ICE JAMS IN NORTH DAKOTA

This document provides information on predicting, preparing for, and responding to ice jam events in North Dakota. It includes information on assessing ice jam threats, potential mitigation strategies, emergency response actions, and public notification procedures. An ice jam mitigation and response matrix is currently under development to serve as a quick-reference tool during emergencies.

OVERVIEW OF ICE JAMS IN NORTH DAKOTA

Predicting the timing, location, and formation of ice jams is challenging. In North Dakota, ice jams are most common during the spring snowmelt period but also form anytime during the winter season, particularly during freeze-up or breakup periods. Ice jams can cause water levels to increase upstream and decrease downstream. If the increase in upstream water levels is large enough, flooding can occur.

FREEZE-UP ICE JAMS

The threat from freeze-up ice jams is typically associated with a rapid increase in water levels rather than flooding, particularly on the Missouri River; other rivers in ND typically don't experience significant water level increases or flooding during freeze-up due to several factors including river size, flow rate, flow dynamics, and sharp meanders. Notably, the Missouri River experiences rapid water level rises in the Bismarck/Mandan area once ice begins accumulating, typically getting caught in the meanders south of the city near the University of Mary. This ice buildup restricts flow, causing a rapid rise in water levels that often rise to a peak stage in less than 24 hours. Since 2010, the Missouri River's rise during freeze-up has ranged from 4.9 to 6.9 feet, with an average rise of just over 6 feet. Once a stable ice cover has formed, the threat from ice-induced flooding diminishes until breakup. If there are cycles of freeze-thaw, the ice cover can weaken, shift, or deteriorate unevenly, increasing the potential for mid-winter breakups

BREAKUP ICE JAMS

Breakup ice jams have been recorded on many rivers throughout the state; however, breakup ice jams are most prevalent on the Missouri, Little Missouri and Red Rivers. In general, breakup ice jams tend to form at sharp bends, river confluences, and at obstructions, such as bridges and low-head dams. Spring breakup jams are usually more destructive than freeze-up jams due to the large amount of ice involved. There are two types of ice breakup events: thermal and mechanical. During thermal breakup, ice cover melts gradually in place, with little fluctuation in flow or water levels, breaking down before being carried downstream. In contrast, mechanical breakup is driven by hydrodynamic forces typically caused by rapid increases in flow and water levels, often during spring freshets. During mechanical breakup, thick, strong ice breaks apart and moves downstream before it can naturally weaken and melt. Ice jams are more common during mechanical breakup events because the ice is broken up before deteriorating, allowing it to accumulate and create blockages.

ASSESSING ICE JAM THREATS AND TRENDS

One of the first measures in assessing the ice jam threat to a particular community is to review their history of ice jam flooding. This review can provide insight into the frequency of past ice jam induced flooding and highlights the most common locations of ice jams. A detailed analysis of past ice jam events is essential for predicting the risk of future occurrences. Identifying local ice jamming trends and the key variables that influence them is essential for understanding the causes of ice jams and serves as the foundation for predicting future ice jam occurrences. Local residents can offer valuable information regarding specific ice jam locations and associated flood damages. Reviewing peak stages and flows from past flood events is another way to evaluate the potential threat. One good source for locating ice jam information is the Cold Regions Research and Engineering Laboratory's (CRREL) Ice Jam Database (IJDB). Although not a comprehensive list, the IJDB contains information on many known ice jams and ice-affected events as well as a map of historical ice jams.

POTENTIAL ICE JAM MITIGATION METHODS

Note: Many of the following methods were identified in the USACE's "Assessment of 2011 North Dakota Ice Jam Threat and Potential Mitigation Measures".

PERMANENT MEASURES

The following permanent measures are a local jurisdictional responsibility. Permanent measures are often the most expensive (and often most politically challenging) means of mitigating ice jams but may prove to be the most cost-effective over a long period of time. Detailed studies and analysis are often required prior to implementation of any of these measures, as solutions are often site-specific.

