



Office of the State Engineer

The winter blizzards and spring floods of 1997 have been among the worst in history. Snowfall records were broken across the state, setting the foundation for flooding, at times, of historical proportions. John McCormick of *Newsweek Magazine* summed up our most recent weather season most appropriately, "On the northern plains, nature is less an enemy than a sparring partner, trading rounds in a grudge bout that never ends."

The North Dakota floods of 1997 were felt across the state. In the southwest, rapid snowmelt runoff and ice jams caused flooding the weekend of March 21-23 along the Cannonball, Knife, and Heart Rivers and their tributaries. This flooding forced the evacuation of more than 200 families in Hettinger, Mercer, Morton, and Sioux Counties.

In eastern North Dakota, disastrous overland flooding inundated homes and communities, caused massive power outages, disrupted water, sewage, and electrical services, blocked major transportation arteries, and caused the evacuation of over 50,000 people in the Fargo and Grand Forks areas.

In Devils Lake, water has risen above the record 1830 water level of 1441 above mean sea level (amsl). The lake now stands at an elevation of 1442.2 amsl. Major transportation routes have been temporarily closed throughout the basin and agricultural land continues to be inundated throughout the region.

This publication is not intended to be a definitive text on the impacts of flooding in North Dakota. Rather, it is an overview designed to provide insight into the causes of the flood, to explain modern monitoring and forecasting processes, to provide information of local, state, and federal organizations involved, and to explore the long-term effects of the flood on future decision-making. By working in partnership together, North Dakota will recover from this disastrous flooding to fight another day.

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NORTH DAKOTA STATE ENGINEER



Grand Forks, April 1997.

NORTH DAKOTA STATE WATER COMMISSION

THE Floods of 1997

A SPECIAL REPORT

JUNE 1997

NORTH DAKOTA STATE WATER COMMISSION

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INTRODUCTION

On any given year there is likely to be spring flooding in North Dakota. However, in no single year on record has the state witnessed floods equal to the magnitude of those in 1997. Record or near record water levels were recorded in all areas of the state and on almost every river system. Statewide flooding resulted in a Presidential Disaster Declaration for all 53 counties.

Flooding in the Red River Valley alone caused the evacuation of over 50,000 residents, resulting in disaster housing assistance for over 20,000 residents at a cost of over \$35.6 million. The Small Business Adminis-

tration has issued \$49.9 million in special disaster loans to over 2,500 local businesses.

The agricultural community has suffered a total impact of \$270 million in losses due to blizzards and flooding, including nearly 1.1 million acres in prevented planting acreage and over 123,000 head of livestock lost.

Although the financial cost of flooding in 1997 is yet to be fully determined, the emotional loss will be felt for years to come.



Flooding and Blizzard General Impacts as of May 1997

- More than 33,800 residents registered for assistance.
- 1,118 applications for \$1.8 million in approved grants from the Individual and Family Grant Program
- 20,536 disaster housing assistance checks have been issued totaling \$34.6 million.
- FEMA has paid \$2 million to state and local governments for emergency services, flood-fighting, and debris removal.
- The Small Business Administration has received 7,907 loan applications. Of these, 3,368 have been approved for a total of \$70 million in loans.
- Temporary housing alternatives in Grand Forks includes several hundred dormitory beds at the University of North Dakota and several dozen travel trailers that are at Grand Forks Campgrounds and private residences. Sixty more trailers are on order.
- As of May 12, approximately 3,000 customers in Grand Forks remain without power and 9,200 customers are reported as not having natural gas service. Nearly 800 people are still in shelters.
- Preliminary costs for North Dakota National Guard emergency operation "Good Neighbor" are approaching \$3.5 million. At the height of the disaster, 900 National Guard members were on duty to assist in the winter storms and flooding. The Guard was instrumental in assisting with the air evacuation of 328 people from East Grand Forks.

Flooding and Blizzard Agricultural Losses

Direct Losses:

Prevented Planting	\$141,544,000
Delayed Planting	34,104,000
Beef cattle losses	55,098,000
Sheep & hog losses	998,000
Dumped milk	623,000
Farm buildings	27,200,000
Farm machinery	8,200,000
Stored crops	2,304,000

Indirect losses:

Value of lost crop & livestock production	\$665,192,000
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TOTAL DOLLAR IMPACT..... \$935,253,000

Livestock death totals:

Cattle	123,000
Sheep	9,733
Hogs	2,866
Poultry	1,588

Dairy loss:

Pounds of milk destroyed	5,192,499
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Estimated cropland loss:

Prevented planting acreage	1,097,594
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SOURCE: NORTH DAKOTA EXTENSION SERVICE/FARM SERVICE AGENCY

HOW DID IT OCCUR?

Beulah residents, March 23, 1997.

At its most basic level, flooding in North Dakota is easily explained. During the winter season, snow accumulates across an entire river watershed. Although some moisture is lost during the winter through sublimation and mid-winter thaws, snow is generally retained until spring.

During the spring thaw, snow can melt within a short period of time, sending months of precipitation through a watershed within a few days time.

In general, the magnitude of flooding is dependent on the amount of moisture stored in a watershed and the rate at which it is released through the melting process.

North Dakota flooding, however, is affected by more than the simple relationship between precipitation and melting. There is a set of geographical conditions that exist throughout the state that act as constant precursors to spring flooding. The magnitude of any particular flood is based on the interaction of variable environmental factors with these constant geographical conditions.

This section will highlight those conditions that contributed to the 1997 flooding and the environmental events that determined the magnitude and areal extent of the disaster.



THE BISMARCK TRIBUNE

PRECURSORS TO THE FLOOD

Constant Factors

The major basins of North Dakota, although all unique, have similar geographic characteristics that make them susceptible to flooding in any given year. The following is a set of constant conditions that form the foundation for a potential flood.

- Gradient - With the exception of a few areas in extreme western North Dakota, the state is characterized by gentle rolling slopes with little elevation change along a given watershed. This is particularly apparent in the Red River Basin where



gradients are as little as 1/2 foot per mile. The low velocity of the state's rivers and creeks is largely a result of this gentle gradient and contributes to their slow movement and limited drainage capacity. Additionally, channel depths are generally shallow and the flat topography easily allows water to spill over the banks during high input spring melting events.

