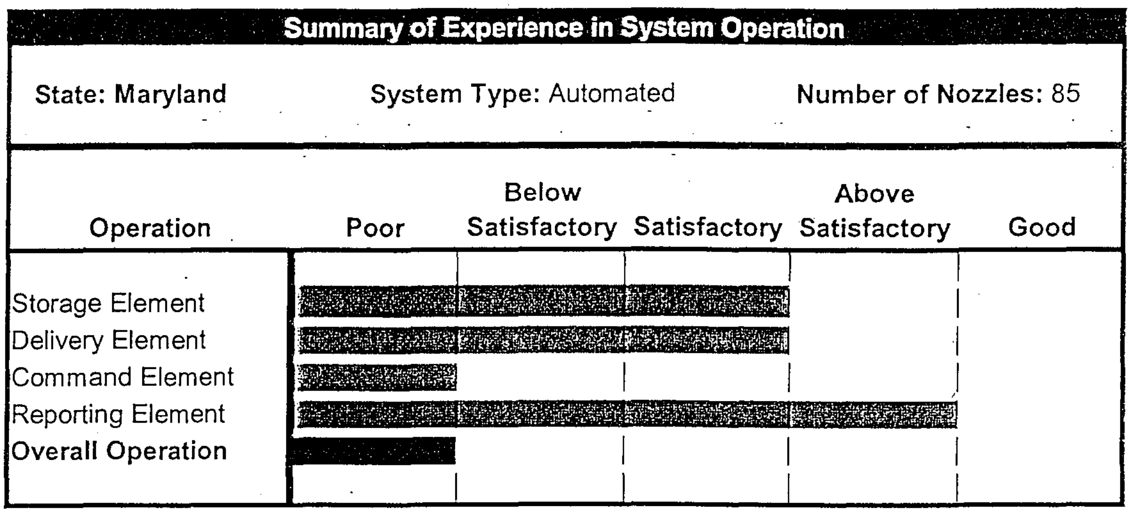
The system was test-fired three times (twice manually at the site and once remotely from St. Louis). There were no visible problems during the three activations. From March 6, 2003 to April 9, 2003, the system activated 25 times. There were no problems experienced with the nozzles, connections, address modules, etc. However, the precipitation sensor had a recurring problem. It indicated precipitation when there is none. MDSHA continues to have difficulty understanding the spray logic when compared to actual conditions that existed when the system activated.

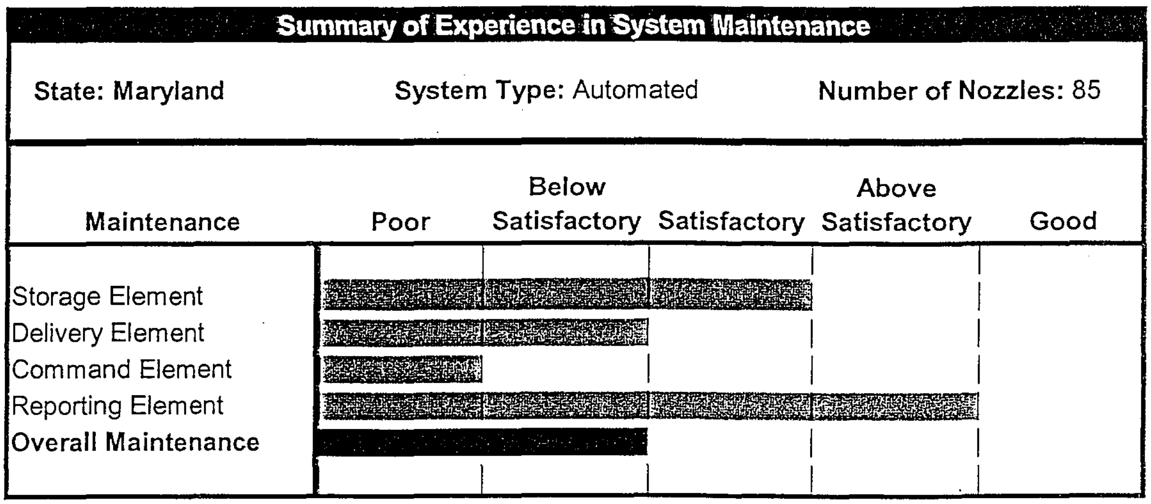
b) Winter 2003-2004

- The FreezeFree System was re-commissioned on November 4, 2003. During the winter of 2003-2004, a total of 74 inches of snow was received at the site. The system activated a total of 137 times between November 13, 2003 and April 2, 2004.
- The system did not experience any significant mechanical problems during this period. During re-commissioning, three address relays and one solenoid were replaced.
- The main concern centered on the inability of active sensors to report a freeze point at the onset of deck coverage. The significance of this situation is that the system has to have a freeze point to compare to the surface temperature before the spray system can activate. Maryland State Highway Administration (MDSHA) has recorded and documented a number of instances where the system had not activated even after receiving heavy snow squalls on the deck.
- In February of 2004, based on the recommendation of the manufacturer of the active sensor, SSI representative advised MDSHA to add two additional sensors. This suggestion was accepted by MDSHA. They are currently waiting to get an installation date from SSI.

c) Anecdotal Rating

Based on the overall experience at the Maryland site, the MDSHA representative(s) rated the FreezeFree Automated System as:





Comments on Ratings from Site Representative(s)

- Had to replace several address modules during first winter.
- System was down for 3 weeks during October & November of 2002 waiting for response to various problems.
- System was down completely from 12-27-02 to 3-4-03
- During the winter of 03-04, the active sensors did not provide a freeze point at critical times (when the deck first covers with frozen precipitation).
- The ScanWeb reporting system worked very well and presented the data in a clear, easy-to-understand format.

5.3.2 Wisconsin-K

The County Highway Department personnel from Kenosha County, who are responsible for the operation and maintenance of the FreezeFree system, provided the following comments and observations:

a) Prior to 2003-2004 Winter Season

- After the system became operational in January, 2000, there were no opportunities to activate the system during the remainder of the 1999-2000 winter season.
- Due to over-activation of the system, WisDOT personnel requested that the automatic activation codes be changed in October 2000 and December 2000 to be more representative of winter weather in Kenosha County.
- The tank level monitor failed and the motor had to be replaced after it burned out. Minor warranty work was performed by Energy Absorption Systems, Inc. personnel on the system equipment.
- There was some damage caused to the telephone line and electrical wiring installation due to rodents entering the pump house.
- In general, the system worked well. The automatic activation parameters were more consistent. The Vaisala moisture sensor worked well, and the system did not over activate.

b) 2003-2004 Winter Season

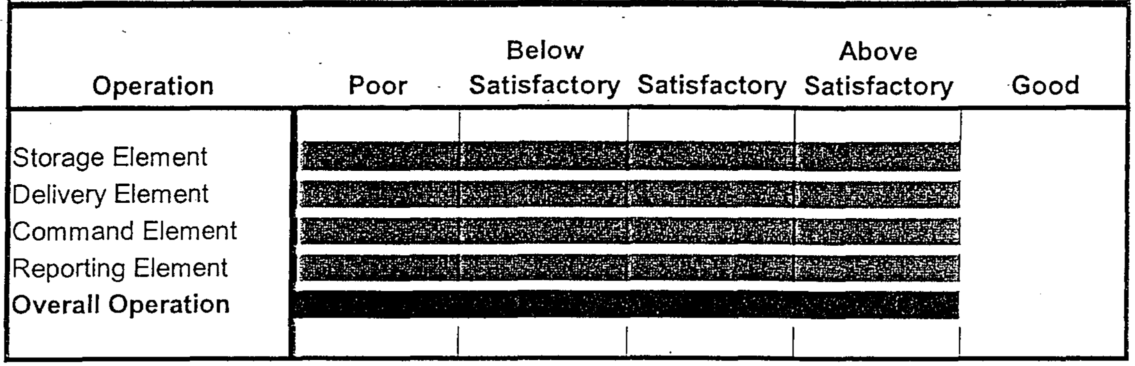
- In 2003-2004 winter season, all nozzle plungers were replaced by units treated with zinc coating because the spray nozzles had become inoperative due to corrosion of the nozzle plunger by the magnesium chloride product.
- The system was more reliable than the past winter seasons. The pump house was sealed to prevent rodents from accessing the wiring. Activation parameters were kept the same as those of the previous season.
- There were various problems encountered with the voice dialer during this period. These problems were related to over-reporting of "low fluid" notification, and the system consistently not reporting spray activation. The voice dialer was later repaired, but it continued not reporting spray activation. It was learned that the pressure gauge was not reading properly, and was not providing proper pressure to activate the dialer. There were also incidents when the dialer reported system activation when none had occurred according to the spray log history. These problems were resolved in February 2004, and did not occur since then.

c) Anecdotal Rating

Based on the overall experience at the Wisconsin-K site, the WisDOT representative(s) rated the FreezeFree Automated System as:

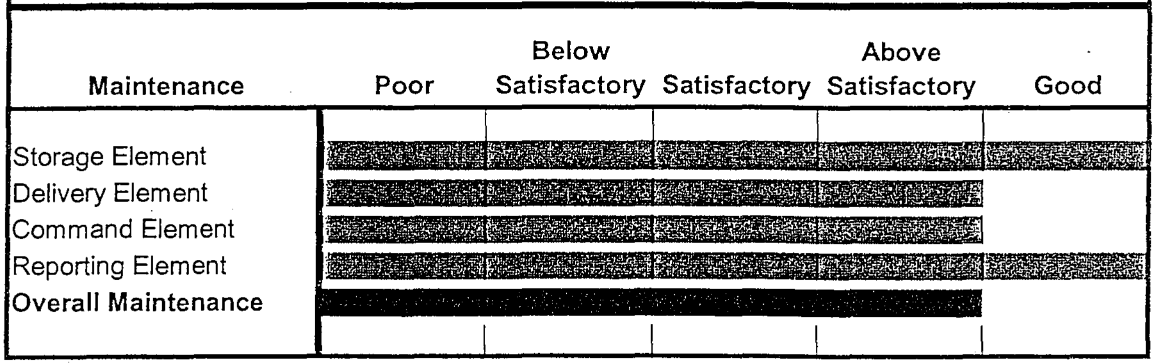
Summary of Experience in System Operation

State: Wisconsin-K **System Type:** Automated **Number of Nozzles:** 6



Summary of Experience in System Maintenance

State: Wisconsin-K **System Type:** Automated **Number of Nozzles:** 6



Comments on Ratings from Site Representatives

- Needed to retrofit the storage tank inlet by installing an access port on the side of the building.
- Replaced low flow switch paddle in the storage tank.
- Replaced spray nozzle's solenoids due to corrosion of the "plungers" in the nozzle.
- Needed to reprogram the logic tree to change activation parameters so that the system would not activate as often.
- Had to address issue with rodents entering the building and chewing on the coating on the telephone and electrical wiring causing the system to malfunction.
- The pressure gauge was not reading properly and was not providing proper pressure to activate the voice dialer to properly report an activation of the system. The voice dialer was repaired and functioned satisfactorily for the remainder of the season.
- Minor operational and maintenance issues were addressed and corrected and

the system performed in an acceptable manner for most of the time during the winter seasons.

5.3.3 Wisconsin-R

County Highway Department personnel from Racine County, who are responsible for the operation and maintenance of the FreezeFree system, provided the following comments and observations:

a) Prior to 2003-2004 Winter Season

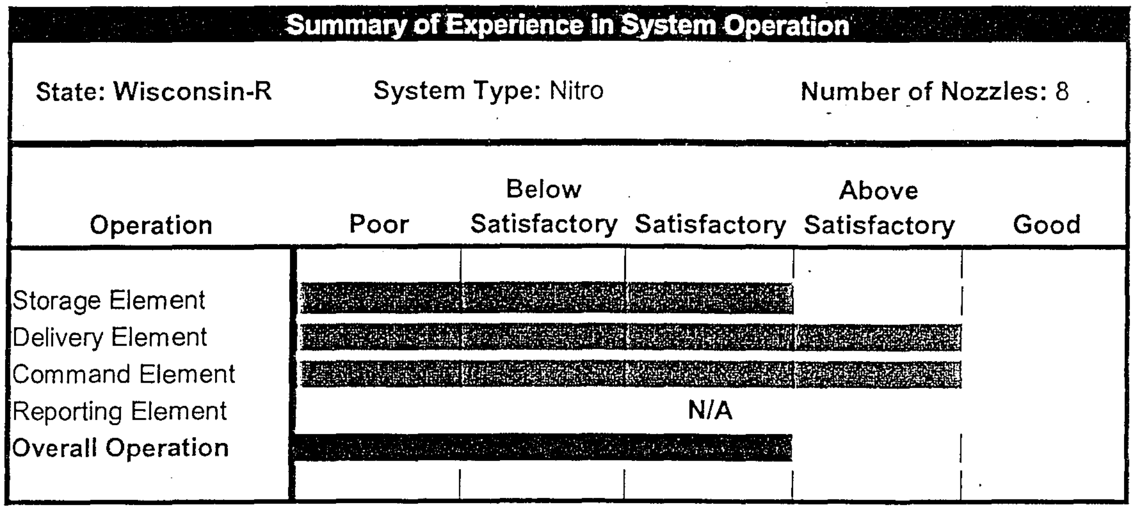
- The system was activated two times per week (Tuesday and Thursday or Friday) to be consistent with County's mobile anti-icing operation. It was only used for bridge frost or black ice control.
- From January 2001 to April 2002, erratic system activation occurred at a rate of 22% of all calls made to the system. On some occasions, system would not activate until a second or third call. During other activations, the system line pressure did not provide a spray pattern across the entire deck width. It was observed that periodically, line pressure was not sufficient to allow spray pattern to reach the opposite side of the bridge deck. The personnel speculated that this condition might be due to weather (temperature) conditions.
- The flush-mounted nozzle assembly installed in the bridge approach pavement performed well with no clogging due to sand or other debris on the pavement. The mechanical components of the system required no maintenance during this period.
- Energy Absorption Systems, Inc. added an access port to the liquid storage tank through the storage-shed wall to allow for easier filling of the tank.
- WisDOT personnel observed vehicle reaction to spraying sequence and no braking action by vehicles was observed.

