



Edge Storms: A Case Study

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ABSTRACT

When a blizzard drops 50 cm of snow over a twenty four hour period, combined with 50 kilometer per hour (kph) winds, it is apparent to most people that this is a severe winter storm. Likewise, if an ice storm results in 2 cm of ice on every surface, highway travel will be curtailed for a while. But there are a number of other storms which can pose unexpectedly difficult problems for winter service providers. Many such storms involve pavement temperatures at or around the freezing point, and the physical boundary between rain, freezing rain, and snow may move significantly during a storm. Part of the difficulty in such storms relates to the phase changes that occur at the freezing point. These phase changes are energy intensive and predicting those energy flows is difficult, making weather forecasting of, for example, the boundaries between snow, freezing rain, and rain in a given storm extremely difficult.

This paper explores the difficulties associated with such edge storms by way of a case study of a storm that occurred in Iowa in December 2012. The case study uses information taken from the City of West Des Moines and specifically from their Department of Public Works, which provides winter services for the city. In addition to details of the storm, the lessons learned from handling this particular storm will be detailed and expanded upon.

Keywords: winter storm case study; winter highway maintenance; pavement temperature

1 INTRODUCTION

The City of West Des Moines is located about 320 miles (512 kilometres) west of Chicago, as shown in Figure 1. It is a suburb of Des Moines, the State Capital of Iowa. It has experienced significant growth over the past two decades and now has a population of about 62,100. West Des Moines maintains about 770 lane miles (1232 lane kilometres) of roads of which 714 lane miles (1,142 lane kilometres) are paved, broken into three priority levels as described in their policy manual available at: <http://www.wdm.iowa.gov/Index.aspx?page=311>¹.

In terms of strategies employed by the City of West Des Moines, they make extensive use of liquid brines in their winter service activities, often using a variety of blended brines. They have 13 single axle dump trucks and 5 tandem axle dump trucks, along with two one ton trucks, a motor grader, three snow blowers, and four pickup trucks with plows for use in their winter service activities. They have a meteorological services contract that allows them to contact their forecaster at any time, and also provides regular updates every 12 hours. They are recognized to be one of the leaders in winter maintenance practice in the US.

The climate in Iowa is a typical continental climate, so very cold weather in winter is relatively normal. This means that winter storms are common, and heavy storms, such as blizzards, are not too unusual [1]. A typical storm in West Des Moines would involve about 10 to 20 cm of total snowfall, with pavement temperatures of between 0° and -5° C. In such circumstances, a strategy of pre-treatment of the road system with brine, followed by plowing and additional treatment with pre-wet solid salt is extremely effective at maintaining suitable levels of service in West Des Moines. One challenge of a typical storm in Iowa is that often after the storm the temperature will drop and winds will pick up. This means that unless roads are dry at the end of the storm, or

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soon thereafter, blowing and drifting snow can stick to wet patches on the road and create icy spots. However, careful monitoring of pavement conditions, along with experienced crew who know to reduce salt application as the storm progresses in general avoids this sort of situation.