FLOODPLAIN MANAGEMENT

- The most effective flood prevention technique is floodplain management. Floodplain management is the operation of a community program of corrective and preventative measures for reducing flood damage. It is crucial that cities and counties implement floodplain management through zoning ordinances, acquisition/relocation of affected properties, and other means. Keeping people and property from encroaching into the floodplain, as well as voluntarily removing those that are there, will prevent flood related losses.
- The floodplain is normally delineated by floodplain mapping performed for the National Flood Insurance Program. However, this mapping is often based on open water conditions and generally does not account for reduced channel capacity caused by ice jams, making it a minimum estimate of the floodplain area for the analyzed flow rate.
- Floodplain mapping has been completed for limited North Dakota cities and counties. A community should reference the Federal Emergency Management Agency (FEMA)'s regulatory projects such as Flood Insurance Study to better understand if an ice jam analysis was completed as part of the community's flood risk package.
- The possibility of larger floodplains should be considered if ice jams were not considered in the floodplain analysis.
- A community should consider the following resources when assessing the potential extent of flooding: FEMA Map Service Center (https://msc.fema.gov/), USGS Gage data

(https://waterdata.usgs.gov/nwis/sw), North Dakota Risk Assessment MapService (https://ndram.dwr.nd.gov/).

FLOODPROOFING

- Floodproofing involves minimizing the impact of a flood on a structure. There are four types of floodproofing: raising or moving a structure, building a barrier, dry floodproofing, and wet floodproofing. Floodproofing is an attractive option for historic buildings built in the floodplain or when residents refuse buyout programs. Raising a structure involves building up the foundation so that flood-prone features, such as lower levels and utilities, are above the expected flood elevation. The new foundation must be designed to handle forces caused by flowing water and ice as well as the loads from the building.
- Barriers and floodwalls can be alternatives to raising the foundation. A floodwall is simply built to keep water out of a building. All openings in a floodwall should be easily closed with the proper material. Groundwater seepage and water flow through sewer and water lines should be considered in the design.
- Dry proofing requires the outside of a building become watertight. This would allow the building to be flooded up to three feet without major flood damage. Dry proofing above a few feet is discouraged because the building walls can collapse under higher water pressure.
- Wet proofing assumes flood water will flow through the structure, up to a designed elevation. Building design below the expected flood elevation will minimize the damages and losses during flooding. HVAC, electrical and fiber optics cables will be located above expected flood levels. Wet proofing is often the least attractive option.

PERMANENT LEVEES

- Levees create a barrier between the river and the protected property. Levees allow river stages to rise above bank full without damaging the properties behind the levee that they're designed to protect, shielding those properties from ice jams and open water floods up to the levees design capacity. If a storm event or ice jam occurs that exceeds the levee's design capacity, the property protected by the levee may be damaged and lead to a life safety issue.
- Levees can be constructed along most streams if sufficient area is available, but construction can be expensive, and levees require ongoing maintenance. A detailed engineering design would be needed to assess which communities could benefit from levees.
- Local jurisdictions must coordinate with the NDDWR, USACE, and other relevant agencies to identify permitting requirements before proceeding with construction of levees.

CHANNEL MODIFICATION (I.E. DREDGING, RESHAPING)

- River channels can be modified to move ice downstream more efficiently by removing snags, bars, and other constrictions that impede ice passage and cause jams.
- A flood diversion channel can be constructed to route flow around an ice jam, decreasing upstream flooding. These options are not as useful in braided river channels or channels with high sediment loads (i.e. Missouri River) where constant maintenance would be required to preserve the modifications.

- The channel and overbank areas can also be modified to slow the flow of ice and increase ice storage. Shaping the channel and overbank areas can allow ice to leave the channel during breakup. This reduces the volume of ice available to form ice jams downstream. Changing the bank slope, removing trees and creating berms in specific locations can utilize the available floodplain and reduce the risk of damage downstream. These modification methods are useful when a large floodplain is present.
- Both of these channel modification options require site-specific detailed analysis to determine the most effective means of mitigating the ice jam hazard, or if it's even possible to accomplish this type of mitigation at the site.
- Local jurisdictions must coordinate with the NDDWR, USACE, and other relevant agencies to identify permitting requirements before proceeding with any channel modifications.