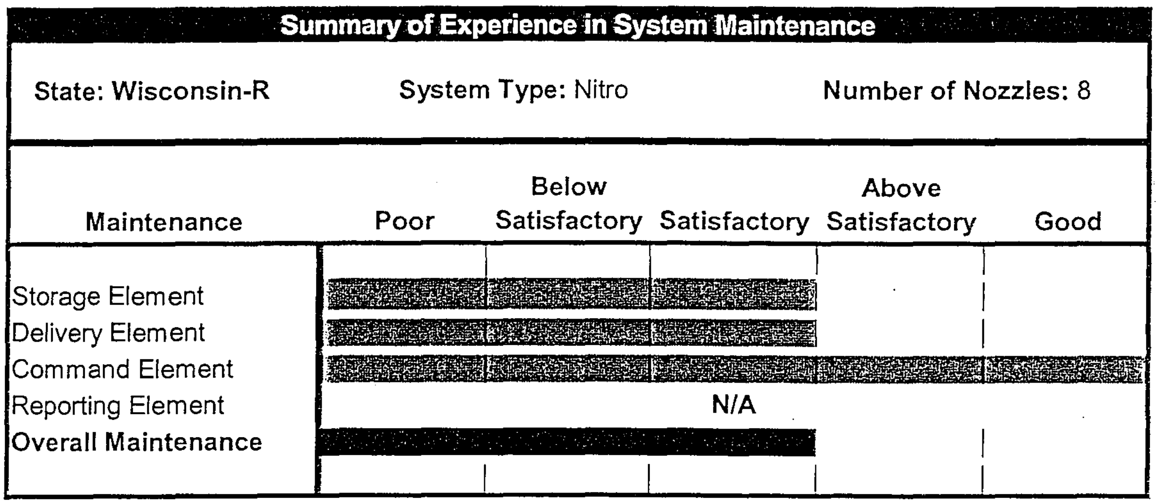
b) 2003-2004 Winter Season

- Some nozzle plungers were replaced by units treated with electrolysis nickel coating. This is because the spray nozzles had become inoperative due to corrosion of nozzle plunger by the magnesium chloride product. They were replaced in October of 2003, and this problem did not occur since then.
- Leaking of nitrogen from the storage tank regulator caused a decrease in spray line pressure. The cause of leakage is still unknown.
- The paging activation system continued to show inconsistency. On occasions, the system did not activate by the paging method, and staff had to travel to the site to activate manually at the control panel.

c) Anecdotal Rating

Based on the overall experience at the Wisconsin-R site, the WisDOT representative(s) rated the FreezeFree Nitro System as:





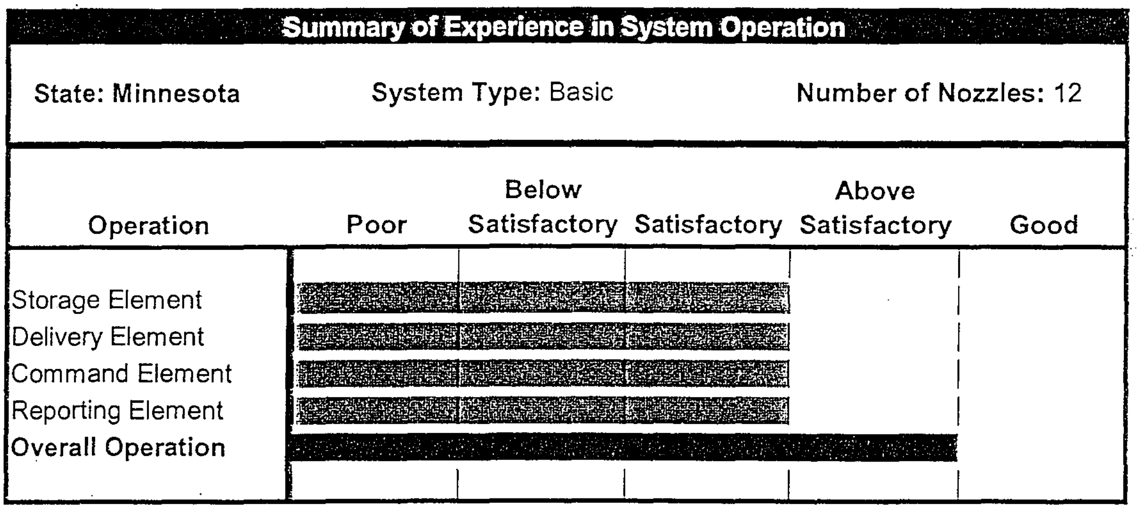
Comments on Ratings from Site Representatives

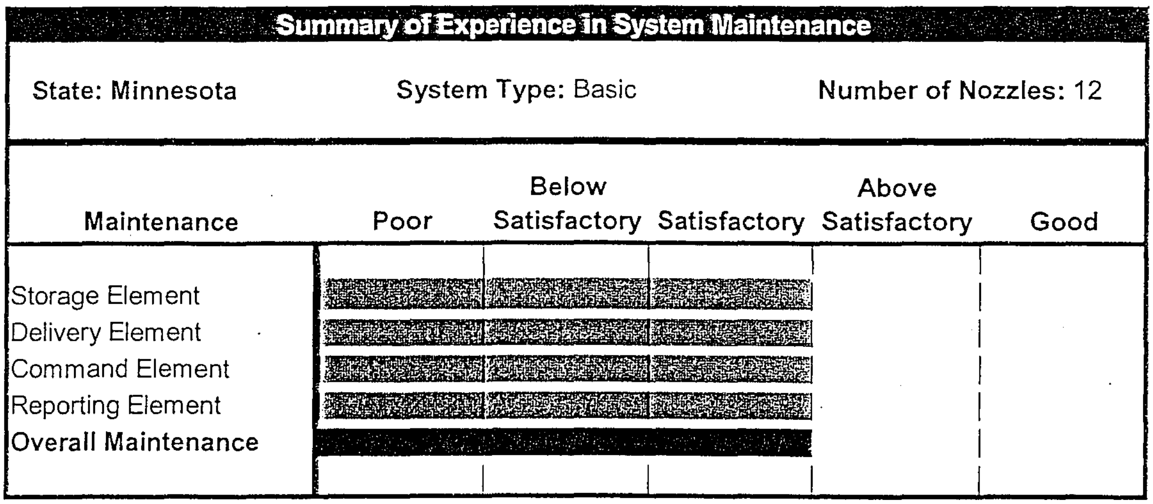
- Crack in nitrogen storage tank regulator allowed nitrogen gas to escape which led to a drop in spray line pressure.
- The outside surface of the pressure tank is showing signs of surface corrosion.
- Spray nozzle plungers (valve) became corroded by $MgCl_2$ product and had to be replaced with units treated with a zinc coating.
- Inconsistency of pager activation system: First call into system does not always activate spray system. Discussed raising pager antenna at the site to possibly provide better reception of signal, but had not been done as of summer of 2004.
- Poor cell phone tower coverage in the area of bridge. Problem may also be due to adjacent high power lines.
- Changed nozzle plungers so they would function properly.
- On site crew decided not to make any major changes to the system to improve operation of the system since this was a test installation and they wanted to observe what the possible operations would be.

5.3.4 Minnesota

The FreezeFree Basic System installed in the City of Duluth, Minnesota, works under simple manual operation. The system did not experience any significant problems during the past winter seasons, except the system failures in March of 2002 and 2003 due to the entry of water into the boxes that house the solenoids for the nozzle. Observations indicate that the system works as it was designed to spray chemicals on the roadway. The frequency of site visits is dictated by plowing or sanding requirements.

<u>Anecdotal Rating</u>
Based on the overall experience at the Minnesota site, the MNDOT representative(s) rated the FreezeFree Basic System as:





Comments on Ratings from Site Representatives

- The storage system is adequate and meets the department's needs.
- Operation and Maintenance of the system are generally in the acceptable ranges for MNDOT's needs. There is a float problem inside the tank, where the tank needs to be drained and a person needs to climb inside it. There needs to be an easier solution for this problem.

5.3.5 North Dakota

The North Dakota Department of Transportation (NDDOT) representative(s), who are responsible for the operation and maintenance of the FreezeFree system, provided the following comments and observations:

a) <u>Prior to 2003-2004 Winter Season</u>

- The system only required general maintenance such as flushing fresh water through the system at the end of the winter season. NDDOT has had problems with rodents getting into the pump house, and has been required to keep rat poison in the building.
- The FP 2000 sensor does a satisfactory job; however, sediments can collect in the sampling cup and record a damp or wet deck condition when the deck is actually dry. The passive sensor also does not work when there are multiple chemicals on the roadway or bridge deck.
- Daily site visits to confirm computer data found that the system indicated it had fired when it actually did not. NDDOT found this out by marking the liquid level on the tank along with a date. Several trips were made by SSI to try and fix this problem. When the system was working, several instances were observed in which the system indicated it fired and it did when it should have.
- Numerous problems were encountered with the automated bridge spray system. As a result, the entire controller for the system was redesigned. The RWIS system was upgraded in 2002. The upgraded RWIS included a new FP-2000 roadway sensor to provide roadway temperatures and chemical freeze points. The FP-2000 sensor is a passive sensor that relies on electrical conductivity readings to calculate the freeze point of the chemical present on the roadway. Electrical conductivity readings are only accurate with the FP 2000 sensor if only one chemical is used or a known mixture of chemicals is used for anti-icing or de-icing. It is common practice for the NDDOT to apply a mixture of salt and sand to roadways as a de-icing practice for snow and ice control. The application of salt to the structures was detected by the FP 2000 roadway sensors and skewed the conductivity readings that were developed for potassium acetate (CF-7). The computer algorithm was based on strictly potassium acetate (CF-7), and therefore the computer logic programmed to trigger the system provided erroneous information to the controller.

- An active Frensor sensor was installed in the northbound bridge deck in the fall of 2003 to improve the system's performance. The Frensor sensor is an active sensor that electronically cools a sample irrespective of its chemical make up and calculates the freeze point of the liquid. The Frensor Sensor was therefore expected to maintain accurate readings when other chemicals such as sodium chloride were applied to the roadway by maintenance crews.

b) <u>2003-2004 Winter Season</u>

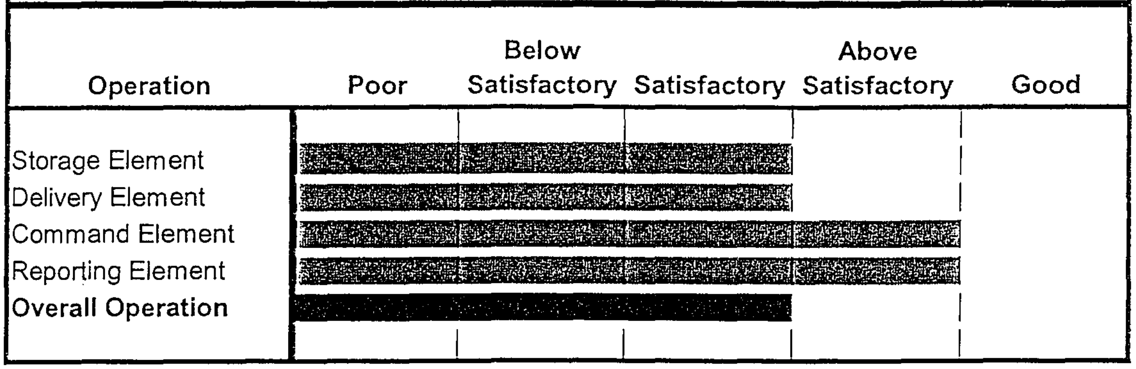
- Representatives from Energy Absorptions and Global Specialties upgraded the bridge spray system. Frensor sensors and a new controller system were installed.
- Between November 5 and November 12 there were several incidents (about 12) where the RWIS triggered the sprayer due frost or ice conditions, and the FreezeFree sprayer did not respond or spray. Energy Absorptions found an error in the computer program that provides the switch closure for the sprayer that gives a confirmation signal back to the RWIS. The computer program was changed and a new computer board was programmed and mailed to the NDDOT.
- It was determined that pump pressure was lost as it had dropped from the 200 psi setting that had previously been set. The system would not work due to the pump pressure being below the operating range set in the system as 185 psi-220 psi.
- Several other problems were encountered during this period, and were well-documented by NDDOT. These include problems with pump pressure, problem with relays not reacting as fast under colder temperatures and staying open/closed longer, thus resulting in spraying more chemical than programmed (about 4 times more), replacement of the computer board, installation of pressure relief valve gaskets, replacement of the relay control box, some spray nozzles not working due to loose wires, and so forth.
- Several problems with the system were encountered, even after the FreezeFree controller was installed in the fall of 2003. A total of 190 events were documented and evaluated for system accuracy from December 25, 2003 to April 11, 2004. Of the 190 events, 24 inaccurate events were recorded. Of these 24 inaccurate events, 13 (or 6.8% of the total number of events) were documented which met the criteria and parameters set for the system in which the system should have fired and it did not, and 11 events (or 5.8% of the total number of events) were documented which did not meet the criteria and parameters set for the system in which the system fired and it should not have. The accuracy for the system as a bridge anti-icing system for this time period was therefore 87.4%.
- For several of the events that were recorded, the RWIS data notes that the system was "Active Due to Freeze Point Condition". However "No Data" or no chemical freeze point was recorded by the Frensor sensor. This occurs if the Frensor sensor detects moisture and the surface temperature is below 32° F. If the chemical freeze point is already below -20° F, the Frensor cannot calculate the freeze point and therefore may fire under a moisture-detected incident. This has the potential to provide inaccurate activation of the system since the chemical being used at the site (potassium acetate) has a freeze point of –76° F when applied to the roadway. The system could theoretically be activated due to the moisture detected from chemical applied by the system when its freeze point cannot be measured by the Frensor sensor.