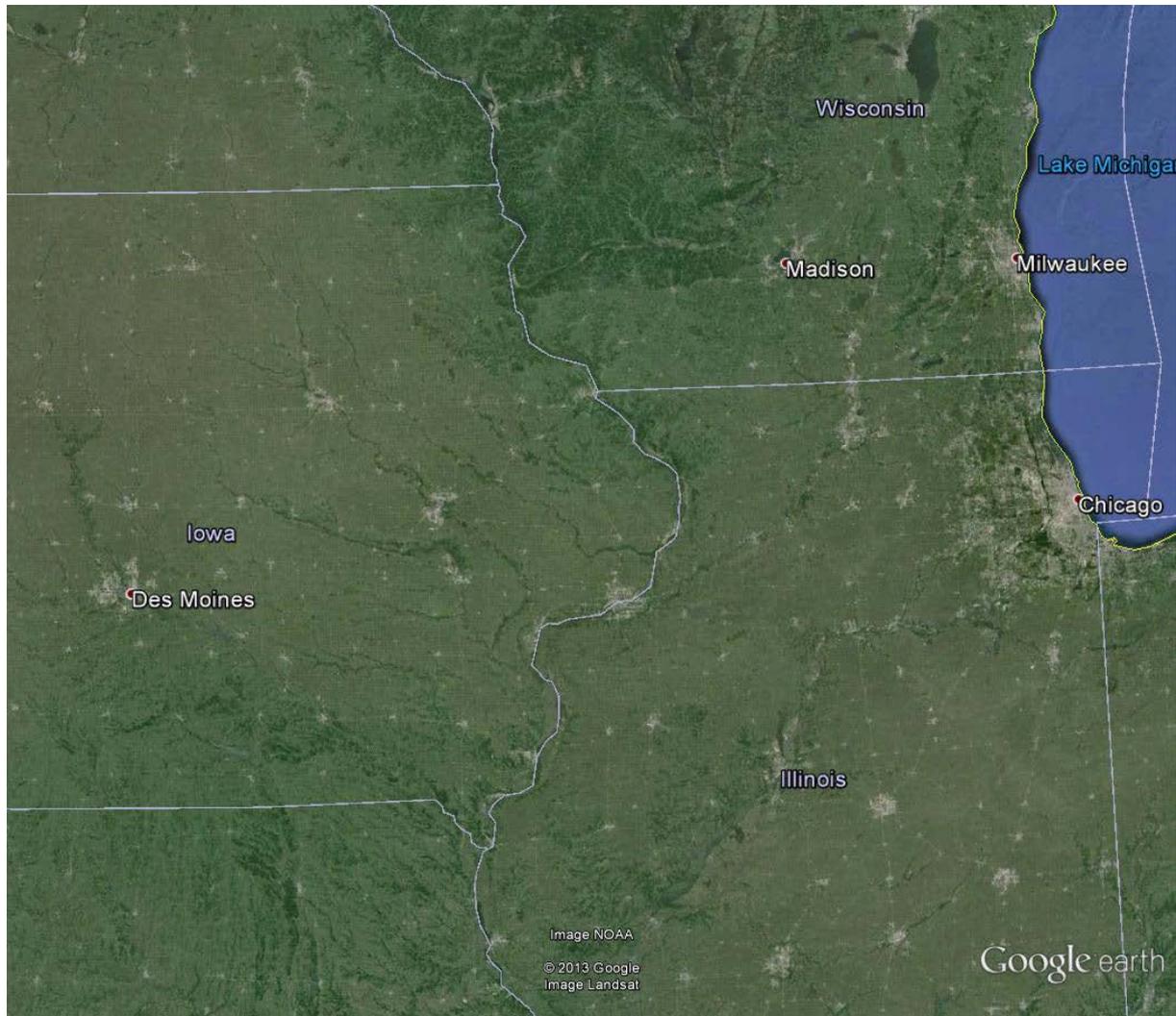


Figure 1: The General Location of West Des Moines Relative to Chicago

While responses are well understood for standard storms and for extreme storms, recent experience shows that it may be helpful to think in terms of a third operational category of storms – edge storms. Edge storms are those which at first glance (and certainly from a purely meteorological perspective) do not appear to be particularly hard to deal with operationally. However, some aspect of the storm may be such that a slight change in weather patterns could result in a storm that is far from straightforward to address operationally.

For the most part, edge storms happen at the beginning and the end of the winter season in any given locale. They are most often those storms in which the nature of the precipitation is not immediately obvious. A given storm system may comprise bands of snow, freezing rain, and rain. All three may be thought of as simply precipitation, but clearly operationally they pose very different challenges. Predicting what sort of precipitation will occur at a given location, or when during a storm the precipitation will change from one type to another at a given location is extremely difficult.

Even if a storm does not involve differing types of precipitation it may still be an edge storm, because of energy flows in the pavement (the road surface). This is one reason why edge storms are more common in the early and late winter season. If the pavement is slightly above freezing when precipitation starts, initially the precipitation will melt when it hits the pavement. If the event does not last long, or if the amount of precipitation is low, there may be no need for either plowing or application of ice control chemicals, because the pavement will melt any snow or ice. However, as precipitation continues, there comes a point when sufficient heat has been extracted from the pavement that subsequent frozen precipitation does not melt, and further the melt-water present on the pavement (from the earlier precipitation) may refreeze, creating a layer of ice between pavement and snow.

