Agenda Item: 6.a.

MEMORANDUM

TO: Finance, Expenditure and Legal Subcommittee

SUBJECT: Platte River Ice Thickness Measurement Along Union Dike

DATE: February 3, 2010

FROM: Ron Lehman, O&M Superintendent

On February 3, 2010, the writer performed ice thickness measurements on the Platte River. The measurements were taken perpendicular to the river flow, near the Dike's 10 jetties project location, near Werner's Property south line, at approximately Station 160+00 (1.2 miles upstream of Highway 64).

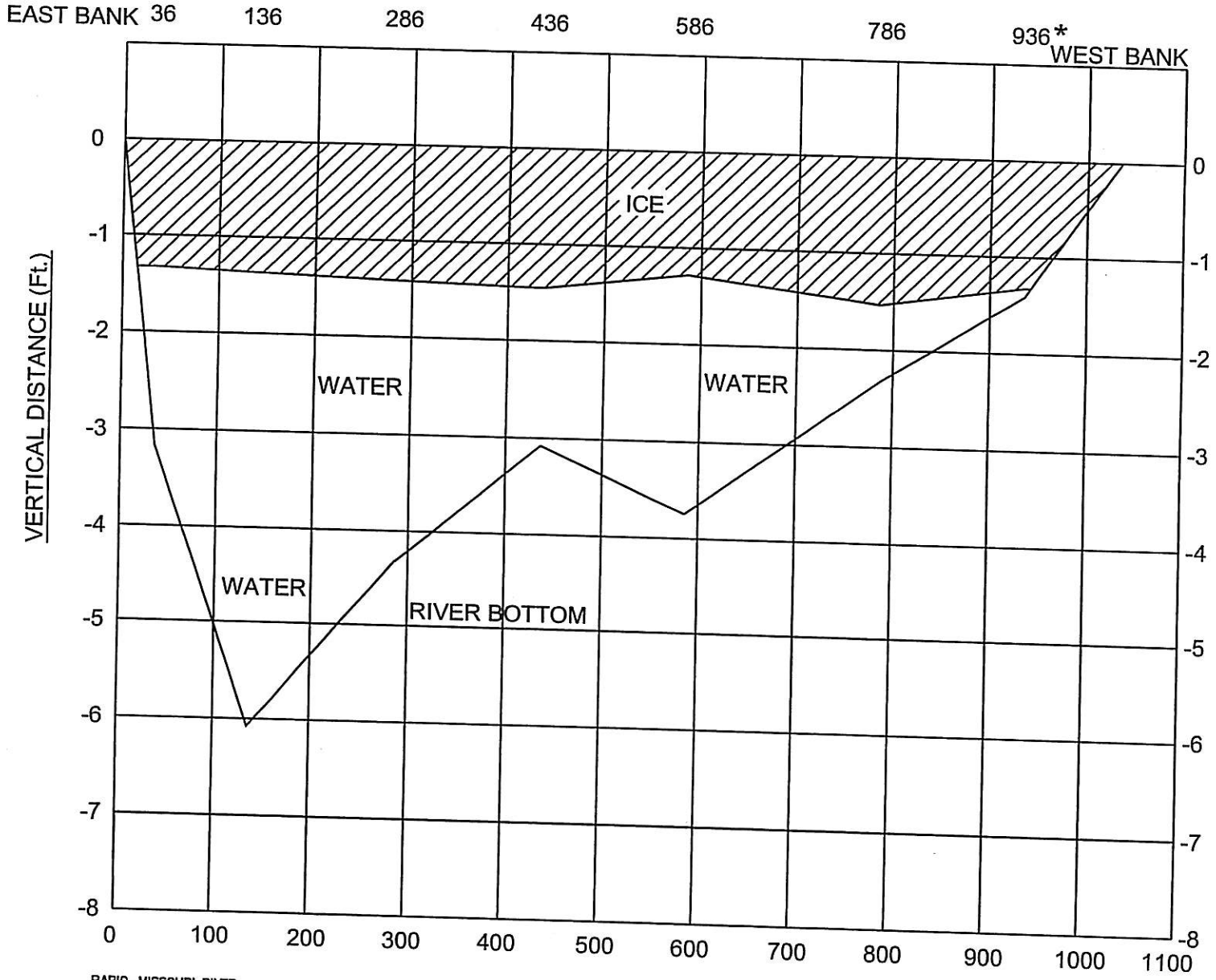
A gas powered auger was used to drill the holes. The location of the holes on the table below were measured (stepped off) from the east bank of the Platte River. There was little snow cover on river ice.

Distance From East Bank (Feet)	Ice Thickness (Inches)	Depth From Top of Ice to River Bed (Inches)
36	16	38
136	16.5	73
286	17	52
436	17.5	37
586	15.5	45
786	18.5	28
936*	16	17

*This hole is located about 75 feet from the west bank of the river.

The average ice thickness is **16.7 inches**.

PLATTE RIVER: 1.2 Miles Upstream of Hwy. 64 (STA. 160+00, UNION DIKE)



PAPIO–MISSOURI RIVER NATURAL RESOURCES DISTRICT
8901 S. 154th St.
Omaha, NE 68138–3621

WEST
Looking Downstream

*Hole location is approx. 75' from the west bank.

February 3rd, 2010

TO: Finance, Expenditure and Legal Subcommittee

SUBJECT: Platte River Ice Thickness Measurement Along Western Sarpy Levee

DATE: February 3, 2010

FROM: Ron Lehman, O&M Superintendent

On February 3, 2010, the writer performed ice thickness measurements on the Platte River. The measurements were taken perpendicular to the river flow, in the Beacon View Area, approximately 0.25 mile upstream of Highway 6.