c) <u>Anecdotal Rating</u>

Based on the overall experience at the North Dakota site, the NDDOT representative(s) rated the FreezeFree Automated System as:

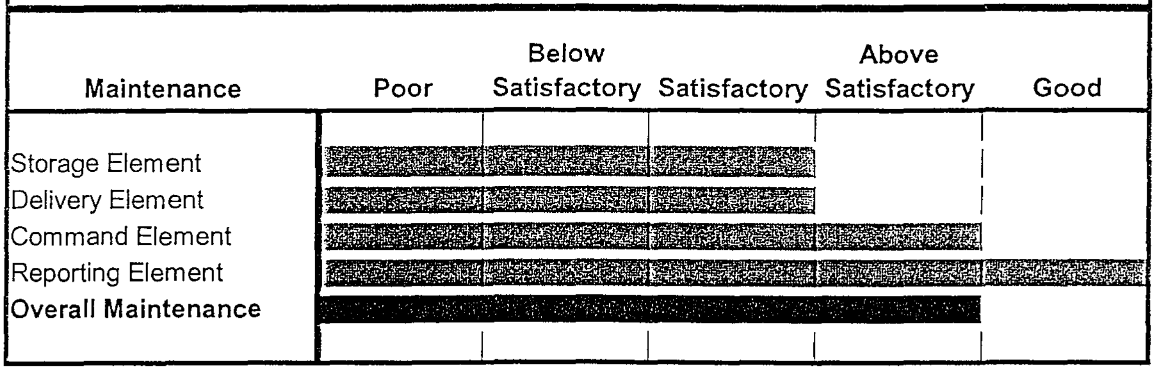
Summary of Experience in System Operation

State: North Dakota	System Type: Automated	Number of Nozzles: 10



Summary of Experience in System Maintenance

State: North Dakota	System Type: Automated	Number of Nozzles: 10



Comments on Ratings from Site Representatives

- There was a problem with mice getting into the pump house, and NDDOT still has to keep mouse poison in the pump house.
- Maintaining the low level warning switch and low level shut off switch could be improved as one has to drain the tank, tip it on its side and crawl inside the small opening in the top of the tank to switch out the floats.
- NDDOT had some trouble at times with the pump maintaining the required pressure. It would be nice if the pressure gauge and adjustment nuts were at eye level so that one does not have to go down on the floor trying to read and adjust the gauge.
- There are no filters on the supply lines in the pump house to filter out debris and

particles. Several of the electrical lines are not encased in conduit and have the potential to become damaged or eaten by rodents.
- The Frensor sensor can calculate a freeze point down to -20°F. If the sensor detects moisture and it cannot calculate a freeze point it will activate the system. It has the potential to activate from moisture from the chemicals applied whose freeze point is below -20°F.
- The control boxes on the North Dakota System are powder coated paint and are rusting. Some of the bolts that hold the controller box doors shut are rusted off.
- Operating the software is simple and gives good data. It does not give an explanation of why the system fired due to freeze point condition, yet no freeze point is calculated.
- Some maintenance of the output data is required at times. SSI has responded when adjustments were needed to the output data screen.
- The system in North Dakota operated with an 87% accuracy rate from the time period of December 25, 2003 to April 11 2004 in which data was collected.
- Overall system maintenance is fairly good with the exception of noted improvement suggestions.

5.3.6 Oregon

The Oregon Department of Transportation (ODOT) representative(s), responsible for the operation and maintenance of the FreezeFree system, provided the following comments and observations:

a) Prior to 2003-2004 Winter Season

No data was collected due to the following issues:

- During the later part of November and all of December 2002, and part of January 2003, there was no commercial power due to a storm. However, test firing was completed using a portable generator. The test appeared to be satisfactory.
- With the power on, the system would not communicate with RWIS. Therefore, the RWIS components were upgraded. RWIS existed at this site prior to the installation of the FreezeFree system.
- There was a problem in the common Freeze Free relay board.
- There was a problem with the valves. ODOT thought that the valve box control relays were burned out (not broken). There was also a problem with control panel communication. A new control panel and a line conditioner were installed. The line conditioner didn't work with the system, and was unwired. (Apparently, it was not tested with the system before being tried in field).
- Of the valves that were stuck or malfunctioning, two appeared to be due to defective relay controls on the bridge, and three to five appeared to be malfunctioning due to mechanical problems. A deposit was found in the valve actuators. The deposit could be from precipitation of the solution that had bled through a breather hole in the valve

diaphragm. All valves were cleaned, and five valves and three relays that appeared to be malfunctioning were replaced. The system was then tested, and it was found that the valves at the east end were still malfunctioning.

b) <u>2003-2004 Winter Season</u>

- The control system, valve boxes, and control wiring were upgraded. The plungers in the solenoid valves were replaced with new electrolysis nickel-coated stainless steel plungers to resist corrosion from magnesium chloride.
- Between December 20, 2003 and January 1, 2004 there were 28 spray requests. Only four were responded to by the FreezeFree system. Power was intermittent during this time period.
- Other problems occurred during that period and were recorded and documented by ODOT.

c) <u>Anecdotal Rating</u>

Based on the overall experience at the Oregon site, the ODOT representative(s) rated the FreezeFree Automated System as:

Summary of Experience in System Operation

State: Oregon | System Type: Automated | Number of Nozzles: 25

Operation	Poor	Below Satisfactory	Satisfactory	Above Satisfactory	Good
Storage Element					
Delivery Element					
Command Element					
Reporting Element					
Overall Operation					

Summary of Experience in System Maintenance

State: Oregon | System Type: Automated | Number of Nozzles: 25

Maintenance	Poor	Below Satisfactory	Satisfactory	Above Satisfactory	Good
Storage Element					
Delivery Element					
Command Element	Maintenance performed by outside representative. Rating information not available				
Reporting Element	Maintenance performed by outside representative. Rating information not available				
Overall Maintenance					

Comments on Ratings from Site Representative(s)

- The electronic components for the FreezeFree RPU were installed and connected to the existing RWIS by a factory representative. Communication between the two seemed to be problematic and required all new components to be installed in the RWIS RPU. System activation can be monitored from the district office. Maintenance at this time is unknown.
- ScanWeb information is easy to read and understand. Maintenance is performed by others.

5.4 Market Readiness

Another key question that was posed to the test sites' representatives was whether they considered the FreezeFree system to be market ready. The respondents were also asked whether the system met their performance expectations. A summary of responses to these questions is presented in Table 5.3.

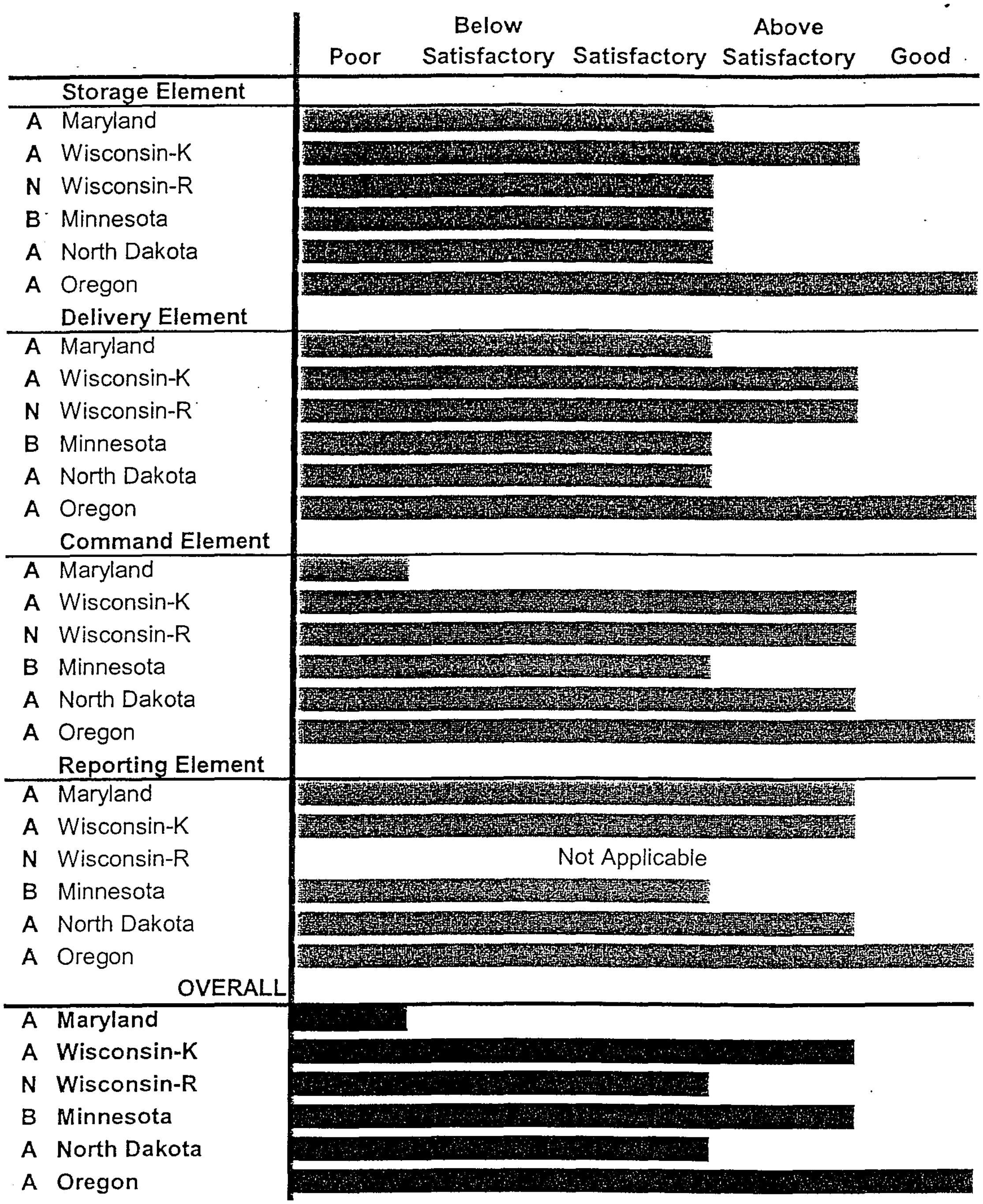
Table 5.3: Performance Expectation and Market Readiness

	Did the system meet your performance expectations?	Do you consider the system to be market ready?
MD	No	No
WI-K	Yes	Yes
WI-R	Yes	Yes
MN	No response	Yes, however some improvements are needed
ND	Yes, however some improvements are needed	Yes, however some improvements are needed
OR	No	No, but it will be

5.5 Summary of Ratings for System Operation and Maintenance

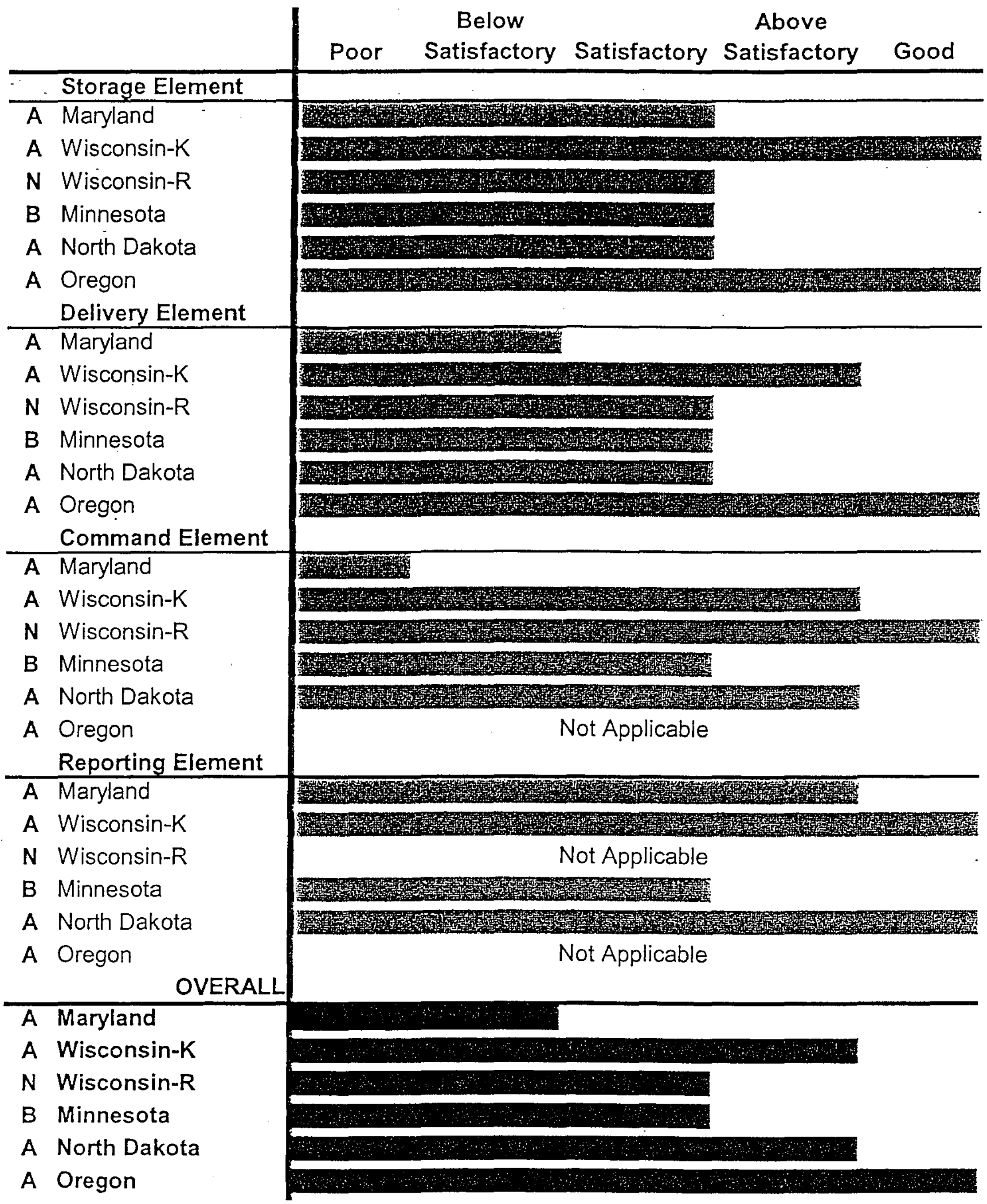
Figure 5.1 shows summary ratings of system operation based on the input received from the representatives and personnel responsible for the test sites.