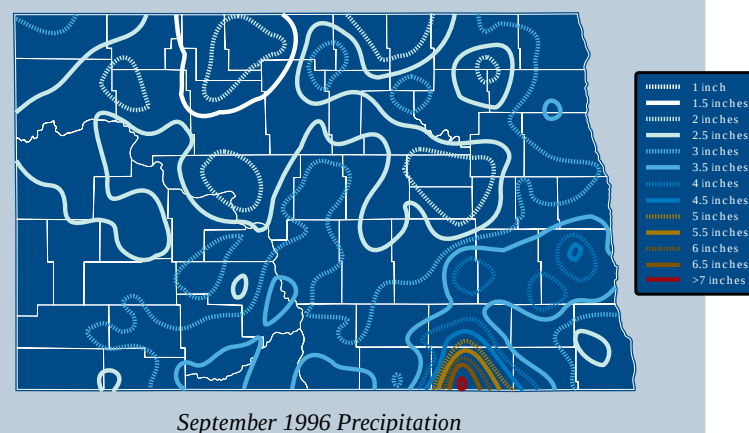
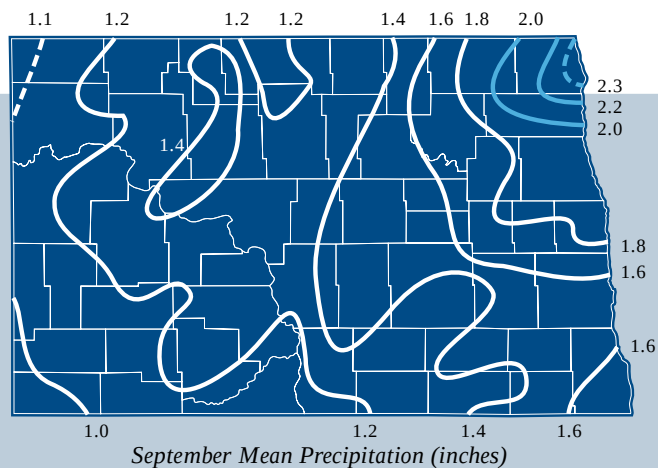
North Dakota's five major basins.



Ice jams caused many problems, particularly in the western part of the state.

• **River Direction** - Although most rivers in North Dakota flow in a southerly direction, the Red River moves northward into Canada. This creates an unusual situation during the spring melting period with meltwater and runoff occurring first at the southern headwaters of the river. As water begins to flow northward, it is blocked by still frozen portions of the river creating an enormous potential for flooding.

Ice jams additionally occur in the western section of the state. Most rivers in this area flow on a southeasterly course. Spring thaw generally occurs first in the western part of the state and moves in a northeastern direction. The headwaters and uplands of the easterly flowing rivers and creeks thaw first and begin moving into the still frozen portions of the watershed, again, creating the potential for ice jam flooding.



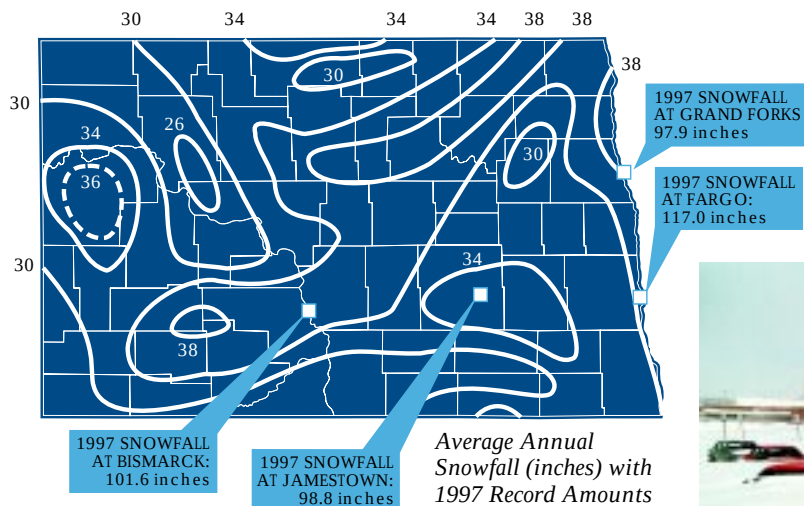
Variable Factors

Although many areas of North Dakota are prone to flooding, a complicated set of environmental factors determine the magnitude of a flood. The following primary conditions formed the foundation for the 1997 flooding.

• **Fall Precipitation** - North Dakota has reported above average precipitation across the state since late 1993. This has left much of the land with a higher than normal water content. During the spring thaw, the saturated land is unable to absorb the resulting meltwaters and a greater percentage runs off into nearby rivers and creeks or overland.

Heavy precipitation in the fall of 1996 directly contributed to the spring flooding in 1997. As the figures above illustrate, fall rainfall ranged from 8.8 inches to 3.5 inches in the watersheds of the Cannonball, Knife, Heart, Sheyenne, James and Red Rivers. These rivers also reported much of the greatest frequency and areal extent of flooding during the spring of 1997.

Comparison of the maps above shows these same areas normally receive between 1.0 to 2.3 inches during the same time period. The amount of moisture frozen in the soil during the 1996-97 winter season was increased by earlier than normal snowfall and cold temperatures.



Kirkwood Mall parking lot, Bismarck, April 6, 1997.



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• Snow Accumulation - The 1996-97 snow season produced record amounts of snowfall throughout North Dakota. As the figure above illustrates, the average amount of snowfall across the state ranges from 38 inches in Grand Forks, to 34 inches in Bismarck, Fargo and Jamestown, to 30 inches in Williston. Accumulations during the most recent winter broke seasonal records in the central and eastern portions of the state.

As the figure above indicates, Fargo received 117.0 inches of snow, breaking the 1993-94 record of 89.1 inches; Grand Forks reported 97.9 inches, breaking the 1896-97 record of 91 inches; Jamestown noted 98.8 inches, surpassing the 1949-50 record of 96.6

inches; and Bismarck witnessed 101.6 inches, breaking the record of 91.8 inches set in 1993-94.

Snow accumulation was of particular importance to the 1997 flooding across the state. In the Red River Valley, a late spring blizzard on April 4-6 left 10 to 12 inches of snow in broad areas of the watershed. This snow was equivalent to 2.66 inches of water. A history of flooding in this valley indicates that nearly all large floods were preceded by an unusually heavy snowfall and a late spring blizzard. Cooler than normal temperatures delayed the melting of the snow for nearly one week. This delay likely contributed to the proximate timing of the

Red River and the Red Lake River crests in the Grand Forks area.

• Soil Condition - With lands already saturated by four years of above average precipitation, the extraordinarily large snowfall amounts during the 1996-97 winter season greatly contributed to record spring runoff on nearly all rivers and tributaries throughout the state. Most soils, especially in the Devils Lake and Red River Valley, were either frozen or inundated during the early spring of 1997, significantly reducing the opportunity for infiltration to reduce overland runoff.

A lack of mid-winter thaws likely influenced the large amount of snow retained on the ground until the spring thaw.

Bismarck blizzard, April 7, 1997.



