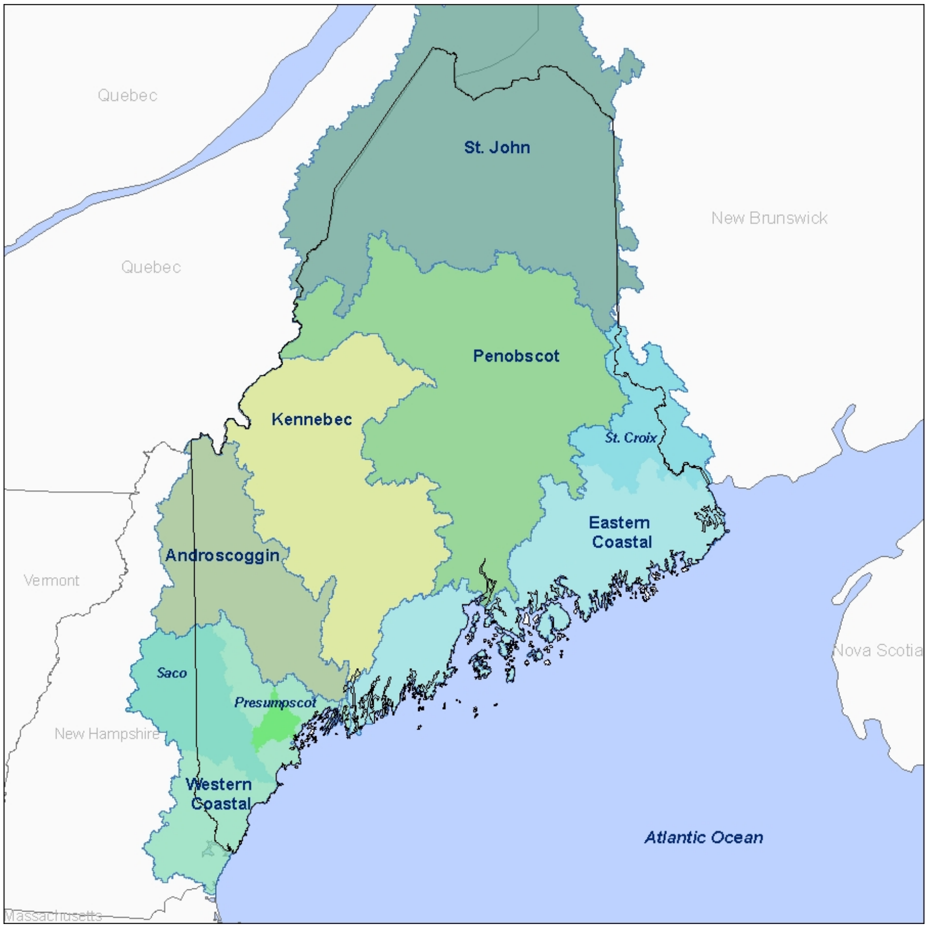

Historic Flooding in Major Drainage Basins, Maine

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0.0

1.0 Introduction

This study was funded by a federal grant awarded to the Maine State Planning Office (SPO) and the Maine Emergency Management Agency (MEMA) in 2007. Stakeholders contributing to this study include the Maine Geological Survey (MGS), Maine Coastal Storm Management, Maine Emergency Management Agency (MEMA), Maine Floodplain Management (MFPM), Maine GIS (MEGIS), U.S. Geological Survey (USGS), and the National Weather Service (NWS) at the National Oceanic and Atmospheric Administration (NOAA).

1.1 Purpose

This report provides a basin-by-basin analysis of available data for riverine flood events from 1970 to the present (2007) in support of the State Hazard Mitigation Plan to provide detailed flood data in an accessible format to the public, local governments, and state and federal agencies. The information presented in this report will support future work, which may include developing an interactive, web-based summary of historical flooding. To date, no document has been produced to provide a comprehensive list of resources on historical flooding in Maine. This report is a foundation for future work and will serve to minimize the possible duplication of efforts.

1.2 Study Area

This report documents the availability of flood data and historical flooding for the entire state of Maine on a basin-by-basin basis. The U.S. Geological Survey divides the United States into twenty-one major geographic area (regions). Maine and most of New England are located in Region 1. Regions are further divided into subregions. For this study, the subregion classification has been used to identify six major drainage basins located within Maine including four riverine basins and two coastal basins. Some of the hydrologic regions described in this study expand beyond the borders of Maine into New Hampshire, US and New Brunswick and Quebec, Canada.

The four riverine subregions include the St. John (region 0101), the Penobscot (0102), the Kennebec (0103), and the Androscoggin (0104). The two coastal subregions include the Eastern Maine Coastal Drainage Basin (0105) and the Western Maine Coastal Drainage Basin (0106). The Eastern and Western Coastal Drainage Basins are divided by the mouth of the Androscoggin River. The Eastern Maine Coastal Region is further divided into two non-contiguous sections separated by the mouth of the Penobscot River; the northeast section contains catalog unit 0105001 (the St Croix River Basin) and parts of 0105002, which includes the Bagaduce, Dennys, Narraguagus, Pennamaquan, Pleasant, Machias, and East Machias Rivers, and Tomah, Trunk, and Big Musquash Streams, the southeast section contains parts of catalog units 0105002 and 0105003 and includes the Ducktrap, Sheepscot, St. George, Damariscotta and Medomak Rivers. The western Maine Coastal Regions is subdivided into three catalog units including the Presumpscot River (catalog unit 01060001), the Saco River (0106002), and the Piscataqua-Salmon Falls River (0106003).

This report contains chapters describing historical flooding within the four riverine basins and three of the major rivers located within the coastal drainage basins including the St. Croix River, the Saco River, and the Presumpscot River. Other coastal rivers are not included in this report because little flood data was available at the time of publication. Future work on expanding this report may include adding information on riverine flooding in these coastal rivers and streams.

Table 1 lists and Figure 1 illustrates the major drainage basins within Maine and their corresponding hydrologic unit code (HUC) as defined by the USGS.

Table 1. Major Drainage Basins and Subbasins in Maine

Hydrologic Unit Code	Name
010100	St. John River
010200	Penobscot River
010300	Kennebec River
010400	Androscoggin River
010500	Eastern Maine Coastal
	St. Croix River
010600	Western Maine Coastal
	Saco River
	Presumpscot River

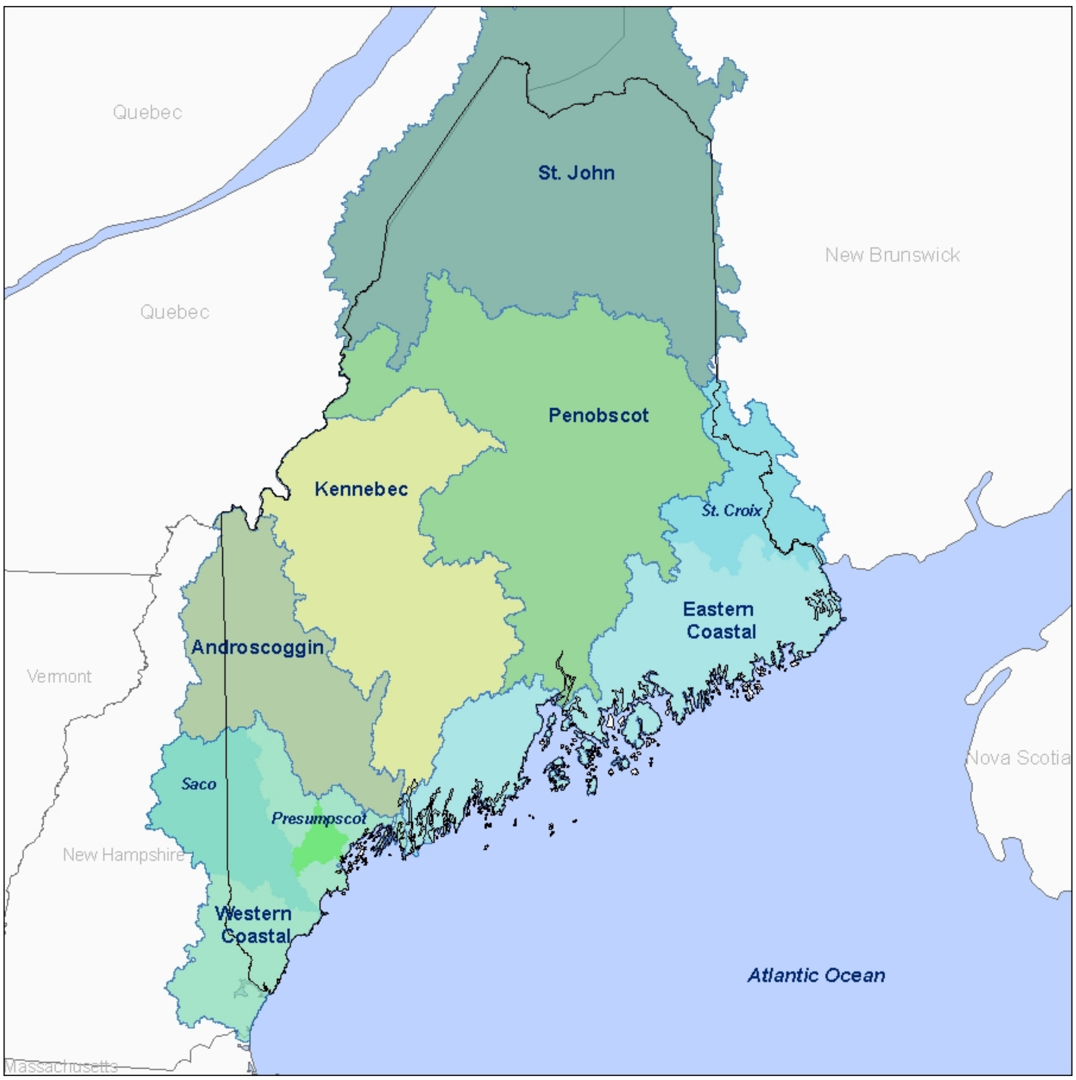


Figure 1. Major Drainage Basins in Maine, USGS

1.2.1 Natural Hazards

Flooding is one of the many natural hazards that may arise to disrupt the lives of people living in Maine. Historically, Maine has experienced fires, landslide, and earthquakes although they are relatively rare and are not a significant source of monetary losses as compared to flooding. The Maine Emergency Management Agency has developed mitigation plans for the state as a whole and for all sixteen counties to document ways to minimize the risk of loss due to natural hazards. The Maine Geological Survey (MGS) is in the process of developing a database of landslide hazard mapping which will be available in the future. The remainder of this report focuses exclusively on the riverine flooding hazards in Maine on a basin-by-basin basis.

1.2.2 Flooding

The National Flood Insurance Program provides a definition of flooding in the code of federal regulations Title 44, Emergency Management and Assistance; Chapter 1, Federal Emergency Management Agency; Part 59, General Provisions (44 CFR 59.1). In 44 CFR 59.1, flooding is defined as:

a. *A general or temporary condition of partial or complete inundation of normally dry land areas from:*

    1) *The overflow of inland or tidal waters.*

    2) *The unusual and rapid accumulation or runoff of surface waters from any source.*

    3) *Mudslides (i.e., mudflows which are proximately caused by flooding as defined in paragraph (a) (2) of this definition and are akin to a river of liquid and flowing mud on the surfaces of normally dry land areas, as when the earth is carried by a current of water and deposited along the path of the current.*

b. *The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels or suddenly caused by an unusually high water level in a natural body of water, accompanied by a severe storm, or by an unanticipated force of nature, such as flash flood or an abnormal tide surge, or by some similarly unusual and unforeseeable event which results in flooding as defined in paragraph (a) (1) of this definition.*

A flood is declared when a "*general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or two or more properties* " are affected by the flooding conditions described above.

Inland flooding may be caused by rainfall, melting snow, and/or obstructions (i.e., debris and log jams). Coastal flooding may be caused by wind, high tides, and waves that force water beyond the normal shoreline. Flooding becomes a problem when it affects people through the loss of life, property, and infrastructure. The most effective way to reduce flood losses is to minimize vulnerable property and infrastructure within the flood prone area. When property and infrastructure are removed, people are less likely to enter the flood hazard zone during a flood event.

Flooding in Maine typically occurs during the rainy periods in the spring and autumn. In the springtime, rainfall at a moderate intensity spanning several days (e.g., a Nor'easter), melting snow, and possible ice and debris jams combine to cause the most severe floods. The waterlogged or frozen soil and the lack of vegetative foliage reduce the ability of the ground to absorb excess water. Nor'easters often cause coastal flooding in addition to riverine flooding as seen during the "Groundhog Day" storm of 1978. The most recent flood of record for many rivers in Maine, occurring in April 1987, was caused by a combination of rainfall, snowmelt, and ice jams. The previous floods of record, in 1936 and 1953, resulted from heavy precipitation caused by tropical storms.

Floods occurring in the autumn are usually the result of a large precipitation event (e.g., a hurricane). Dry soil conditions and the presence of vegetative foliage may reduce the severity of flooding as the ground absorbs excess water. Hurricanes often cause coastal flooding in addition to riverine flooding as seen during Hurricane Bob in 1991.

Severe flooding over a small area may occur at any time as the result of an acute precipitation event (e.g., a thunderstorm) or an obstruction in the flow of a stream or river.

Flood prone areas must be identified so that life and property may remain safely outside of them. The Federal Emergency Management Agency (FEMA) provides maps for most communities within the United States illustrating the areas expected to become inundated with a probability of one percent and 0.02 percent each year (known as the 100-year flood and the 500-year flood, or the floods with an expected return period of 100 years and 500 years, respectively). An area that is not mapped as a flood prone area on a FEMA map is not necessarily an area without flood risk, the risk may be small or the risk may be undetermined. Historical images and high water marks can be powerful (and often surprising) reminders of flood levels when the collective human memory has forgotten the severity of past flooding. For areas with unknown flood risk, adequate forecasting and communication can reduce the risk of death and loss.

Effective community planning combining knowledge of flood prone areas and proper community development controls can minimize future flood losses. By implementing proper zoning controls, communities can minimize development within the floodplain. By implementing proper development controls, communities can reduce impervious area in the contributing watersheds which may keep flood flows to a minimum.

Large floods that cause extensive monetary damage may be declared disasters at the State and Federal level. Table 2 presents the list of disasters declared within the State of Maine from 1970 to the present, the estimated damages, the counties declared, and the river basins affected by the declaration.

Table 2 is generated from the information presented in the MEMA/SPO disaster declaration list. The table indicates the counties included in each disaster declaration. Because disasters are declared by county and not by flood source, it is not straightforward to identify which river basins were affected by the flood disaster. In addition the large river basins often fall partially within many counties. All river basins falling partially within a declared county are indicated in yellow. In cases where the river basin that experienced flooding has been identified in documentation referenced in this report, the river basin is identified with a dark or light grey marking. Future work may go towards eliminating the yellow boxes by determining whether the river basin experienced flooding as part of the respective disaster declaration.