Given the complexity of the energy flows involved in these sorts of scenarios, predicting when or if freeze-up will occur is extremely difficult. Often, the change from melting to refreeze happens very rapidly and it may appear to be unexpected (especially if pavement temperature is not being closely monitored).

2 THE EDGE STORM IN QUESTION

The storm lasted from the afternoon of December 19, 2012 through the evening of December 20, 2012. While temperatures were in general close to freezing at the start of the storm, they began to fall on the second day. Wind speeds were high throughout the storm. Figure 2 shows the temperatures, barometric pressure and wind data from December 19 and figure 3 shows the same data for December 20 [2]. Figure 4 shows the weather map from NOAA for December 20, 2012 [3].

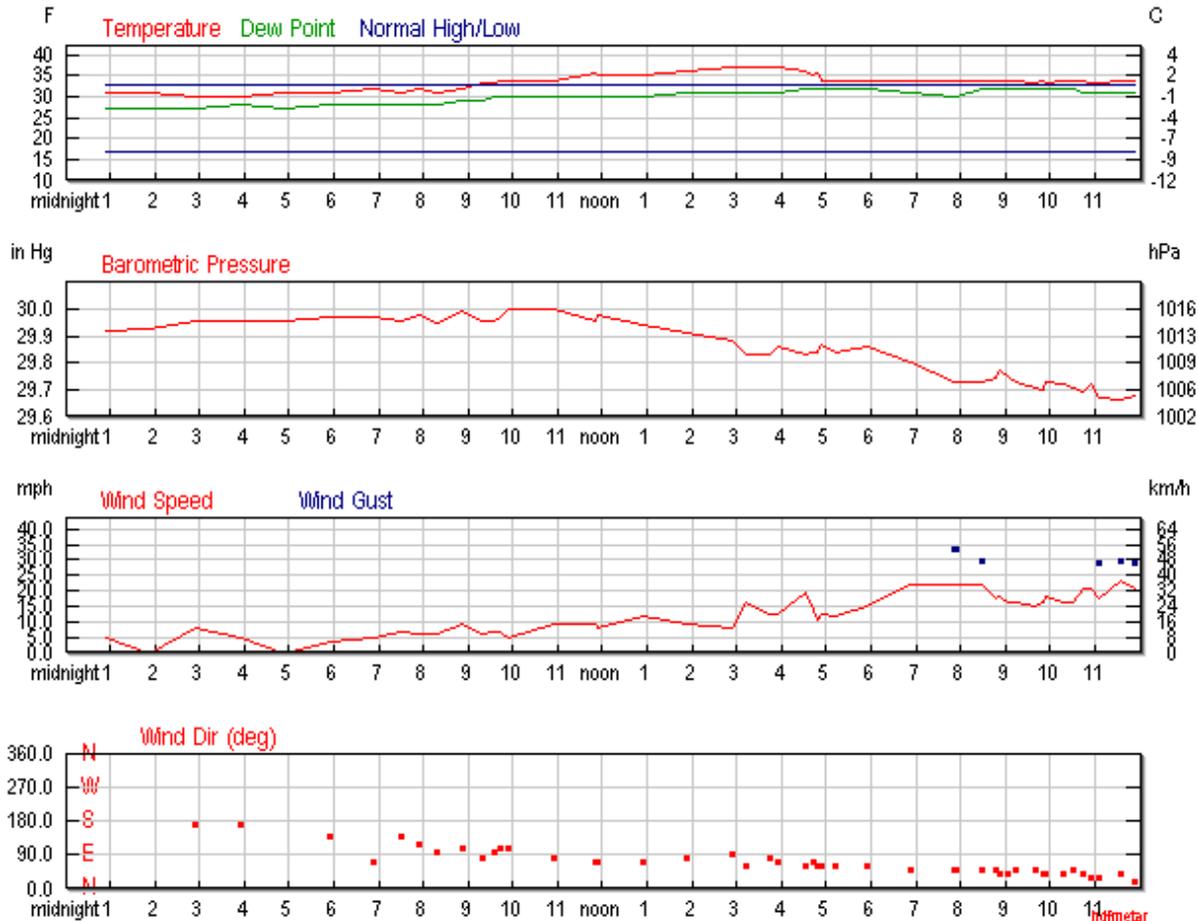


Figure 2: Temperature, Pressure, and Wind Data for 12/19/2012 [2]