Bismarck blizzard, April 7, 1997.

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THE CHAIN OF EVENTS

Spring Melting

Although an extraordinarily large amount of snow, unusually cold winter, and saturated soil conditions are strong precursors to flooding, they do not alone guarantee a flood. Flooding is highly

dependent on the rate of the spring thaw. The magnitude of a particular flood event is directly related to the rate at which the snowpack melts. A slow and gradual warm-up, with an intermingling of cooler periods during the spring, can greatly reduce the

magnitude of a flood. A sudden and prolonged late spring warming will increase the likelihood of a significant flood event.

The spring thaws of 1994 and 1996 provide two contrasting scenarios in the figures below.

SCENARIO 1:

The Spring Thaw of 1994

The winter of 1993-1994 established what was then an all-time record snowfall at Fargo of 89.1 inches. Snow depth during the month of February ranged from 12 to 24 inches, with an eventual snow depth of 15 inches heading into March. Water equivalency from the snowpack at peak depth ranged from 3 to 4 inches of water.

Precipitation in February and March was normal. Daytime high temperatures during the month of March and into April were greater than 32 degrees on all but 5 days, allowing for a gradual snow melt. During this period, daytime highs ranged from 35 to 45 degrees, with five days at or greater than 50 degrees. Nighttime lows fell below 32 degrees on all but five days

during March. This cooling allowed rivulettes to freeze at night, slowing down the melting and runoff that occurred during the day. As a result, the Red River crested in Fargo on April 3, 1994 at a stage of 26.70 feet. Despite Fargo's 17-foot flood stage, the event was categorized as a minor to slightly moderate flood.

SCENARIO 2:

The Spring Thaw of 1996

Snowfall for the winter of 1995-1996, the fifth largest on record, was again heavy, with a seasonal total of 74.6 inches. A mild February caused snow depths to shrink from nearly two feet at the beginning of the month to less than a foot by March. Mild conditions again occurred the second week in March reducing the snow depth to a trace. However, a cool down, occurring during the second half of March continuing into the first week in April, halted the

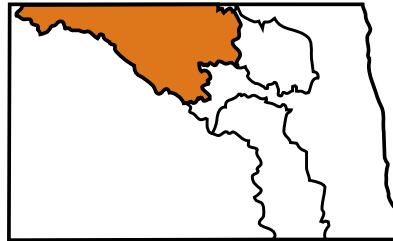
melting of the remaining snow cover. From March 16 to April 8, temperatures stayed below 40 degrees and climbed above 32 degrees less than 40 percent during the time period. A series of snowfalls raised snow depths up to eight inches by April. Beginning on April 8, temperatures dramatically changed rising to the middle 40s to middle 60s across the entire basin. The warmer temperatures melted the remaining snow pack in a

matter of a few days, causing rapid runoff. As a result of the sudden warming late in the spring melt season, moderate to major flooding occurred over a large portion of the basin. The Red River at Fargo crested at 28.73 feet on April 16, resulting in moderate flooding. The Red River at Grand Forks crested at a stage of 45.82 feet, causing significant flooding. Significant flooding was additionally observed at Drayton, Pembina and Winnipeg.



River Basin Flooding

The 1996-97 winter season was characterized by an unexpected and pronounced spring thaw in the western section of the state and a sudden, late spring thaw in the eastern part. This section narrates scenarios for each river basin.



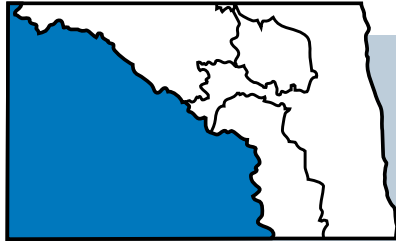
Souris River Basin Flooding

Flooding in the Souris River area was considered to be moderate. The Souris River exceeded flood stage at Sherwood, Foxholm, Westhope, and Bantry.

Crests moved through the system between April 3-12 and averaged only 2.79 feet above flood stage.

The limited flooding along the river can be attributed to the use of Rafferty and Alameda Dams in Canada to regulate flows along the river system.

Winter '97 in Burleigh County.



Missouri River Basin Flooding

Flooding in the western section of the state along the Missouri, Cannonball, Knife, and Heart Rivers



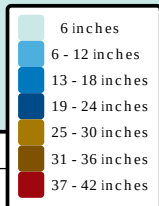
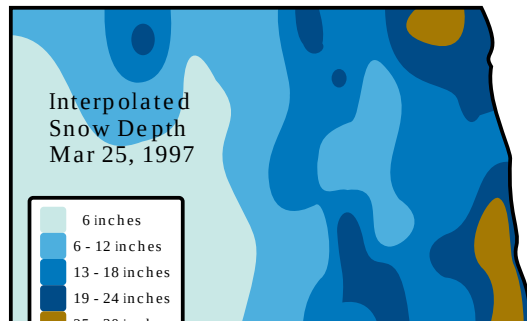
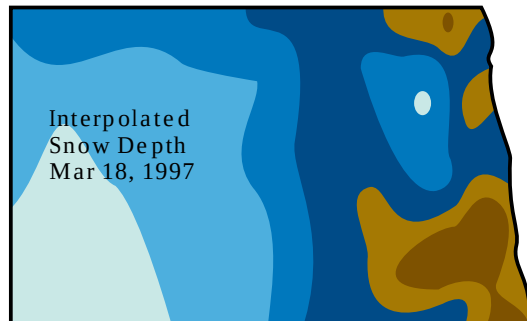
U.S. GEOLOGICAL SURVEY

began in early March and peaked March 21-23. The peak was preceded by two days of above normal temperatures. Mean temperatures for March in the Cannonball, Knife, and Heart watersheds range from 24 to 28 degrees. Temperatures during the period from March 19 to March 22 ranged from a mean of 35.5 to 42 degrees, 11.5 to 14 degrees above normal.

gauging stations along these rivers from March 21-23. This flooding forced the evacuation of more than 200 families in Hettinger, Mercer, Morton, and Sioux Counties.

Much of the flooding along the Missouri, Cannonball, Knife and Heart Rivers was the result of ice jam flooding. The headwaters and uplands of these easterly flowing rivers and creeks thawed first and began moving into the unthawed portions of the watershed. The table below displays the crest, flood stage, and crest date for the four rivers.