Table 2. Disaster Declarations in Counties and River Basins

			Counties Declared Disaster Areas																River Basins Affected					
Date	**Year**	**Estimated Damage**	**Androscoggin**	**Aroostook**	**Cumberland**	**Franklin**	**Hancock**	**Kennebec**	**Knox**	**Lincoln**	**Oxford**	**Penobscot**	**Piscataquis**	**Sagadahoc**	**Somerset**	**Waldo**	**Washington**	**York**	**St. John**	**Penobscot**	**Kennebec**	**Androscoggin**	**Eastern Coast**	**Western Coast**
January - February	1970	$3,000,000				x					x		x		x				x	x	y	x		x
February 12	1972	Coastal flooding			x													x				x	x	x
April 24	1973	$908,404		x		x					x	x				x	x		y	y	x	x	x	x
May 6	1973			x															x	y			x	
July 1	1973			x		x					x	x				x			x	x	x	x	x	x
September 24	1973																							
December	1973	$3,000,000						x		x		x		x	x	x			y	x	y	x	x	x
May 26	1974	$3,000,000																	y					
May 8	1975	$300,000			x				x									x				x	x	x
February 9	1976											x					x		x	x	x		x	x
April 2	1976	$200,000		x															y	x			x	
August	1976	Crop damage		x															x	x			x	
March 20	1977		x		x						x							x			x	x	x	x
February 8	1978	$20,693,181	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	y	x	x	x
April 30	1979	$648,500		x				x				x	x						y	x	y	x	x	
June	1984		x		x			x				x		x	x				x	x	y	x	x	x
January	1986	Roads, bridges,	x		x	x		x			x			x	x			x	x	x	x	x	x	x
April	1987	$100,000,000	x		x	x	x	x	x	x	x	x	x	x	x	x		x	y	y	y	y		y
May	1989	$1,396,120	x			x					x										x	y		y
April 10 - 12	1991	$12,916,819		x															y					
March 27	1992	$3,462,787	x		x	x		x	x		x		x		x	x		x	x	x	y	y	x	x
April (Easter Flood)	1993	$3,476,507	x	x	x	x	x	x		x	x	x	x		x	x		x	t	t	t	t		t
April 15	1994	$5,700,000		x															y					
October 21	1995					x			x		x										x	x	x	x
January - February	1996	$2,671,119	x			x					x	x	x		x	x				t	y			
April 16 - 17	1996	$2,492,944	x		x				x		x							x				y	t	y
October 20 - 21	1996	$8,998,501			x						x							x						y
June 12 - 21	1998	$2,519,458	x			x		x			x				x			x			x	x		
October 8 - 11	1998	$1,997,555			x													x						y
September 11	1999																							
March - April	2000	$2,884,207	x	x		x		x			x		x		x		x		y	x	x	x	x	x
March 5 - 31	2001	$1,761,573				x		x			x	x					x	x	x	x	x	x	x	x
December 11 - 31	2003	$1,500,00 (est.)				x		x			x		x		x	x			y	x	y	y	x	x
March 29 - May 3	2005		x	x		x	x	x	x		x		x		x	x	x	x	y	x	y	x	x	x
May 13	2006	$7,000,000 (est.)																x	y					x

Notes:

* Possible Flood Event (continue research)

Flood event

Major Flood Event

1.3 Identifying Significant Historical Flood Events

Localized flooding may occur at any place at any time for any combination of reasons. It is not possible to compile a list of every single flood event that occurred within Maine over the past 37 years, many have undoubtedly gone unnoticed. Flood events may be captured in the historic record in a number of ways including:

- Collection of stage and discharge via USGS streamgaging stations,
- Collection of ice-jam data via personal observations and recorded in the CRREL database,
- Declaration of a disaster triggered by monetary losses and historically described in interagency reports,
- Newspaper articles,
- Photos,
- High water marks and monuments,
- FEMA Flood Insurance Studies, and
- The National Climatic Data Center (NCDC) Storm Event Database

Historical records of stage and discharge along the rivers of Maine are collected and analyzed by the U.S. Geological Survey. The USGS maintains 64 active streamgages within Maine (down from a total of 134). Daily streamflow data is available to the general public via the web-based National Water Information System (NWIS) database. Periodically, the USGS publishes synthesis reports providing statistical analysis and trends determined using streamgage data. The USGS streamgage record has some limitations for flood identification. The USGS streamgage record will not support the identification of a flood event occurring on an ungaged body of water.

The Army Corps of Engineers (ACOE) Cold Regions Research and Engineering Laboratory (CRREL) maintains a historical record of ice jams. CRREL data entries are limited to the personal observations by citizens and/or ACOE field technicians, USGS field notes, and newspaper reports. There is no fixed network of ice-jam recording stations. A flood caused by an ice jam may be isolated to a very small area and/or may not be associated with larger-than-normal discharge. The ice jam database contains a description for each recorded ice jam event and indicates whether the ice jam was associated with flood stages and/or caused any damage.

The Maine State Planning Office and the Maine Emergency Management Agency maintain a record of disaster declarations. Disaster declarations are made at the State and Federal levels when damages incurred as the result of a natural event reach a minimum threshold value. If a flood occurs but causes no damage, the flood will not be represented on the disaster declaration list. Historically, disasters have been documented in interagency hazard mitigation reports (IHMRs), which were used to summarize the event and the damages for disaster aid purposes. Interpretation of the IHMR is necessary to determine the location of the flood event. The reports typically describe events and damages on the county level and may not explicitly identify the flood source that caused the damage. In the early 2000s, IHMRs were discontinued and are no longer being produced following flood events.

Newspapers provide a unique source of flood history. Text and photos describe and illustrate large and small events that have been observed by people. A non-comprehensive set of newspaper clippings provided from the SPO files have been used to document some of the floods described in this report.

Information relevant to high-water marks and monuments is available on a town-by-town basis. This information was not compiled for inclusion with this publication. Future efforts for expanding this report may include compiling all town high-water marks and monuments into a single database.

The Federal Emergency Management Agency (FEMA) conducts Flood Insurance Studies (FISs) and publishes flood insurance rate maps (FIRMs) based on those studies to illustrate the floodplain boundaries within a community. The FIS reports often contain information on historic flood events. FIS reports are of limited utility for identifying recent flood events in Maine. Many of the FIS reports were developed in the 1970s and the 1980s prior to the flood of record at most locations.

The National Climatic Data Center (NCDC) of NOAA distributes a description of extreme weather events via the searchable Storm Event database available on the World Wide Web. The data in the Storm Event database originates from National Weather Service publications based on information obtained from county, state, and federal emergency management officials, local law enforcement officials, skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. The event record within the database includes the dates of the beginning and end of the event, the location of the event, magnitude, fatalities, injuries, property damage, and crop damage. The description of the event often includes the weather conditions leading to the event. The Storm Event database includes information on three hundred and nine flood events dating between April 4, 1993 and October 10, 2007. Future efforts for expanding this report may include adding the narrative text included in the Storm Event database to the flood event descriptions found in this report. The web address to the searchable storm event database is included here.

http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

A list of historic flood events within the major drainage basins within Maine have been compiled using the sources described above. A list of the flood events occurring within each basin is included in the corresponding section of the report. Where available, a brief description of the causative factors of the event, the corresponding USGS peak flow data, the estimated recurrence interval, and the extent of damages is included.

2.0 St. John River Basin

2.1 Watershed Description

The St. John River Basin occupies approximately 21,400 square miles in Aroostook, Somerset, Piscataquis and Penobscot Counties, Maine and extends into the provinces of Quebec and New Brunswick, Canada. The St. John River originates at the Little St. John Lake in the unincorporated township of T5 R20 WLS Somerset County, Maine and ends at the Bay of Fundy near St. John, New Brunswick. The St. John River forms the US-Canada border between St. Francis, Maine and Grand Falls, New Brunswick where the river crosses exclusively into Canadian territory. The river is approximately 420 miles long. The topography within the drainage basin is generally flat with rolling hills. The drainage basin is largely undeveloped and much of the land is used as a forestry resource. Major communities within the St. John River Basin include Fort Kent, Fort Fairfield, Houlton, Caribou, St. Agatha, Presque Isle, Van Buren, and Frenchville.

Table 3 presents the major Maine tributaries to the St. John River along with their respective drainage areas within Maine. Figure 2 illustrates the Maine portion of the St. John River basin including major tributaries and population centers.

Table 3. St. John River, Tributaries from Upstream to Downstream and Drainage Areas

Tributary	Drainage Area (square miles)
Allagash River	1,240
Fish River	890
Aroostook River	2,460
Big Presque Isle and Meduxnekeag River	750
Total	**11,580**

Figure 2. St. John River Basin and Major Tributaries

2.2 Dams and Reservoirs

In 1987, the ACOE began compiling the National Inventory of Dams (NID) in cooperation with FEMA's National Dam Safety Program. The NID is a congressionally authorized dam safety and management tool that documents dams that are at least 25 feet in height or impound at least 50 acre-feet of water at maximum pool level. The Maine Department of Environmental Protection and the Bureau of Land and Water Quality (BL&WQ) have expanded on the ACOE NID database by adding smaller dams to the inventory and making the database available to MEMA for review and MEGIS for distribution.

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that at the present (2007), the St. John River Basin contains over 50 dams. Nineteen dams are used for recreation, fifteen for flood control and stormwater management, ten for reservoir storage, two for debris control, and two for hydroelectric power generation. Sixteen are used for "other" purposes. The storage capacity of impoundments within the Maine portion of the St. John River Basin is approximately 71,800 acre-feet. Appendix E contains the list of dams located within the St. John River Basin and included in the collaborative dam database.

2.3 Precipitation

The St. John River Basin to Hamlin, Maine, which includes the Allagash, Aroostook, and Fish River subbasins and other Canadian subbasins, occupies approximately 11,600 square miles of land. The annual average precipitation in the basin is approximately thirty-eight inches distributed uniformly throughout the year. Snowfall averages approximately 110 inches per year, the average water equivalent of the spring snowpack is approximately eight inches. The average annual runoff as recorded at the USGS stream gage in Hamlin (Station ID 01015100) indicates that 50% of all water running off the drainage basin occurs during the spring snowmelt period (ACOE, 1987).

2.4 Population

Within Maine, the St. John River Basin contains all or portions of two cities (e.g., Presque Isle, Caribou), forty-four towns, 163 unincorporated territories, and falls within four counties. The St. John River Basin is sparsely populated; only three communities, Presque Isle, Caribou, and Houlton, have a population greater than 5,000 (US Census, 2000). Table 4 presents the population data within the drainage basin since 1970. Population within the basin has been decreasing steadily, which most of the losses occurring in the rural areas outside the cities.

Table 4. St. John River Basin, Population within Maine

Census date	Population	Population in cities
1970	89,000	22,000
1980	86,000	21,000
1990	81,000	20,000
2000	69,000	18,000

2.5 Historic Flooding Events (1970 – 2007)

Flooding within the St. John River Basin is most often caused by a combination of precipitation, snowmelt, and ice jams. Conditions favorable for flooding typically occur during the month of April when the region transitions from winter to spring. As compared to all other major rivers basins in Maine, the St. John River Basin is the farthest north and the least developed and experiences the majority of ice jam flooding.

Table 5 presents the list of major and minor flood events identified within the St. John River basin between 1970 and the present using the sources of data described in Section 1 of this report. The flood events indicated with an “x” are described in greater detail in following sections of the report.

Table 5. St. John River Basin, Identified Flood Events

	Event Date	Flood Location	Flood Documentation	Damages
	December 1973	Aroostook River, Fort Fairfield	CRREL	Basement flooding
x	April 1973	Fish River near Fort Kent Maine	USGS, ACOE	Second worst flood
x	May 1974	St. John River at Ninemile Bridge	USGS, ACOE	Severe damages
x	April 1976	Meduxnikeag River, town of Houlton	USGS, CRREL, ACOE	
	August 1976	St. John River	FIS, Fort Kent	Tropical storm Belle
x	April 1979	St. John River at Dickey	USGS, ACOE	
x	April 1983	Aroostook River Masardis to Fort Fairfield	USGS, CRREL, ACOE	Flood of record on Aroostook.
	August 1981	Upper St. John River Basin	ACOE, USGS	Large precipitation event
x	April 1987		USGS	
	April 1988	Allagash River	CRREL	High stage, low flows
	April 1990	Aroostook River	CRREL	
x	April 1991	St. John, Little Black, Allagash, and Aroostook	IHMT, CRREL, Photos, USGS	Severe damages
x	April 1993	Flood warnings from interagency report	IHMT	
x	April 1994	Fort Fairfield	IHMT, CRREL, Photos	
x	December 1994		Photos	
	April 1998	Aroostook River, Fort Fairfield, Crouseville	CRREL	Business district flooding
	March 2000	Aroostook River	CRREL	
	December 2003	Allagash River	CRREL	Row 18. 10-15 feet of ice
	April 2005	Aroostook River, St. John	CRREL	Moderate damages
	December 2005	Aroostook River	CRREL	Record high stages
	April/May 2006	St. John River	CRREL	Minor road flooding
	January 2007	Allagash River	CRREL	Minor road flooding
	April 2007	St. John River	CRREL	Road flooding

CRREL – Ice jam database, USGS – Streamgage record, ACOE – 1987 study, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report

The USGS record of peak discharge and stage at streamgages within the St. John drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the Penobscot River Basin. Table 6 presents the highest recorded daily discharge at selected streamgages. The streamgage record indicates that major flood events resulting from high flows occurred in April 1973, May 1974, April 1976, April 1979, April 1983, and April 1987.

Table 6. St. John River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01010000	St. John River at Ninemile Bridge, Maine	5/1/1974	44,400	12.63
01010070	Big Black River near Depot Mtn, Maine	4/1/1987	8,680	15.62
01010500	St. John River at Dickey, Maine	4/29/1979	91,700	19.13
01011000	Allagash River near Allagash, Maine	4/18/1983	36,900	13.68
01013500	Fish River near Fort Kent, Maine	4/30/1973	15,800	12.43
01015800	Aroostook River near Masardis, Maine	4/19/1983	23,100	17.7
01017000	Aroostook River at Washburn, Maine	4/19/1983	43,400	13.73
01018000	Meduxnekeag River near Houlton, Maine	4/3/1976	6,640	9.98

2.5.1 April 1973

Between April 27 and 29 of 1973, the St. John River basin received approximately two inches of rainfall accompanied by warm temperatures and melting snowpack. The resulting runoff caused record flows on the Allagash and Fish Rivers and the fourth largest discharge observed on the St. John River at Fort Kent. Table 7 presents the observed stage, discharge, and recurrence interval (where available) for the April 1973 flood. The USGS estimated the return period of the flows on the Fish River to be one hundred to five hundred years and the St. John River and tributaries to be five to fifty years.

Table 7. St. John River Basin, USGS Streamgage Peaks, April 1973

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)[a]
01010500	St. John River at Dickey, Maine	16.98	72,000	5-10
01011000	Allagash River near Allagash, Maine	12.33	29,400	25-50
01013500	Fish River near Fort Kent, Maine	12.43	15,800	100-500
01014700	Factory Brook near Madawaska, Maine	9.63	253	5-10
01015700	Houlton Brook near Oxbow Maine	7.89	236	25-50
01015800	Aroostook River near Masardis, Maine	16.95	20,800	10-25
01016500	Machias River near Ashland, Maine	9.03	11,400	10-25
01017000	Aroostook River at Washburn, Maine	13.68	43,100	25-50
01018000	Meduxnekeag River near Houlton, Maine	9.32	6,460	10-25
01014700	St. John River at Fort Kent		136,000	25-50
	Grand Falls New Brunswick[a]		199,000	-

a. Recurrence intervals are adapted from the gage estimated recurrence intervals in USGS WSP 2502, 2474, and SIR 2005-5194.

b. ACOE, 1987.

2.5.2 May 1974

In May of 1974, the St. John River basin received 1.2 inches of rainfall accompanied by warm temperatures and melting snowpack. The simultaneous runoff and ice jams resulted in flooding. Table 8 presents the observed stage, discharge, and recurrence interval (where available) for the May 1974 flood. The USGS estimated the return period of the flows on the St. John River to be ten to fifty years and the Aroostook River to be twenty-five to fifty years.

Table 8. St. John River Basin, USGS Streamgage Peaks, May 1974

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01010000	St. John River at Ninemile Bridge, Maine	12.63	44,400	25-50
01010500	St. John River at Dickey, Maine	18.67	87,200	10-25
01011000	Allagash River near Allagash, Maine	11.71	26,400	10-25
01013500	Fish River near Fort Kent, Maine	10.04	11,000	5-10
01014700	St. John River below Fish R, at Fort Kent, Maine	9.91	281	10-25
01015700	St. John River near Hamlin, Maine	6.75	168	5-10
01015800	Aroostook River near Masardis, Maine	15.56	17,200	2-5
01016500	Machias River near Ashland, Maine	7.62	8,560	2-5
01017000	Aroostook River at Washburn, Maine	13.58	42,500	25-50
01018000	Meduxnekeag River near Houlton, Maine	7.89	4,330	2-5

2.5.3 April 1976

The USGS historical record of discharge and stages, the CRREL ice jam database, and the ACOE investigation of the St. John River document a flood event occurring in April 1976. Information on this flood event is not comprehensive. The ACOE report indicates that extensive ice jams occurred on the mainstem Aroostook River from Masardis to Fort Fairfield (ACOE, 1987). Table 9 presents the observed stage, discharge, and recurrence interval (where available) for the May 1974 flood. The USGS estimated the return period of the flows on the Aroostook River to be five to twenty-five years and the St. John River to be two to ten years.