Snow started falling at 4:00pm 12/19/2012 and continued to fall until 10:00pm 12/20/2012 (all times, including in Figures 2 and 3 are local time). A total of 12.4 inches (31.5 cm) of snow fell in this time, with 5.6 inches (14.2 cm) on 12/19/2012 and 6.8 inches (17.3 cm) on 12/20/2012. The snow was very wet, and was interspersed with periods of sleet on 12/19. Wind speeds began at about 14 mph sustained (about 22 kph) at the start of the storm and rose as high as 35 mph sustained (about 56 kph) in mid-afternoon on 12/20/2012. Wind gusts were as high as 54 mph (86 kph) that afternoon. The air temperature was slightly above freezing from the start of the storm until about 3 a.m. on 12/20/2012. Thereafter it dropped steadily until, at the end of the snow event, the air temperature was about -9°C .

Pavement temperatures started at about $+0.5^{\circ}\text{C}$ and continued to hold relatively steady in the range of 0° to -0.5°C during most of the storm. However, at about 3 p.m. on 12/20/2012 the pavement temperature began to fall steadily, reaching -10°C on 12/22/2012 at about 7 a.m.

The storm posed three main challenges. First, the wet nature of the snow (and the occasional sleet within the snow) meant that chemicals diluted rapidly. It also meant that there were some problems with downed power lines and tree limbs. Second, the high wind speed meant that drifting was a significant concern, especially at the end of the storm when snow drifted across roads that had been plowed and refroze. Third, the rapid drop in



pavement temperature in the latter part of the storm and thereafter meant that any wet roads would rapidly refreeze and that any unplowed snow would become much harder to plow as time passed.