This sudden warming trend created flashflood conditions along the Missouri River at Williston, the Cannonball River at Mott, the Knife River at Beulah and Hazen, and the Heart River west of Mandan. The United States Geological Survey (USGS) reported 25 to 50 year flooding events at 10



SOURCE: NORTH CENTRAL RIVER FORECAST CENTER, MN

RIVER	CREST	FLOOD STAGE	CREST DATE
Cannonball	21.6 ft	22 ft	Mar 21, 1997
Heart	24.1 ft	17 ft	Mar 22, 1997
Knife	26.9 ft	21 ft	Mar 23, 1997
Missouri at Bismarck	13.6 ft	16 ft	Mar 25, 1997
Missouri at Williston	24.0 ft	20 ft	Mar 26, 1997



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The Heart River south of Mandan, March 24, 1997.



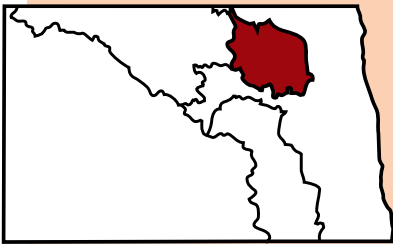
Devils Lake.

the spring of 1993, the lake was at 1422.6 feet above mean sea level (amsl), covering about 45,000 acres, with an estimated volume of 550,000 acre-feet.

Although the FEMA disaster incident period for North Dakota ended May 24, it remains open for Benson, Nelson, and Ramsey Counties and the Spirit Lake Nation Reservation.

Federal, State, and local officials are continuing to work together to address the problems and needs associated with the rising waters of Devils Lake.

Cap's South Shore, Devils Lake.



Devils Lake Basin Flooding

Flooding continues to be significant in the Devils Lake Basin. The lake, which has been steadily rising since 1993, has surpassed the 130-year-old record elevation. In

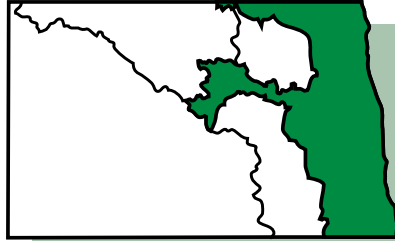
In 1997, the water began rising around April 12 from an elevation of 1438 feet amsl. As of June 13, the lake was at 1442.2 feet amsl, rising about 4 feet from the beginning of the spring runoff.

Normal spring runoff is expected to cause the lake to peak between 1443 and 1443.5 feet amsl in mid-July. At the level of 1444 feet amsl, the lake will cover approximately 105,000 acres and will have a volume of more than two million acre-feet.



Devils Lake, May 1997.

*The Grand Forks flood,
April 21, 1997.*



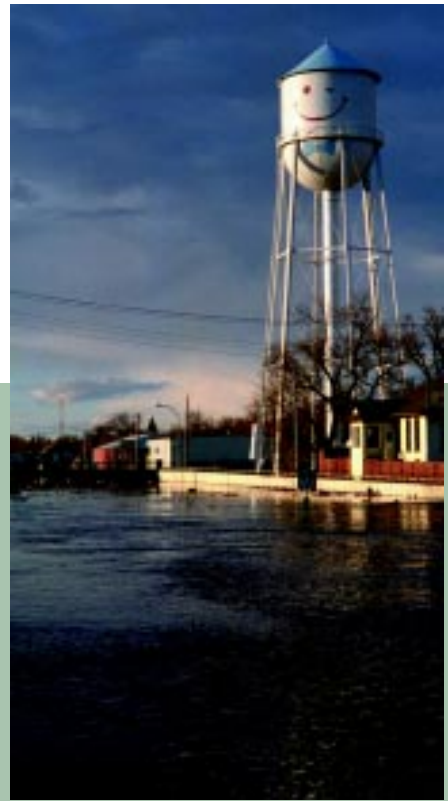
Red River Basin Flooding

Spring melting in the eastern section of the state caused flooding on the Sheyenne River beginning in late March, with the water levels cresting from April 7 - 10. Flooding occurred at Lisbon, Cooperstown, Kindred, and Valley City. The river at Kindred and Lisbon established a new flood record, reaching 21.87 feet, and breaking the previous record of 21.7 feet. The

Sheyenne River is one of the state's main tributaries to the Red River of the North.

Although originally forecasted to be historically significant, the spring thaw in the Red River Valley was complicated by a late spring blizzard. The storm and several days of record low temperatures delayed the spring melting in the Red River Valley.

Temperatures in the basin rose from an average of 9 degrees on April 8 to an average of 58 degrees on



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April 18. This sudden warm-up created extensive melting throughout the region, swelling the rivers and streams to record levels. Flooding was additionally exacerbated by large unrecorded overland flows of water.

Crests in the basin, delayed by a cool spring, did not occur until April 16 in Wahpeton, April 18 in Fargo, April 22 in Grand Forks, April 25 in Drayton, and April 26 in Pembina.

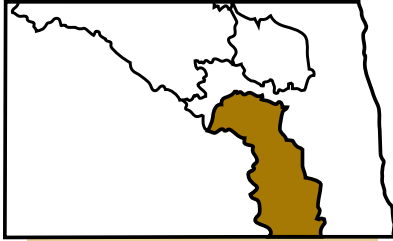
Crests from the spring snowmelt broke water level records at nearly all sites adjacent to the Red River. Although only 95 years of historical water records exist for the basin, the flood is generally considered, according to forecasting models, to be a 300- to 500-year occurrence.



*Grand Forks begins a
massive clean-up job,
May 1997.*



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James River Basin Flooding

Flooding along the James River and its tributaries was considered to be moderate. Flooding occurred in LaMoure and Dickey Counties on March 30. At the city of LaMoure, the level of the river exceeded the 14-foot flood stage at 14.2 feet. The river crested at around 15 feet. The flooding also caused roads to be washed out along Bone Hill, Cottonwood, and Maple Creeks.

Late spring flooding caused record elevations at the Jamestown and Pipestem Dams. These dams were kept at higher than normal elevations to allow for a controlled release of water through the city of Jamestown after local runoff began to diminish.

Disaster Declarations

The winter blizzards and spring floods caused a myriad of damages and hardships for the people of North Dakota. These impacts have yet to be fully realized and will continue to impact the state for many years.

Financial relief for clean-up and rebuilding is often borne by the state and federal government through normal and special disaster funding. As the timeline below illustrates, the state received a series of special disaster declarations and aid.

During his April 22 visit to the Grand Forks area, President Clinton announced that the Federal Emergency Management Agency was directed to reimburse 100 percent of North Dakota's costs for immediate disaster-related emergency work.

Following the President's action, all of the state's 53 counties were eligible for federal funding to supplement the recovery needs of stricken residents and business owners. The aid,

coordinated by FEMA, includes grants to help pay for temporary housing, minor home repairs, and other serious disaster-related expenses.