THERMAL CONTROL

- Warm water can be used to thin an ice cover or melt ice jams. Warm water is a relative term because all water that is above freezing (32°F) carries enough heat that can melt ice.
- Heat can be added to a stream by applying wastewater treatment effluent, ground water or power plant cooling water. Cities could utilize all these sources of warm water by developing the outfalls of these facilities upstream of ice jam problem locations. However, most cities prefer to locate the outfall facilities downstream of the city because of water quality concerns.
- Water with a temperature greater than 32°F is often located below the surface of large water storage reservoirs. Air bubblers or pumps can be used to bring this water to the surface and melt ice. Reservoirs can release this warmer water and melt ice downstream.

Ice Control Structures

- Ice control structures (ICS) are structures that are designed and installed specifically to control ice and prevent or reduce ice jam flooding. Structures built to control flooding from freeze up jam formation include floating booms and low head weirs. Structures built to control breakup jam flooding are designed to arrest an ice run in a safe location and allow flow around the accumulation to reduce upstream water levels. Breakup structures include a series of piers across the river channel to retain ice and a bypass channel to pass water around the jam. A detailed engineering design would be needed to assess which communities could benefit from ICS.

PREPAREDNESS (MONITORING)

Preparedness involves proactive efforts to monitor conditions and assess risks before ice jam flooding occurs. Factors such as rapidly rising air temperatures, increased water temperature, increased river flow, and precipitation should be closely monitored. Ice thickness, snowpack, and upstream ice conditions can also contribute to the potential for ice movement and jamming. Monitoring efforts may include conducting aerial or ground surveys to assess ice coverage and characteristics or to identify potential choke points where ice accumulation could obstruct flow.

MONITORING CONDITIONS

- Monitoring weather conditions can guide advance measures decisions. Cold winters, especially those with below normal temperatures in late January and February, may justify

advance measures. Above normal temperatures forecasted during ice breakup may also validate the need for advance measures.

- Measuring ice thicknesses can provide ice strength and ice volume information. Mechanical breakups, where intact, high-strength ice dislodges with little deterioration, can cause severe ice jams by sending thick ice downstream. Indicators of a potential mechanical breakup include factors that increase driving forces, such as rapid snowmelt (high snow water equivalent, warm spring temperatures, rain on snow events, and strong solar radiation), and factors that increase resisting forces, such as thick ice cover from a harsh winter or lack of snow cover that acts as an insulator from cold temperatures.
- Ice motion detectors can alert local officials when ice movement begins.
- Stage-only stream gages help locate ice jams by showing the rapid stage increases caused by ice jams; however, many ice jams form in areas without stream gages.
- Ice jam mitigation and monitoring programs have been developed in Nebraska and Manitoba. These programs could be used as templates in development of local and statewide ice jam mitigation efforts. Questions regarding the Manitoba program can be directed to Darrell Kupchik, Selkirk Emergency Coordinator, at 204-785-4945 or emo@cityofselkirk.com. Questions regarding the Nebraska program can be directed to Jamie Reinke, Floodplain Division Head at the Nebraska Department of Natural Resources, at 402-471-3957 or Jamie.Reinke@nebraska.gov.

CAPABILITIES/RESPONSIBILITIES

- The thickness of river ice covers can vary extensively with distance and time. The state does not have an ice sampling or measuring program and therefore relies heavily on local observation reports from public works, emergency management, law enforcement and the public to provide situational awareness in the field.
- NDDWR has the ability to deploy field staff to verify local observation and obtain data as needed.
- NDDWR staff monitors USGS river gages throughout the state as needed, particularly during freeze and thaw periods. The NDDWR, US Army Corps of Engineers (USACE), US Geological Survey (USGS), coordinate closely regarding river levels, gage data, reservoir releases and critical situations that arise.
- If conditions warrant, the state has the ability to leverage field personnel and aerial assets for both air and ground reconnaissance to monitor ice conditions, ice breakup, ice jams, etc.

CONSIDERATIONS

- Ice monitoring that includes personnel on the river ice cover is always hazardous and should only be done by those with appropriate training. Appropriate safety measures must be taken.