Figure 5.2 shows summary rating of system maintenance based on the input received from the representatives and personnel responsible for the test sites.



A = Automated; B = Basic; N = Nitro

Figure 5.1: Summary of System Operation Ratings



A = Automated; B = Basic; N = Nitro

Figure 5.2: Summary of System Maintenance Rating

Chapter 6: Data Collection and Analysis

6.1 System Data - Adherence to Spray Logic

In addition to evaluating the installation, operation, and maintenance requirements of the FreezeFree System, a key measure of performance is the ability of the automated system to perform according to the need to perform, and activate the spray cycle when the pavement and atmospheric conditions are conducive to the formation of ice. It essentially means that there needs to be a check to see that the system obeys the spray logic that governs its activation.

Figure 6.1 shows sample spray logic settings that can be specified using ScanWeb to set up automatic activation of the system.

Sprayer Mode

- Allow the RPU to **automatically** activate the sprayer while also allowing **on demand** activation.
- Only allow **on demand** activation of the sprayer.
- **Do not** allow activation of the sprayer.

Automatic Mode Operating Ranges

- Only allow automatic activation when the surface temperature is between:
  - High Temperature: 35.0 (F) *(Max value is 50 F)*
  - Low Temperature: 20.0 (F) *(Min value is -40 F)*
- Do not allow automatic activation to occur when the average wind speed is above 25 (mph).

- Activate sprayer when the surface temperature is within 1.8 (F) or is less than the freeze point temperature. A negative value can be specified to delay the automatic activation of the sprayer. *Valid range is -18 to 18 F.*
- Require a minimum of 60 minutes to elapse before reactivating the sprayer due to a freeze point condition. *Valid range is 0 to 1440 mins.*

- Activate sprayer when the surface temperature is within 3.8 (F) or is less than the dew point. A negative value can be specified to delay the automatic activation of the sprayer. *Valid range is -18 to 18 F.*
- Require a minimum of 240 minutes to elapse before reactivating the sprayer due to a frost condition. *Valid range is 0 to 1440 mins.*

Figure 6.1: Sample Spray Logic

The two possible errors that can be detected by running the spray logic against the electronic data that is collected at any given site are:

- **Type I Error (Safety Concern):** The system did not fire when it was supposed to fire
- **Type II Error (Economic/Environmental Concern):** The system fired when it was not supposed to fire.

These errors can most accurately be identified by studying the electronic data against the spray logic, and checking the site for spray patterns by either remotely monitoring the site through a camera, or physically inspecting the pavement. Of the seven (7) test sites used for this evaluation, five (5) sites carry automatic systems. Out of these five sites, the FreezeFree system in California has not yet been commissioned. The system in Oregon was not able to collect substantial electronic data due to power breakdowns, and physical site data due to remoteness of the site. The FreezeFree Automated site in North Dakota proved to be the best equipped installation for determining the percentage of these errors since it has live web-camera installed that can be used to check the spray patterns for all day-time activations.

Table 6-1 shows a summary of the error data collected at the North Dakota site. Field logs from the North Dakota site were provided by the site representative. Selected analysis sheets of data from that test site are presented in Appendix-B.

Table 6.1: Summary of Analysis of Data from North Dakota Site

Site	North Dakota
Data Collection Period	12/25/03 – 04/11/04
Number of Events	190
Type-I Errors	13
Percentage of Type-I Errors	7%
Type-II Errors	11
Percentage of Type-II Errors	6%
Total System Errors	24
Percentage of Total System Errors	13%

Field logs from Wisconsin-K and Maryland sites were also submitted to HITEC by the site representatives. The data shows that in the 2003-2004 winter season, there were a total of 45 activations recorded at the Wisconsin-K site, and 137 activations recorded at the Maryland site. Both sites do not have the ability to remotely monitor the bridge decks through a video camera to confirm the actual spray of the anti-icing fluid upon each activation. However, the site representative in Wisconsin kept a check on the level of the fluid in the storage tank by using a flow-switch, while the site representative in Maryland frequently marked the fluid level in the tank to determine whether or not any material was dispensed. Based on their observation of the data, they also noticed some instances of Type-I and Type-II errors.

6.2 External Data - Safety, Environmental, and Economic Benefits

The very purpose of FAST systems is to automatically provide timely application of de-icing fluid on the road surface when conditions are such that ice or frost is about to form. FAST systems are intended to deliver an appropriate amount of de-icing fluid onto the road surface when and only when these conditions are met. This would lead to infer that FAST systems can:

a) Substantially improve traffic safety during inclement weather periods by eliminating dangerous road surface conditions in the winter season in a timely manner, thereby reducing the number and possibly the seriousness of crashes[18];

b) Reduce the quantity of de-icing fluid used and the total amount of such chemicals that will find its way into the environment, resulting in reduced environmental impact and operational costs; and

c) Eliminate other labor and equipment costs associated with alternate methods of preventing dangerous road surface conditions during inclement winter weather, such as salting or spraying using trucks, hence, resulting in reduced operational costs

Evaluation and measurement of safety, environmental, and economic benefits of FreezeFree system requires a controlled experiment, starting with selection of test sites with high-crash locations and availability of detailed crash data and transcripts, and proper documentation of all the costs (chemicals, labor, and equipment) at a sufficient number of sites and over a sufficient number of winter seasons. This information was not sufficiently available to perform a calculated assessment of safety, environmental, and economic benefits at the FreezeFree test sites.

[18] In a recent study conducted in Canada, it was determined that a FAST system installation resulted in complete success, effectively eliminating crashes during a severe winter season (Ministry of Transportation, Ontario, "Anti-Icing on Structures Using Fixed Automated Spray Technology," May 1, 2001)

Chapter 7: Summary of Findings & Conclusions

While the comments received from the test sites were spread over a wide range of observations and experiences, it is clear from this evaluation that there were a number of problems that were experienced by the test sites, which in most cases, were resolved over time. Some of the problems that are related to the command element of the automated systems sill remain to be resolved. Since the systems evolved over time due to repairs and upgrades, the test sites were not able to achieve a stable/equilibrium state over the past winter seasons to collect data and information that could be compared from one season to another. That being said, there is little doubt that theoretically, when fully and reliably operational, the system has demonstrated the potential to maintain a high level of service, i.e., result in only a few cases of ice or snow bonding to the pavement surface, with minimal labor and material used. Consequently, one would expect :

a) Enhanced traffic safety by preventing ice formation on sensitive locations on highways and bridges at all times;
b) Reduced winter maintenance costs by intelligent application of an appropriate amount of anti-icing chemical when and only when necessary, and by providing an alternative to dispatching winter maintenance crews to remote locations; and
c) Reduced environmental impacts that could otherwise result from excessive regular application of winter maintenance materials.

The overall findings and conclusions of this evaluation will be presented in two separate sections. The first section summarizes and makes direct references to the conclusions that were provided by the representatives of the various test sites. The second section summarizes the overall ratings of the system provided by these representatives, along with their responses to some broader questions related to whether or not the system's performance met their expectations, and whether or not they consider the system to be market ready.

7.1 Summary Documentation of Findings and Conclusions from the Test Sites

7.1.1 Maryland

The performance of the FreezeFree Automated Anti-Icing system during the winter of 2002-2003 was poor. The vendor response to the variety of problems experienced was inadequate. It was the hope of Maryland State Highway Administration (MDSHA) that the FreezeFree system could become an effective component of winter operations. The system's ability to perform as advertised is suspect.

The performance of the FreezeFree System during the winter of 2003-2004 was inadequate. The reporting system (ScanWeb) performed satisfactorily. The hydraulic system, although performing better than the previous year, was not problem free. The system as a whole failed to demonstrate the ability to mitigate dangerous surface conditions at critical times.

The system's inability to respond in a timely manner to unpredictable occurrences, such as frost or snow squalls, and its failure to detect and treat potentially dangerous surface conditions at the beginning of a snow event make it questionable that the FreezeFree System can be an effective component of MDSHA's winter operations.

7.1.2 Wisconsin-K

- The FreezeFree bridge deck anti-icing system technology appears to be operationally reliable with only minor repairs reported for the basic system on the S.T.H. 50 bridge in Kenosha County.
- The installation and operational cost effectiveness of bridge deck anti-icing system in the Wisconsin winter climate has not yet been determined by those involved with the FreezeFree system. Operational costs for liquid anti-icing agents, and telephone/electrical service appear to be minimal to date.
- Activation reliability of the Kenosha County basic system has been very acceptable.
- Adjustments to the Kenosha County basic system's automatic activation codes were required to minimize the amount of liquid anti-icing agent dispensed during multiple activations of the system for an event.
- WisDOT personnel were unable to remotely access or monitor the Kenosha County site due to WisDOT internal "firewall" criteria. This problems was resolved in-house.
- Liquid magnesium chloride performs well as an anti-icing agent in the FreezeFree system.
- Recorded crash data is not sufficient at this time to reach any conclusions on the ability of the bridge deck anti-icing system to significantly reduce the number of crashes at the site.
- Additional field-testing and activation of this bridge deck anti-icing system are required before any additional significant conclusions about the system can be reached.

7.1.3 Wisconsin-R

- The FreezeFree bridge deck anti-icing system technology appears to be operationally reliable, with minor repairs reported for the Nitro system on the S.T.H. 36 bridge in Racine County.
- The installation and operational cost effectiveness of bridge deck anti-icing system in the Wisconsin winter climate has not yet been determined by those involved with the FreezeFree system. Operational costs for liquid anti-icing agents, nitrogen gas containers, and telephone/electrical service appear to be minimal to date.
- Activation of the Racine County Nitro system has been erratic with 22% of the attempted activations requiring two or three calls or manual activation at the site. This problem diminished over time, and rarely occurs now.
- Liquid magnesium chloride performs well as an anti-icing agent in the FreezeFree system.
- Recorded crash data is not sufficient at this time to reach any conclusions on the ability of this bridge deck anti-icing system to significantly reduce the number of crashes at the site.

- Additional field-testing and activation of the bridge deck anti-icing system are required before any additional significant conclusions about the system can be reached.

7.1.4 Minnesota

The evaluation of FreezeFree Basic System in City of Duluth in Minnesota is unique in the sense that the representative from City of Duluth retired during the course of the evaluation, and it was handed over to MNDOT late last year. The comments received from MNDOT on this transition and the overall experience are presented below.

The Minnesota Department of Transportation took back the responsibility for the test section in the Fall of 2003 at the beginning of the winter maintenance season. At the time of this take over, a new person was charged with getting this system functional for use during the Winter Season. The only information that was received from the City of Duluth was that the system had never worked up to expectations.

The system was left until late in the season with water in it with some of the valves frozen. The damaged valves and solenoids were replaced and the system was charged with magnesium chloride. Some training was provided to the MNDOT operators. The operators were unfamiliar with the system, and did not use it very often. However, a total of about 400 gallons of magnesium chloride was used.

MNDOT's representative's opinion is that the system had or will have some positive effects on this area. The manufacturer made some modifications to the nozzles and closed the outside holes to try and keep more of the material on the road surface as there was a percentage that was being sprayed up onto the shoulders and the sidewalk. They also made some changes to the software that controlled the amount of material being applied and reduced the amounts from 30 gallons per firing to 15 gallons. From experience in other areas in the district depending on temperatures and amount of snow fall, a volume of 15 gallons seemed to work. If more anti-icing fluid was needed, the system could simply be activated a second or a third time to achieve the desired result. When the system was used, improved traction and overall better driving conditions on this ramp were observed.

7.1.5 North Dakota

NDDOT encountered numerous problems with the automated bridge spray system that was installed in 2002. As a result, the entire controller for the system was redesigned. After the upgrades, several problems with the system were experienced in the 2003-2004 season. With help from the manufacturer, NDDOT was very successful in correcting those problems, and the system did a very good job of preventing snow and ice from forming on the bridge decks from December 25, 2003 through April 11, 2004. However, of the total events recorded for this period, the system did not fire when it was supposed to, and fired when it was not supposed to for 13% of the time. The automated bridge spray system has been very beneficial in keeping the bridge decks free from ice and snow, which NDDOT believes, has prevented several crashes from occurring at this location. Energy Absorption Systems, SSI, and Traffic Technologies put an extra effort in responding to NDDOT's requests for assistance in making repairs and adjustments to the system. NDDOT feels that automated bridge spray systems have a lot of potential in the future for keeping roadways free from snow and ice and improving roadway safety.

As discussed in Chapter-6, the two possible errors that can be detected by running the spray logic against the electronic data that is collected at any given site are:

Type I Error (Safety Concern): The system did not fire when it was supposed to fire
Type II Error (Economic/Environmental Concern): The system fired when it was not supposed to fire.