Table 9. St. John River Basin, USGS Streamgage Peaks, April 1976.

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01010000	St. John River at Ninemile Bridge, Maine		32,000	5-10
01010500	St. John River at Dickey, Maine	16.01	63,300	2-5
01011000	Allagash River near Allagash, Maine		18,000	5-10
01013500	Fish River near Fort Kent, Maine	8.92	8,740	2-5
01015800	Aroostook River near Masardis, Maine	16.81	20,500	10-25
01016500	Machias River near Ashland, Maine		10,000	5-10
01017000	Aroostook River at Washburn, Maine	11.84	32,200	5-10
01017900	Marley Brook near Ludlow, Maine	7.1	138	2-5
01018000	Meduxnekeag River near Houlton, Maine	9.98	6,640	10-25

2.5.4 April 1979

In April of 1979, the St. John River basin received 1.5 inches of rainfall over 3 days accompanied by warming temperatures and melting snowpack. The runoff resulted in record flows between Dickey, Maine and Grand Falls, New Brunswick. Fort Kent sustained severe damages. Table 10 presents the observed stage, discharge, and recurrence interval (where available) for the May 1974 flood. The USGS estimated the return period of the flows on the Aroostook River to be five to twenty-five years and the St. John River to be five to fifty years.

Table 10. St. John River Basin, USGS Streamgage Peaks, April 1979

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
	Grand Falls, New Brunswick[a]		226,000	
01010000	St. John River at Ninemile Bridge, Maine	11.05	34,700	5-10
01010500	St. John River at Dickey, Maine	19.13	91,700	25-50
01011000	Allagash River near Allagash, Maine	-	28,400	10-25
01013500	Fish River near Fort Kent, Maine	11.11	13,100	10-25
01015800	Aroostook River near Masardis, Maine	16.76	20,400	5-10
01016500	Machias River near Ashland, Maine	8.6	8,500	2-5
01017000	Aroostook River at Washburn, Maine	13.17	37,700	10-25
01017900	Marley Brook near Ludlow, Maine	7.14	141	2-5

a. ACOE, 1987.

2.5.5 April 1983

In April of 1983, the St. John River basin received approximately two inches of precipitation over two days accompanied by warm temperatures and melting snowpack. Table 11 presents the observed stage, discharge, and recurrence interval (where available) for the May 1974 flood. The USGS estimated the return period of the flows on the Allagash River to be one hundred to five hundred years and the St. John and Aroostook Rivers five to fifty years.

Table 11. St. John River Basin, USGS Streamgage Peaks, April 1983

Station	Name	Stage	Discharge (cfs)	Recurrence Interval (year)
01010000	St. John River at Ninemile Bridge, Maine	10.64	32,300	5-10
01010500	St. John River at Dickey, Maine	18.52	85,600	10-25
01011000	Allagash River near Allagash, Maine	13.68	36,900	100-500
01012520	Bald Mountain Brook near Bald Mt.	7.57	198	-
01013500	Fish River near Fort Kent, Maine	11.75	14,000	25-50
01015800	Aroostook River near Masardis, Maine	17.7	23,100	10-25
01016500	Machias River near Ashland, Maine	9.14	7,950	2-5
01017000	Aroostook River at Washburn, Maine	13.73	43,400	25-50
01019000	Grand Lake Stream at Grand Lake Stream, Maine	6.69	2,870	50-100

2.5.6 March/April 1987

In April 1987, runoff caused by a high volume rainfall following several days of warm temperatures and melting snowpack causing a new flood of record for many rivers in Maine. This event was caused by a coastal storm and resulted in only minor flooding the St. John River Basin. Table 12 presents the observed stage, discharge, and recurrence interval (where available) for the May 1974 flood. The USGS estimated the return period of the flows on the St. John River to be five to twenty-five years.

Table 12. St. John River Basin, USGS Streamgage Peaks, April 1987

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01010000	St. John River at Ninemile Bridge, Maine	10.86	33,600	5-10
01010070	Big Black River near Depot Mtn, Maine	15.62	8,680	10-25
01010500	St. John River at Dickey, Maine	18.01	80,400	10-25
01011000	Allagash River near Allagash, Maine	10.66	21,200	5-10
01013500	Fish River near Fort Kent, Maine	8.67	8,390	2-5
01015800	Aroostook River near Masardis, Maine	16.28	19,100	5-10
01017000	Aroostook River at Washburn, Maine	12.14	34,000	5-10

2.5.7 April 1991

In April of 1991, rainfall, snowmelt, and ice jams combined to result in flooding along the St. John, Little Black, Allagash, and Aroostook Rivers. The runoff and backwater resulting from this combination of events resulted in severe damages to Allagash, Fort Fairfield, Grand Isle, Caribou, and the Crouseville area of Washburn. Table 13 presents the observed stage, discharge, and recurrence interval (where available) for the April 1991 flood. The USGS estimated the return period of the flows on the St. John River and tributaries to be two to five years and the Aroostook River to be five to ten years.

Table 13. St. John River Basin, USGS Streamgage Peaks, April 1991

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01010000	St. John River at Ninemile Bridge, Maine	23	28,400	2-5
01010070	Big Black River near Depot Mtn, Maine		3,640	<2
01010500	St. John River at Dickey, Maine		56,200	2-5
01011000	Allagash River near Allagash, Maine	9.62	17,000	2-5
01017000	Aroostook River at Washburn, Maine		31,100	5-10

Figure 3. Ice Jams and Flooding Along the Allagash River at Dickey, Maine, April 11, 1991

2.5.8 April 1993

An interagency hazard mitigation team report describing flooding during the spring of 1993 indicates that flood warnings were issued on the Aroostook River in response to a moderate precipitation event falling on a snowpack with high water content. Information on this flood event is not comprehensive. Table 14 presents the observed stage, discharge, and recurrence interval (where available) for the April 1993 event. The USGS estimated the return period of the flows on the St. John River and tributaries to be two to five years.

Table 14. St. John River Basin, USGS Streamgage Peaks, April 1993

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01010000	St. John River at Ninemile Bridge, Maine	8.98	23,500	<2
01010070	Big Black River near Depot Mtn, Maine		4,350	2
01010500	St. John River at Dickey, Maine	15.38	57,100	2-5
01011000	Allagash River near Allagash, Maine	9.85	17,800	2-5
01013500	Fish River near Fort Kent, Maine	8.15	7,480	<2
01015800	Aroostook River near Masardis, Maine	15.6	17,300	2-5
01017000	Aroostook River at Washburn, Maine	11.37	30,200	2-5

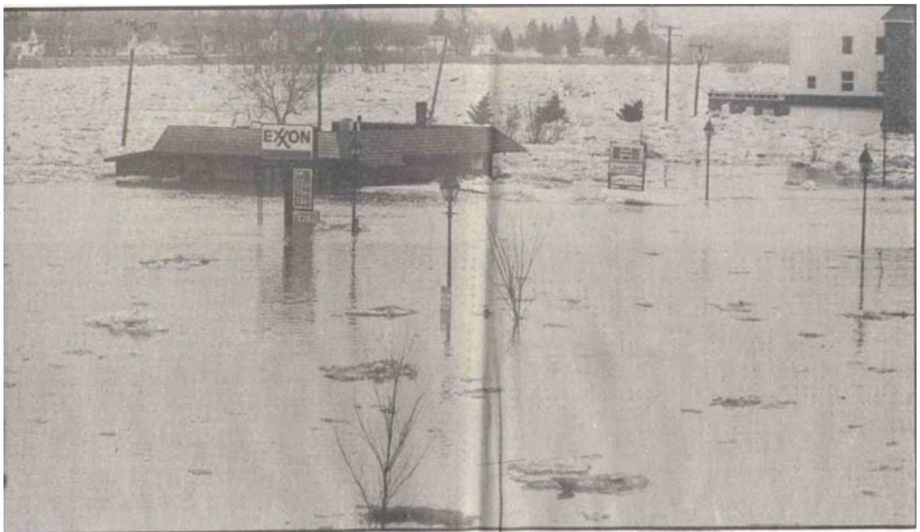
2.5.9 April 1994

The CRREL ice jam database and an interagency hazard mitigation team report describe flooding occurring along the Aroostook River at Fort Fairfield during April of 1994. Photos presented in Figure 4, Figure 5, and Figure 6 illustrate the flooding. The Aroostook River basin received approximately one-half inch of rain accompanied by warm weather and melting snowpack. Rising waters caused a break-up ice jam that resulted in flooding at Fort Fairfield. Table 15 presents the observed stage, discharge, and recurrence interval (where available) for the April 1994 flood. The USGS estimated the return period of the flows on the St. John River and tributaries to be five to ten years.

Table 15. St. John River Basin, USGS Streamgage Peaks, April 1994

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01010000	St. John River at Ninemile Bridge, Maine	11.42	38,700	10-25
01010070	Big Black River near Depot Mtn, Maine		6,160	5-10
01010500	St. John River at Dickey, Maine	16.71	69,700	5-10
01011000	Allagash River near Allagash, Maine	10.14	18,900	2-5
01015800	Aroostook River near Masardis, Maine	16.2	18,900	5-10
01017000	Aroostook River at Washburn, Maine	12.29	35,100	5-10

Figure 4. Aroostook River, Main Street Fort Fairfield, April 1994



Lenny's Restaurant on Main Street in Fort Fairfield, Me., was one of the first businesses to be affected when the rising waters of the Aroostook River overflowed its banks in what is being described as the worst flood in the town's recorded history. (Marcia Reed photo)

Figure 5. Aroostook River, April 1994

Helen Underwood dwelling taken from the opposite side of the river during the flood event on April16, 1994. Photo provide by the Fort Fairfield Code Officer.

Figure 6. Aroostook River, April 1994

2.5.10 December 1994

The CRREL ice jam database and the photo record indicate that ice jams and flooding occurred along the St. John River at Dickey and Big Rapids, Maine during December 1994. Figure 7 and Figure 8 illustrate the ice coverage on the St. John River during this event.

Figure 7. St. John River, Big Rapids Shearwall, December 29, 1994

Figure 8. Ice Jam on the St. John River, Route 161 at Dickey, December 29, 2004

3.0 Penobscot River Basin

3.1 Watershed Description

The Penobscot River Basin occupies 8,570 square miles in northeastern Maine. The Penobscot River flows for 105 miles from the confluence of its East and West Branches in Medway, south to its mouth in Penobscot Bay. The River Basin is largely undeveloped, approximately 95% is forested. Major communities in this basin include Millinocket, Howland, Lincoln, Old Town, Orono, Veazie, Bangor, and Brewer.

Table 16 presents the major tributaries to the Penobscot River and their respective drainage areas.

Table 16. Penobscot River, Tributaries from Upstream to Downstream and Drainage Areas

Tributary	Drainage Area (square miles)
West Branch Penobscot River	2,140
East Branch Penobscot River	1,150
Mattawamkeag River	1,520
Piscataquis River	1,470
Penobscot River	2,400
Total	**8,670**

The Penobscot River is influenced by tides as far as Bangor, 30 miles above the confluence with Penobscot Bay. Figure 9 illustrates the location of the Penobscot River basin within Maine as well as the subbasins of major tributaries.

Figure 9. Penobscot River Basin and Major Tributaries

3.2 Dams and Reservoirs

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that the Penobscot River Basin contains approximately 119 dams. At the present, sixteen of the dams on the Penobscot River are used for generating hydroelectric power, twelve for flood control and stormwater management, twelve for water supply, twenty-six for recreational purposes and thirty-nine for “other” uses. The storage capacity of impoundments in the Penobscot River Basin is approximately 1,192,000 acre-feet. Appendix E contains the list of dams located within the Penobscot River Basin and included in the collaborative dam database.

3.3 Precipitation

The average annual precipitation in the Penobscot River Basin is approximately forty-one inches uniformly distributed throughout the year. Snowfall contributes the water equivalent of six to eight inches per year.

3.4 Population

The Penobscot River Basin contains all or portions of three cities (including Bangor, Brewer, and Old Town), 108 towns, and 184 unincorporated areas, and falls within seven counties. Table 17 presents the historical population data within the Penobscot River Basin. The population within the drainage basin has increased since the 1970s, but the proportion of the population residing within cities has remained relatively constant.

Census date	Population	Population in cities
1970	149,000	51,000
1980	165,000	49,000
1990	174,000	51,000
2000	172,000	49,000

Table 17. Penobscot River Basin, Population

3.5 Historic Flooding Events (1970 – 2007)

Flooding within the Penobscot River Basin is most often caused by a combination of precipitation and snowmelt. Ice jams can exacerbate high flow conditions and cause acute localized flooding. Conditions favorable for flooding typically occur during the spring months. Table 5 presents the list of major and minor flood events identified within the Penobscot basin between 1970 and the present using the sources of data described in Section 1 of this report. The flood events indicated with an “x” are described in greater detail in the following sections of the report.

Table 18. Penobscot River Basin, Identified Flood Events.

	Date	Flood Location	Source of Flood Record	Damages
x	April/May 1973	Penobscot River	ACOE, USGS	
	1974		FIS Howland	
	1975		FIS Howland	
	April 1976	Mattawamkeag River, Passadumkeag River	USGS	
x	January 1978	Penobscot River, Piscataquis Rivers	CRREL	Moderate damages
	April 1983	Penobscot River	FIS Howland, FIS Enfield	
	April 1979	Piscataquis River	FIS Howland, USGS	
x	March/April 1987	Penobscot River, Sebec River, Piscataquis River, Kenduskeag Stream	CRREL, IHMT, USGS, ACOE	Severe damages
	1988		FIS Howland	
x	April 1993		IHMT	
x	January 1996	Penobscot River, Piscataquis Rivers	CRREL	Severe damages
	January 1997	Penobscot River	CRREL	Road flooded
	March 1999	Piscataquis River	CRREL	One home flooded
x	April 2005	E. Br. Penobscot River	CRREL	House evacuations
x	October 2005		Unknown	
	January 2006	East Branch Mattawamkeag River	CRREL	Store, parking lot
	April 2007			
	May 2006			

CRREL – Ice jam database, USGS – Streamgage record, ACOE – 1990 study, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report

The USGS record of peak discharge and stage at streamgages within the Penobscot drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the Penobscot River Basin. Table 19 presents the highest recorded daily discharge at selected streamgages. The streamgage record indicates that major flood events resulting from high flows occurred in April/May 1923, April/May 1973, and April 1987. The flood of record within the Penobscot River Basin occurred in May 1923 as the result of three days of rainfall totaling 5.3 inches on a high water content snowpack. The flood of April 1987 is considered the flood of record in the Penobscot River Basin.

Table 19. Penobscot River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01029500	East Branch Penobscot River at Grindstone, Maine	4/30/1923	37,000	16.9
01030500	Mattawamkeag River near Mattawamkeag, Maine	5/1/1923	46,600	
01031500	Piscataquis River near Dover-Foxcroft, Maine	4/1/1987	37,300	22.62
01034000	Piscataquis River at Medford, Maine	4/1/1987	85,000	18.65
01034500	Penobscot River at West Enfield, Maine	5/1/1923	153,000	25.15
01036390	Penobscot River at Eddington, Maine	4/3/1987	159,000	23.53

3.5.1 April/May 1973

The Penobscot River Basin received approximately three inches of rainfall accompanied by warm temperatures and melting snowpack. The communities of Bradley, Costigan, and Old Town experienced significant losses of property. Table 20 presents the observed stage, discharge, and recurrence interval (where available) for the April/May 1973 flood. The USGS estimated the return period of the flows on the East Branch Penobscot River and the upper reaches of the Penobscot River to be fifty to one hundred years.