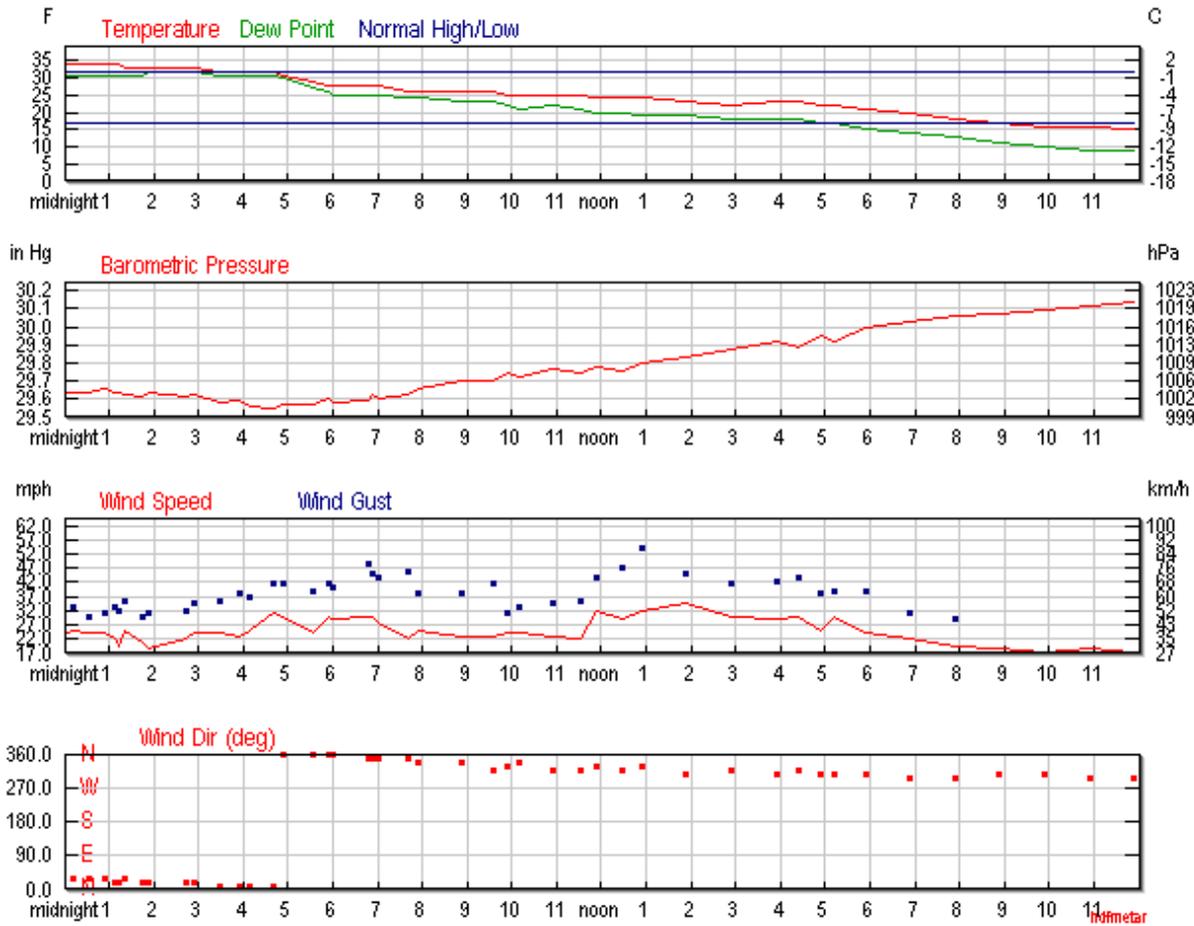


Figure 3: Temperature, Pressure, and Wind Data for 12/20/2012 [2]