COORDINATION

- NDDWR, USACE, USGS, National Weather Service (NWS), Local Emergency Managers (EMs), ND Department of Emergency Services (NDDES)
- NDDES will coordinate with other state and federal agencies as necessary, i.e. Civil Air Patrol (CAP), National Guard (NG), etc.

ADVANCE MEASURES (ACTIVE INTERVENTIONS)

Advance measures are intervention methods used when ice jam flooding is imminent or occurring. If meteorological and river conditions suggest a risk of ice jam flooding, mitigation measures such as controlled ice cutting, mechanical ice breaking, or dusting may be considered to reduce the risk of ice jam flooding. These methods are explained below and have all been successful factors in mitigating ice jam flooding; though not necessarily locally; they have also been executed without success in some instances. Assessing their effectiveness is challenging due to the numerous uncertainties contributing to ice jam formation and flooding.

ICE CUTTING

- Ice cutting weakens the ice cover. Cutting can influence where ice sheets break providing more control over how and when the ice moves out. Ice cutting is primarily used to move the location of ice jams downstream and out of reaches where damaging ice jam flooding occurs. Ice can be cut in the direction of flow to create a flow channel for ice and water during breakup, decreasing ice jam probability. Cuts can be made manually with a trenching machine, chainsaw or repeated auger bores. Warm water and melting chemicals can also make cuts in the ice.
- CAPABILITIES/RESPONSIBILITIES
  - The state does not have capabilities to perform ice cutting. However, specialized ice cutting equipment is available from commercial vendors.
- CONSIDERATIONS
  - Ice cutting could potentially be hazardous.
  - Safety measures should be taken.
  - Timing of ice cutting is crucial, i.e. ice cuts can refreeze, if done too early.
  - Local jurisdictions must coordinate with the NDDWR and other appropriate agencies prior to implementing any control measures.
- COORDINATION
  - NDDWR, USACE, USGS, NWS, Local EMs, NDDES (will coordinate with other state and federal agencies as necessary)

AQUATIC EXCAVATORS

- An aquatic excavator, like the Amphibex, is a floating vessel equipped with an excavating arm capable of breaking and removing ice from a channel. The Amphibex is 35’ long by 11-1/2’ wide, which is longer and wider than a semi-truck. Aquatic excavators can break up ice sheets downstream of a major jam or excavate small ice jams.
- CAPABILITIES/RESPONSIBILITIES
  - The state does not own aquatic excavators. However, specialized equipment is available from commercial vendors.
- CONSIDERATIONS
  - They are not capable of removing large, heavy ice jams or if the ice thickness exceeds two feet.
  - The Amphibex would be limited to channels large enough to accommodate the excavator and to those sites with ice thicknesses less than two feet.
  - Safety measures must be taken.

        - Local jurisdictions must coordinate with the NDDWR and other appropriate agencies prior to implementing any control measures.
    - COORDINATION
        - NDDWR, USACE, USGS, NWS, Local EMs, NDDES (will coordinate with other state and federal agencies as necessary)

DUSTING

- Dusting typically uses aircraft or other means to apply a thin layer of dark material on the ice cover. The dark material can be soil, sand, fly ash or any other dark material that spreads evenly and absorbs energy more rapidly than snow and ice. The material is applied to decrease the albedo of the ice cover. Albedo is the ratio of reflected sunlight to downwelling sunlight. An albedo of 1 means all the sunlight is reflected. Dusting reduces the albedo allowing the ice cover to absorb the energy of sunlight and melt. The lower albedo absorbs more energy from the sun, melting and weakening the ice. There have been some instances of dusting river ice with leaf mulch, or other organic material, in order to deteriorate the ice cover.
- CAPABILITIES/RESPONSIBILITIES
    - Ice dusting should be initiated and implemented at the local level.
    - The ND Department of Environmental Quality (NDDEQ) can provide assistance in determining appropriate permits. NDDWR can assist with determining type and quantity of material, as well as timing and placement.
    - Implementation assistance can be requested if needed. State aviation assets can be leveraged to conduct ice dusting operations if required.
- CONSIDERATIONS
    - Some materials may be deemed environmentally unacceptable, while others may require significant lead time in obtaining necessary approvals. The NDDEQ should be involved in early discussion in order to address water quality issues/concerns and necessary permits. Local jurisdictions must also coordinate with the NDDWR and USACE for all permitting requirements prior to implementing any control measures.
    - The longer the dust is on the ice, the more effective the dust will be. Application two to three weeks ahead of ice breakup is recommended for maximum effectiveness.
    - If dusting is performed too early, the dust can be blown away by wind or covered by a new layer of snow, making it ineffective.
    - Safety measures should be taken.
    - Dusting is most effective on flat sheets of ice. It has minimal effect on jagged or jumbled ice sheets.
    - Too light of an application of material significantly reduces the ability of the material to absorb enough energy to effectively weaken the ice, while too heavy of an application of material reduces effectiveness by insulating the ice surface.
- COORDINATION
    - NDDWR, USACE, Local EMs, NDDEQ, NDDES (will coordinate with other state and federal agencies as necessary, i.e. NG)