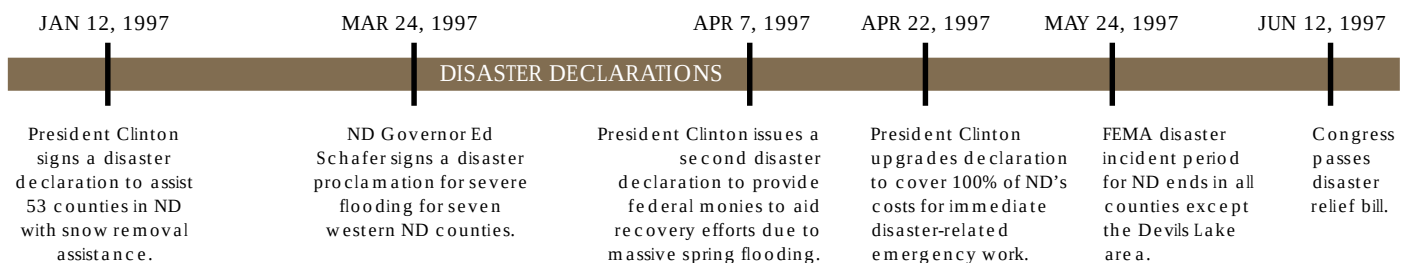
Low-interest loans from the U.S. Small Business Administration also are available to cover residential and business losses not fully compensated by insurance.

Additionally, the President announced that the U.S. Congress would be asked to appropriate another \$200 million in emergency contingency funds to help North Dakota, South Dakota, and Minnesota address flooding problems. The relief bill was passed in Congress on June 12, 1997.

Grand Forks, May 1997.



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Flood Protection That Worked

Despite the vast flooding that occurred across the State of North Dakota in 1997, it could have been worse.

The actions of thousands of volunteers, who spent countless hours sandbagging temporary levees and dikes, saved whole communities and millions of dollars in damages. Neighbors pulled together to help other neighbors with selfless effort and without question. Local, state, and federal agencies worked around-the-clock planning and coordinating action, supplying materials, equipment and manpower, and offering technical assistance to levee-building volunteers.

Without the tremendous effort and giving of the people of North Dakota, a way of life for many people could have been lost forever.

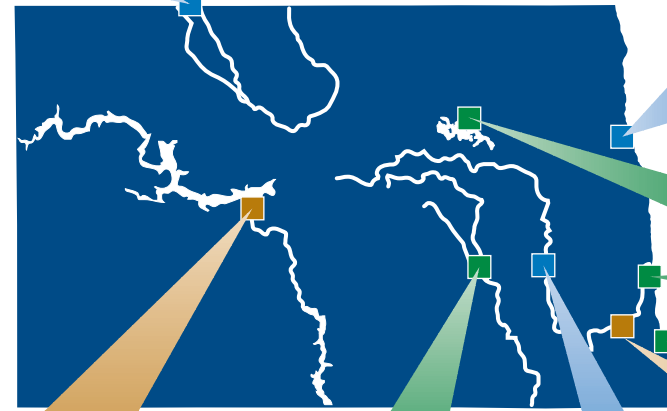
In addition, these two pages display a few of many long-term planning efforts that saved lives and money during the flooding of 1997.



NDSWC

Souris River Flood Control - Historically, North Dakota's most prominent flooding disasters have been adjacent to the Souris River at Minot. The development of the Souris River Flood Control Project in the 1980s has greatly lessened the threat of flooding in the basin. Flows through Minot are kept below 5,000 cfs and are monitored by USGS stream gages. Cooperative flood control on the river is achieved by holding back flows at Rafferty and Alameda Dams in Canada until local runoff begins to diminish.

Garrison Dam - The early winter thaw of March 21-23, created ice jams on many of the tributaries and main stem of the Missouri River south of Bismarck. The Corps of Engineers worked cooperatively with the State Water Commission to regulate flows from Garrison Dam. Normal flows from the dam are released at a minimum of 10,000 cfs for electrical power plants and water supply for Bismarck, Mandan, and Washburn. During the ice jam event, water levels south of Bismarck reached within 1/2 foot of the all-time record since the construction of the dam. The Corps cut releases to 4,000 cfs to help relieve flooding caused by the ice jams. Flows were slowly returned to normal without damage to the power plants and with a minimum amount of flooding.



English Coulee - This 6-mile earthen dam cuts the 115 square mile English Coulee watershed near the city of Grand Forks in half by damming up runoff from the upper basin. A 36-inch pipe underneath the dam is used to draw down the 240 acre pool to provide future flood storage. The structure protected much of the western side of Grand Forks from severe flooding.

Fargo, Wahpeton, and Devils Lake Levees - The levees at Fargo and Wahpeton held throughout the flood, despite record water levels. Built through the coordinated efforts of volunteers and local and state agencies, the dikes prevented water from engulfing the cities. In Devils Lake, a levee system between the urbanized area and the lake is in the process of being raised by the U.S. Army Corps of Engineers. The dike will protect the city to a lake elevation of 1445 feet amsl and is designed to go higher if needed. The lake is currently forecasted to reach an elevation between 1443 and 1443.5 feet amsl by mid-July.

Pipestem and Jamestown Dams - These two dams provide flooding protection to the city of Jamestown by holding water along Pipestem Creek and the James River, respectively. On April 20, the pools of both dams reached record elevations. The Pipestem crested at 1484.29 feet, 4.79 feet higher than the record set in 1995 and the Jamestown Dam peaked at 1445.6 feet, nearly one foot higher than the record set in 1996. The U.S. Army Corps of Engineers held releases from the dams to allow more time for runoff downstream. Once water was released, it was maintained at 1750 cfs through Jamestown. The releases were monitored using a river gage at Interstate 94 until the water levels at the dams reached a normal operating level. The slow release of water kept flooding in the city of Jamestown to a minimum.

Baldhill Dam - With near record flows occurring on the Sheyenne River at Cooperstown and along Baldhill Creek at Dazey the U.S. Army Corps of Engineers held water in Lake Astabula at the Baldhill Dam to allow for a slower release through Valley City, Lisbon, and eventually into the already swollen Red River. The dam was held to near capacity with a controlled release as local runoff diminished.



NDSWC

Sheyenne Diversion - This project, built by the U.S. Army Corps of Engineers, kept the town of West Fargo from disastrous flooding by diverting Sheyenne River water around the city. Additionally, the built-up channel contained overland flows from spreading into the urbanized areas.