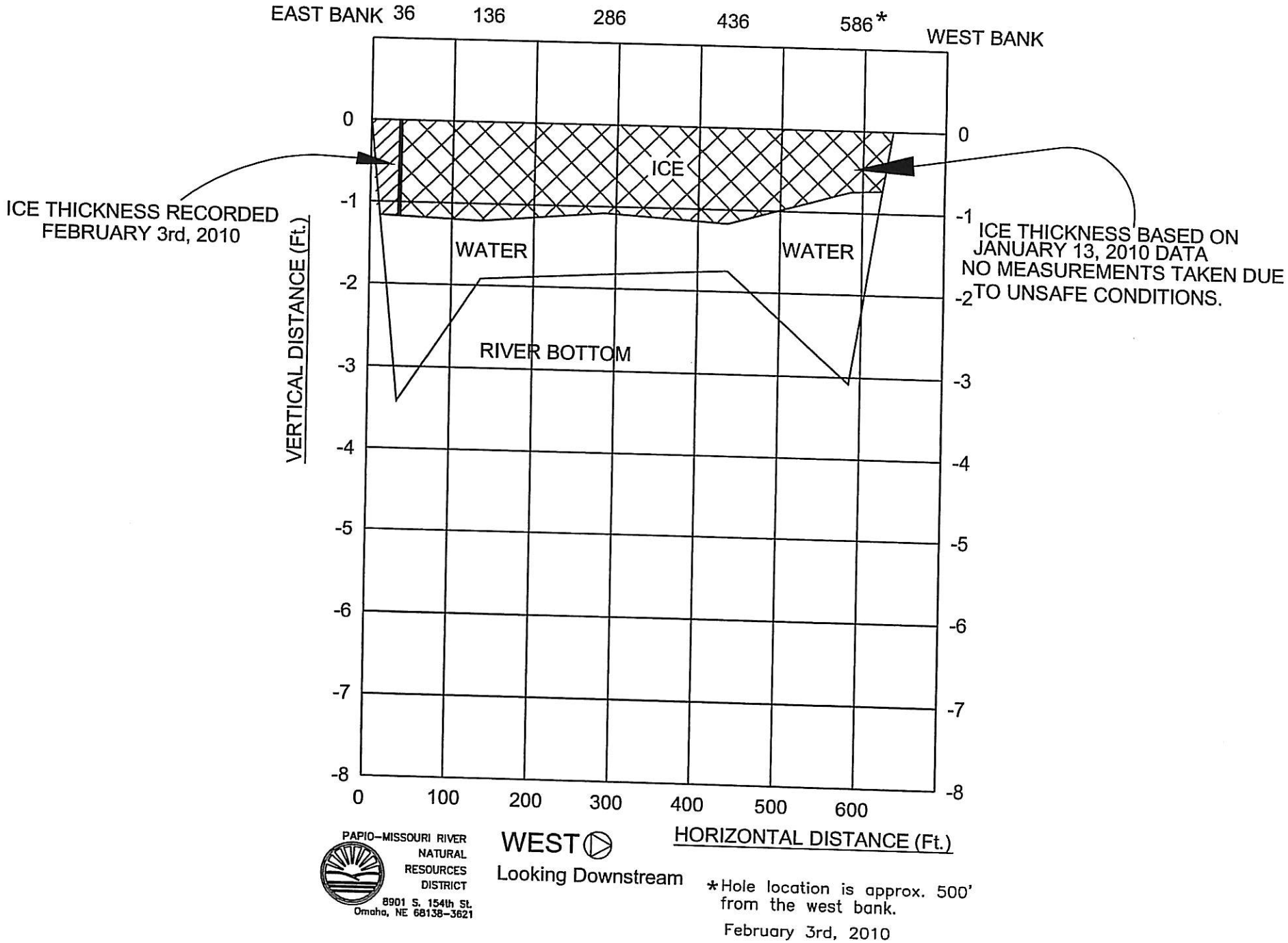
A gas powered auger was used to drill the holes. The location of the hole on the table below was measured (stepped off) from the east bank of the Platte River. There was little snow cover on river ice.

Distance From East Bank (Feet)	**Ice Thickness (Inches)**	**Depth From Top of Ice to River Bed (Inches)**
36*	14	41

*This hole is located about 1050 feet from the west bank (Saunders County Side) of the river. There is a layer of soft ice (it was ponded water last week) on top of mature ice beyond this location, so no additional borings were attempted.

The average ice thickness is **14.0 inches**.

PLATTE RIVER: .25 Miles Upstream of Hwy. 6 (WESTERN SARPY LEVEE)



Assessment of Ice Conditions on Lower Platte River
January 19, 2010

Background. A request from the State of Nebraska was received by Emergency Management personnel on January 7, 2010 (see Attachment 1), requesting technical assistance to prepare for the threat of flooding caused by break-up of ice jams. Since the request has been received, the weather forecast over the next week has changed to include much above normal temperatures and the potential for heavy rainfall.

Ice jams have historically been a problem on the Platte River, with some of the most damaging recent floods occurring in 1960, 1978 and 1993. Previous ice jam mitigation strategies on the Platte River have included ice dusting (1979, 1994, and 2001) and explosives (1966, 1978, 1982, 1993, 1997 for the most recent uses), as well as the current network of observers that has been in place since 1994. The threat of ice jam flooding may be perceived as high this year due to the below normal temperatures and above normal precipitation in much of the area tributary to the lower Platte River.

Ice jams can be especially dangerous, as they may form quickly and cause rapid rises in stage with little warning, thereby endangering property, infrastructure and life in areas in the adjacent floodplain. The most damaging ice jams form as a result of a significant warmup, leading to a rapid melt of the snowpack and inflow of water to rivers and streams, breaking up the ice cover as stages increase. The location and timing of ice jams can be difficult to predict in any specific year, although they tend to form in the same general areas when they do form. The "Lower Platte River Ice Jam Flooding" Section 22 study (USACE, Omaha District, 1994) identified 6 of the most common areas for ice jams to form on the Lower Platte as: 1) Highway 79 at North Bend; 2) Big Island at Fremont; 3) west channel at Leshara; 4) 1.5 miles north of Highway 64 bridge; 5) Highway 92; and 6) Platte River-Elkhorn River confluence.