Table 20. Penobscot River Basin, USGS Streamgage Peaks, April/May 1973

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01029500	East Branch Penobscot River at Grindstone, Maine	14.71	30,600	50-100
01030000	Penobscot River near Mattawamkeag, Maine	16.89	66,000	50-100
01030300	Trout Brook near Danforth, Maine	4.51	229	2-5
01030500	Mattawamkeag River near Mattawamkeag, Maine	13.26	23,800	5-10
01031500	Piscataquis River near Dover-Foxcroft, Maine	11.33	10,500	2-5
01031600	Morrison Brook near Sebec Corners, Maine		125	2-5
01033000	Sebec River at Sebec, Maine	8.99	5,140	2-5
01033500	Pleasant River near Milo, Maine	9.87	14,100	5-10
01034000	Piscataquis River at Medford, Maine	11.36	33,200	5-10
01034500	Penobscot River at West Enfield, Maine	21.66	128,000	25-50
01035000	Passadumkeag River at Lowell, Maine	5.99	2,760	5-10
01036500	Kenduskeag Stream near Kenduskeag, Maine	8.48	2,850	<2

3.5.2 January 1978

The CRREL ice jam database indicates that flooding occurred on the Penobscot and Piscataquis Rivers as a result of ice jams. The USGS estimated the return period of the flows on the Penobscot River and tributaries to be two to five years.

Table 21. Penobscot River Basin, USGS Streamgage Peaks, January 1978

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01031500	Piscataquis River near Dover-Foxcroft, Maine	11.51	10,800	2-5
01033000	Sebec River at Sebec, Maine	7.35	3,640	<2
01033500	Pleasant River near Milo, Maine	8.66	7,300	<2
01034000	Piscataquis River at Medford, Maine	9.58	23,200	2-5
01036500	Kenduskeag Stream near Kenduskeag, Maine	11.1	4,410	2-5

3.5.3 March/April 1987

The Penobscot River Basin received approximately three inches of rainfall between March 31 and April 1, 1987. The rainfall was accompanied by warm temperatures and melting snowpack. Three days later, the river basin received an additional two inches of rain. This event caused the flood of record within the Piscataquis River subbasin. Table 22 presents the observed stage, discharge, and recurrence interval (where available) for the March/April 1987 flood. The USGS estimated the return period of the flows on the Penobscot River to be one hundred to five hundred years and the Piscataquis to be greater than five hundred years.

Table 22. Penobscot River Basin, USGS Streamgage Peaks, March/April 1987

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01030000	Penobscot River near Mattawamkeag, Maine	12.9	55,400	25-50
01030500	Mattawamkeag River near Mattawamkeag, Maine	13.1	23,300	5-10
01031500	Piscataquis River near Dover-Foxcroft, Maine	22.62	37,300	>500
01033000	Sebec River at Sebec, Maine	12.89	11,000	100
01034000	Piscataquis River at Medford, Maine	18.65	85,000	100-500
01034500	Penobscot River at West Enfield, Maine	23.58	147,000	50-100
01036390	Penobscot River at Eddington, Maine	23.53	159,000	
01036500	Kenduskeag Stream near Kenduskeag, Maine	15.84	7,400	50-100

3.5.4 April 1993

An interagency hazard mitigation team report describing flooding during the spring of 1993 indicates that flood warnings were issued on the Penobscot River in response to a moderate rainfall event falling on a snowpack with high water content. Information on this flood event is not comprehensive. Table 23 presents the observed stage, discharge, and recurrence interval (where available) for the April 1993 event. The USGS estimated the return period of the flows on the Penobscot River and tributaries to be five to twenty-five years.

Table 23. Penobscot River Basin, USGS Streamgage Peaks, March/April 1993

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01030500	Mattawamkeag River near Mattawamkeag, Maine	16.16	26,100	10-25
01031500	Piscataquis River near Dover-Foxcroft, Maine	12	12,100	2-5
01033000	Sebec River at Sebec, Maine	9.33	5,820	5-10
01034000	Piscataquis River at Medford, Maine	12.33	37,300	5-10
01034500	Penobscot River at West Enfield, Maine	18.93	101,000	10-25
01036390	Penobscot River at Eddington, Maine	18.62	106,000	n/a

3.5.5 January 1996

The CRREL ice jam database indicates that ice jams caused severe flooding and damages along the Penobscot and Piscataquis Rivers in January 1996. Table 24 presents the observed stage, discharge, and recurrence interval (where available) for the January 1996 event. The USGS estimated the return period of the flows on the Piscataquis to be two to five years.

Table 24. Penobscot River Basin, USGS Streamgage Peaks, January 1996

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01031500	Piscataquis River near Dover-Foxcroft, Maine	11.48	11,200	2-5
01034000	Piscataquis River at Medford, Maine	9.89	24,000	2-5
01036390	Penobscot River at Eddington, Maine	16.7	92,300	n/a

3.5.6 April 2005

The CRREL ice jam database indicates that ice jams caused severe flooding and damages along the East Branch Penobscot River in April 2005. Table 25 presents the observed stage, discharge, and recurrence interval (where available) for the January 1996 event. The USGS estimated the return period of the flows on the Penobscot River and tributaries to be five to twenty-five years.

Table 25. Penobscot River Basin, USGS Streamgage Peaks, April 2005

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01027200	North Branch Penobscot River nr Pittston Farm, ME	9.32	8,410	
01029200	Seboeis River near Shin Pond, Maine	11.62	4,280	
01029500	East Branch Penobscot River at Grindstone, Maine	13.56	25,600	10-25
01030500	Mattawamkeag River near Mattawamkeag, Maine	14.31	19,100	2-5
01031300	Piscataquis River at Blanchard, Maine	10.79	7,150	
01031500	Piscataquis River near Dover-Foxcroft, Maine	12.19	12,600	5-10
01034000	Piscataquis River at Medford, Maine	12.11	35,800	5-10
01034500	Penobscot River at West Enfield, Maine	19.76	107,000	10-25

3.5.7 October 2005

[information on this event was not available at the time of publication]

Table 26. Penobscot River Basin, USGS Streamgage Peaks, October 2005

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01027200	North Branch Penobscot River nr Pittston Farm, ME	8.61	6,270	
01029200	Seboeis River near Shin Pond, Maine	10.55	3,360	
01029500	East Branch Penobscot River at Grindstone, Maine	12.38	20,700	5-10
01031300	Piscataquis River at Blanchard, Maine	9.93	5,330	
01031450	Kingsbury Stream at Abbot Village, Maine	13.32	6,670	
01031500	Piscataquis River near Dover-Foxcroft, Maine	12.89	13,900	5-10
01034000	Piscataquis River at Medford, Maine	11.46	32,000	5-10
01034500	Penobscot River at West Enfield, Maine	16.63	79,600	2-5

4.0 Kennebec River Basin

4.1 Watershed Description

The Kennebec River Basin occupies approximately 5,900 square miles of southwestern Maine. The headwaters of the river basin originate in the Appalachian Mountains on the international border with Canada. The upper two-thirds of the basin above Waterville are hilly and mountainous and the lower third of the basin has the gentle topography representative of a coastal drainage area. Major communities in this basin include Bingham, Anson, Madison, Norridgewock, Skowhegan, Waterville, Winslow, Augusta, Hallowell, and Gardiner.

The Kennebec River originates at Moosehead Lake and flows south approximately 145 miles to Merrymeeting Bay. Table 27 presents the major tributaries to the Kennebec River along with their respective contributing area. The Kennebec River joins the Androscoggin River in Merrymeeting Bay before exiting to the ocean at Fort Popham. The Kennebec River is influenced by tidal process as far as Augusta, 25 miles above Abagadassett Point. Figure 10 illustrates the locations of major tributaries located within the Kennebec River basin.

Table 27. Kennebec River, Tributaries from Upstream to Downstream and Drainage Areas

Tributary	Contributing Area (square miles)
South Branch Moose River	70
Moose River (2) above Attean Pond	180
Moose River (3) at Long Pond	310
Brassua Lake	160
Moosehead Lake	550
Kennebec River (2) above The Forks	320
North Branch Dead River	200
South Branch Dead River	150
Flagstaff Lake	170
Dead River	360
Kennebec River (4) at Wyman Dam	160
Austin Stream	90
Kennebec River (6)	110
Carrabassett River	400
Sandy River	590
Kennebec River at Waterville Dam	410
Sebasticook River at Pittsfield	320
Sebasticook River (3) at Burnham	270
Sebasticook River (4) at Winslow	370
Messalonskee Stream	210
Cobbosseecontee Stream	220
Kennebec River at Merrymeeting Bay	320
Total	**5,930**

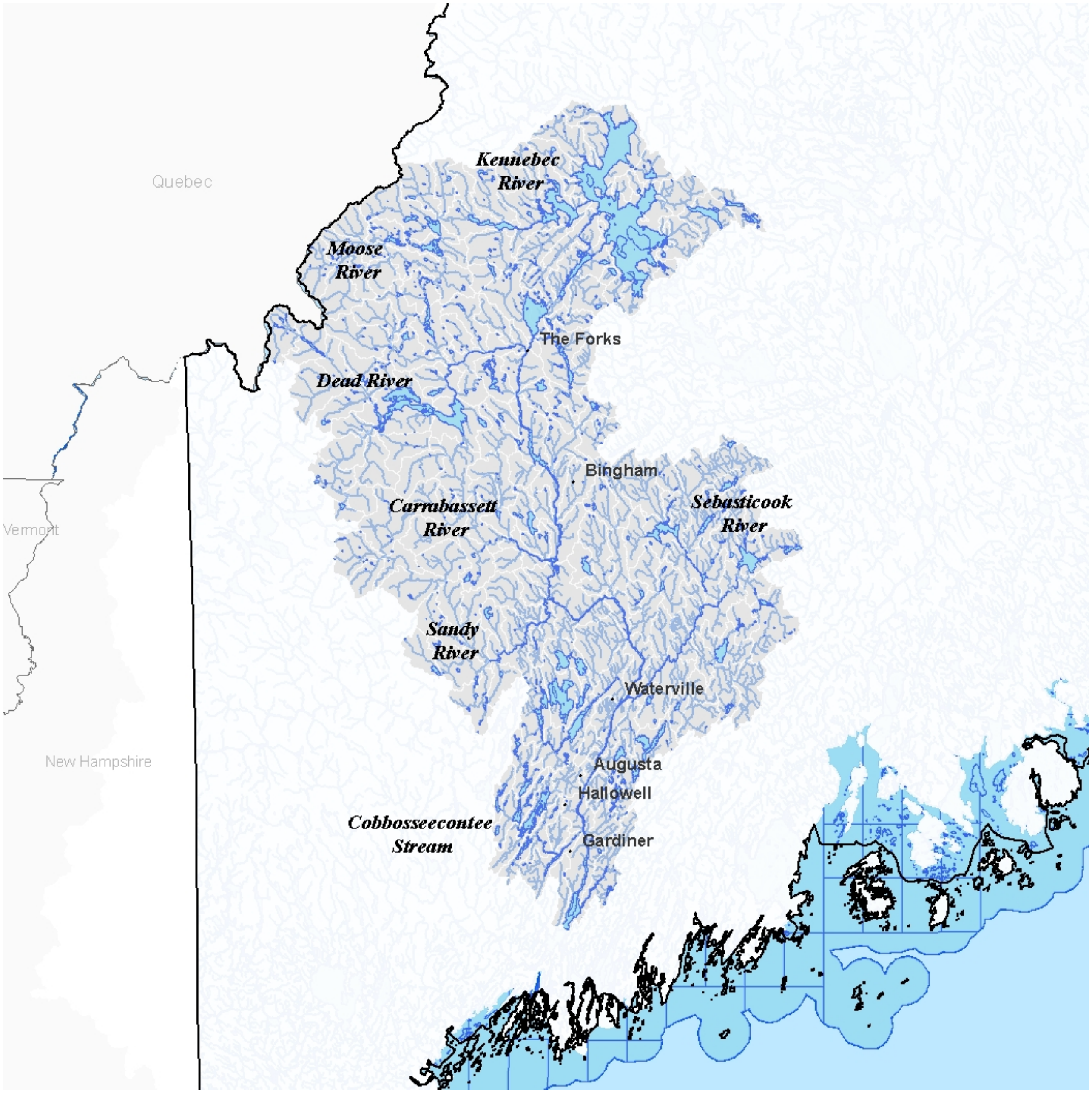


Figure 10. Kennebec River Basin and Major Tributaries

The Carrabassett and Sandy Rivers are major contributors to flooding in the Kennebec River. Both tributaries are considered hydrologically flashy and contribute approximately 40% of the peak discharge of the Kennebec River during flood events. Table 28 presents the average proportional contribution of each tributary to total flooding within the mainstem Kennebec River (ACOE, 1990).

Table 28. Kennebec River Basin, Contribution of Tributaries to Flooding (ACOE, 1990)

Location	Contribution (% of total)	Basin Size (% of total)
Sandy River	24.2	14.0
Carrabassett River	16.0	9.4
Kennebec River, Weston Dam to Waterville	13.0	7.8
Dead River	9.6	20.8
Sebasticook River	8.5	22.4
Kennebec River at the Forks	7.0	7.6
Kennebec River Forks to Bingham	5.7	3.8
Kennebec River, Bingham to Carrabassett River	4.5	2.6
Austin Stream	4.3	2.2
Waterville to Augusta Dam	3.7	7.6
Kennebec River, Carrabassett River to Weston Dam	3.5	1.8

4.2 Dams and Reservoirs

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that the Kennebec River Basin contains over 140 dams. Fifty-two are identified for recreational use, thirty-six for "other" use, nineteen for hydrologic power generation, ten for flood control and stormwater management, six for flood supply, and two for debris control. The storage capacity of impoundments in the Kennebec River Basin is approximately 826,200 acre-feet. Appendix E contains the list of dams located within the Kennebec River Basin and included in the collaborative dam database.

4.3 Precipitation

The average annual precipitation in the Kennebec River Drainage Basin is approximately forty-two inches distributed uniformly throughout year. Snowfall contributes the equivalent of five to eight inches of rainfall along the coast and approximately twelve inches in the headwater areas. The average annual streamflow of the Kennebec River is approximately 1.6 cubic feet per second per square mile of contributing area, equivalent to approximately twenty-two inches of runoff.

4.4 Population

The Kennebec River Basin contains all or portions of four cities (Hallowell, Augusta, Gardiner, and Waterville), eighty-six towns, 129 unincorporated areas, and falls within nine counties. Table 29 presents the historical population data within the Kennebec River Basin. The population within the river basin as a whole has increased since 1970; however the population residing within cities has decreased.

Table 29. Kennebec River Basin, Population

Census date	Population	Population in cities
1970	168,000	50,000
1980	193,000	49,000
1990	208,000	48,000
2000	211,000	43,000

4.5 Historic Flooding Events (1970 – 2007)

Flooding within the Kennebec River Basin is most often caused by snowmelt in combination with rainfall. Flood events have also resulted from extreme precipitation events. Table 30 presents the list of major and minor flood events identified within the Kennebec River Basin between 1970 and the present using sources of data described in Section 1 of this report. The flood events indicated with an “x” are described in greater detail in the following sections of the report.

Table 30. Kennebec River Basin. Identified Flood Events

	Date	Flood Location	Source of Flood Record	Description
	February 1970	Cobbosseecontee Stream	CRREL	Major damage
x	December 1973	Kennebec River, Mountain Brook, Pelton Brook, North Branch Tanning Brook, Gardiner Pond Brook	ACOE, CRREL, USGS	Major damage
	May 1974	Kennebec River	USGS	
	February 1978	Carrabassett River	CRREL	Peak stage of record
x	April 1979		ACOE	
	September 1981		USGS	
x	April 1983		USGS, ACOE	
x	May/June 1984	Kennebec River	USGS, ACOE	
x	March/April 1987	Kennebec River, Carrabassett River, Sandy River, Sebasticook River, Johnson Brook, Mill Stream, Cobbosseecontee Stream, Togus Stream	USGS, ACOE, Photos	
	January/February 1996	Kennebec River, Marsh Stream	CRREL	
	April 1993		IHMT	
	April 1992		(FEMA 940-DR-ME)	
x	December 2003	Sandy River	Photos, CRREL	
x	March 2003		Photos	
x	April 2005		Photos	
x	February 2006	Sandy River	Photos, CRREL	

CRREL – Ice jam database, USGS – Streamgage record, ACOE – 1990 study, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report

The USGS record of peak discharge and stage at streamgages within the Kennebec drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the Kennebec River Basin. Table 31 presents the highest recorded daily discharge at selected streamgages. The streamgage record indicates that major flood events resulting from high flows occurred in March 1936, September 1981, April 1983, June 1984, April 1987, and May 2000.