EMERGENCY OPERATIONS (RESPONSE)

Sometimes, in spite of existing measures in place, or implementation of advance measures, ice jams can still form and cause significant damage. In such cases, it is often desirable to undertake emergency measures to remove the ice jam; however, it is often difficult and expensive to do so. The methods below are the most commonly undertaken. Other measures not shown below (e.g. deployment of materials to deflect or divert flows) that are commonly used in normal flood-fighting may also be practical under emergency conditions.

PUBLIC WARNING

- Reverse 911 systems, phone or personal notification, media, Integrated Public Alert and Warning System (IPAWS), NWS, etc. can be leveraged to disseminate emergency information to threatened residents.

FLOOD PROTECTIVE MEASURES

- All activities that are performed during open water flood fighting can be undertaken to fight ice jam floods. These include temporary levee construction, sandbagging, flood barriers (i.e. Hesco, big bags, etc.), blocking of culverts, pumping, evacuations, etc.
- CAPABILITIES/RESPONSIBILITIES
  - Local jurisdictions are expected to procure necessary flood fighting resources, to include material, equipment and volunteer support, based on anticipated need and not rely on state and federal resources.
  - NDDES has a limited cache of flood fighting resources to include sandbags, Hesco, big bags, trap bags, one ton sandbags and rapid deployable floodwall.
  - The NDDWR can provide technical assistance as needed.
- CONSIDERATIONS
  - State owned resources, including NDDES and NG, may be made available to local jurisdictions responding to incidents or emergencies when local, mutual aid and private sector resources have been exhausted, or are unavailable or cannot be deployed in time.
  - Assets are allocated on a priority basis depending upon the extent and duration of need, lack of local availability, and delivery time.
  - Local jurisdictions must coordinate with the NDDWR and USACE for all permitting requirements prior to implementing any control measures. NDDWR requires a permit for emergency dikes.
- COORDINATION
  - NDDWR, USACE, Local EMs, NDDES (will coordinate with other state and federal agencies as necessary, i.e. NG, NDDOT)

MECHANICAL INTERVENTION

- Ice jams can be removed from river using construction equipment like excavators, drag lines, and bulldozers. Equipment can sometimes be located in the stream, but equipment is often operated from the bank. Wrecking balls or other heavy objects can be dropped onto an ice cover to break the ice and assist passage of ice jams around obstacles and bridges.
- CAPABILITIES/RESPONSIBILITIES
  - Local jurisdictions are expected to utilize local resources, to include mutual aid and private contractors and not rely on state and federal resources.

        - The NDDWR can provide technical assistance as necessary.
        - The NDDWR, NDDOT and NG have equipment that is capable of removing ice from bridges and shorelines, pending access and river width.
    - CONSIDERATIONS
        - Mechanical removal is often only viable on small streams with low flows; safety concerns deter mechanical removal on wide or deep rivers.
        - Mechanical removal can be a slow, expensive process.
        - Access, location, river width and landowner permission must be taken into account.
        - Ice jam removal can be extremely dangerous.
        - Safety measures should be taken.
        - Local jurisdictions must coordinate with the NDDWR and USACE for all permitting requirements prior to implementing any control measures.
    - COORDINATION
        - NDDWR, USACE, USGS, NWS, Local EMs, Local Landowner, NDDES (will coordinate with other state and federal agencies as necessary, i.e. NG, NDDOT)