Analysis of Conditions To-Date. The two greatest factors in determining the potential for ice jams to form are 1) the strength and thickness of ice; and 2) the volume of water available to enter the river. Each of these factors will be addressed in the following paragraphs.

Strength and Thickness of Ice. Ice thickness and strength can be a major determining factor in the formation of ice jams. Historic observations have shown that ice jams on the Platte are more likely once the average ice thickness exceeds 15-18 inches. Ice that has shown little or no evidence of decay is more resistant to breaking up as stages increase, but once that ice breaks up, it is more likely to lead to a competent ice jam, should one form.

The strength and thickness of ice is highly correlated to the winter's temperatures. One of the most common means to determine the 'severity' or 'mildness' of a winter season is the use of accumulated freezing degree days, or AFDD. A freezing degree day, FDD, is defined as the difference between freezing and the observed average daily temperature, and can be expressed mathematically as:

$FDD = 32 - \left(\frac{T_{max} - T_{min}}{2} \right)$, where T_{max} and T_{min} are the daily maximum and minimum air temperatures, respectively. The AFDD then is the sum of the FDD for each day in the winter season, starting on the day when FDD turns positive and the slope of the AFDD goes from negative to consistently positive. To date, the AFDD is well above normal. Figure 1 below shows the AFDD for the 2009-10 winter season, along with a comparison of several past years and an average year, using the daily air temperatures recorded at the NWS-Valley office (and at Omaha-Eppley prior to establishment of the Valley office).

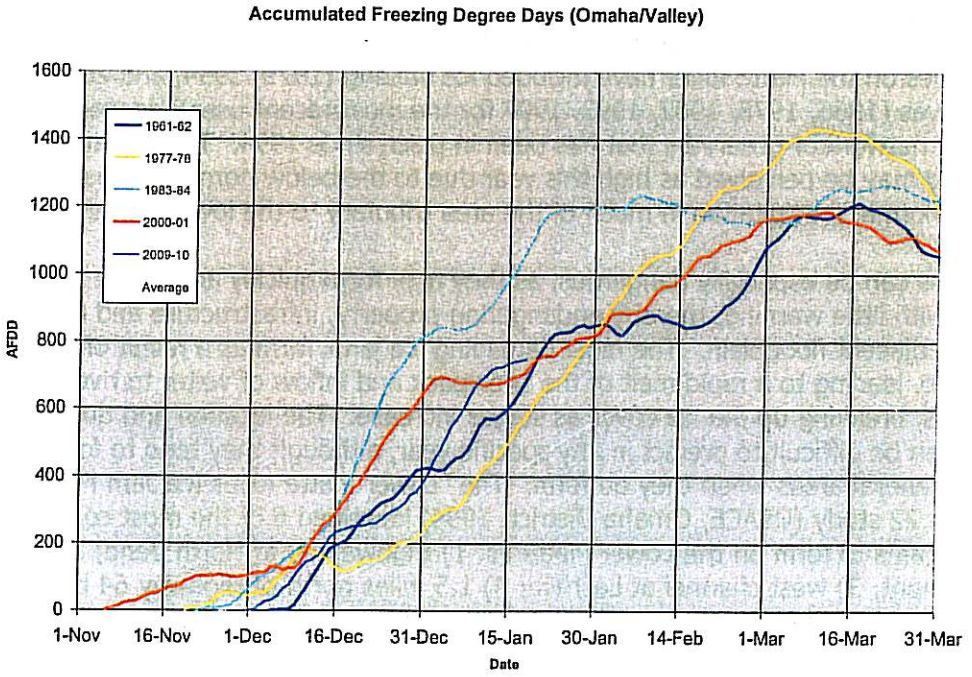


Figure 1. AFDD for 2009-10 Winter Season and Other Select Years

As can be seen, the AFDD for 2009-10 through January 18 is computed as 747, compared to an average year of 430.5. It can be seen, however, that in 1984 and 2001, the AFDD was substantially above average at this time of year, yet significant ice jams did not form in those years.

However, the thickness and strength of ice is not determined solely by the air temperature. The presence of a heavy snow cover can retard the growth of ice, while conversely, the absence of a snow cover can lead to accelerated growth of ice. The Papio-Missouri River NRD made ice thickness measurements on 13-Jan-2010 at a position along the Union Dike and found the average ice thickness to be 16.6 inches, while the average ice thickness below the Platte-Elkhorn confluence was found to be 13.2 inches.

As previously mentioned, the thickness of ice is highly correlated with the AFDD. Ice thickness can be estimated using the modified Stefan equation:

$t_i = C \times (AFDD)^{0.5}$, where t_i is ice thickness in inches and C is a coefficient, usually ranging between 0.3 and 0.6 on smaller rivers. The AFDD on 13-Jan was 719, which leads to a computed C coefficient of 0.62 along Union Dike and 0.49 below the Platte-Elkhorn confluence. These values are not outside the range of C values that can be expected on the Platte River, as past year's measurements have shown the C value to range from 0.48 to 0.67 since 2001 along Union Dike and somewhat lower below the Platte-Elkhorn confluence. The C value appears to be most sensitive to the amount of snowfall occurring in the first several weeks of ice cover formation. Anticipated ice thicknesses are shown in Table 1 below, assuming temperatures remain normal, 5°F above normal or 5°F below normal. The latest Nebraska river ice report indicates an intermittent small open channel in the ice cover between the Highway 6 bridge and Platte-Elkhorn confluence and a solid ice cover in the Union Dike reach. There is no evidence of ice decay anywhere on the Platte River.

Table 1. Anticipated Ice Thickness along Platte River, 2010

Remaining Winter Season Temperatures	Below Platte-Elkhorn Confluence	Along Union Dike
	Ice thickness, inches	
1-Feb-2010		
5°F below normal	14.1	17.9
Normal	14.0	17.7
5°F above normal	13.8	17.5
1-Mar-2010		
5°F below normal	16.3	20.6
Normal	15.1	19.1
5°F above normal	14.0*	17.7*

* Ice thickness would peak on 16-Feb if temperatures average 5 degrees above normal.