NDSWC

MONITORING AND PREDICTION

ND STATE WATER COMMISSION



*Grand Forks,
May 1997.*

FLOOD FORECASTING METHODS

The National Weather Service (NWS), part of the National Oceanic and Atmospheric Administration, is the federal agency in charge of weather forecasting and warning for the nation. The NWS is also charged by law with the responsibility of issuing river forecasts and flood warnings. The National Weather Bureau Organic Act of 1890 (U.S. Code Title 15, Section 311) mandates that the National Weather Service is the responsible agent for "...the forecasting of weather, the issue of storm warnings, the display of weather and flood signals for the benefit of agriculture. . ." The NWS uses many sources of data to develop its flood forecasts. The U.S. Geological Survey is the principal source of data on river depth and flow.

The National Weather Service issues two types of forecasts for predicting floods. Predictions are initially issued as a "flood outlook" and are based on actual conditions

present before spring runoff, such as existing snow cover, water equivalents, soil moisture, frost conditions, river ice, baseflows, and assumed normal future precipitation and snowmelt rates for the remainder of the snow season.

Later, a "flood forecast" is issued as an attempt to predict a specific river or lake crest and crest date based on variable weather conditions. Forecasts are commonly updated when weather conditions change from the expected norm.

Data for flood forecasts are collected through an automated set of stream gages set up on the main stem and various tributaries of a river. Gages represent the water level based on the USGS reference datum, commonly measured in feet, subtracted from the gage reading. For example, if a gage is at 500 feet above mean sea level and the water level on the

gage is at 540 feet, then the water would be approximately 40 feet in height at the main channel of the river.

The USGS has 144 streamflow and lake level gaging stations in North Dakota. Additionally, the gaging network collects data on the flow rate or discharge. This number represents the total volume of water that flows past a point on the river for some period of time, and is usually measured in cubic feet per second or gallons per minute.

By using automated equipment in the gaging station, river stages can be continuously monitored and reported to an accuracy of 1/8 of an inch. Linking battery-powered stage recorders with satellite radios enables transmission of stage data to computers in USGS and NWS facilities even when extremely high waters and strong winds disrupt normal telephone and power services.

In this way, USGS or NWS hydrologists know the river stage at remote sites and how fast the water is rising or falling. It is important to note, however, that mechanical problems do occasionally occur and users of this information must be aware and able to recognize this possibility.

River-flood forecasts are prepared by 13 NWS river-

forecast centers across the United States and disseminated by NWS offices to the public. During periods of flooding, the NWS river-forecast centers issue forecasts for the height of the flood crest, the date and time when the river is expected to overflow its banks, and the date and time when the flow in the river is expected to recede to within its banks. Forecasts are updated as new information is acquired.

To develop flood forecasts, the NWS develops and calibrates complex mathematical models of how the

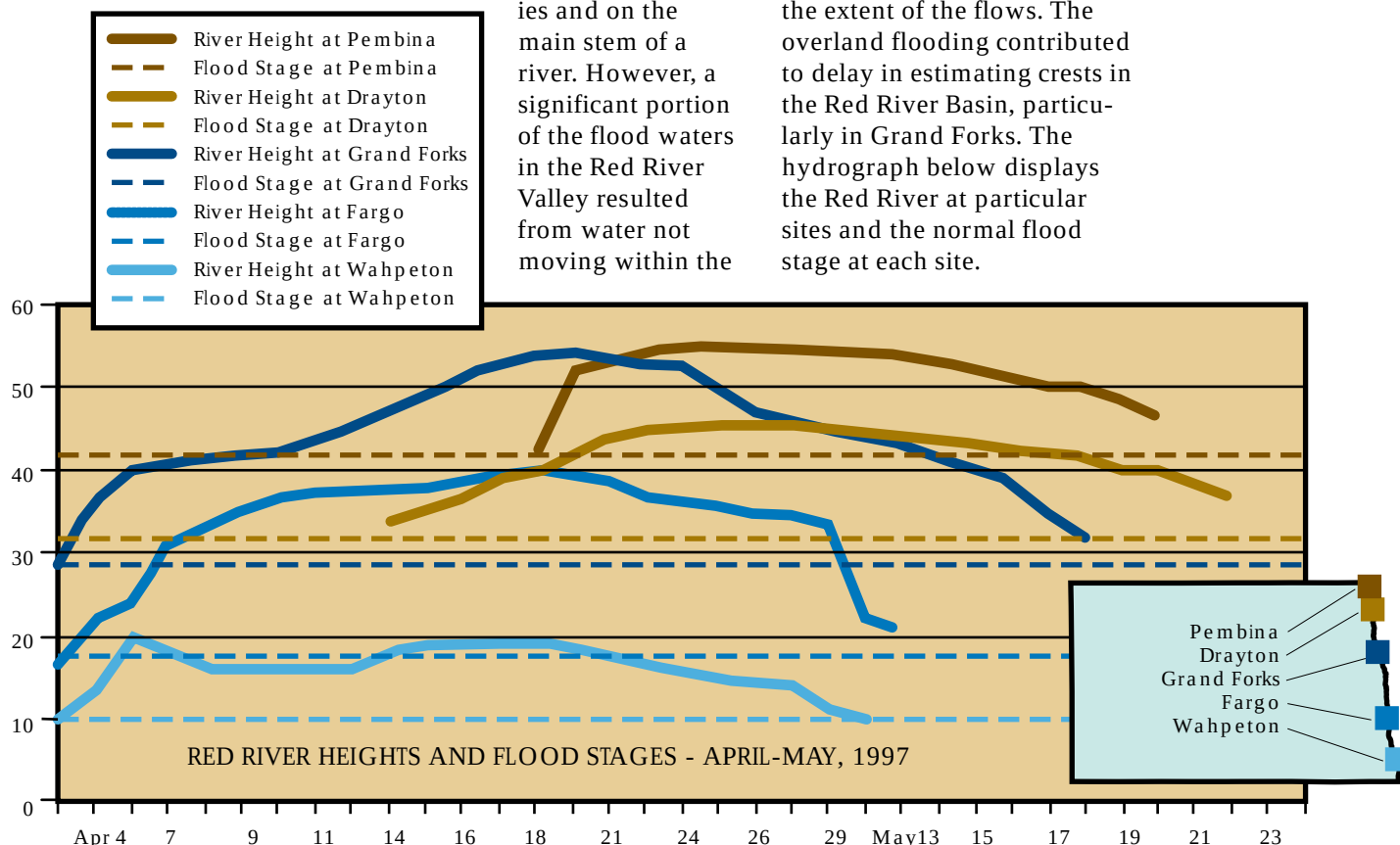
state's rivers and streams respond to rainfall and snowmelt. These models are developed for forecast service points, which are usually located along major rivers or on small streams near urban areas that have a history of flooding. When heavy rainfall is forecast for a

river basin, historical discharge amounts help the model estimate the river stage and discharge that will result. As new river and rainfall data are collected during a storm, the new data are entered into the computer, and new river forecasts are produced.