Table 7-1 shows a summary of the error data collected at the North Dakota site. Field logs from the North Dakota site were provided by the site representative. Selected analysis sheets of data from that test site are presented in Appendix-B.

Table 7.1: Summary of Analysis of Data from North Dakota Site

Site	North Dakota
Data Collection Period	12/25/03 – 04/11/04
Number of Events	190
Type-I Errors	13
Percentage of Type-I Errors	7%
Type-II Errors	11
Percentage of Type-II Errors	6%
Total System Errors	24
Percentage of Total System Errors	13%

7.1.6 Oregon

The performance of the FreezeFree Automated Anti-icing system is inconclusive at this time. ODOT has encountered many problems with the system and existing RWIS station, primarily due to the remote site location. The site is located in the Coast Mountain Range and is susceptible to winter weather conditions. Typically during winter weather events winds are a large factor having an adverse affect on the power supply to operate the system. That is why site was without power during the times when the system would have been requested to fire. To compensate for the loss of power and to adequately evaluate the system during winter events, ODOT is installing an automatic start/stop auxiliary power generator.

ODOT experienced numerous problems when the system did have power, the vendor/sales representatives responses to the variety of problems were very timely. ODOT's opinion is that the system will have a positive effect at this location and has made a commitment to make the installation useable to evaluate its effectiveness.

7.1.7 Key Lessons Learned

The key lessons learned from this evaluation study include:

1. The FreezeFree system is not an off-the-shelf system that can be purchased and installed right away at any given site. It requires customization of the installation at each

site after studying the site requirements and conditions, and designing a specific system and its installation to meet those requirements.

2. Selection of the proper site for the installation of the system is key to obtaining the maximum benefit out of the system. The site should have unique characteristics like high crash history, remote location away from the regular maintenance routine, etc.

3. The type and quality of the anti-icing liquid used can significantly affect the performance of the system.

4. The system can be most effective under frost conditions. It should not be expected to enhance safety under moderate to heavy snow conditions.

5. The installation and maintenance of the system is fairly simple. Apart from some isolated problems that have been documented in this report, the installation and maintenance requirements generally met the expectations of the users.

6. There were a number of problems that were experienced in the operation of the system. Some sites reported erratic response to the spray logic, which includes firing of the system when not required (6% of all events), and not firing when required (7% of all events), as observed at the North Dakota test site. There needs to be more work done in order to eliminate or significantly reduce this problem to get maximum safety and economic benefits, and to increase the overall reliability of the system.

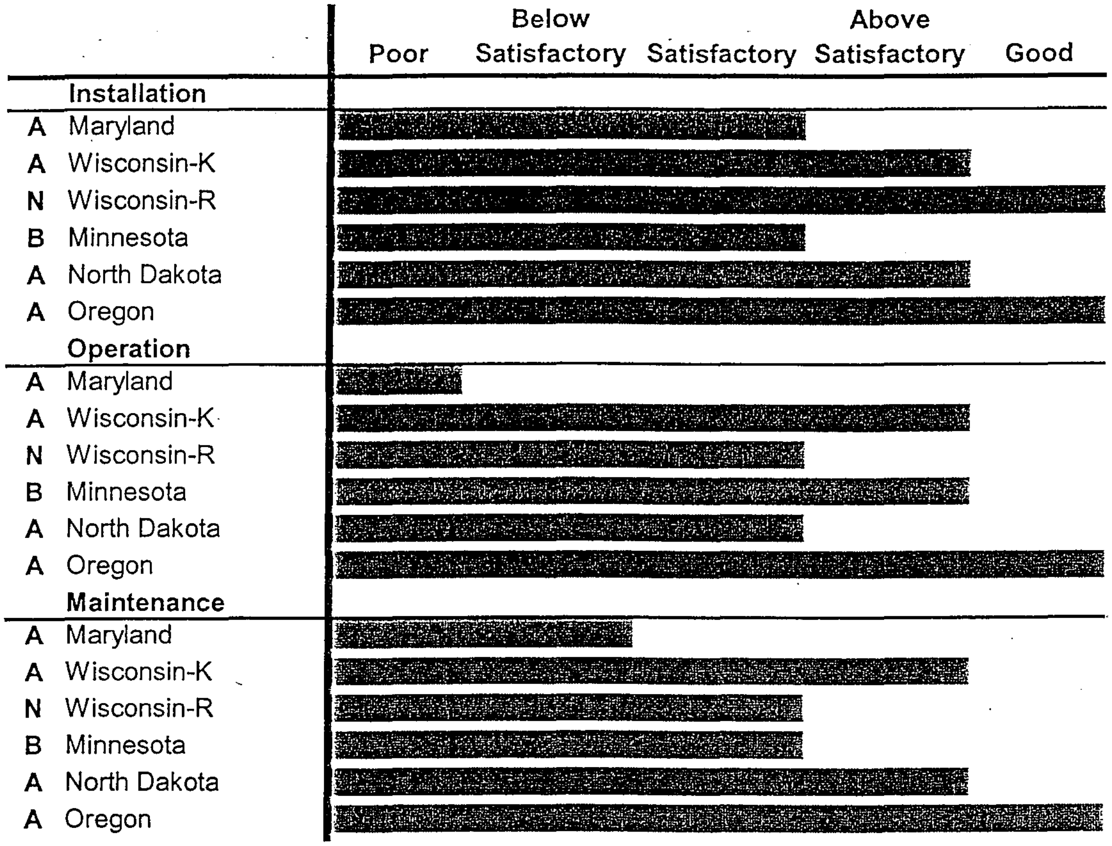
7.2 System Ratings

The summary of ratings as submitted by the representatives of test sites is presented in Table 7.2 below. A graphical representation of the overall rating of installation, operation, and maintenance of the system is shown in Figure 7.1.

Table 7.2: Summary of Ratings

	MD	WI-K	WI-R	MN	ND	OR
	Auto	Auto	Nitro	Basic	Auto	Auto
Installation						
Storage Element	S	AS	G	S	AS	G
Delivery Element	S	AS	G	S	AS	G
Command Element	S	G	G	S	G	N/A
Reporting Element	AS	G	N/A	S	G	G
Overall	**S**	**AS**	**G**	**S**	**AS**	**G**
Operation						
Storage Element	S	AS	S	S	S	G
Delivery Element	S	AS	AS	S	S	G
Command Element	P	AS	AS	S	AS	G
Reporting Element	AS	AS	N/A	S	AS	G
Overall	**P**	**AS**	**S**	**AS**	**S**	**G**
Maintenance						
Storage Element	S	G	S	S	S	G
Delivery Element	BS	AS	S	S	S	G
Command Element	P	AS	G	S	AS	N/A
Reporting Element	AS	G	N/A	S	G	N/A
Overall	**BS**	**AS**	**S**	**S**	**AS**	**G**

P = Poor; BS = Below Satisfactory, S = Satisfactory; AS = Above Satisfactory; G = Good; N/A = Not Applicable



A = Automated; B = Basic; N = Nitro

Figure 7.1: Graphical Representation of Overall System Rating

Since the system at each site is unique, and has evolved over time with repairs and upgrades, and since the conditions and staff at each of the sites are different, aggregation of qualitative assessment scores across the states would not reflect a true aggregate representation. If it was assumed that all parameters and factors at each site were constant, then such an aggregation would rate system installation as *Above Satisfactory*, system operation at *Satisfactory*, and system maintenance as *Satisfactory*.

Another key question that was posed to test sites' representatives was whether they considered the FreezeFree system to be market ready. The respondents were also asked whether the system met their performance expectations. A summary of responses to these questions is presented in Table 7.3.

Table 7.3: Performance Expectation and Market Readiness

	Did the system meet your performance expectations?	Do you consider the system to be market ready?
MD	No	No
WI-K	Yes	Yes
WI-R	Yes	Yes
MN	No response	Yes, however some improvements are needed
ND	Yes, however some improvements are needed	Yes, however some improvements are needed
OR	No	No, but it will be

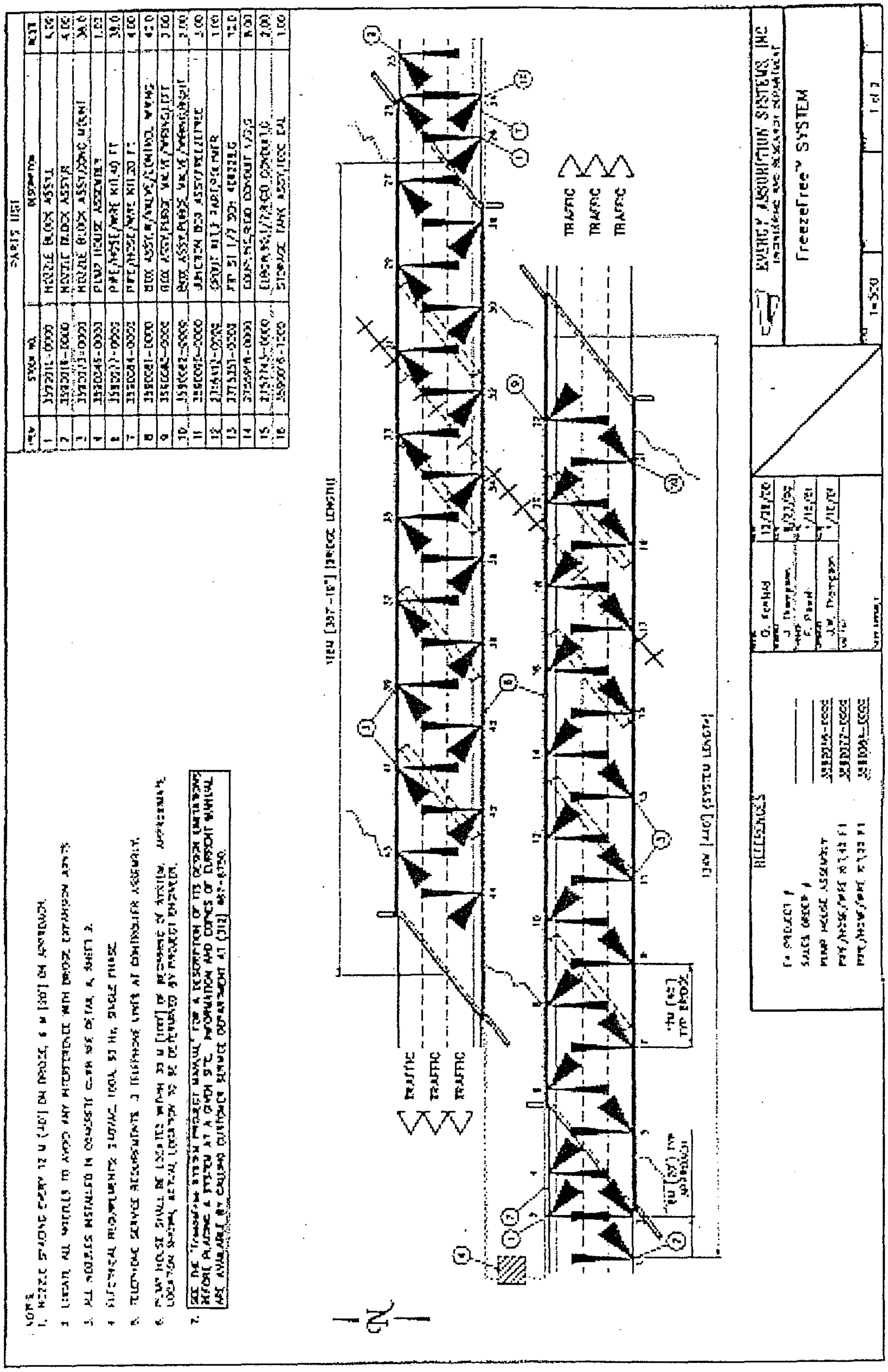
As mentioned earlier, over the course of this evaluation, the period for which the FreezeFree System was operational without any repairs, replacements, or upgrades, and with a reasonable degree of reliability, did not span a significant stretch of time. In order to objectively document the benefits of the system and its contribution to winter weather operations, the system definition at each site needs to remain unchanged to study performance over time, and the data and information related to the system needs to be gathered for a number of winter seasons to reach definitive conclusions on the benefits and performance of the system.