Based on current conditions, and in comparison to historic observations, it can be concluded that the present and anticipated condition of Platte River ice is that it is of sufficient strength and thickness to pose a threat to ice jam formation.

Volume of Water Available. The volume of water available to runoff into the Platte River is a major factor in determining if the ice cover breaks up and causes an ice jam. As a general rule of thumb, a stage increase of 1.5 to 3 times the ice thickness is required lift and break up an ice cover. Assuming the current ice cover is 17.0 inches, this leads to roughly a 2 to 4 foot increase in stage needed to break up the current ice cover.

Precipitation in the Omaha area has been above normal this winter season. The same is true of areas to the north and west of Omaha. As can be seen in Figure 2 below, much of the Loup and Elkhorn River basins have experienced precipitation in excess of 125 percent of normal since 1-October.

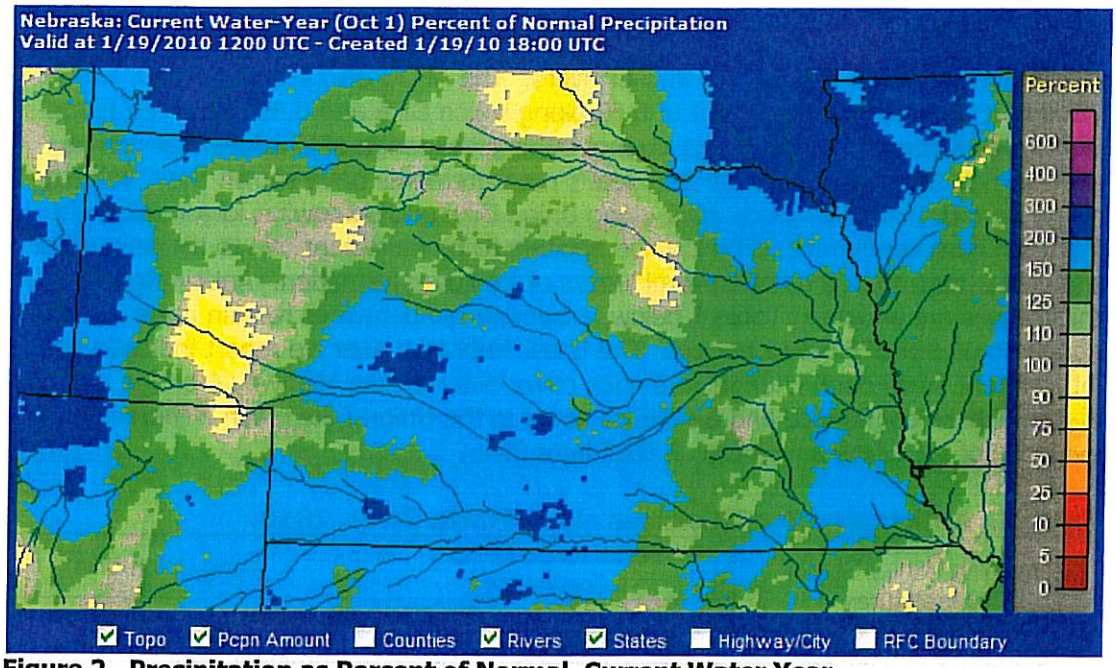


Figure 2. Precipitation as Percent of Normal, Current Water Year.

The snowpack within the basin has increased in portions of the basin and decreased in other portions during the past week, according to the National Weather Service National Operational Hydrologic Remote Sensing Center (NOHRSC). As can be seen in Figure 3 and Figure 4 below from the NOHRSC, warmer weather to our west has decreased the western fringe of the snowpack over the lower Platte basin, but the snowpack water equivalent has increased over northeast Nebraska, including the Elkhorn basin. The recent melting of snowcover has led to minor increases in stage on the Loup River at Genoa and Platte River at North Bend and Ashland.

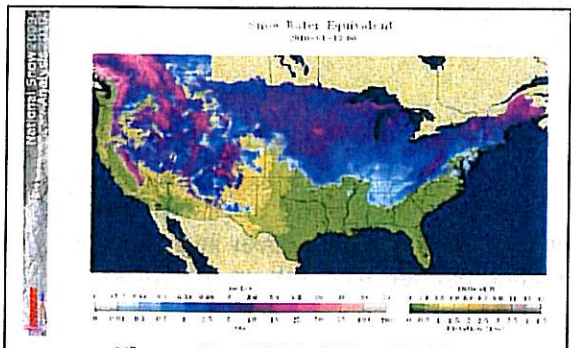


Figure 3. SWE, 12Jan2010

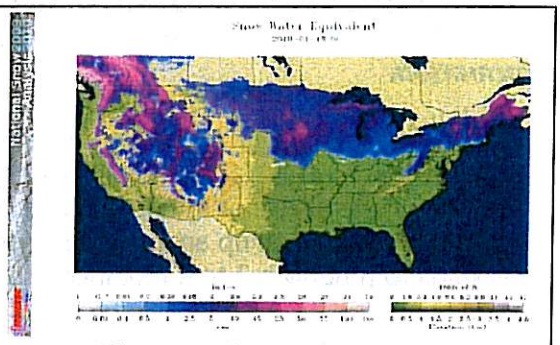


Figure 4. SWE, 19Jan2010

Based on current conditions, it can be concluded that the present condition of water available to cause breakup of Platte River ice is relatively high.

Short-Term Threat Level. As demonstrated above, current conditions show that the Platte River ice is of sufficient strength and thickness to pose a threat to ice jam formation, and the volume of water available to break up the existing ice cover appears

to be sufficient. There are factors that may increase the threat of ice jam formation over the next 5 days.