Table 31. Kennebec River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01041000	Kennebec River at Moosehead, Maine	9/25/1981	16,700	9.76
01042500	Kennebec River at The Forks, Maine	4/18/1983	32,900	14.41
01044550	Spencer Stream at mouth, near Grand Falls, Maine	5/11/2000	5,500	7.24
01046500	Kennebec River at Bingham, Maine	6/1/1984	65,200	15.61
01047000	Carrabassett River near North Anson, Maine	4/1/1987	50,700	26.66
01048000	Sandy River near Mercer, Maine	4/1/1987	51,100	19.25
01049000	Sebasticook River near Pittsfield, Maine	4/3/1987	17,600	15.53
01049205	Kennebec River near Waterville, ME	4/2/1987	224,000	-
01049265	Kennebec River at North Sidney, Maine	4/2/1987	232,000	39.31
01049500	Cobbosseecontee Stream at Gardiner, Maine	3/21/1936	5,020	-

4.5.1 December 1973

The Kennebec River basin received over three inches of rainfall in a 24-hour period between the 16 and 17 of December 1973. Two additional inches fell on the 20 and 21 of December. Total rainfall in December approached twelve inches. The rainfall was accompanied by warm temperatures and melting snowpack. At the beginning of this precipitation event, Moosehead and Flagstaff reservoir levels were high. Table 32 presents the observed stage, discharge, and recurrence interval (where available) for the December 1973 flood. The USGS estimated the return period of the flows on the Kennebec River to be ten to fifty years.

Table 32. Kennebec River Basin, USGS Streamgage Peaks, December 1973

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at the Forks, ME	12.68	27,600	30
01046500	Kennebec River at Bingham, ME	14.41	50,300	10-25
Central Maine Power Co.	Kennebec River at Skowhegan	-	123,000	-
Hollingworth and Whitney	Kennebec River at Waterville	-	145,000	25-50
01048000	Sandy River near Mercer, ME	-	25,600	10
01047000	Carrabassett River near North Anson, ME	-	21,200	5-10

4.5.2 April 1979

The Kennebec river basin received approximately 2.6 inches of rainfall between 26 and 28 April 1979. The rainfall was accompanied by warm temperatures and melting snowpack. At the beginning of this precipitation event, Moosehead and Flagstaff reservoir levels were high. Table 33 presents the observed stage, discharge, and recurrence interval (where available) for the April 1979 flood. The USGS estimated the return period of the flows on the Kennebec River and tributaries to be five to ten years.

Table 33. Kennebec River Basin, USGS Streamgage Peaks, April 1979

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at the Forks, ME	9.15	17,200	5-10
01046500	Kennebec River at Bingham, ME	13.31	41,000	10
Central Maine Power Co.	Kennebec River at Skowhegan	-	101,000	-
Hollingworth and Whitney	Kennebec River at Waterville	-	105,000	5-10
01049265	Kennebec River at North Sidney, ME	26.4	111,000	-
01048000	Sandy River near Mercer, ME	13.48	24,900	5-10
01047000	Carrabassett River near North Anson, ME	17.46	22,400	5-10

4.5.3 April 1983

The Kennebec River Basin received approximately two inches of rainfall between 17 and 18 April 1983. One week later, the basin received three inches of precipitation between the 24 and 25 of April. The second precipitation event was accompanied by warm temperatures and snowmelt. At the beginning of this precipitation event, Moosehead and Flagstaff reservoir levels were high. Table 34 presents the observed stage, discharge, and recurrence interval (where available) for the April 1983 flood. The USGS estimated the return period of the flows on the Kennebec River to be ten to seventy years.

Table 34. Kennebec River Basin, USGS Streamgage Peaks, April 1983

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at the Forks, ME	14.41	32,900	60-70
01046500	Kennebec River at Bingham, ME	12.1	55,400	25-50
Central Maine Power Co.	Kennebec River at Skowhegan	-	82,000	-
Hollingworth and Whitney	Kennebec River at Waterville	-	103,000	10-25
01049265	Kennebec River at North Sidney, ME	-	107,000	-
01047000	Carrabassett River near North Anson, ME	13.55	14,100	2

4.5.4 May/June 1984

The Kennebec River Basin received approximately six inches of rainfall between May 29 and June 2, 1984. At the beginning of this precipitation event, Moosehead and Flagstaff reservoir levels were high and could provide little storage to mitigate this event. The flood of record was established for the upper watershed at the USGS gaging stations at the Forks and Bingham, Maine. Peak flows along the lower Kennebec River were comparable to flood levels seen during the April 1979 and April 1983 events. Table 35 presents the observed stage, discharge, and recurrence interval (where available) for the May/June 1984 flood. The USGS estimated the return period of the flows on the Kennebec River to be twenty-five to one hundred years.

Table 35. Kennebec River Basin, USGS Streamgage Peaks, May/June 1984

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at the Forks, ME	13.78	30,300	100
01046500	Kennebec River at Bingham, ME	15.61	65,200	75-100
Central Maine Power Co.	Kennebec River at Skowhegan	-	76,000	-
Hollingworth and Whitney	Kennebec River at Waterville	-	109,000	25-50
01049265	Kennebec River at North Sidney, ME	-	113,000	-
01047000	Carrabassett River near North Anson, ME	-	13,000	2-5

4.5.5 March/April 1987

In April 1987, runoff caused by a high volume of rainfall following several days of warm temperatures and melting snowpack caused a new flood of record for the Kennebec River from the mouth of the Carrabassett tributary to the mouth of the Kennebec River. Reservoir storage in the upper watershed was successful at controlling the runoff from the upper subbasins. Peak flows along the lower main-stem Kennebec and tributaries were 30% higher than flows recorded in the previous flood of record, March 1936 (ACOE, 1990). The photos presented in Figure 11, Figure 12, Figure 13, and Figure 14 illustrate the extent of flooding at various points along the Kennebec River. Table 36 presents the observed stage, discharge, and recurrence interval (where available) for the March/April 1987 flood. The USGS estimated the return period of the flows on the Kennebec River and many tributaries to be greater than one hundred years.

Losses caused by the April 1987 flood were estimated to be approximately $34 million within the Kennebec River Basin. The estimated assisted payouts totaled approximately $9.1 million.

Fourteen communities including (Augusta, Randolph, Fairfield, Anson, Hartland, Hallowell, Waterville, Skowhegan, Madison, Farmington, Gardiner, Winslow, Norridgewock, and Pittsfield) incurred estimated losses of $500,000 each or greater.

Table 36. Kennebec River Basin, USGS Streamgage Peaks, March/April 1987

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at the Forks, ME	9.87	20,400	10-25
01046500	Kennebec River at Bingham, ME	15.46	63,400	50-75
Hollingworth and Whitney	Kennebec River at Waterville	-	224,000	>100
01049265	Kennebec River at North Sidney, ME	39.31	232,000	>100
01048000	Sandy River near Mercer, ME	19.25	51,100	>100
01047000	Carrabassett River near North Anson, ME	26.66	50,700	>100
01049000	Sebasticook River near Pittsfield, MD	15.53	17,600	>100
01049130	Johnson Brook at South Albion, ME	12.34	178	10-25
01049373	Mill Stream at Winthrop, ME	6.16	1,330	50-100
01049550	Togus Stream at Togus, ME	7.5	1,010	25-50

Figure 11. Kennebec River, Waterville Commercial Development, April 1987 (Sun Journal)

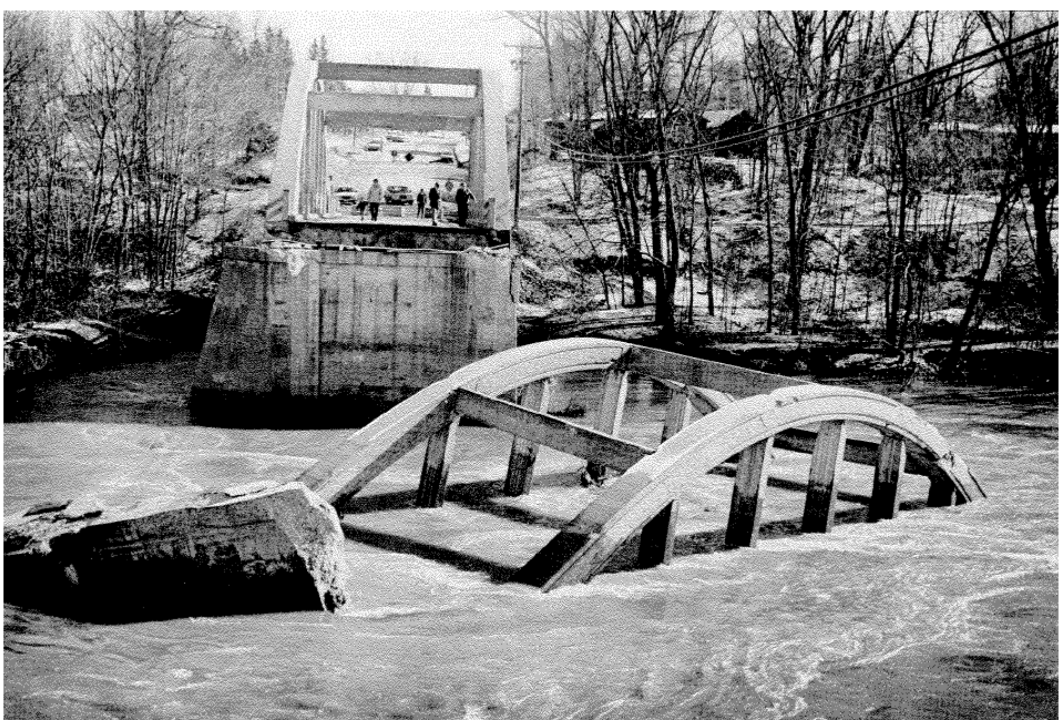


Figure 12. Sandy River, Fairbanks Bridge on Route 4, Farmington, April 1987 (Sun Journal)

Figure 13. Carrabassett River, Forster Manufacturing Co., Dryden, April 1987 (Sun Journal)

Figure 14. Kennebec River, Water Street, Gardiner, April 1987 (Sun Journal)

4.5.6 December 2003

The CRREL database indicates that ice jams and moderate flows contributed to flooding along the Sandy River in December 2003. Table 37 presents the observed stage, discharge, and recurrence interval (where available) for the December 2003 flood. Figure 15, Figure 16, and Figure 17 document the flooding at Farmington. The USGS estimated the return period of the flows on the Kennebec River to be two to ten years.

Table 37. Kennebec River Basin, USGS Streamgage Peaks, December 2003

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at The Forks, Maine	7.46	11,700	<2
01044550	Spencer Stream at mouth, near Grand Falls, Maine	5.8	3,240	
01046500	Kennebec River at Bingham, Maine	12.22	29,000	2-5
01047000	Carrabassett River near North Anson, Maine	16.57	20,300	5-10
01048000	Sandy River near Mercer, Maine	13.03	24,100	5-10
01049265	Kennebec River at North Sidney, Maine	22.23	102,000	
01049500	Cobbosseecontee Stream at Gardiner, Maine	6.64	1,490	<2
01042500	Kennebec River at The Forks, Maine	7.46	11,700	<2
01044550	Spencer Stream at mouth, near Grand Falls, Maine	5.8	3,240	
01046500	Kennebec River at Bingham, Maine	12.22	29,000	2-5

Figure 15. Sandy River in Farmington, near Route 2, December 12, 2003

Figure 16. Ice Jam on the Sandy River in Farmington, near Route 2, December 12, 2003

In the photo below, the University of Maine at Farmington can be seen on the left side.

Figure 17. Sandy River in Farmington, Flyover View, December 12, 2003

4.5.7 March 2003

Figure 18 and Figure 19 document an ice jam occurring in Augusta during March 2003. The CRREL ice jam database does not indicate flooding associated with this event. Table 38 presents the observed stage, discharge, and recurrence interval (where available) for the March 2003 event. The USGS estimated the return period of the flows on the Kennebec River and tributaries to be less than two years.

Table 38. Kennebec River Basin, USGS Streamgage Peaks, March 2003

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01048000	Sandy River near Mercer, Maine	7.79	7,050	<2
01049265	Kennebec River at North Sidney, Maine	12.71	35,200	
01049500	Cobbosseecontee Stream at Gardiner, Maine	6.23	1,250	<2

Figure 18. Ice Jam in Augusta, March 26, 2003

Figure 19. Ice Jam in Augusta, March 26, 2003

4.5.8 April 2005

The photo record indicates that flooding occurred along the Kennebec and Cobbosseecontee Rivers in Gardiner and Hallowell during April of 2005. Figure 20, Figure 21, Figure 22, Figure 23, Figure 24, and Figure 25 document the extent of flooding within these communities during this event. Table 39 presents the observed stage, discharge, and recurrence interval (where available) for the April 2005 event. The USGS estimated the return period of the flows on the Kennebec River to be five to ten years and the Sandy River to be ten to twenty-five years.

Table 39. Kennebec River Basin, USGS Streamgage Peaks, April 2005

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01042500	Kennebec River at The Forks, Maine	10.56	19,900	5-10
01044550	Spencer Stream at mouth, near Grand Falls, Maine		5,450	
01046500	Kennebec River at Bingham, Maine	13.79	43,800	5-10
01047000	Carrabassett River near North Anson, Maine	16.7	21,500	5-10
01048000	Sandy River near Mercer, Maine	13.73	27,300	10-25
01049000	Sebasticook River near Pittsfield, Maine	10.67	9,920	5-10
01049265	Kennebec River at North Sidney, Maine	22.29	93,900	
01049500	Cobbosseecontee Stream at Gardiner, Maine	9.86	3,870	

Figure 20. Kennebec River and Cobbosseecontee Stream near Hannaford and Route 201 Gardiner, April 29, 2005

Figure 21. Kennebec River and Cobbosseecontee Stream near Hannaford and Route 201 Gardiner, April 29, 2005

Figure 22. Kennebec River in Hallowell, April 29, 2005

Figure 23. Kennebec River in Hallowell, April 4, 2005

Figure 24. Kennebec River in Hallowell, April 4, 2005

Figure 25. Cobbosseecontee Stream in Gardiner near Route 201, April 4, 2005

4.5.9 February 2006

The photo record and the CRREL ice jam database indicate a flooding event caused by ice jams along the Sandy River at Farmington during February 2006. Figure 26 and Figure 27 document the extent of flooding within Farmington during this event. This event did not result in annual peak flows for any tributaries within the Kennebec River Basin.

Figure 26. Sandy River near Route 2, Flooding of Commercial Area in Farmington, February 2006

Figure 27. Sandy River near Route 2, Farmington Showing an Ice Jam at the Bridge

5.0 Androscoggin River Basin

5.1 Watershed Description

The Androscoggin River Basin occupies 3,500 square miles in western Maine and northeastern New Hampshire. The Androscoggin River flows 169 miles from the headwaters in Umbagog Lake in Errol, New Hampshire (near Mount Washington) to its mouth at Merrymeeting Bay.

The Androscoggin River originates in the White Mountains. Below Rumsford, Maine the river basin becomes hilly and flat and is generally suitable for agriculture. Large communities in this basin include Bethel, Rumford, Mexico, Canton, Jay, Livermore, Lewiston, Auburn, and Brunswick/Topsham.

Table 40 presents the major tributaries to the Androscoggin River from upstream to downstream along with their respective drainage areas. The Androscoggin River is influenced by tidal process as far as Brunswick, Maine. Figure 28 illustrates the location of the Androscoggin River basin within Maine and the major tributaries.