AERIAL BREAKUP

- Aerial assets can be used to break up thin ice in areas where access is limited or non-existent.
- CAPABILITIES/RESPONSIBILITIES
    - Private contractors can be leveraged by local or state agencies.
    - NG Blackhawks equipped with Helibuckets have been used to successfully break up an ice jam by picking up water and dumping it on the leading edge of the ice jam (2024 Missouri River)
    - Skycrane Helicopter companies can also be contracted.
- CONSIDERATIONS
    - Environmental considerations need to be taken into account.
    - Safety measures should be taken.
    - Local jurisdictions must coordinate with the NDDWR and USACE for all permitting requirements prior to implementing any control measures.
- COORDINATION
    - NDDWR, USACE, NWS, Local EMs, NDDEQ, NDDES (will coordinate with other state and federal agencies as necessary, i.e. NG)

BLASTING

- Blasting is a popular method of ice removal in emergency operations situations. Blasting is used primarily to dislodge ice jams that are already in place. Explosive charges are strategically placed to dislodge the jam or reroute the flow of water.
- CAPABILITIES/RESPONSIBILITIES
    - The state considers this emergency response method to be of last resort. If deemed absolutely necessary, the NG does have a limited capability to perform this mission. However, they do not have any hydro/ice jam experts and would require technical assistance.
- CONSIDERATIONS

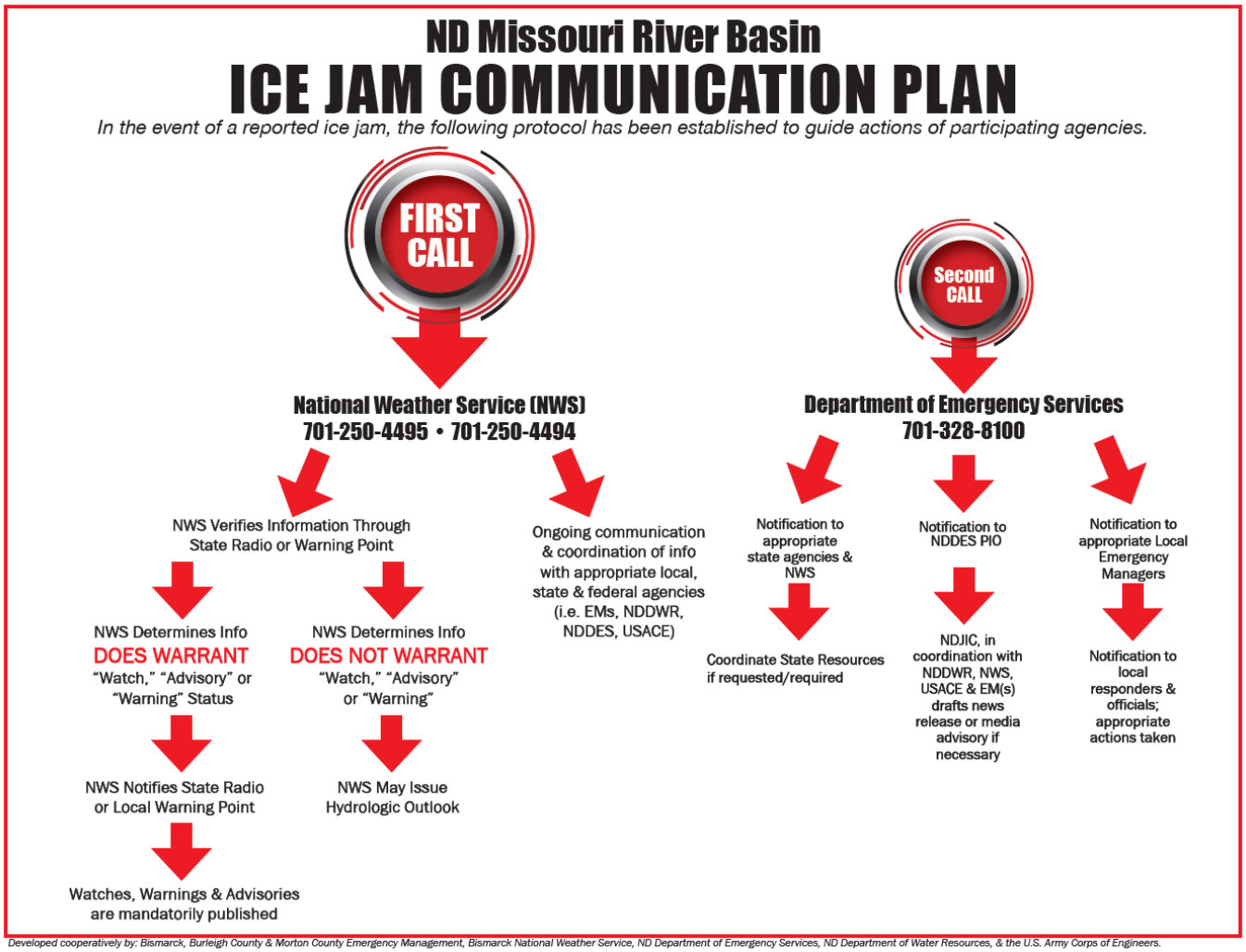
        - Blasting requires adequate flow and open water downstream of the ice jam to carry the ice downstream. If these requirements are not met, the jam will likely reform downstream.
        - If explosive charges are not imbedded into or placed under the ice, their effectiveness will be reduced; however, placement of personnel on an ice jam is never recommended, as it is far too dangerous.
        - Blasting of an ice jam is extremely dangerous and should not be undertaken without properly trained or certified demolition experts and the proper approvals. Another consideration may be legal liability associated with damages caused by such an operation.
        - Safety measures must be taken.
        - Local jurisdictions must coordinate with the NDDWR and USACE for all permitting requirements prior to implementing any control measures.
    - COORDINATION
        - NDDWR, USACE, NWS, Local EMs, Contractors, NDDEQ, NDDES (will coordinate with other state and federal agencies as necessary, i.e. NG)