Temperature Forecast. The current 7-day forecast issued by the National Weather Service at Valley points to air temperatures above normal for the next week, as seen in Table 2 below. The threat posed by these warmer temperatures is low, as the average daily temperature is projected to be above freezing on one day (Jan. 23). The near-freezing temperatures, combined with low sunshine, indicate that ice thickness will remain relatively constant over the next week.

Table 2. Forecast Temperatures in Vicinity of Valley, NE

Date	Hi Temperature	Lo Temperature	Freezing Degree Days	Departure from Normal
19-Jan-2010	31	29	+2	+9
20-Jan-2010	32	28	+2	+9
21-Jan-2010	32	27	+2.5	+8.5
22-Jan-2010	38	26	0	+11
23-Jan-2010	42	33	-5.5	+16.5
24-Jan-2010	33	27	+2	+9
25-Jan-2010	29	19	+8	+2.5

Precipitation Forecast. The current 7-day forecast issued by the National Weather Service at Valley indicates a 90% chance of freezing rain during the overnight hours of 19-Jan through the day of 20-Jan, and a 40% chance of snow and freezing rain the evening of 20-Jan. It is forecast to remain cloudy through Friday, when there is a 20% chance of rain, with a chance of rain throughout the day Saturday (23-Jan). Precipitation is then forecast to change over to snow, with a chance of snow Sunday through Monday. As shown in Figure 5 below, the Quantitative Precipitation Forecast (QPF) for Friday morning through Sunday morning indicates the potential for 0.1-0.5 inches of precipitation over much of the lower Platte River basin, including the Loup and Elkhorn River basins, with locally higher amounts possible. Given the lead time on the QPF forecast, the actual rainfall amounts may differ significantly from that shown, however. Heavy rainfall over a large area of frozen ground could lead to significant flooding over a wide area, as in February 1971.

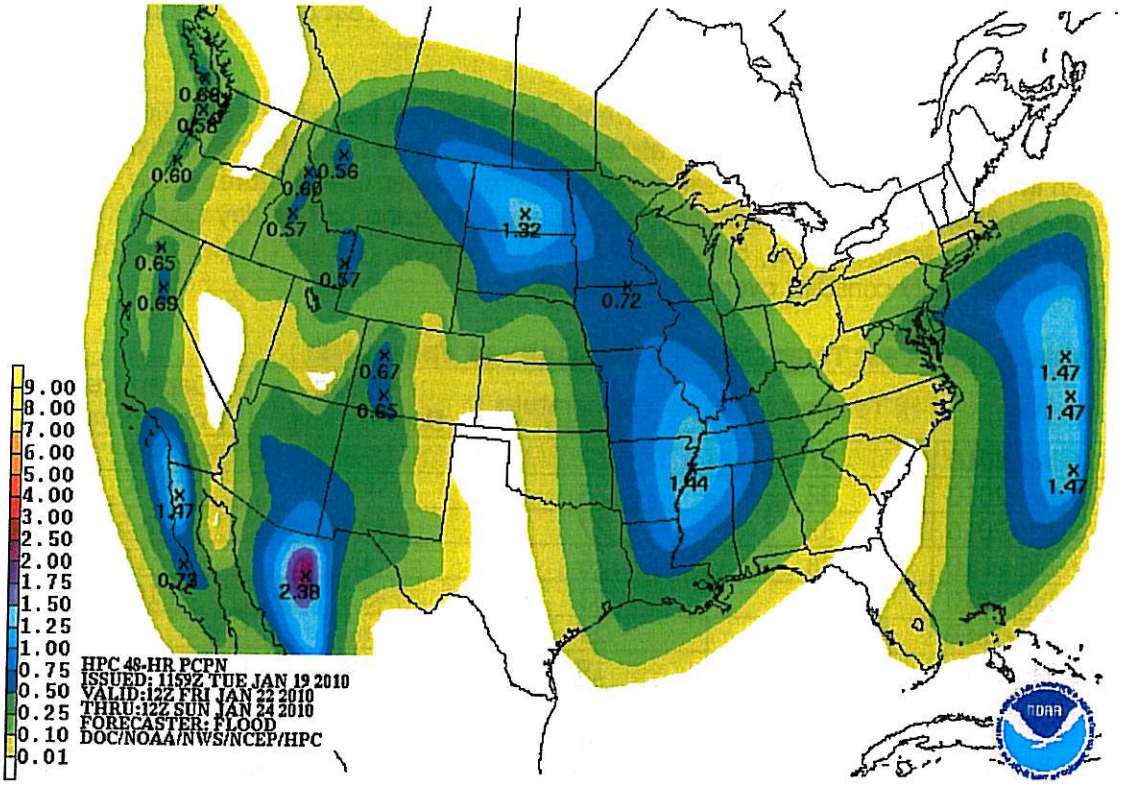


Figure 5. QPF for 22-Jan a.m. through 24-Jan a.m.

Based on the current forecast, with slightly above normal temperatures and rain in the forecast, the threat of ice jam flooding may be elevated over the period 22-Jan through 25-Jan, depending on the location, amount and intensity of rain that falls. The threat of ice jam flooding will cover the Elkhorn and Loup Rivers, as well as the lower Platte River.

Long-Range Threat Level. Although the threat of ice jam formation may be elevated over the next several days, the river ice may not move out during these next several days, depending on what meteorologic conditions actually occur. The next few paragraphs explore the meteorologic conditions that may be encountered for the remainder of the winter.

Temperatures. The Climate Prediction Center has issued long-range forecasts for temperature for the next 6-14 days as seen in Figure 6 and Figure 7 below. Both forecasts indicate an equal chance for above normal, below normal or normal temperatures, as does the forecast for the month of January (Figure 8). The 3-month outlook (Figure 9) indicates a fairly strong likelihood of above normal temperatures; however, this winter has been colder than forecast since October and this trend may continue, in spite of the Climate Prediction Center's forecasts.