FORECASTING THE 1997 FLOODS

Forecasting the river crests for the floods of 1997 was greatly hampered by water from overland flows. Generally, forecasts are based on gage readings from tributaries and on the main stem of a river. However, a significant portion of the flood waters in the Red River Valley resulted from water not moving within the

normal river channels. Forecasting the impact of this overland flooding on future river crests became a difficult task because there were no automated gages to measure the extent of the flows. The overland flooding contributed to delay in estimating crests in the Red River Basin, particularly in Grand Forks. The hydrograph below displays the Red River at particular sites and the normal flood stage at each site.



WHERE DO WE GO FROM HERE?

BRUCE BOE, ATMOSPHERIC RESOURCE BOARD



UNDERSTANDING THE SIGNIFICANCE

The magnitude of a particular flood is often expressed in terms of its recurrence interval. This time designation is the average number of years separating floods of a given magnitude and is based on the past streamflow record at a given location. The interval is computed by dividing the number of times a particular height flood has occurred over the time period of record keeping.

In other words, assume that a flood 30 feet high or higher has occurred ten times in the past 100 years. It is expected that a flood at least that high would occur on an average of once in ten years, also known as a 10-year flood. Based on the example, the recurrence

interval represents the chance of having a flood 30 feet high or higher is one out of ten or 1/10 for every year.

The interval, however, does not imply that if a 30-foot flood occurs this year, another of that magnitude will not occur for ten years. Rather, over a period of 40 years about four floods of this magnitude can be expected. It is not known, however, when the floods will occur or how many years will separate them. Due to the appearance of a wet cycle in the state since 1993, the chances of a flood recurrence are likely greater.

Throughout the state, the floods of 1997 created a long-lasting impression. Along the Cannonball, Knife, and Heart Rivers, 10 gaging stations reported 25- to 50-year flood events.

At Devils Lake, the 1867 water elevation record of 1440.5 feet amsl has been surpassed by over 1.5 feet as of June 1, 1997.

Water levels in the Red River Basin are, according to forecasting models, estimated to have been between a 300- and 500-year recurrence interval. Although mathematically unlikely, the flooding experienced in 1997 could be repeated in the spring of 1998.

LOUIS HUFFMAN, U.S. DEPARTMENT OF AGRICULTURE



Livestock that perished during the state's blizzard had to be recovered and buried, April 1997.



Devils Lake.



NDSWC PHOTOS



DEVILS LAKE

Since 1993, federal, state, and local officials have pursued a comprehensive approach to flooding problems in the basin. This has taken the form of a three-pronged approach:

Upper Basin Storage - The Devils Lake Water Management Plan identified storing water in the upper basin as a necessary management activity to help stabilize the water level at Devils Lake.

The U.S. Fish and Wildlife Service (FWS) and the U.S. Bureau of Reclamation (BOR) have been active in securing water storage for the upper basin. The FWS, together with North Dakota Wetlands Trust, and Ducks Unlimited, Inc. (DU), have begun implementation of numerous projects on public land to permanently increase runoff

**DEVILS LAKE BASIN
TOTAL FEDERAL FLOOD-RELATED EXPENDITURES
1993-1996**

Federal Crop Insurance Corporation	\$61.9 million
Federal Highway Administration	\$25.8 million
U.S. Army Corps of Engineers	\$7.2 million
Federal Emergency Management Agency—NFIP	\$7.9 million
Economic Development Administration	\$4.4 million
U.S. Fish and Wildlife Service	\$3.4 million
Natural Resources Conservation Service	\$2.0 million
Housing and Urban Development	\$1.2 million
Environmental Protection Agency	\$73,300
U.S. Geological Survey	\$66,400
Rural Economic and Community Development Service (loan)	\$748,000
Total	\$114.6 million

water storage and enhance wetland and wildlife management. A total of approximately 1,500 acre-feet of new water storage on public land was developed in 1996.

The state, working through the State Water Commission, achieved new water storage in three areas.

First, the Available Storage Acreage Program (ASAP) was developed to pay landowners to temporarily store water on private land. This program stored 8,000 acre-feet of water in 1996 and will store an additional 10,000 acre-feet in 1997. The 18,000 acre-feet of stored water for 1997 will be spread over 150 individual sites.

Second, additional storage was created by operating a portion of the upper chain of lakes at higher water levels.

Last, land bought for impact mitigation along the proposed outlet to Stump Lake was used to keep flood water from entering the larger Devils Lake.

Basin landowners have been involved either directly or indirectly in all of the federal and state water storage activities in the Devils Lake Basin. Due to flooding, however, many landowners have been inundated by water on their land. Unlike the state's ASAP, this water storage has been involuntary and uncompensated.

Infrastructure Protection - The steady rise of Devils Lake has resulted in the raising of many major transportation routes. As of 1996, the NDDOT has completed nearly \$35 million in road upgrades in the region. If the lake reaches its

forecasted level of 1444 feet amsl, another \$58 million in road upgrades will be needed. The cost to upgrade local roads at the 1444 feet amsl elevation is estimated at \$97.2 million.

The flooding has caused additional expenditures for rural utility systems. In 1995, the City of Minnewaukan was forced to move their sewage treatment ponds.

In Ramsey County, the Rural Utility System reports that twelve lift stations and four manholes have been sealed in 1997. The Rural Utility System has lost 62 sewer accounts as of May 30 and will lose the Wolford Subdivision soon. This combination of events has created a substantial business loss for the Ramsey County Rural Utility System. The U.S. Army Corps of Engineers is currently assisting the Rural Utility System with the upgrading of five lift stations and access roads.

The U.S. Army Corps of Engineers continues construction on the levee raise at the City of Devils Lake.

Stage 1 of the raise is approximately 55 percent complete. The contract completion date is September 21, 1997.

Stage 2 is currently being redesigned to accommodate

higher elevations. Additionally, the east end of the project is being studied for a possible realignment back to the original Corps of Engineers proposed alignment in the Stage 1 Contract. This alignment ties into elevations above 1460 feet amsl in case future levee raises are required. The realignment is expected to protect a larger area, but at a much higher construction cost.

The Corps of Engineers is additionally providing technical assistance for levees in Crary, Minnewaukan, and Churchs Ferry.

North Dakota State Parks reports that the Grahams Island State Park was closed on April 30 for the summer due to flooding. Additionally, a boat ramp at Black Tiger Bay installed in 1995 was flooded in April. A new high water boat ramp has been installed at the entrance to the area. This new ramp was ready for public use as of May 23 and constructed at a cost of \$270,000. The elevation of the new ramp is approximately 1448 feet amsl. Currently only two of the State Park boat ramps remain in use.