NOTIFICATION PROCEDURES

The expectation is for local emergency management to report ice data (i.e. ice thickness) and information (i.e. ice breakup, flooding, impacts, ice jams occurrence, etc.) to the NWS and the ND Watch Center at NDDES. The NWS will issue necessary watches, warnings, and advisories based on the situation. The NDDES will share information with appropriate state agencies and emergency managers and coordinate state resources if requested/required.

PUBLIC INFORMATION

Local emergency management officials are responsible for dissemination of emergency public information. If an ice jam is suspected or occurs, local observers should notify the NWS who will validate the information and determine if issuance of a WATCH, WARNING, ADVISORY, and/or PUBLIC INFORMATION STATEMENT is warranted. In addition, notifications should be made to appropriate local and state emergency management officials. In instances where issuance of NWS products are not warranted, the ND Joint Information Center (NDJIC) will take a lead role in coordinating necessary messaging with federal, state and local emergency management officials under some circumstances if needed. Federal, state, and local officials should coordinate messaging between impacted cities and counties as well as pertinent state and federal agencies. Any form of public information should be coordinated with the NWS for possible inclusion into public information statements, watches, warnings, and/or advisories.



NDDES encourages local emergency management officials to develop and maintain relationships during non-emergency times with USACE, USGS, NWS, as well as NDDWR and NDDES to facilitate message development and dissemination during emergency incidents. NDDES is available to support local efforts to develop and disseminate coordinated emergency messaging, either through the NDJIC or ND Response .

REQUEST PROCEDURES

The normal emergency management process should be followed to request state and federal assistance as outlined in the NDDES Resource Handbook.

FURTHER INFORMATION

For questions or further information please contact one of the following:

- ND Department of Emergency Services (NDDES)
  - Eric Upton
  - 701-328-8206
  - eupton@nd.gov

- ND Department of Water Resources (NDDWR)
  - Alexis Faber, Investigations Section Manager
  - 701-328-2762
  - afaber@nd.gov
- National Weather Service (NWS)
  - Bismarck NWS Office
  - 701-223-4582
  - Grand Forks NWS Office
  - 701-795-5127
- US Army Corps of Engineers (USACE) Omaha District
  - Jacob Kelliher
  - 402-971-9893
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