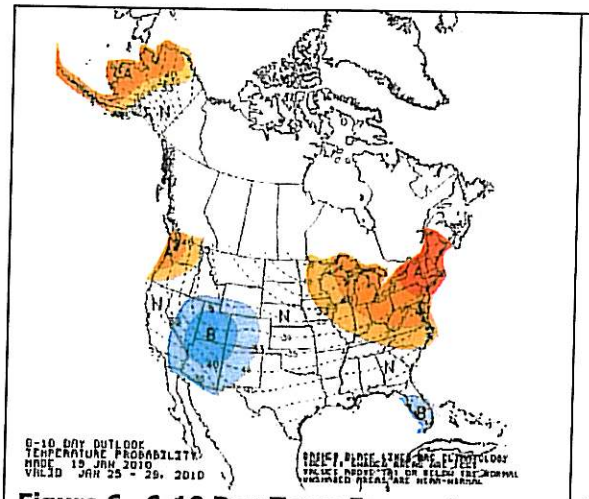


Figure 6. 6-10 Day Temp Forecast

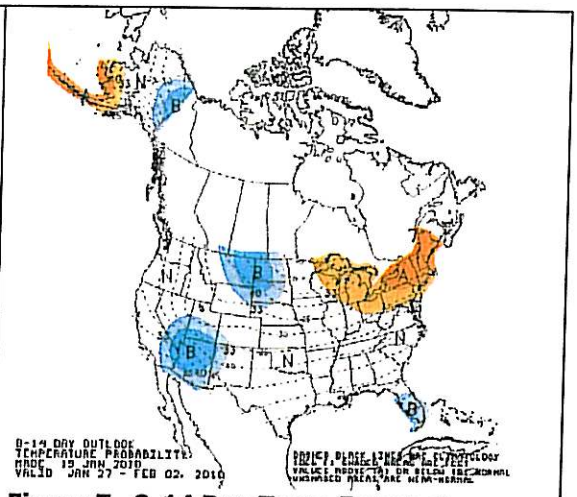


Figure 7. 8-14 Day Temp Forecast

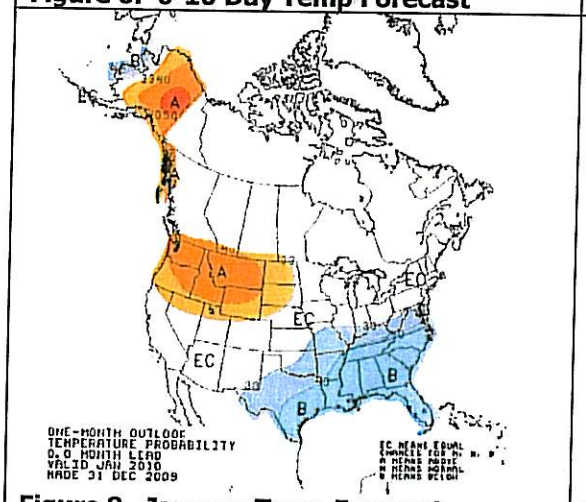


Figure 8. January Temp Forecast

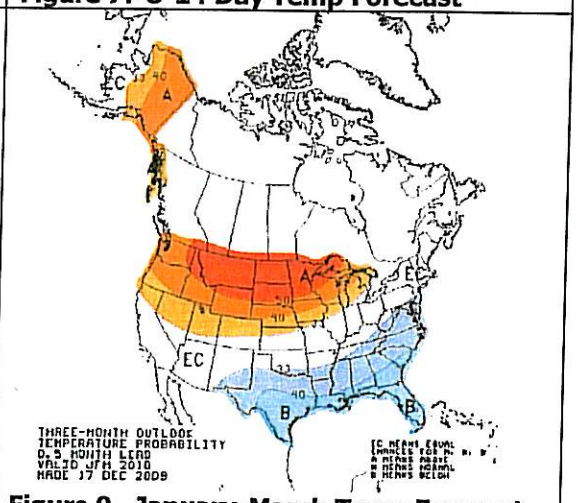


Figure 9. January-March Temp Forecast

Precipitation. The Climate Prediction Center forecasts point to above normal precipitation over the next two weeks, as shown in Figure 10 and Figure 11 below. Both the 6-10 and 8-14 day forecasts show a fairly strong likelihood of above normal precipitation. The January forecast (Figure 12) was for an equal chance of normal, above normal or below normal precipitation. Given the heavy snowfall in the first week of January, the near-term forecast of freezing rain, rain and snow and the 2-week forecast, it is probable that precipitation for January will be above normal. The 3-month forecast (Figure 13) for January through March indicates an equal chance of normal, above normal or below normal precipitation over the lower Platte basin, although the area of above normal precipitation lies very close to the Platter River basin. As long as temperatures remain normal to below normal through the end of February, it is likely that further precipitation will fall as snow, with the potential for record seasonal snowfall by the end of winter in the Omaha area.