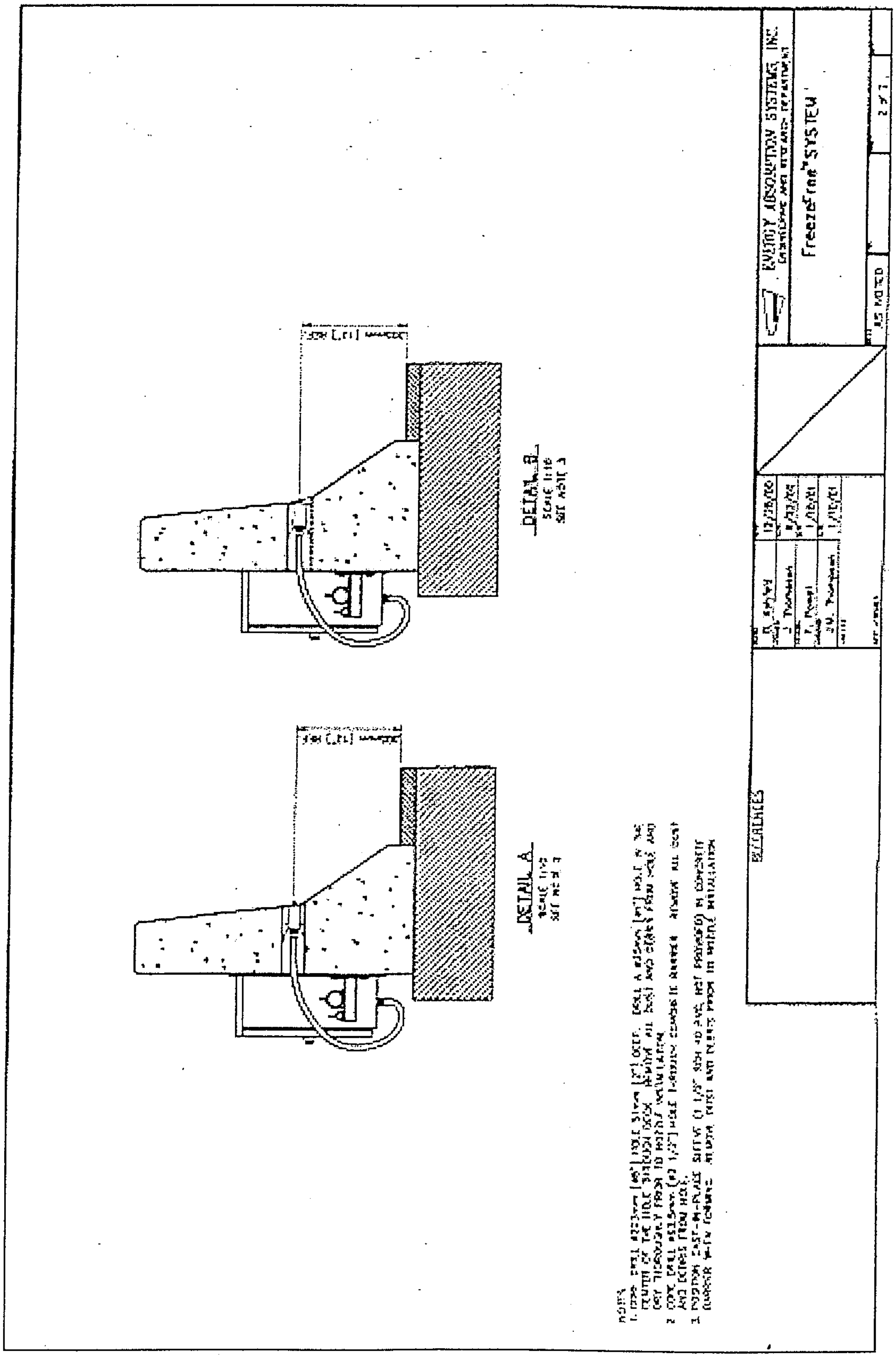
APPENDICES

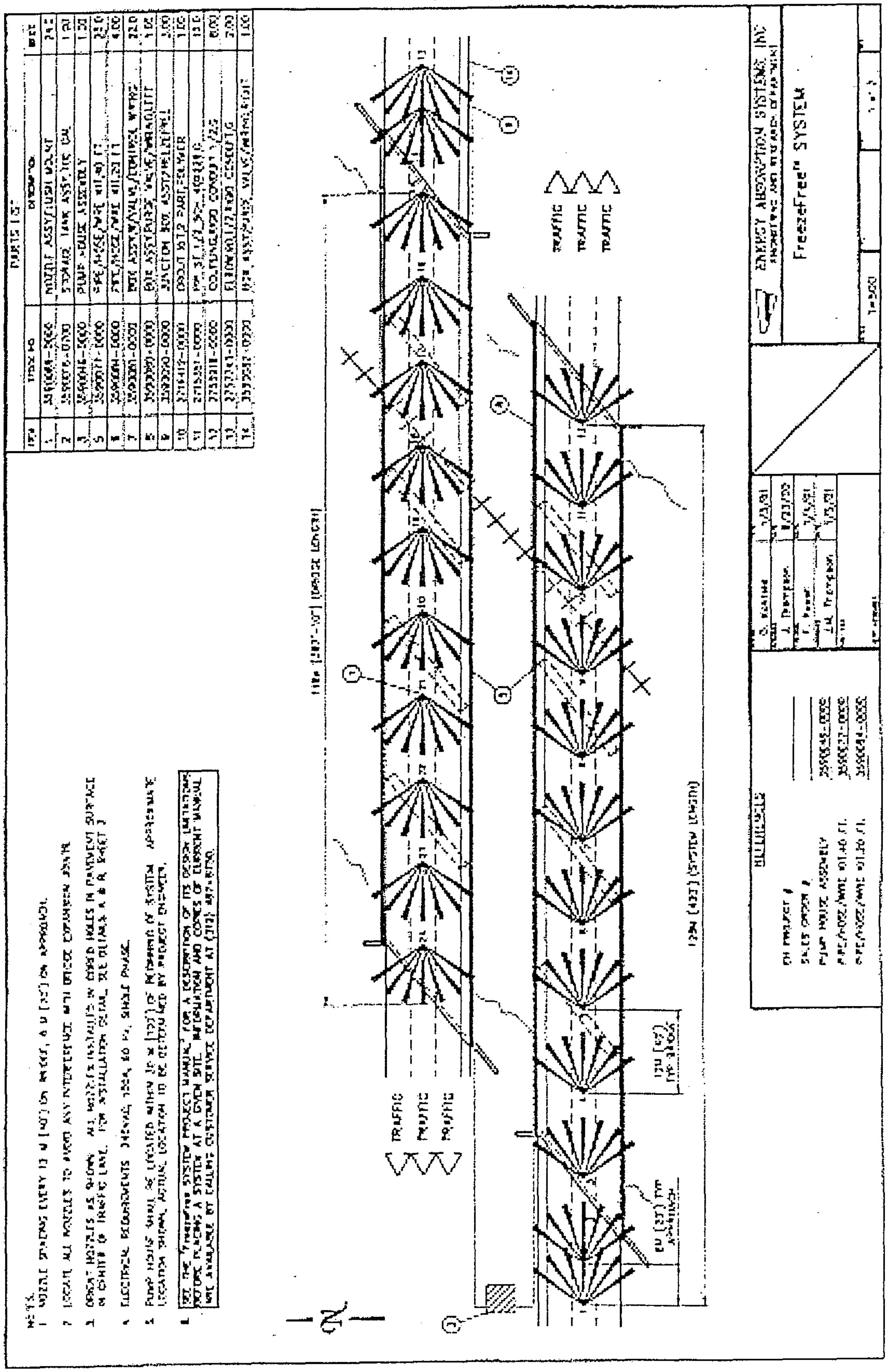
A. Selected Shop Drawings – FreezeFree System (Typical)
B. Data Analysis (North Dakota)

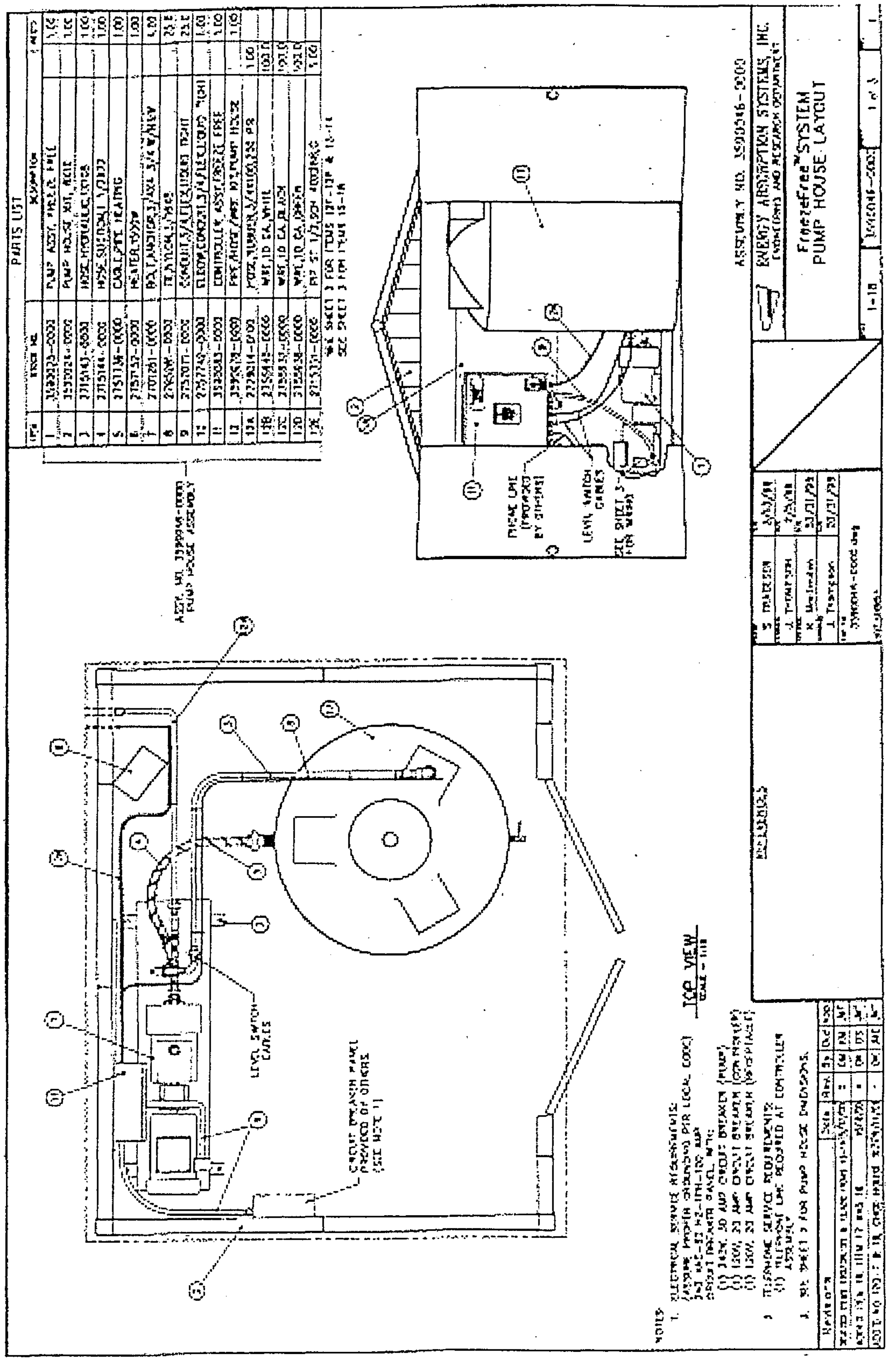
Appendix-A

Selected Shop Drawings – FreezeFree System (Typical)


PARTS LIST
TRAFFIC
TRAFFIC
TRAFFIC
FreezeFree™ SYSTEM
REFERENCES


ENERGY ABSORPTION SYSTEMS, INC.
FreezeFree SYSTEM
DETAIL A
DETAIL B
REFERENCES
AS NOTED


TRAFFIC
TRAFFIC
TRAFFIC
ENERGY ABSORPTION SYSTEMS, INC.
FreezeFree™ SYSTEM


PARTS LIST
TOP VIEW
ENERGY ABSORPTION SYSTEMS, INC.
FreezeFree™ SYSTEM
PUMP HOUSE LAYOUT
NOTES:

Appendix-B

Data Analysis (North Dakota)