Outlet to the Sheyenne River - In an attempt to move water from Devils Lake, an outlet to the Sheyenne River is currently under consideration. The project has been

studied since the 1980s. It resumed, however, with a renewed interest in 1993 through the cooperative efforts of the U.S. Army Corps of Engineers, the North Dakota State Water Commission, the Federal Emergency Management Agency, and local governmental organizations.

Currently, the Corps of Engineers is conducting feasibility studies on the capacity of the Sheyenne River. It is estimated that the river could handle approximately 200 cfs from Devils Lake without significantly affecting the water quality of downstream systems. Funding for the project, despite significant lobbying within Congress, was not

fully approved in the 1997 federal budget. The project is estimated to cost nearly \$21 million with an annual operating budget of nearly \$1 million per year.

Of additional concern is the potential increase in the amount of Total Dissolved Solids (TDS) in the Red River via the introduction of water in the Sheyenne River from Devils Lake. The Red occasionally exceeds the 500 mg/l TDS International Border objectives set forth in the U.S./Canadian Boundary Water Treaty. The U.S. Army Corps of Engineers notes that, it is likely that the "outlet operation could increase the frequency, magnitude, and duration of those occurrences."

Some flooded homes that couldn't be moved were burned at Devils Lake, June 1997.



THE DEVILSLAKE JOURNAL



Moving homes away from Devils Lake.



Volunteers at Mott load up flood relief supplies, March 28, 1997.

MITIGATION AND INSURANCE

Natural disaster mitigation is an ongoing process to reduce or eliminate long-term risk to people and property from natural hazards and their effects. The mitigation strategy used by FEMA involves partnering with other federal agencies, state

and local governments, private institutions and associations, and the natural and technological community at large. The cornerstone of the strategy is the need to take personal responsibility for rebuilding both a sense of community and communities which are "safer, smarter, and out of harm's way." The role of the federal government in this task is to provide leadership, coordination, and research support. Additionally, financial incentives are created to support communities, businesses, and individuals who undertake mitigation actions both to minimize potential disasters and speed recovery following disasters. Mitigation in the Red River Valley will take many forms, including:

- Promoting land use planning based on known hazards.
- Buying flood insurance to protect belongings and structures.
- Relocating or elevating structures out of the floodplains.
- Securing shelves and water heaters to nearby walls.
- Developing, adopting, and enforcing effective building codes and standards.

RED RIVER BASIN BOARD

The Red River Basin Board (RRBB) is a new organization formed at the grass-roots level to develop consistent water management philosophies in the Red River Basin.

The mission of the RRBB is to develop and cause to be implemented a comprehensive water management plan for the Red River Basin and to facilitate and pursue the resolution of inter-jurisdictional issues.

The organization will be run by a 21-member governing board of directors comprised of seven representatives from Manitoba, five from Minnesota, five from North Dakota, two from South Dakota, and two delegates from the basin's tribal/aboriginal groups.

The anticipated 1997 budget goal for RRBB is \$390,000 and a 1998 expectation of \$499,000. Potential funding sources include state, provincial, city, county and local

sources, and private foundations and grants.

The need for the RRBB was conceived in late 1995 in the wake of several important water management activities. Formal action to create the RRBB resulted from The

International Coalition Leader's Summit in February 1996.

It is likely that the RRBB will serve as an important water management planning tool, especially in the aftermath of flooding in the Red River Valley.

Red River Valley home, April 1997.



INTERNATIONAL JOINT COMMISSION AND MISSOURI RIVER BASIN ASSOCIATION

Although joint commission meetings have not begun at the time of this publication, this international commission

will discuss water issues common to the United States and Canada. The Basin Association is a partnership

of states along the Missouri River dedicated to proactively solving multi-state water issues.

DISASTER ASSISTANCE

Homeowners, renters, and business owners who suffered damages or losses as a result of the recent disaster

may be eligible for assistance from a variety of state, federal and voluntary agencies.

These two pages contain a quick reference chart for information on disaster assistance.

PROGRAM/AGENCY	ASSISTANCE	ELIGIBILITY	SPECIFIC CRITERIA
 Grand Forks.			

PROGRAM/AGENCY	ASSISTANCE	ELIGIBILITY	SPECIFIC CRITERIA
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ORGANIZATIONAL RESPONSIBILITIES

Several agencies and organizations were involved in the floods of 1997:

LOCAL

Local Division of Emergency Managements - prepare and maintain the local emergency operational plan.

Local Water Resource Districts - provide local assistance with levees, emergency coordination and information dissemination, and coordination with FEMA recovery personnel.

STATE

Division of Emergency Management - provides a state-wide system for effective mitigation, preparation for, response to, and recovery from man-made and natural disasters.

North Dakota Department of Agriculture - provides comprehensive information on all disaster services, educational materials, and relief programs available to farmers and ranchers. Coordinates the statewide effort to dispose of animal carcasses.

North Dakota Department of Health - provides information and regulatory control for disease control, food and lodging, food safety, maternal and child health, municipal facilities, waste management,

and water quality.

North Dakota Department of Transportation - completes state road repair and emergency work, clears roadways, and provides assistance to local communities.

North Dakota National Guard - operates the "Good Neighbor" emergency operation, providing needed assistance to persons affected by winter storms and flooding. The Guard has contributed up to 1,400 persons to provide assistance and was instrumental in assisting with the air evacuation of 328 people from East Grand Forks in the 1997 flood.

North Dakota State Water Commission - provides assistance with flood control design and construction, emergency information coordination and dissemination, and coordinates with FEMA recovery personnel.

FEDERAL

Federal Emergency Management Agency - provides a comprehensive, risk-based, all-hazards emergency management program of mitigation, preparedness, response, and recovery.

Housing and Urban Development - enables the use of community development grants for new housing construction, the repair or

construction of buildings used for the general conduct of government, and the modification of certain relocation requirements.

National Weather Service - provides current weather, flooding, and hydrologic forecasting and information. Small Business Administration - provides homeowners, renters and businesses in all 53 counties of North Dakota eligibility to apply for SBA disaster loans to cover uninsured damages. U.S. Army Corps of Engineers - coordinates projects to increase water supplies, provides temporary water hook-ups, and constructs needed levees and dikes.

U.S. Department of Agriculture - provides emergency food assistance to those forced from their homes, logistical and transportation support to FEMA, low-cost loans to replace farm buildings, and Federal Crop Insurance.

U.S. Department of Transportation - administers the Emergency Relief program, which reimburses states for completed emergency work and construction to repair damage to federal-aid highways. Eligible repair work includes reconstructing damaged bridges and pavement surfaces, establishing emergency detours, removing slides and debris, and replacing signs, lighting and guardrails.

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