Table 40. Androscoggin River, Tributaries from Upstream to Downstream and Drainage Areas

Tributary	Drainage Area (square miles)
Mooselookmeguntic Lake	470
Umbagog Lake Drainage	120
Aziscohos Lake Drainage	250
Magalloway River	200
Clear Stream	60
Middle Androscoggin River	270
Gorham-Shelburne Tributaries	150
Androscoggin River (2) at Rumford Point	310
Ellis River	160
Ellis River	200
Androscoggin River (3) above Webb River	250
Androscoggin River (4) at Riley Dam	200
Androscoggin River (5) at Nezinscot River	180
Nezinscot River	80
Androscoggin River (6) above Little Androscoggin River	350
Little Androscoggin River	260
Total	**3530**

Figure 28. Androscoggin River Basin and Major Tributaries

5.2 Dams and Reservoirs

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that the Androscoggin River Basin contains over 100 dams. Of the 100 dams, thirty-two are used for recreation, nine for flood control and stormwater management, sixteen for hydropower generation, nine for reservoir storage, twenty-eight for "other" purposes. The storage capacity of impoundments in the Androscoggin River Basin is approximately 215,300 acre-feet. Appendix E contains the list of dams located within the Androscoggin River Basin and included in the collaborative dam database.

5.3 Precipitation

The average annual precipitation in the Androscoggin River Drainage Basin is approximately forty inches uniformly distributed throughout the year. Snowfall contributes the equivalent of six to ten inches of rainfall. The average annual streamflow of the Androscoggin River Basin is approximately 1.8 cubic feet per second per square mile, equivalent to approximately twenty-five inches of runoff.

5.4 Population

The basin contains all or portions of sixty-three towns, three cities (Auburn, Bath, and Lewiston), thirty-seven unincorporated areas, and falls within six counties. Table 41 presents the US census data for the Androscoggin River basin from 1970 to 2000. The population within the drainage basin has increased since the 1970s, but the proportion of the population residing within cities has decreased by about 10% since 1990.

Table 41. Androscoggin River Basin, Population within Maine

Census date	Population	Population in cities
1970	141,000	62,000
1980	156,000	60,000
1990	168,000	60,000
2000	169,000	55,000

5.5 Historic Flooding Events (1970 – 2007)

Flooding within the Androscoggin River Basin is most often caused by rainfall in combination with snowmelt. Ice jams have been known to cause acute localized flooding. Conditions favorable for flooding typically occur during the spring. Table 42 presents the list of major and minor flood events identified within the Androscoggin River basin between 1970 and the present using the sources of data described in Section 1 of this report. The flood events indicated with an "x" are described in greater detail in the following section of the report.

Table 42. Androscoggin River Basin, Identified Flood Events

	Date	Flood Location	Flood Documentation	Damages
	December 1973	Androscoggin River	FIS Lewiston, Bethel	
	March 1977	Nezinscot, Little Andro. River	USGS	
	January/February 1978	Androscoggin River	CRREL	Major damages
	April 1984	Androscoggin River	FIS Bethel, USGS	
	1986		FIS Bethel	
x	March/April 1987	Androscoggin, Wild, Swift, Nezinscot, Little Andro. Rivers	USGS, CRREL, ACOE	Flood of record
	February 1981	Androscoggin River	CRREL, Newspaper	
	April 1992		FEMA 940-DR-ME	
	October 1995	Wild River	USGS	
x	December 2003	Oxford County	USGS, CRREL, Photos	Severe damages
x	April 2005	Androscoggin River	CRREL, Photos	
	January 2006	Androscoggin River	CRREL	Bethel
	July 2007	Swift River	[Need reference]	Water supply in Bethel was destroyed

CRREL – Ice jam database, USGS – Streamgage record, ACOE – 1990 study, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report

The USGS record of peak discharge and stage at streamgages within the Androscoggin drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the Androscoggin River Basin. Table 43 presents the highest daily discharge recorded at selected streamgages. The floods of record on the Androscoggin River include events that occurred in March 1936, March 1953, October 1959, and March/April 1987. The 1936 flood was caused by heavy rainfall on a dense, melting snowpack. The March 1953 flood was primarily caused by a large quantity of rainfall. Information on the event of 1959 was not available at the time of publication. Photos shown below document the extent of flooding for both storms in Auburn, Maine. The March/April 1987 flood was caused by precipitation and snowmelt and the December 2003 event was caused by higher than average flows and extensive ice jams.

Table 43. Androscoggin River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01054200	Wild River at Gilead, Maine	10/24/1959	28,300	15.6
01054300	Ellis River at South Andover, Maine	12/18/2003	7,830	19.26
01054500	Androscoggin River at Rumford, Maine	3/20/1936	74,000	
01055000	Swift River near Roxbury, Maine	10/24/1959	16,800	12.87
01055500	Nezinscot River at Turner Center, Maine	3/27/1953	13,900	11.18
01057000	Little Androscoggin River near South Paris, Maine	4/1/1987	9,340	12.22
01059000	Androscoggin River near Auburn, Maine	3/20/1936	135,000	27.57

5.5.1 Notable Historical Floods

Figure 29, Figure 30, and Figure 31 illustrate the extent of flooding during the floods of 1936 and 1953.

Figure 15 - March 1936 Flood - Little Androscoggin River overflows between Main and South Main Streets, Auburn.

Figure 29. Little Androscoggin River, March 1936

Figure 18 - March 1953 Flood - Little Androscoggin River, Auburn, looking west on Route 11 about 0.2 mile west of Haskell's Corner. High water mark is 4" below top of foundation.

Figure 30. Little Androscoggin River, March 1953

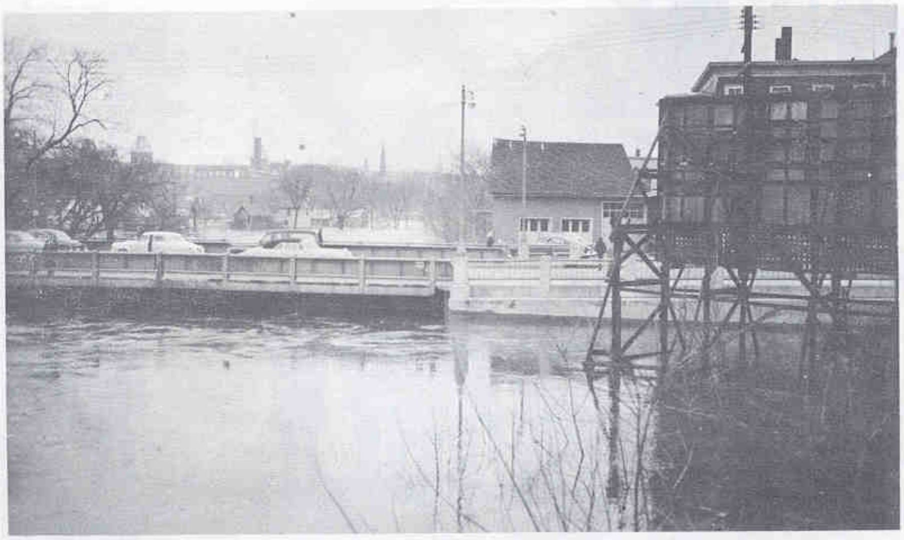


Figure 17 - March 1953 Flood - Little Androscoggin River looking downstream at Main Street Bridge, Auburn.

Figure 31. Little Androscoggin River, March 1953

5.5.2 March/April 1987

The Androscoggin River Basin received approximately three inches of precipitation between March 31 and April 1, 1987. The rainfall was accompanied by warm temperatures and melting snowpack. Three days later, a second storm dropped approximately two inches of rain over the saturated basin. The resultant runoff caused the flood of record for the Androscoggin River Basin. Table 44 presents the observed stage, discharge, and recurrence interval (where available) for the March/April 1987 flood. The photos presented in Figure 32, Figure 33, Figure 34, Figure 35, Figure 36, Figure 37, and Figure 38 illustrate the extent of flooding at various locations along the Androscoggin River and tributaries. The USGS estimated the return period of the flows on the Androscoggin River and tributaries to be one hundred to five hundred years or greater.

Table 44. Androscoggin River Basin, USGS Streamgage Peaks, March/April 1987

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01054200	Wild River at Gilead, Maine	13.03	17,000	10-25
01054500	Androscoggin River at Rumford, Maine	23.22	63,900	100-500
01055000	Swift River near Roxbury, Maine	12.54	15,900	25-50
01055500	Nezinscot River at Turner Center, Maine	10.2	11,600	100-500
01057000	Little Androscoggin River near South Paris, Maine	12.22	9,340	100-500
01059000	Androscoggin River near Auburn, Maine	23.71	103,000	>500

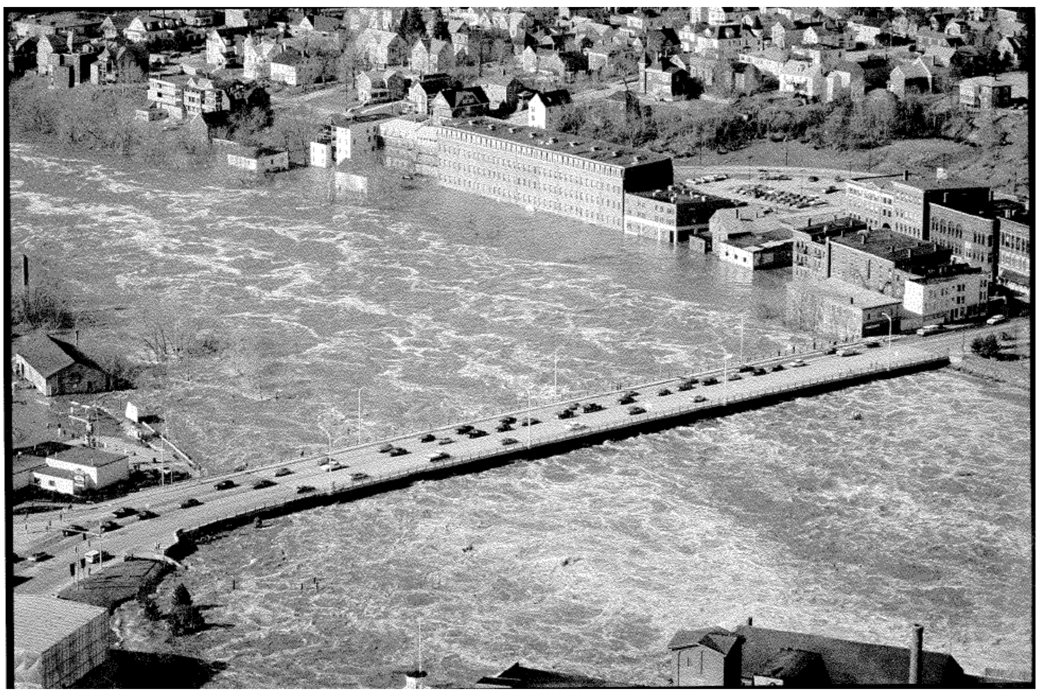


Figure 32. Androscoggin River at the Longley Bridge between Lewiston and Auburn (Sun Journal)

Figure 33. Androscoggin River Lewiston's Great Falls from the Auburn Esplanade (Sun Journal)

Figure 34. Androscoggin River Newbury Street, Auburn (Sun Journal)

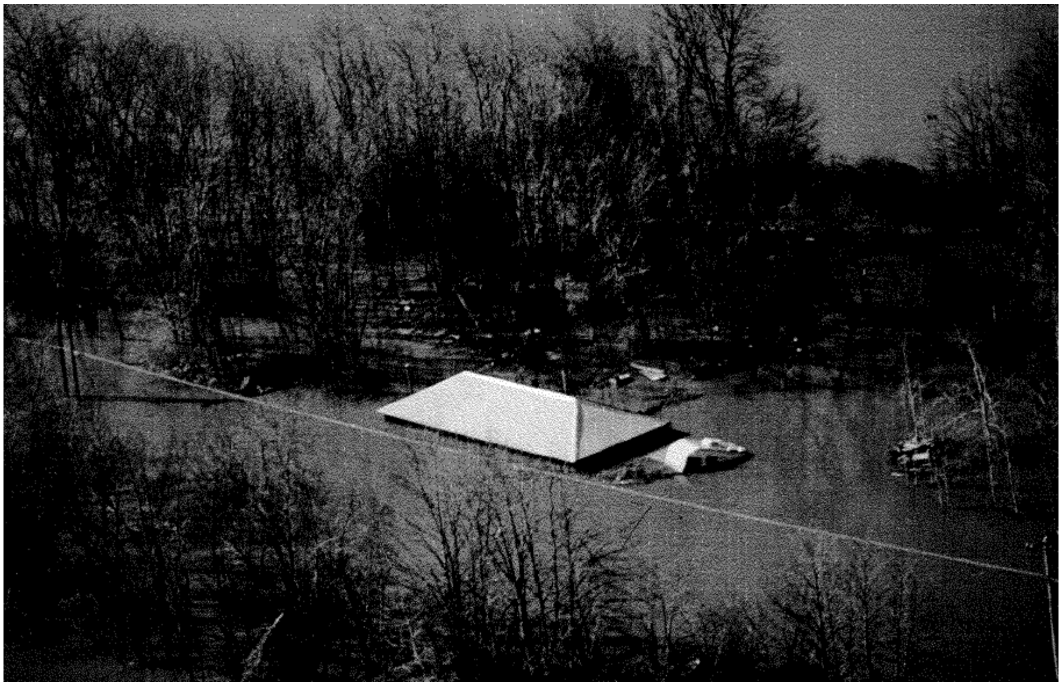


Figure 35. Androscoggin River, Durham, April 1987 (Sun Journal)

Figure 36. Androscoggin River, Jay – Livermore Falls, April 1987 (Sun Journal)

Figure 37. Androscoggin River, Rumford, April 1987 (Sun Journal)

Figure 38. Androscoggin River, Miller Street and Road Block, Auburn, April 1987 (Sun Journal)

5.5.3 December 2003

In December 2003, moderate to high flows coupled with ice jams caused extraordinary flooding in Oxford County. Farmington and Rumford were inundated and Bethel was isolated due to road closures. Vulnerable portions of the town of Canton were purchased and moved as a consequence of this event. Table 45 presents the observed stage, discharge, and recurrence interval (where available) for the December 2003 flood. Figure 39 and Figure 40 illustrate the damage caused by the flood event. The USGS estimated the return period of the flows on the Ellis River to be one hundred to five hundred years.

Table 45. Androscoggin River Basin, USGS Streamgage Peaks, December 2003

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01054200	Wild River at Gilead, Maine	12.06	15,000	5-10
01054300	Ellis River at South Andover, Maine	19.26	7,830	100-500
01054500	Androscoggin River at Rumford, Maine	14.56	35,200	2-5
01055000	Swift River near Roxbury, Maine	10.91	11,900	5-10
01055500	Nezinscot River at Turner Center, Maine	5.81	3,790	2-5
01057000	Little Androscoggin River near South Paris, Maine	8.82	3,470	5-10
01059000	Androscoggin River near Auburn, Maine	14.18	48,000	2-5

Figure 39. Canton Maine, Property Damage, December 23, 2003

Figure 40. Canton Maine, December 23, 2003

5.5.4 April 2005

The CRREL ice jam database and the photo record document flooding along the Androscoggin River during April 2005. Ice jams and moderate flows caused road washouts along route 120 in Andover. Table 46 presents the observed stage, discharge, and recurrence interval (where available) for the April 2005 flood. The USGS estimated the return period of the flows on the Androscoggin River and tributaries to be two to twenty-five years.

Table 46. Androscoggin River Basin, USGS Streamgage Peaks, April 2005.