	North Dakota Department on Transportation											
	Automated Anti icing System Evalauation Report											
	Interstate I-29 NB & SB Bridges Near R.P. 114											
	Spray History Results From 12/25/03 to 4/11/04											
	Project Manager Troy Gilbertson, NDDOT Fargo											
Date/Time	Bridge Sprayer History Status	User Activation	Sfc	Frenzor Freeze Pt. Frz *	Dew	Wind SpdAvg	Status	Chem %	Chem Factor	Atmos Temp	Should System Have Fired	Did System Fire
12/25/2003 20:01	Active Due to Frost Condition	No	26.1	No Data	27.7	12	Wet	5%	85	28.9	Yes	Yes
12/26/2003 0:00	Active Due to Frost Condition	No	33.1	No Data	33.4	13	Wet	4%	95	34	Yes	Yes
1/1/2004 9:37	Active Due to Frost Condition	No	20.1	No Data	19.4	9	Chemical Wet	7%	95	21.9	Yes	Yes
1/2/2004 12:58	Active Due to Freeze Point Condition	No	25.7	29.3	16.2	15	Chemical Wet	3%	95	16.9	Yes	Yes
1/2/2004 10:38	Active Due to Freeze Point Condition	No	24.4	No Data	19.6	9	Chemical Wet	-	75	20.1	Yes	Yes
1/2/2004 9:07	Active Due to Frost Condition	No	20.3	No Data	18.7	14	Ice Warning	-	60	19.2	Yes	Yes
1/10/2004 8:46	Active Due to Frost Condition	No	22.6	No Data	22.8	11	Chemical Wet	-	95	23	Yes	Yes
1/10/2004 4:44	Active Due to Frost Condition	No	20.1	No Data	20.3	8	Ice Warning	0%	30	20.7	Yes	Yes
1/9/2004 19:52	Active Due to Frost Condition	No	20.1	No Data	18.3	4	Ice Warning	0%	5	19.4	Yes	Yes
1/11/2004 6:40	Active Due to Frost Condition	No	21.6	No Data	19.8	7	Chemical Wet	-	95	19.9	Yes	Yes
1/11/2004 2:39	Active Due to Frost Condition	No	22.6	No Data	21	8	Chemical Wet	5%	75	21.4	Yes	Yes
1/10/2004 22:37	Active Due to Frost Condition	No	23.5	No Data	23.5	6	Chemical Wet	5%	55	23.7	Yes	Yes
1/10/2004 18:36	Active Due to Frost Condition	No	25	No Data	23.7	7	Chemical Wet	4%	55	24.3	Yes	Yes
1/10/2004 17:01	Active Due to Frost Condition	No	26.4	No Data	24.6	9	Chemical Wet	3%	70	25.2	Yes	Yes
1/12/2004 15:34	Active Due to Frost Condition	No	31.1	No Data	29.3	11	Chemical Wet	4%	45	30.2	Yes	Yes
1/12/2004 9:24	Active Due to Frost Condition	No	23.9	No Data	23	4	Chemical Wet	5%	95	23.9	Yes	Yes
1/12/2004 5:23	Active Due to Frost Condition	No	20.1	No Data	24.6	11	Ice Warning	1%	20	25.2	Yes	Yes
1/12/2004 19:13	Active Due to Freeze Point Condition	No	25.2	23.4	18.1	17	Chemical Wet	3%	5	20.8	Yes	Yes
1/14/2004 0:37	Active Due to Frost Condition	No	20.1	No Data	22.5	6	Ice Warning	1%	15	22.8	Yes	Yes
1/15/2004 13:16	Active Due to Freeze Point Condition	No	27	No Data	16.2	13	Dry	-	-	19.6	No	Yes
1/15/2004 6:37	Inactive Due to Low Surface Temperature	No	6.6	No Data	6.8	11	Ice Warning	0%	10	7.7	No	Yes
1/16/2004 5:14	Active Due to Frost Condition	No	20.1	No Data	18.7	9	Ice Warning	-	5	19.9	Yes	Yes
1/17/2004 0:13	Active Due to Frost Condition	No	22.8	No Data	21	11	Ice Warning	2%	5	21.9	Yes	Yes
1/16/2004 20:05	Active Due to Freeze Point Condition	No	28.2	No Data	26.4	10	Ice Warning	1%	5	27.1	Yes	Yes
1/20/2004 16:10	RWIS Triggered Due To Frz Pt & Did Not Respond	No	16.9	No Data	13.5	16	Ice Warning	1%	5	14.9	Yes	No
1/20/2004 17:32	RWIS Triggered Due To Frz Pt & Did Not Respond	No	16.7	14	15.4	14	Ice Warning	1%	5	15.6	Yes	No
1/20/2004 20:10	RWIS Triggered Due To Frz Pt & Did Not Respond	No	18	No Data	18.9	13	Ice Warning	1%	5	19.6	Yes	No
1/21/2004 0:11	RWIS Triggered Due to Frost & Did Not Respond	No	22.6	No Data	25.9	11	Ice Warning	1%	15	26.8	Yes	No
1/21/2004 4:32	RWIS Triggered Due to Frost & Did Not Respond	No	18.7	No Data	17.6	12	Ice Warning	0%	15	21.6	Yes	No
1/26/2004 10:20	Manual Activation	Yes	10	No Data	5.9	10	Ice Warning	-	5	6.4	Yes	Yes
1/26/2004 11:56	Active Due to Freeze Point Condition	No	15.1	No Data	5.9	16	Ice Warning	0%	5	6.3	Yes	Yes
2/5/2004 1:51	RWIS Triggered Due To Frz Pt & Did Not Respond	No	15.3	18.3	16.5	16	Ice Warning	0%	5	16.9	Yes	No
2/5/2004 12:47	RWIS Triggered Due To Frz Pt & Did Not Respond	No	31.1	30.9	21.4	12	Ice Warning	0%	20	22.1	Yes	No
2/5/2004 16:56	Active Due to Freeze Point Condition	No	25.5	No Data	21.6	8	Ice Warning	0%	30	21.9	Yes	Yes
2/5/2004 21:30	Active Due to Freeze Point Condition	No	17.8	No Data	13.5	17	Ice Warning	0%	5	14.4	Yes	Yes
2/5/2004 22:50	Active Due to Freeze Point Condition	No	16.3	No Data	12.2	16	Ice Warning	0%	30	13.1	Yes	Yes

2/6/2004 11:00	Active Due to Freeze Point Condition	No	17.4	**14.4**	5.7	21	Ice Warning	1%	5	7	Yes	Yes
2/6/2004 12:00	Active Due to Freeze Point Condition	No	19.6	**No Data**	5.7	23	Ice Warning	1%	10	7.3	Yes	Yes
2/6/2004 15:04	Active Due to Freeze Point Condition	No	17.8	**No Data**	5	19	Ice Warning	0%	5	6.8	Yes	Yes
2/8/2004 8:24	Active Due to Freeze Point Condition	No	14.2	**16.2**	14.7	11	Ice Warning	0%	5	15.1	Yes	Yes
2/8/2004 11:12	Active Due to Freeze Point Condition	No	23.7	**No Data**	20.7	7	Ice Warning	3%	30	21.2	Yes	Yes
2/8/2004 19:22	Active Due to Frost Condition	No	24.6	**No Data**	22.8	12	Ice Warning	0%	35	24.1	Yes	Yes
2/8/2004 23:23	Active Due to Frost Condition	No	24.4	**No Data**	23.9	13	Chemical Wet	0%	90	24.8	Yes	Yes
2/9/2004 1:51	Active Due to Freeze Point Condition	No	23.9	No Data	22.8	14	Chemical Wet	0%	95	23.7	Yes	Yes
2/9/2004 2:53	Active Due to Freeze Point Condition	No	24.1	No Data	23.2	14	Chemical Wet	0%	95	24.1	Yes	Yes
2/9/2004 4:35	Active Due to Freeze Point Condition	No	23.2	14.5	22.6	16	Chemical Wet	0%	95	23.4	Yes	Yes
2/9/2004 5:36	Active Due to Freeze Point Condition	No	23.2	No Data	23	14	Chemical Wet	0%	95	23.5	Yes	Yes
2/9/2004 6:48	Active Due to Freeze Point Condition	No	22.3	No Data	22.3	11	Chemical Wet	0%	95	22.6	Yes	Yes
2/9/2004 9:15	Active Due to Freeze Point Condition	No	22.5	No Data	18.9	18	Ice Warning	1%	50	19.4	Yes	Yes
2/9/2004 10:22	Active Due to Freeze Point Condition	No	26.8	28.9	17.2	16	Chemical Wet	0%	95	19.6	Yes	Yes
2/10/12:43 12:43	Active Due to Freeze Point Condition	No	22.6	No Data	4.1	11	Dry	0%	0	6.4	Yes	Yes
2/10/2004 13:45	Active Due to Freeze Point Condition	No	19.2	No Data	5.7	17	Ice Warning	0%	45	7.5	Yes	Yes
2/10/2004 16:30	Active Due to Freeze Point Condition	No	17.6	No Data	12.4	16	Ice Warning	2%	45	12.9	Yes	Yes
2/10/2004 17:34	Active Due to Freeze Point Condition	No	15.8	No Data	12.9	17	Chemical Wet	0%	65	13.3	Yes	Yes
2/10/2004 19:36	Active Due to Freeze Point Condition	No	15.3	14.9	14.7	16	Ice Warning	2%	20	15.1	Yes	Yes
2/10/2004 20:38	Active Due to Freeze Point Condition	No	15.6	15.1	14.9	14	Ice Warning	0%	55	15.4	Yes	Yes
2/10/2004 21:38	Active Due to Freeze Point Condition	No	16.2	26.6	15.8	14	Ice Warning	2%	25	16.3	Yes	Yes
2/10/2004 22:41	Active Due to Freeze Point Condition	No	16.5	No Data	16.5	9	Chemical Wet	0%	95	16.9	Yes	Yes
2/10/2004 23:42	Active Due to Freeze Point Condition	No	16.3	No Data	16.5	9	Chemical Wet	0%	95	16.9	Yes	Yes
2/11/2004 1:40	Active Due to Freeze Point Condition	No	16.5	No Data	16.5	11	Chemical Wet	0%	95	16.9	Yes	Yes
2/11/2004 5:41	Active Due to Freeze Point Condition	No	15.6	14	14.9	22	Ice Warning	1%	45	15.4	Yes	Yes
2/11/2004 6:42	Active Due to Freeze Point Condition	No	14.9	14	13.6	21	Chemical Wet	0%	65	14.2	Yes	Yes
2/11/2004 9:20	Active Due to Freeze Point Condition	No	16	No Data	12.9	21	Ice Warning	1%	45	13.1	Yes	Yes
2/11/2004 10:22	Active Due to Freeze Point Condition	No	18.7	No Data	13.3	20	Ice Warning	1%	10	13.8	Yes	Yes
2/11/2004 16:11	Active Due to Freeze Point.Condition	No	18.7	No Data	10.9	27	Ice Warning	0%	5	11.5	No	Yes
2/12/2004 13:17	Inactive Critical Conditions not Detected	No	24.4	14	9.1	20	Dry	0%	0	13.1	Yes	Yes
2/12/2004 18:53	Active Due to Frost Condition	No	15.4	No Data	13.6	12	Ice Warning	0%	5	16.3	Yes	Yes
2/13/2004 8:53	Active Due to Freeze Point Condition	No	14.4	18.7	13.1	9	Ice Warning	0%	5	14.4	Yes	Yes
2/13/2004 18:02	Active Due to Freeze Point Condition	No	25.5	No Data	19.2	21	Ice Warning	0%	15	20.1	Yes	Yes
2/14/2004 13:51	Active Due to Freeze Point Condition	No	21.7	No Data	-8.3	9	Dry	0%	0	1.6	Yes	Yes
2/17/2004 12:22	Active Due to Freeze Point Condition	No	22.1	No Data	7	12	Dry	0%	0	7.3	Yes	Yes
2/17/2004 14:06	Active Due to Freeze Point Condition	No	23.7	No Data	10.9	17	Ice Warning	1%	10	11.5	Yes	Yes
2/17/2004 18:08	Active Due to Freeze Point Condition	No	22.5	No Data	22.6	24	Ice Warning	1%	40	22.8	Yes	Yes
2/17/2004 19:09	Active Due to Freeze Point Condition	No	23	No Data	23.9	21	Ice Warning	1%	40	24.1	Yes	Yes
2/17/2004 20:10	Active Due to Freeze Point Condition	No	23.4	21.9	23.9	20	Ice Warning	1%	50	24.3	Yes	Yes
2/17/2004 21:11	Active Due to Freeze Point Condition	No	24.4	No Data	25.7	17	Chemical Wet	0%	60	25.7	Yes	Yes
2/18/2004 1:14	Active Due to Frost Condition	No	17.8	No Data	18.1	10	Ice Warning	1%	40	18.5	Yes	Yes
2/18/2004 5:18	Active Due to Frost Condition	No	17.8	No Data	20.7	17	Chemical Wet	0%	95	20.8	Yes	Yes
2/18/2004 7:27	Active Due to Freeze Point Condition	No	21.4	No Data	23.2	13	Chemical Wet	0%	95	24.1	Yes	Yes
2/19/2004 7:19	Active Due to Frost Condition	No	28	No Data	26.2	10	Chemical Wet	3%	95	27.1	Yes	Yes
2/20/2004 3:32	Active Due to Frost Condition	No	31.1	No Data	29.5	12	Chemical Wet	4%	95	30	Yes	Yes
2/20/2004 7:34	Active Due to Frost Condition	No	30.4	No Data	28.6	19	Chemical Wet	6%	95	28.9	Yes	Yes
2/21/2004 22:39	Active Due to Frost Condition	No	22.8	No Data	22.8	8	Ice Warning	0%	5	21.4	Yes	Yes
2/22/2004 0:58	Active Due to Freeze Point Condition	No	24.8	No Data	24.8	6	Chemical Wet	0%	95	22.5	Yes	Yes
2/22/2004 2:21	Active Due to Freeze Point Condition	No	23.7	No Data	23.7	5	Chemical Wet	0%	95	22.6	Yes	Yes
2/22/2004 3:41	Active Due to Freeze Point Condition	No	23	No Data	23	4	Chemical Wet	0%	95	21.7	Yes	Yes