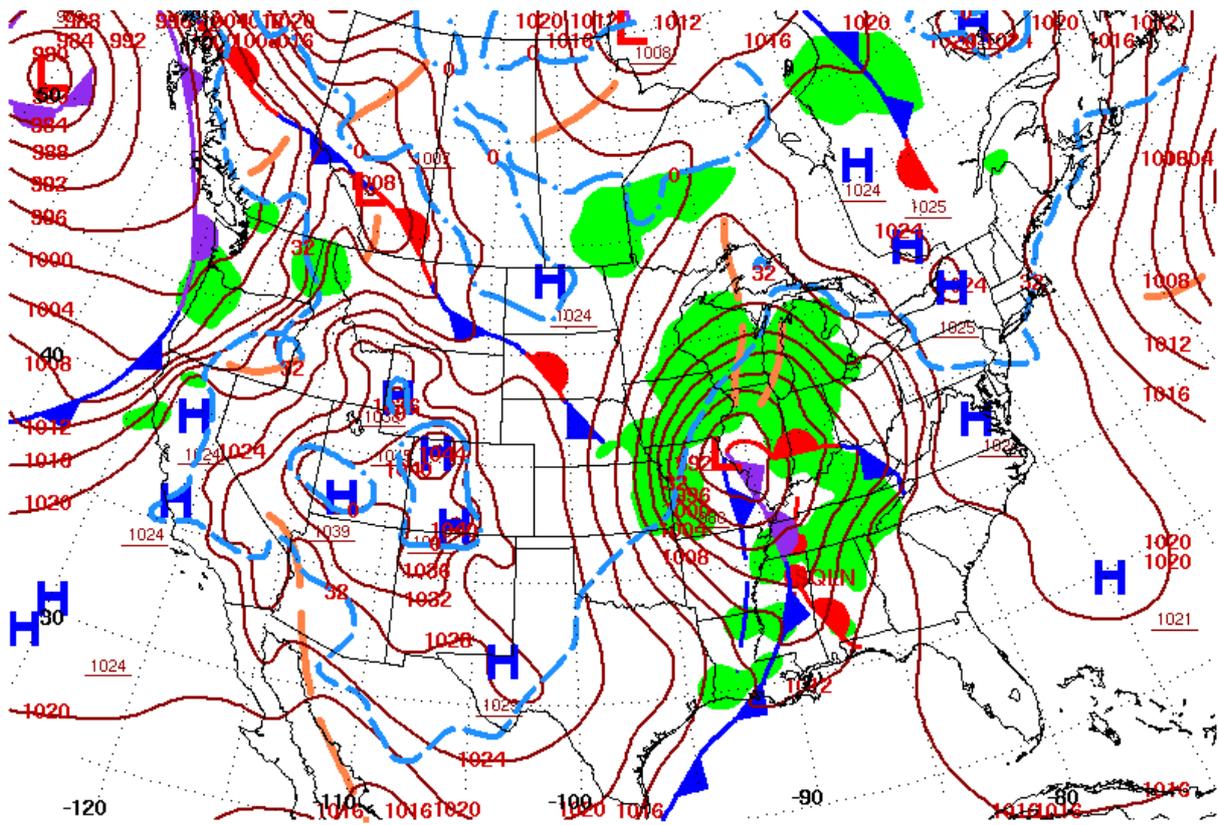
3 RESPONSES AND OUTCOMES

Standard practice for winter storms in the City of West Des Moines is to use two 12 hour shifts until the levels of service have been obtained. This approach was used during the storm of 12/19/2012 and the twin shift approach was in place for four days at which time the roads were deemed to have been cleared to their level of service. Figure 5 shows a typical situation that crews had to address – a fallen tree that had taken down power lines, thus creating a potentially extremely dangerous situation.

The moisture in the snow and the rapidly dropping pavement temperature resulted in road surfaces that were heavily frozen, as illustrated in Figure 6. There were also issues with signs being covered in frozen snow, and with traffic lights (that used LED lights rather than incandescent bulbs, thus producing less waste heat) becoming invisible due to blowing and frozen snow, as illustrated in Figure 7. This was an added burden on an already taxed public works department.

The total chemical usage during the storm was tracked and final numbers indicated 100 tons of solid salt were used, along with 3,100 gallons (11735 litres) of the brine mixture (termed “supermix”) used by West Des Moines. The supermix blend comprises 85% salt brine, 10% calcium chloride brine, and 5% of an agriculturally derived carbohydrate product (commonly called beet juice – it is often derived from sugar beet). The solid salt application rate for the whole storm was 280 lbs per lane mile (21.58 grams per square meter) and the liquid brine application rate was 4.3 gallons per lane mile (10 liters per lane kilometre). These numbers are slightly more than would be used in a normal storm of this duration (one without the wet snow and the cold temperatures) but not significantly so, in part because once it became clear that the temperature was dropping, additional chemical usage was stopped until the temperature rose again.

It is clear from the photographs shown that the road conditions were less than ideal during the storm, but they were appropriate given the nature of the storm, and the policy requirements for the City of West Des Moines. Nonetheless, even achieving these conditions involved a great deal of effort on the part of the maintenance crews.



Surface Weather Map at 7:00 A.M. E.S.T.

Figure 4: Surface Weather Map for US December 20, 2012, from NOAA [3].



Figure 5: Fallen Tree and Downed Power Lines in West Des Moines after 12/19/12 Storm



Figure 6: Frozen Road Surface Resulting from Wet Snow and Low Temperatures



Figure 7: Snow Covered Traffic Lights Being Cleared of Snow



4. LESSONS LEARNED AND CONCLUSIONS

To give some context to the quantities of materials used and the outcomes achieved, it is worth considering how West Des Moines compared with neighbouring municipalities in dealing with the storm (without naming those municipalities to avoid embarrassment). Nobody achieved better levels of service during the storm, and all municipalities that used chemicals as part of their snow and ice program used more chemicals than West Des Moines on a per lane mile basis. One neighbour in particular used nearly ten times as much chemical on a per lane mile basis and achieved a somewhat worse level of service.

The lesson from the comparison is that an agency must recognize when chemicals will not assist in achieving desired levels of service and must stop using them as soon as this is apparent, rather than continuing to use them in the hope that somehow things will get better.

In conclusion, while this was a particularly difficult storm to deal with, because of high moisture content (including sleet) in the snow fall and rapidly dropping temperatures after the storm, the City of West Des Moines was able to achieve their level of service goals, without excessive use of chemicals, primarily because they did not attempt to use chemicals when they would not help.

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5 REFERENCES

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