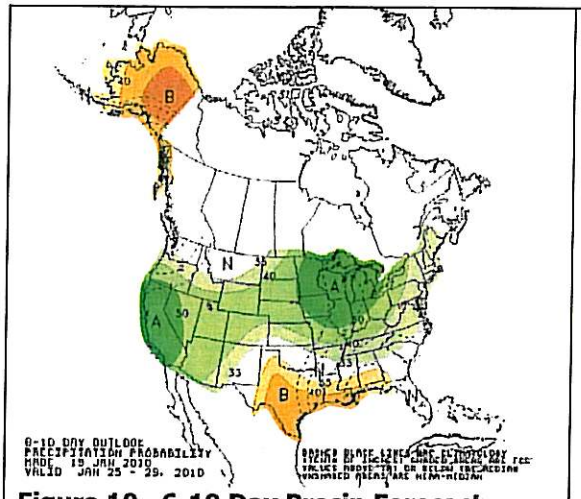


Figure 10. 6-10 Day Precip Forecast

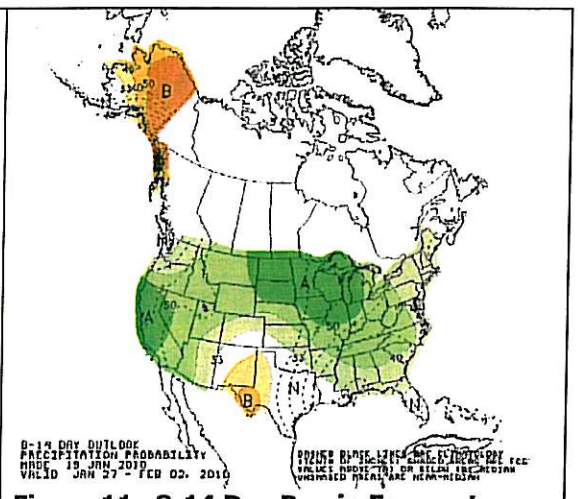


Figure 11. 8-14 Day Precip Forecast

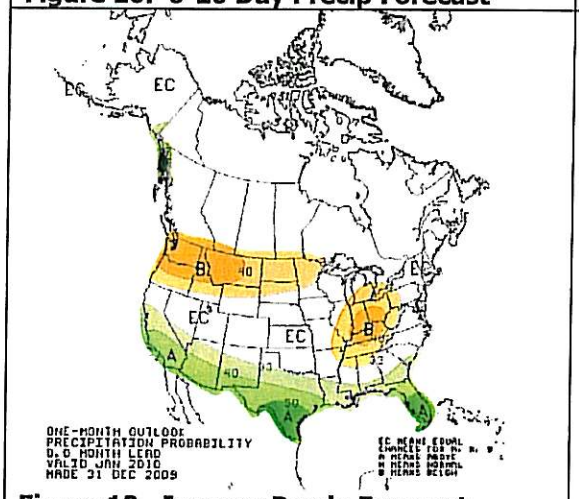


Figure 12. January Precip Forecast

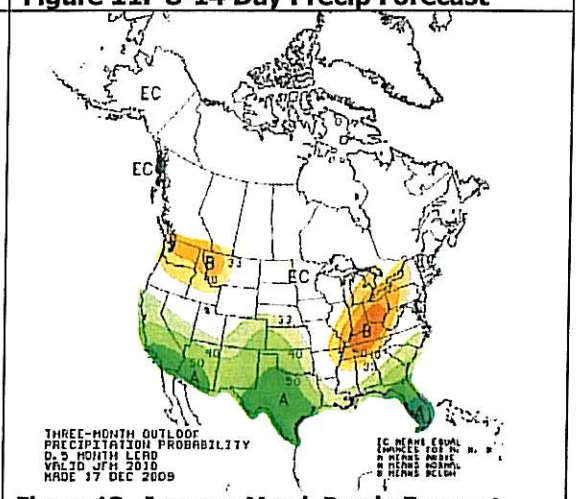


Figure 13. January-March Precip Forecast

Predictive Models. Predicting ice jams is, at best, an inexact science. Several attempts to develop ice jam predictive models have been made, including one on the Platte River (White and Kay, 1994). This model predicts the potential for ice jam formation on the Platte River based on temperature data at Columbus and discharge at the North Bend gage. The model predicts the formation of an ice jam when the AFDD exceeds 400 AND the discharge at North Bend exceeds 6,000 cfs or $0.39*JD^{1.96}$, whichever is greater, where JD is the current water year Julian Date (1 = October 1). While it is easy to compute AFDD, it is difficult to assess discharge at North Bend, as the gage is ice-affected during the winter (when there is an ice cover) and real-time discharge data is not available from the USGS. Based on previous flow events, it is likely that flow at North Bend will exceed the discharge threshold this season, meaning it is quite likely that an ice jam will form on the Platte River. However, this predictive model does not indicate where an ice jam is likely to form, nor does it indicate when an ice jam may form.

In order to overcome the limitations of this predictive model, another model (Kay, 2007) was developed to determine the likely date and value of peak discharge at

the North Bend gage. The model determines the date of maximum discharge based on temperature and snowfall data at the National Weather Service-Valley office, while the estimate of discharge is a function of temperature data and the number of days between peak AFDD and peak discharge. The model successfully predicted the date of peak discharge (within a range specified by the model) for 2007, 2008, and 2009. The model also closely predicted the peak discharge (within a range specified by the model) in 2007 and 2008; 2009 USGS data is still provisional, so it is unknown how well the 2009 discharge matched model predictions.

A range of possible temperature and snowfall scenarios were looked at to predict possible discharges and dates of maximum discharge. Temperature scenarios looked at included normal temperatures, 5°F above normal, 5°F below normal, up to date of peak AFDD, followed by temperatures at normal, 5°F above normal and 5°F above normal. An additional scenario included 1962 temperatures moved up 12 days, as the current year AFDD is currently tracking the 1962 AFDD plot shifted by 12 days. Snowfall scenarios looked at included no more snowfall, 50% of normal snowfall, 100% of normal snowfall and 200% of normal snowfall. The range of possible dates and discharges are shown in the Table 3 below, with the range of discharges and dates covering the various melt scenarios.

Table 3. Predicted Dates and Values of Maximum Discharge at North Bend

Pre-AFDD$_{max}$ Temperature Scenario[1]	Snowfall Scenario	Dates of Potential Peak Discharge @ North Bend	Estimate of Potential Peak Discharge @ North Bend[2]
+5°F 16-Feb	No Snow	18Feb – 02Mar	8700 - 30600
	50% of Normal	20Feb – 04Mar	9200 - 26100
	100% of Normal	22Feb – 06Mar	9300 - 23600
	200% of Normal	25Feb – 10Mar	8800 - 21800
Normal 01-Mar	No Snow	02Mar – 15Mar	9100 - 58800
	50% of Normal	04Mar – 18Mar	9300 - 39000
	100% of Normal	06Mar – 20Mar	9300 - 33200
	200% of Normal	08Mar – 25Mar	8500 - 33000
-5°F 14-Mar	No Snow	16Mar – 21Mar	15300 - 43300
	50% of Normal	17Mar – 23Mar	15700 - 45200
	100% of Normal	18Mar – 25Mar	15500 - 43800
	200% of Normal	20Mar – 28Mar	15200 - 41000
1962 05-Mar	No Snow	07Mar – 11Mar	16800 - 36400
	50% of Normal	09Mar – 12Mar	19200 - 28400
	100% of Normal	11Mar – 13Mar	20300 - 25800
	200% of Normal	13Mar – 15Mar	24200 - 27200
	1962 Snow	13Mar – 15Mar	24800 - 27800