2/22/2004 7:41	Active Due to Frost Condition	No	20.1	No Data	20.1	8	Chemical Wet	0%	95	19.6	Yes	Yes
2/23/2004 2:46	Active Due to Frost Condition	No	26.8	No Data	26.8	11	Chemical Wet	3%	90	25.5	Yes	Yes
2/23/2004 6:48	Active Due to Frost Condition	No	26.6	No Data	26.6	8	Chemical Wet	3%	95	25.9	Yes	Yes
2/24/2004 7:39	Active Due to Freeze Point Condition	No	28.8	No Data	28.8	6	Chemical Wet	0%	90	25.9	Yes	Yes
2/24/2004 21:38	Active Due to Frost Condition	No	30.6	No Data	30.6	17	Chemical Wet	1%	60	29.5	Yes	Yes
2/25/2004 1:40	Active Due to Frost Condition	No	30.4	No Data	30.4	12	Chemical Wet	2%	60	30.2	Yes	Yes
2/25/2004 5:42	Active Due to Frost Condition	No	30	No Data	30	18	Chemical Wet	3%	95	29.3	Yes	Yes
2/25/2004 22:51	Active Due to Frost Condition	No	30.6	No Data	28.8	22	Chemical Wet	2	50	29.8	Yes	Yes
2/26/2004 2:50	Active Due to Frost Condition	No	27.9	No Data	28.2	21	Chemical Wet	3%	50	28.8	Yes	Yes
2/26/2004 3:51	Active Due to Freeze Point Condition	No	28.2	27	28.2	21	Chemical Wet	4%	95	28.6	Yes	Yes
2/26/2004 7:52	Active Due to Frost Condition	No	26.1	No Data	26.1	17	Chemical Wet	5%	95	26.2	Yes	Yes
2/26/2004 20:11	Active Due to Frost Condition	No	33.6	No Data	32	19	Wet	1%	95	33.4	Yes	Yes
2/27/2004 0:34	Active Due to Frost Condition	No	30.7	No Data	31.3	19	Chemical Wet	4%	95	32	Yes	Yes
2/27/2004 4:57	Active Due to Frost Condition	No	31.8	No Data	32.7	25	Chemical Wet	6%	95	34.2	Yes	Yes
2/27/2004 23:28	Active Due to Frost Condition	No	33.6	No Data	33.4	16	Wet	4%	90	34.3	Yes	Yes
2/28/2004 3:29	Active Due to Frost Condition	No	29.8	No Data	30.7	8	Chemical Wet	5%	95	31.1	Yes	Yes
2/28/2004 7:30	Active Due to Frost Condition	No	27.9	No Data	26.4	4	Chemical Wet	4%	95	26.8	Yes	Yes
2/29/2004 4:54	Active Due to Frost Condition	No	31.8	No Data	30.6	14	Chemical Wet	3%	95	31.5	Yes	Yes
2/29/2004 9:39	Active Due to Frost Condition	No	32	No Data	31.3	12	Chemical Wet	5%	95	31.8	Yes	Yes
2/29/2004 18:39	Active Due to Freeze Point Condition	No	33.3	31.8	32.2	14	Wet	1%	30	32.4	Yes	Yes
2/29/2004 20:10	Active Due to Freeze Point Condition	No	33.1	31.5	32.4	13	Wet	0%	45	32.5	Yes	Yes
2/29/2004 22:07	Active Due to Freeze Point Condition	No	32.9	31.3	32.4	14	Wet	1%	55	32.4	Yes	Yes
2/29/2004 23:19	Active Due to Freeze Point Condition	No	32.9	32	32.4	14	Wet	0%	85	32.5	Yes	Yes
3/1/2004 0:20	Active Due to Freeze Point Condition	No	32.7	31.8	32.4	17	Chemical Wet	0	50	32.5	Yes	Yes
3/1/2004 1:21	Active Due to Freeze Point Condition	No	32.2	31.5	32.4	17	Chemical Wet	0	40	32.7	Yes	Yes
3/1/2004 2:23	Active Due to Freeze Point Condition	No	32.2	32	32.4	19	Chemical Wet	0	10	32.7	Yes	Yes
3/1/2004 3:23	Active Due to Freeze Point Condition	No	32.5	31.1	32.4	17	Chemical Wet	0	50	32.5	Yes	Yes
3/1/2004 13:56	Active Due to Freeze Point Condition	No	34.3	30.9	30.2	19	Wet	1%	45	30.4	Yes	Yes
3/1/2004 15:57	Active Due to Freeze Point Condition	No	33.6	32	30.2	22	Wet	1%	60	30.4	Yes	Yes
3/1/2004 16:59	Active Due to Freeze Point Condition	No	32	31.6	29.7	22	Chemical Wet	1%	40	30	Yes	Yes
3/1/2004 18:07	Active Due to Freeze Point Condition	No	30.9	29.7	28.9	26	Chemical Wet	0%	30	29.1	No	Yes
3/1/2004 22:08	Active Due to Frost Condition	No	28.9	No Data	28.4	27	Ice Warning	0%	15	28.8	No	Yes
3/2/2004 2:19	Active Due to Freeze Point Condition	No	27.1	25.5	26.2	21	Ice Warning	1%	30	27.5	Yes	Yes
3/2/2004 4:50	Active Due to Freeze Point Condition	No	23.4	21.7	23.7	15	Chemical Wet	0%	95	25	Yes	Yes
3/3/2004 3:08	Active Due to Frost Condition	No	28.6	No Data	26.6	6	Chemical Wet	3%	95	27	Yes	Yes
3/3/2004 5:53	Active Due to Freeze Point Condition	No	26.8	No Data	23	12	Ice Warning	1%	5	23.5	Yes	Yes
3/3/2004 7:15	Active Due to Freeze Point Condition	No	25	14	21.2	11	Chemical Wet	0%	95	21.7	Yes	Yes
3/3/2004 17:21	Active Due to Freeze Point Condition	No	29.1	29.1	16.2	15	Dry	0%	5	16.7	Yes	Yes
3/3/2004 19:00	Active Due to Freeze Point Condition	No	18.3	No Data	9.3	12	Ice Warning	0%	5	10.4	Yes	Yes
3/4/2004 9:08	Active Due to Freeze Point Condition	No	15.1	No Data	6.8	Calm	Dry	0%	0	7.9	Yes	Yes
3/4/2004 11:09	Active Due to Freeze Point Condition	No	30	No Data	11.7	9	Chemical Wet	1%	5	12.6	Yes	Yes
3/4/2004 18:24	Active Due to Freeze Point Condition	No	24.4	No Data	17.6	6	Chemical Wet	0%	55	19.4	Yes	Yes
3/4/2004 22:26	Active Due to Frost Condition	No	23.5	No Data	21.7	8	Ice Warning	2	5	22.3	Yes	Yes
3/5/2004 2:28	Active Due to Frost Condition	No	24.8	No Data	25.3	6	Ice Warning	1	35	25.7	Yes	Yes
3/5/2004 6:07	Active Due to Freeze Point Condition	No	22.8	No Data	20.7	16	16	1	55	20.8	Yes	Yes
3/5/2004 7:37	Active Due to Freeze Point Condition	No	22.1	27.1	20.1	19	Chemical Wet	0	95	20.5	Yes	Yes
3/5/2004 7:51	Manual Activation Due To Freeze Point	Yes	22.1	27.1	20.3	17	Chemical Wet	0%	95	20.7	Yes	Yes
3/5/2004 8:35	Manual Activation Due To Freeze Point	Yes	24.3	No Data	20.8	16	Chemical Wet	0%	95	21	Yes	Yes
3/5/2004 9:41	Active Due to Freeze Point Condition	No	26.2	27.1	21.7	16	Chemical Wet	0%	95	21.9	Yes	Yes
3/5/2005 22:15	Active Due to Freeze Point Condition	No	27	14	21.2	6	Ice Warning	0%	5	22.1	Yes	Yes

3/6/2004 6:39	Active Due to Frost Condition	No	16.3	No Data	14.5	11	Ice Warning	0%	35	15.1	Yes	Yes
3/6/2004 7:41	Active Due to Freeze Point Condition	No	18.7	No Data	15.6	11	Chemical Wet	0%	95	16	Yes	Yes
3/6/2004 10:06	Active Due to Freeze Point Condition	No	30.4	No Data	19.8	17	Chemical Wet	1%	45	20.3	Yes	Yes
3/6/2004 19:36	Active Due to Freeze Point Condition	No	31.5	29.8	29.7	19	Chemical Wet	2%	85	31.8	Yes	Yes
3/6/2004 23:37	Active Due to Frost Condition	No	26.1	No Data	25.7	17	Chemical Wet	0%	70	20.8	Yes	Yes
3/7/2004 3:39	Active Due to Frost Condition	No	28.9	No Data	27.7	16	Chemical Wet	2%	95	29.8	Yes	Yes
3/7/2004 7:41	Active Due to Frost Condition	No	28.2	No Data	27	18	Ice Warning	1%	35	27.7	Yes	Yes
3/8/2004 0:51	Active Due to Freeze Point Condition	No	19.9	No Data	13.6	9	Ice Warning	0%	5	14.2	Yes	Yes
3/8/2004 4:53	Active Due to Frost Condition	No	23.5	No Data	21.7	16	Chemical Wet	0%	95	24.3	Yes	Yes
3/8/2004 22:41	Active Due to Frost Condition	No	32.4	No Data	30.9	10	Chemical Wet	0%	5	33.3	Yes	Yes
3/9/2004 2:42	Active Due to Frost Condition	No	27.3	No Data	27.1	11	Ice Warning	1%	30	28	Yes	Yes
3/9/2004 6:12	Active Due to Freeze Point Condition	No	23.7	No Data	22.3	9	Chemical Wet	0	65	22.6	Yes	Yes
3/9/2004 7:18	Active Due to Freeze Point Condition	No	24.3	No Data	22.6	9	Chemical Wet	0	75	23.2	Yes	Yes
3/10/2004 3:05	Active Due to Freeze Point Condition	No	33.8	No Data	33.3	15	Wet	2	10	35.1	Yes	Yes
3/10/2004 7:52	Active Due to Freeze Point Condition	No	33.4	32	34	17	Wet	3	95	34.5	Yes	Yes
3/10/2004 17:47	Active Due to Freeze Point Condition	No	33.6	32	24.1	22	Wet	0%	65	25	Yes	Yes
3/10/2004 19:40	Active Due to Freeze Point Condition	No	20.5	21	10.4	28	Ice Warning	0%	5	10.9	No	Yes
3/13/2004 0:22	Active Due to Frost Condition	No	30.6	No Data	28.8	13	Ice Warning	0%	5	30.4	Yes	Yes
3/13/2004 5:22	Active Due to Frost Condition	No	30	No Data	28.4	18	Ice Warning	0%	10	31.3	Yes	Yes
3/13/2004 23:46	Active Due to Freeze Point Condition	No	27	14	23.9	16	Ice Warning	0%	10	24.1	Yes	Yes
3/14/2004 2:12	Active Due to Freeze Point Condition	No	25.7	14	24.3	27	Chemical Wet	0%	55	24.6	No	Yes
3/14/2004 4:13	Active Due to Freeze Point Condition	No	24.3	No Data	23.2	29	Chemical Wet	0%	95	23.5	No	Yes
3/14/2004 5:22	Active Due to Freeze Point Condition	No	23.7	16	22.6	29	Chemical Wet	0%	95	22.8	No	Yes
3/15/2004 22:15	Active Due to Frost Condition	No	24.8	No Data	23	12	Ice Warning	0%	5	23.4	Yes	Yes
3/16/2004 2:16	Active Due to Frost Condition	No	23.2	No Data	25	13	Chemical Wet	0%	95	25.9	Yes	Yes
3/16/2004 6:18	Active Due to Frost Condition	No	26.6	No Data	26.8	14	Chemical Wet	9%	95	27.3	Yes	Yes
3/16/2004 12:38	Active Due to Freeze Point Condition	No	32.2	32	30.4	15	Chemical Wet	4%	95	30.9	Yes	Yes
3/16/2004 13:41	Active Due to Freeze Point Condition	No	32.9	32	30.6	17	Wet	0%	95	30.9	Yes	Yes
3/16/2004 14:46	Active Due to Freeze Point Condition	No	32.2	32	30.7	14	Chemical Wet	0%	95	31.1	Yes	Yes
3/16/2004 19:05	Active Due to Frost Condition	No	31.5	28	32	11	Chemical Wet	0%	65	32	Yes	Yes
3/16/2004 23:06	Active Due to Frost Condition	No	24.4	No Data	24.1	7	Chemical Wet	5%	5	24.3	Yes	Yes
3/17/2004 3:19	Active Due to Frost Condition	No	18	No Data	16.5	11	Ice Warning	3%	40	17.1	Yes	Yes
3/17/2004 7:20	Active Due to Frost Condition	No	17.4	No Data	17.6	6	Ice Warning	7%	50	17.8	Yes	Yes
3/17/2004 21:22	Active Due to Freeze Point Condition	No	32.9	32	32	4	Wet	8%	30	32.4	Yes	Yes
3/17/2004 22:23	Active Due to Freeze Point Condition	No	32.2	32	32	4	Chemical Wet	0%	55	32.5	Yes	Yes
3/17/2004 23:24	Active Due to Freeze Point Condition	No	32.5	32	32.4	5	Chemical Wet	0%	65	32.5	Yes	Yes
3/18/2004 0:26	Active Due to Freeze Point Condition	No	33.1	32	32.2	9	Wet	0%	15	32.4	Yes	Yes
3/18/2004 1:27	Active Due to Freeze Point Condition	No	31.8	31.5	31.8	14	Chemical Wet	0%	70	32	Yes	Yes
3/18/2004 2:29	Active Due to Freeze Point Condition	No	31.8	32	31.3	14	Chemical Wet	0%	95	31.5	Yes	Yes
3/18/2004 3:31	Active Due to Freeze Point Condition	No	29.1	28.8	28.26	11	Chemical Wet	3%	95	28.4	Yes	Yes
3/21/2004 22:07	Active Due to Frost Condition	No	18.1	No Data	16.3	6	Ice Warning	0%	5	17.8	Yes	Yes
3/22/2004 2:09	Active Due to Frost Condition	No	14.9	No Data	18	8	Chemical Wet	0%	60	18.1	No	Yes
3/22/2004 6:10	Active Due to Frost Condition	No	14.7	No Data	18.7	9	Chemical Wet	0%	95	18.9	No	Yes
3/23/2004 0:05	Active Due to Frost Condition	No	29.1	No Data	27.3	14	Chemical Wet	1%	5	28.6	Yes	Yes
4/1/2004 5:24	Active Due to Frost Condition	No	32.2	No Data	30.6	11	Chemical Wet	0%	10	32.5	Yes	Yes
4/3/2004 1:32	Active Due to Frost Condition	No	33.4	No Data	31.8	12	Chemical Wet	0%	5	32.9	Yes	Yes
4/3/2004 5:33	Active Due to Frost Condition	No	29.1	No Data	30.4	5	Chemical Wet	2%	40	30.6	Yes	Yes
4/4/2004 1:45	Active Due to Frost Condition	No	30.6	No Data	28.8	4	Ice Warning	0%	5	30	Yes	Yes
4/4/2004 6:47	Active Due to Frost Condition	No	27.5	No Data	28.9	4	Chemical Wet	0%	80	29.1	Yes	Yes
4/8/2004 1:01	No Status Report Given	No	32.7	No Data	31.3	11	Ice Warning	0%	5	32.2	Yes	No
4/8/2004 6:01	No Status Report Given	No	27.3	No Data	27.7	8	Frost	0%	0	28.9	Yes	No
4/9/2004 6:38	No Status Report Given	No	31.6	32	27.1	4	Ice Warning	0%	35	28.9	Yes	No
4/9/2004 7:40	No Status Report Given	No	31.3	32	26.1	8	Ice Warning	0%	45	28.9	Yes	No
4/9/2004 8:42	No Status Report Given	No	31.5	32	25.5	8	Ice Warning	0%	35	28.4	Yes	No
4/11/2004 5:21	No Status Report Given	No	22.1	No Data	22.8	9	Frost	0%	0	24.4	Yes	No