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01054200	Wild River at Gilead, Maine	10.34	9,860	2-5
01054300	Ellis River at South Andover, Maine	17.67	5,180	5-10
01054500	Androscoggin River at Rumford, Maine	14.16	33,500	2-5
01055000	Swift River near Roxbury, Maine	9.41	8,820	2-5
01055500	Nezinscot River at Turner Center, Maine	8.72	8,630	25-50
01057000	Little Androscoggin River near South Paris, Maine	9.81	4,750	10-25
01059000	Androscoggin River near Auburn, Maine	16.44	58,500	10-25

Figure 41. Route 120 Washout in Andover Caused by Blocked Culvert, Maine April 5, 2005

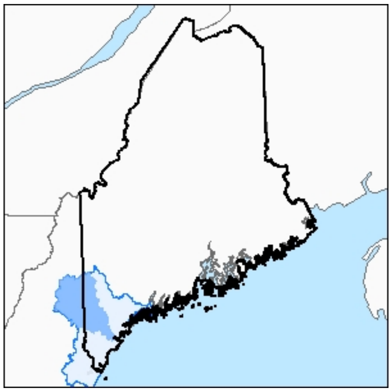
Figure 42. Route 120 Washout in Andover Caused by Blocked Culvert, Maine April 5, 2005

Figure 43. Route 120 Washout in Andover Caused by Blocked Culvert, Maine April 5, 2005

5.5.5 July 2007

In July 2007, an unusually intense thunderstorm tracked up the Swift River basin into Bethel and Newry causing extensive localized damage. Culverts and bridges on Route 131 and Route 2 were washed out, the water supply from Bethel was destroyed, and the Sunday River Ski area sustained substantial damage. Rainfall estimates for this storm were four to seven inches over a period of two hours. [Additional information on this event was not available at the time of publication]

6.0 Saco River Basin (Western Maine Coastal)



The Western Coastal Drainage Basin includes many small rivers draining directly to the Atlantic Ocean including the Presumpscot, the Piscataqua, the Kennebunk, the Mousam, and the Salmon Falls Rivers. Flooding within the western coastal drainage basin is predominantly caused by coastal processes. The Saco River Basin is the largest river basin located within the Western Coastal Drainage Basin. This section of the report describes historical riverine flooding within the Saco River Basin. Large communities within this basin include Fryeburg, Westbrook, and Kennebunk.

6.1 Watershed Description

The Saco River Basin occupies approximately 1,700 square miles of southwestern Maine. The headwaters of the Saco River are located at Crawford Notch in the White Mountains of New Hampshire, 75 miles from the mouth at Biddeford, Maine.

Table 47 presents the major tributaries to the Saco River along with their respective drainage areas.

Table 47. Saco River, Tributaries from Upstream to Downstream and Drainage Areas

Tributary	Drainage Area (square miles)
Upper Saco River	190
Swift River	90
Conway Tributaries	170
Saco River-Lovewell Pond	280
Saco River at Ossipee River	110
Bearcamp River	150
Pine River	90
Ossipee Lake Drainage	90
Ossipee River	120
Little Ossipee River	190
Saco River at mouth	220
Total	**1,700**

Figure 44 illustrates the location of the Saco River Basin within Maine.

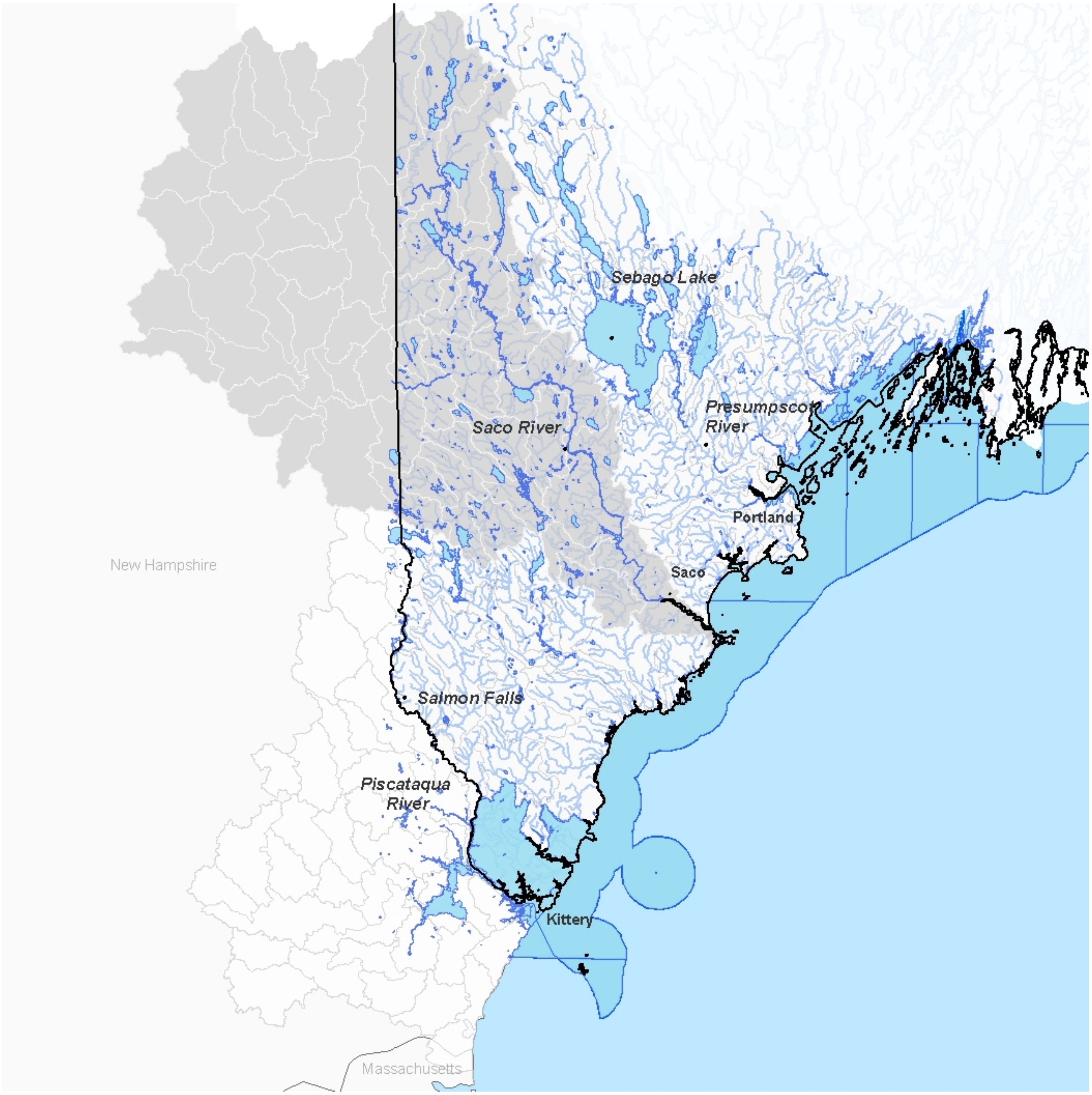


Figure 44. Western Coastal Drainage Basin Featuring the Saco River

6.2 Dams and Reservoirs

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that the Saco River Basin contains approximately 44 dams. Ten of the dams within the river basin are used for generating hydroelectric power, three are used for flood control and stormwater management, three are used for water supply, and fourteen are used for recreational use. Eleven dams are used for “other” purposes.

The storage capacity of impoundments in the Saco River Basin is approximately 96,000 acre-feet. Appendix E contains the list of dams located within the Saco River Basin and included in the collaborative dam database.

6.3 Precipitation

Average annual precipitation within the Saco River Basin is 44.8 inches with a high proportion of rainfall occurring during November and December. Annual snowfall ranges from forty inches near the Atlantic Coast to 115 inches in the mountainous headwaters. The water content of the snow averages five inches over the entire basin.

6.4 Population

The Saco River Basin contains all or portions of two cities (Saco and Biddeford), twenty-nine towns, two unincorporated areas, and falls within three counties. Table 48 presents the historical population data within the Saco River Basin. The population within the drainage basin has increased since the 1970s, and the number of people residing in the cities continues to increase.

Table 48. Saco River Basin, Population within Maine

Census date	Population	Population in cities
1970	38,900	20,600
1980	50,100	20,800
1990	59,200	22,600
2000	67,100	24,000

6.5 Historic Flooding Events (1970 – 2007)

Flooding within the Saco River Basin is most often caused by heavy precipitation alone or moderate precipitation in combination with melting snowpack. Table 49 presents the list of major and minor flood events identified within the Saco River basin between 1970 and the present using the sources of data described in Section 1 of this report. The flood events indicated with an “x” are described in greater detail in the following sections of the report.

Table 49. Saco River Basin. Identified Flood events

	Date	Flood Location	Flood Documentation	Damages
	March 1977	Little Ossipee River	USGS	
x	March 1983	Mousam River	USGS	
x	March/April 1987	Saco River, Ossipee River	USGS	
x	October 1996	Little Ossipee River, Mousam River	USGS	
x	May 2006		Photo Record	

CRREL – Ice jam database, USGS – Streamgage record, ACOE – 1987 study, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report

The USGS record of peak discharge and stage at streamgages within the Saco drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the Saco River Basin. Table 50 presents the highest recorded daily discharge at selected streamgages. The flood of record for the drainage basin occurred in March 1936. The flood of record for the Mousam River occurred In March 1983.

Table 50. Saco River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01065500	Ossipee River at Cornish, Maine	3/21/1936	17,200	16.32
01066000	Saco River at Cornish, Maine	3/21/1936	46,600	21.9
01066500	Little Ossipee River near south Limington, ME	3/19/1936	8,530	
01067000	Saco River at West Buxton, ME	3/22/1936	58,200	
01067500	Saco River at Salmon Falls, ME	3/22/1936	59,000	30.2
01069500	Mousam near West Kennebunk, ME	3/20/1983	4,020	5.64
01072500	Salmon Fall River near South Lebanon, ME	3/19/1936	5,490	12.31

6.5.1 Notable Historical Floods

Flooding within the Saco River basin typically occurs in the spring as the result of snowmelt or in combination with rainfall. The flood of record occurred in March 1936 on the lower reaches of the Saco River Basin and was exacerbated by ice jams. In Hiram, Maine, this event represented the event with a 375-year return period. The event in 1953 is considered the one hundred year return period event.

6.5.2 March 1983

The Mousam River experienced a flood of record during March of 1983. At the time of publication no additional information was available to describe this flood event.

6.5.3 March/April 1987

The Saco River Basin received approximately three inches of precipitation between March 31 and April 1, 1987. The rainfall was accompanied by warm temperatures and melting snowpack. Three days later, a second storm dropped approximately two inches of rain over the saturated basin. Table 51 presents the presents the observed stage, discharge, and recurrence interval (where available) for the March/April 1987 flood. The USGS estimated the return period of the flows on the Saco River to be one hundred to five hundred years.

Table 51. Saco River Basin, USGS Streamgage Peaks, March/April 1987

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01065500	Ossipee River at Cornish, Maine	10.9	9,460	25
01066000	Saco River at Cornish, Maine	16.54	31,300	100-500

6.5.4 October 1996

[At the time of publication, there is no information available to describe this flood event.]

Table 52. Saco River Basin, USGS Streamgage Peaks, October 1996

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01066100	Saco River at Cornish, Maine	5.95	352	10-25
01066500	Little Ossipee River near South Limington, ME	7.02	5,800	25-50

6.5.5 May 2006

The photo record indicates that flood damages occurred in Wells, Maine during May 2006. Table 53 presents the observed stage, discharge, and recurrence interval (where available) for the May 2006 flood. Figure 45, Figure 46, Figure 47, Figure 48, and Figure 49 illustrate the damages incurred during this event.

Table 53. Saco River Basin, USGS Streamgage Peaks, May 2006

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01066000	Saco River at Cornish, Maine	10.34	14,900	2-5

Figure 45. Captain Thomas Road, Wells, Maine. Bridge Washout, May 14, 2006

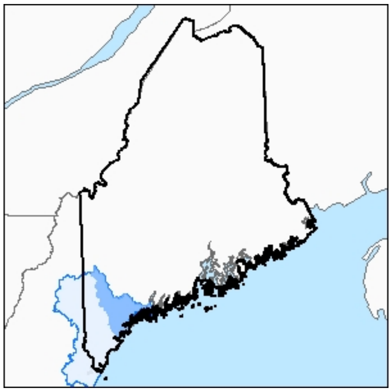
Figure 46. Captain Thomas Road, Wells, Maine. Bridge Washout, May 14, 2006

Figure 47. Cole's Hill Road. Bridge Washout, May 14, 2006

Figure 48. Skinner Mill, Wells. May 14, 2006

Figure 49. Swamp John Road, Wells. May 14, 2006

7.0 Presumpscot River Basin (Western Maine Coastal)



Historically, the Presumpscot River Basin received little damage as a result of flooding. In a 1977 report, the ACOE discounted the Presumpscot as having little to no risk of flooding. The New England River Basin Commission wrote in a 1981 report that “flooding is not a major problem in the basins due to storage capacity of numerous natural and manmade lakes above Sebago Lake and the small size of the watersheds.” Since April 1993, the river has surprised residents several times and inundated Portland and surrounding communities causing extensive damage. Historical flood data on the Presumpscot River is sparse; there is little information available in the scientific record.

7.1 Watershed Description

The Presumpscot River originates at Sebago Lake and terminates in Portland, Maine. The river flows through the towns of Windham, Gorham, and Westbrook before exiting to Casco Bay. The watershed is very hill and is partially developed.

Table 54 presents the major tributaries to the Presumpscot River along with their respective drainage area.

Table 54. Presumpscot River, Tributaries from Upstream to Downstream and Drainage Areas

Tributary	Drainage Area (square miles)
Sebago Lake	440
Royal River	140
Presumpscot River	210
Scarborough River	50
Fore River	50
Casco Bay Coastal Drainages	170
Total	**1,070**

Figure 50 illustrates the location of the Presumpscot River basin within Maine.

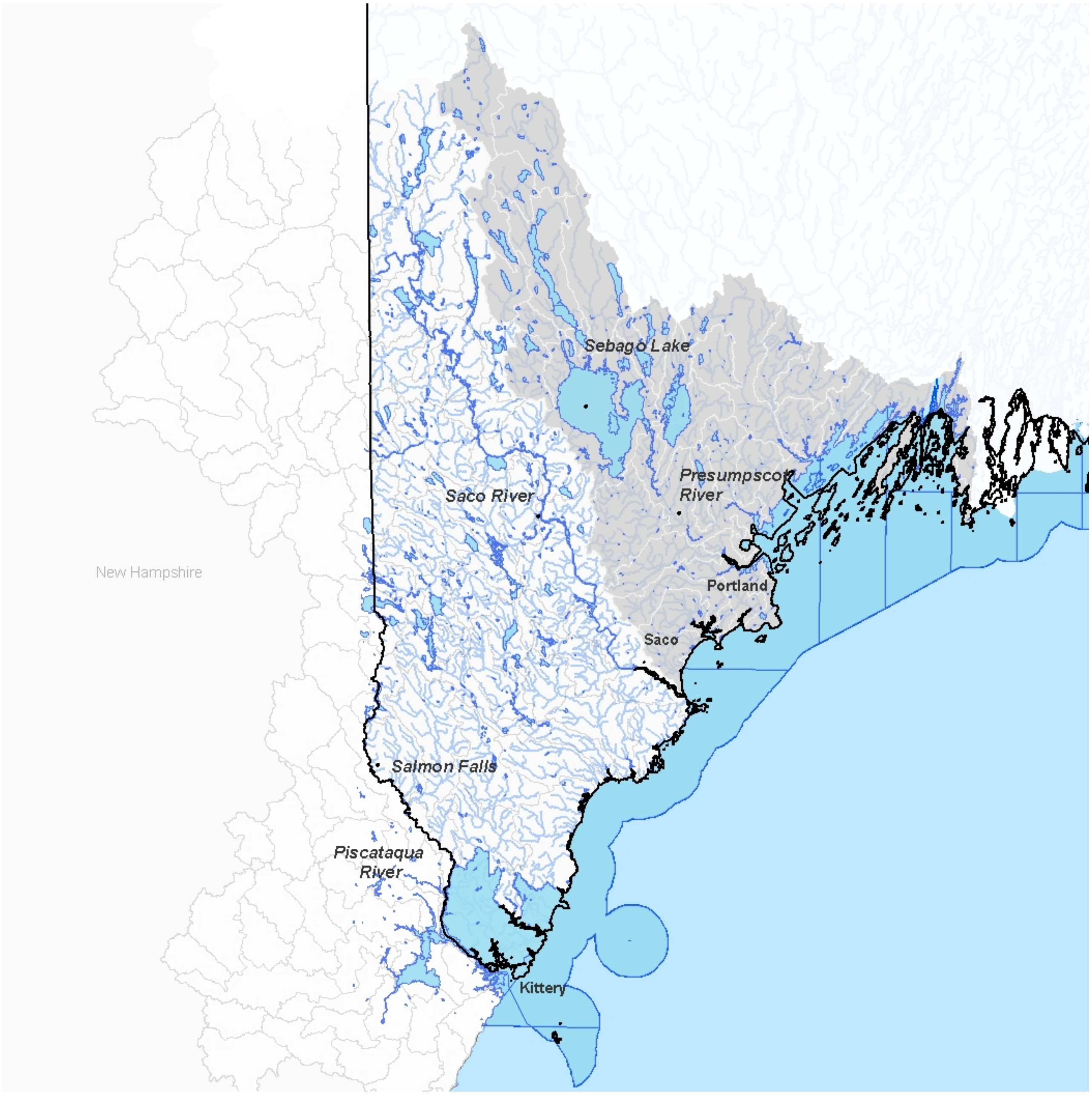


Figure 50. Western Coastal Drainage Basin Featuring the Presumpscot River

7.2 Dams and Reservoirs

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that the Presumpscot River Basin contains approximately 44 dams. Nine of the dams are used for generating hydroelectric power, one for flood control and stormwater management, three for water supply, and four for recreational use. Three dams are used for "other" purposes.