[1] Date indicates when AFDDmax occurs

[2] Color-coding indicates probability of damaging ice jam flooding – green = low, yellow = moderate, red = high

It should be noted that the above is intended merely a guide, as the above forecasts are based on constant deviations from normal temperature and snowfall. Significant deviations may, and do, occur, which may lead to dates and discharges different than shown, particularly if temperatures during the melt out increase dramatically for one or two days. In should also be noted that the above does not account for any rainfall that

may fall during the melt out period; the longer the period of time between date of $AFDD_{max}$ and maximum discharge increases the likelihood of rain occurring, which may greatly increase the observed discharge, thereby increasing the risk of damaging floods. It should also be noted that the seasonal snowfall totals anticipated, if snowfall exceeds 50% of normal for the remainder of the winter season, would exceed snowfall totals for seasons from which the predictive model was developed; therefore, discharges could exceed those shown here. However, the predictive model does point out that the risk of damaging ice jam flooding is moderate to high this season.

Based on current long-range forecasts, the threat of ice jam formation later in February into the month of March remains high. The probability of a damaging ice jam forming appears moderate to high, depending on temperature and snowfall. This probability will be elevated if significant rain falls over the basin before ice breakup. The threat will be substantially elevated if the river ice breaks up and jams over the next week and then freezes in place; this is what led to the extreme flooding that occurred in 1993 along the Platte River below the Platte-Elkhorn confluence.

Summary of Conclusions and Recommendations.

1) The current and anticipated condition of ice leads to an increased risk of ice jam flooding; this risk is exacerbated by the presence of an unusually high snow water equivalent and the potential for rainfall;

2) The 7-day forecast by the National Weather Service indicates temperatures above freezing and a possibility of heavy rainfall. This combination of climatologic factors leads to an increased risk of ice jams forming on the Platte River within the next week;

3) Given the short lead time, mitigation measures such as ice dusting are not warranted at this time to alleviate the flood threat posed by this weekend's forecast rainfall. However, there is adequate time to alert the public to the threat of flooding over the next several days if precipitation falls over the area. Local emergency officials should be alert to rapidly rising river stages during and after any heavy precipitation and should be prepared to evacuate people from low-lying areas should flooding occur;

4) If ice breakup occurs within the next week, the breakup should be carefully monitored by the network of ice observers. All observed ice jams should be reported. Of greatest concern are ice jams that form but do not "flush out" and remain in place as temperatures fall to below freezing. Nebraska Department of Roads personnel should be mobilized to assist in ensuring ice remains moving under various Highway bridges over the Loup, Platte and Elkhorn Rivers;

5) Beyond the middle of next week, forecast trends are inconclusive as to the temperatures we may experience the remainder of the winter season, but precipitation appears likely to remain normal to above normal. This poses a significant risk of ice jam flooding later in February or March if the existing ice

cover remains in place or an ice jam forms in the next several days and remains in place;

6) If the existing ice cover does not move out over the next week, ice dusting plans will be prepared in order to mitigate the increased risk of ice jams later in the winter season. Previous studies have indicated that dusting material should be placed 3 to 4 weeks ahead of anticipated ice breakup, but that placement of material is ineffective prior to 14-Feb due to the lower angle of sunlight. Ice dusting plans will include recommended dusting sites, as well as approximate quantity of material and time to dust each site. Application dates will coordinated with State of Nebraska, and will take into account anticipated long-range forecasts for temperature and precipitation;

7) Due to the moderate to high risk of damaging ice jams along the Platte, officials should be prepared with other actions to deal with ice jams, even if ice dusting is implemented, as previous dusting efforts on the Platte have not conclusively demonstrated their effectiveness;

8) The threat of ice jam flooding on streams tributary to the Platte, mainly the Elkhorn, appears to be high as well, due to the unusually high snow water equivalent on the ground. Local emergency officials should be alerted to the possibility of significant ice jam formation along the Elkhorn River so as to be prepared for evacuations, should they be needed, particularly in low-lying areas, and areas behind levees, if floodwaters rise appreciably.

Attachment 1: Letter of Request from State of Nebraska

STATE OF NEBRASKA

EMERGENCY MANAGEMENT AGENCY
Judd H. Lyons
Director
1300 Military Road
Lincoln, Nebraska 68508-1090
Phone: (402) 471-7421

Dave Heineman
Governor

January 4, 2010

U.S. Army Corps of Engineers, Omaha District
% Colonel David Press, District Engineer
106 South 15th Street
Omaha, NE 68102

Subject: Request for technical assistance Nebraska

Dear Colonel Press:

In anticipation of winter weather conditions we are potentially at risk for ice jams on the Lower Platte River this spring. The possibility exists for the use of ice dusting as a mitigating measure to prevent the formation of major jams.

We have activated our Lower Platte River Ice Reporting System and have posted our summaries to our web site to allow the monitoring of potential problem areas along the Platte. We have also contracted for aerial photos of the Lower Platte River below Fremont to the mouth of the Missouri River. The Civil Air Patrol flew the river December 2, 2009 to define the river channels in the event an ice dusting would be necessary.

We are therefore requesting technical assistance to help us prepare for the threat of flooding caused by break-up of ice jams.

Sincerely,

Al Berndt
Assistant Director

Enclosures:
Platte River Fremont to the Mouth of the Missouri
DVD Film
CD Photos

Cc: Pamela Graham, Program Manager
Roger Kay, Hydraulic Engineer