The storage capacity of impoundments in the Presumpscot River Basin is approximately 367,000 acre-feet. Appendix E contains the list of dams located within the Presumpscot River Basin and included in the collaborative dam database.

7.3 Precipitation

Average annual precipitation within the Presumpscot River Basin is 44.8 inches with a high proportion of rainfall occurring during November and December. Annual snowfall ranges from forty inches near the Atlantic Coast to 115 inches in the mountainous headwaters. The water content of the snow averages five inches over the entire basin.

7.4 Population

The Presumpscot River Basin contains all or portions of two cities (including Portland and Westbrook), ten towns, and falls within two counties. Table 55 presents the historical population data within the Presumpscot River Basin. The population within the drainage basin has increased since the 1970s. The number of people residing in the cities has remained relatively constant.

Table 55. Presumpscot River Basin, Population

Census date	Population	Population in cities
1970	49,000	25,000
1980	58,000	24,000
1990	65,000	26,000
2000	73,000	26,000

7.5 Historic Flooding Events (1970 – 2007)

Flooding within the Presumpscot River Basin is most often caused by heavy precipitation or moderate precipitation in combination with snowmelt. The flood of record on the Presumpscot River occurred in March 1936. Gaging is generally inadequate to capture the flooding that has occurred recently on the Presumpscot River in Portland Maine. Table 56 presents the list of major and minor flood events identified within the Presumpscot River basin between 1970 and the present using the sources of data described in Section 1 of this report. The flood events indicated with an "x" are described in greater detail in the following sections of the report.

Table 56. Presumpscot River Basin. Identified Flood events.

	Date	Flood Location	Flood Documentation	Damages
	March 1977	Presumpscot River	USGS, FIS	
	April 1987	Royal River	USGS	
x	April 1993	Presumpscot River		
x	April 1996	Presumpscot River	USGS	
x	October 1996	Presumpscot River	USGS	
x	October 1998	Presumpscot River	USGS	

CRREL – Ice jam database, USGS – Streamgage record, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report

The USGS record of peak discharge and stage at streamgages within the Presumpscot drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the Presumpscot River Basin. Table 57 presents the highest recorded daily discharge at selected streamgages. The basin-wide flood of record occurred in March 1936. The flood of record at the headwaters of Sebago Lake occurred in 1917.

Table 57. Presumpscot River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01060000	Royal River at Yarmouth, Maine	3/13/1977	11500	8.46
01064118	Presumpscot River at Westbrook, Maine	10/22/1996	23300	34.1
01064140	Presumpscot River near West Falmouth, ME	3/14/1977	12500	21.11

7.5.1 April 1993

[At the time of publication, no additional information was available for this event]

Table 58. Presumpscot River Basin, USGS Streamgage Peaks, March/April 1993

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01064118	Presumpscot River at Westbrook, Maine	16.1	5,080	<2
01064000	Presumpscot River at outlet of Sebago Lake, ME		1,650	2-5
01060000	Royal River at Yarmouth, Maine	5.86	4,910	2-5

7.5.2 April 1996

[At the time of publication, no additional information was available for this event]

7.5.3 October 1996

[At the time of publication, no additional information was available for this event]

Table 59. Presumpscot River Basin, USGS Streamgage Peaks, October 1996

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01064118	Presumpscot River at Westbrook, Maine	34.1	23,300	100-500

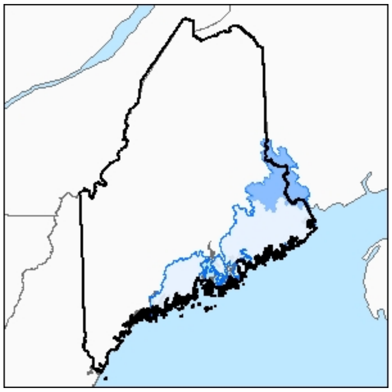
7.5.4 October 1998

[At the time of publication, no additional information was available for this event.]

Table 60. Presumpscot River Basin, USGS Streamgage Peaks, October 1996

Station	Name	Stage	Discharge (cfs)	Estimated Recurrence Interval (years)
01060000	Royal River at Yarmouth, Maine	6.41	5,840	5-10

8.0 St. Croix River Basin (Eastern Maine Coastal)



The Eastern Coastal Drainage Basin includes many small rivers draining directly to the Atlantic Ocean. The St. Croix River Basin is the largest river basin located within the Eastern Coastal Drainage Basin. This section of the report describes historical flooding within the St. Croix River Basin.

The St. Croix River forms the border between Maine and Canada with a major border crossing at the Route 1 Bridge at Calais – St. Stephen. [Additional information on the St. Croix River Basin was not available at the time of publication of this report]

8.1 Watershed Description

The St. Croix River Basin occupies approximately 1,650 square miles of northeastern Maine. Table 61 presents the major tributaries to the St. Croix River along with their respective drainage areas.

Table 61. St. Croix River, Tributaries and Contributing Areas

Tributary	Drainage Area (square miles)
Spednick Lake	410
St. Croix River (2) at Spednick Falls	220
West Grand Lake	230
Big Musquash Stream	120
Big Lake at Peter Dana Point	120
Tomah Stream	150
St. Croix River (3) at Grand Falls	70
St. Croix River (6) at Robbinston	330
Total	**1,650**

Figure 51 illustrates the location of the St. Croix River basin within Maine.

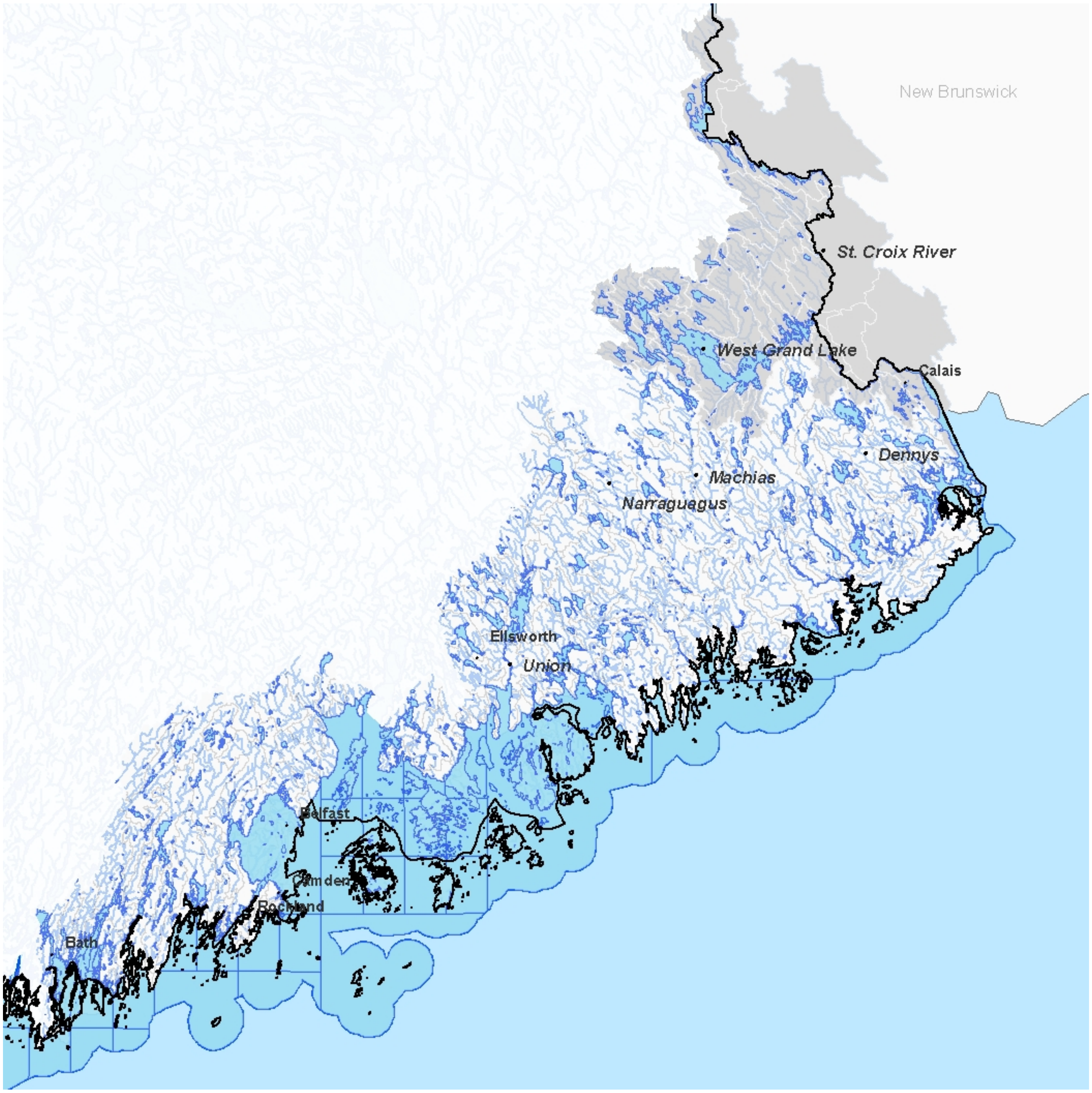


Figure 51. Eastern Coastal Drainage Basin Featuring the St. Croix River Basin

8.2 Dams and Reservoirs

In general, dams in Maine are not constructed as flood control structures. However, the dams with large impoundment capacity can be useful for controlling flood discharges if their reservoirs are below capacity. Many dams in the lower reaches of Maine's rivers are run-of-river dams, and have little or no capacity to capture and hold runoff during floods (MGS, 2005).

The collaborative dam database indicates that the St. Croix River Basin contains approximately 20 dams. Three of the dams within the river basin are used for generating hydroelectric power, three are used for flood control and stormwater management, two are used for water supply, and three are used for recreational use. Fourteen dams are used for “other” purposes.

The storage capacity of impoundments in the St. Croix River Basin is approximately 1,048,000 acre-feet. Appendix E contains the list of dams located within the St. Croix River Basin and included in the collaborative dam database.

8.3 Precipitation

The average annual precipitation in the St. Croix River Basin is approximately forty inches uniformly distributed throughout the year. The average annual snowfall in the St. Croix River Basin ranges between 70 and 100 inches with an average water content in March of three to six inches.

8.4 Population

The St. Croix River Basin contains all or portions of one city (Calais), seventeen towns, four plantations, one reservation, eighteen unincorporated areas, and falls within four counties. Table 55 presents the historical population data within the St. Croix River Basin.

Table 62. St. Croix River Basin, Population within Maine

Census date	Population	Population in cities
1970	8,300	4,000
1980	9,000	4,200
1990	8,700	4,000
2000	7,900	3,400

8.5 Historic Flooding Events (1970 – 2007)

Flooding within the St. Croix River Basin is most often caused by heavy precipitation or moderate precipitation in combination with snowmelt.

A 1981 report indicates that the worst flood in the basin occurred in May 1923. The second largest flood occurred in 1909 due to precipitation following a drought. One community FIS indicates that the flood of record in their town occurred in May 1961. [At the time of publication, no additional information was available to determine the event of record for the St. Croix River Basin.]

Table 49 presents the list of major and minor flood events identified within the Saco River basin between 1970 and the present using the sources of data described in Section 1 of this report. The flood events indicated with an “x” are described in greater detail in the following section of the report.

Table 63. St. Croix River Basin, Identified Flood Events

	Date	Flood Location	Flood Documentation	Damages
x	April 1973	St. Croix River	USGS, NERBC	$21,000 damages
	April 1976	St. Croix River	USGS	
	April 1983	Grand Lake Stream	USGS	
	April 1984			
	June 1984	St. Croix River	USGS	
	April 1996			
	December 2005			

CRREL – Ice jam database, USGS – Streamgage record, FIS – Flood Insurance Study, IHMT – Interagency Hazard Mitigation Report
NERBC – New England River Basin Commission

The USGS record of peak discharge and stage at streamgages within the St. Croix drainage basin indicate major high flow events, which may have resulted in flooding. Appendix B contains a streamgage inventory of all active and historical gages in the St. Croix River Basin. Table 64 presents the highest recorded daily discharge at selected streamgages.

Table 64. St. Croix River Basin, Flood of Record at Streamgages

Site	Site Name	Date	Discharge (cfs)	Gage Height
01018500	St. Croix River at Vanceboro, Maine	6/3/1984	6,730	11.28
01019000	Grand Lake Stream at Grand Lake Stream, Maine	12/2/2005	3,990	7.75
01021000	St. Croix River at Baring, Maine	5/1/1923	24,100	

8.5.1 April 1973

Between April 21 and 23, 1973, rain fell on melting snowpack (NERBC, 1981).

[At the time of publication, no additional information was available for this event]

9.0 Data Inventory

9.1 USGS Stream Gage Inventory

The USGS maintains a network of water-resource data collection sites across the United States, Puerto Rico, and Guam. The type of data collected at any one station may vary, but can be classified as either surface-water data or ground-water data. Surface water data collection stations typically maintain a continuous record of gage height (stage) and streamflow (discharge). This report includes an inventory of all historical and current stream gaging stations in Maine recorded within the National Water Information System (NWIS) database. The database is publicly available to users in real-time via the internet. Appendix B contains the inventory of stream gaging stations located in Maine and sorted by HUC 6 drainage basin.

9.2 USGS Peak Annual Discharge Inventory

The USGS has developed summary data for a large number of stream gaging stations. The NWIS database provides summary data including the peak annual flow and stage at most, but not all, stream gages. The peak annual discharge can be used to identify flood events in years where there has been only one event. The peak annual discharge can also be used to compare the discharge from flood events to the typical peak flow for years without measurable flooding. Appendix C contains the peak annual data for all gaging stations within Maine that report summary data.

9.3 Precipitation and Weather Data

The NOAA National Weather Service produces many data products that may be used to predict or analyze flood events. As a stakeholder in this study, the NWS has provided the location of weather stations within Maine and New Hampshire and total daily precipitation data recorded at weather stations for the days leading up to and during flood events listed the Maine disaster declaration list. The NWS has also provided maps showing 24-hour precipitation data, surface weather, pressure data, and temperature data across the United States. Appendix D contains the data compiled for the purpose of this study.

9.4 Dams

The Maine Office of Geographical Information Systems (MEGIS) distributes a geo-spatial database of dams located within Maine. The database combines dam surveys initiated by the US Army Corps of Engineers 1987 Dam Survey, the Maine Department of Environmental Protection (MEDEP), and the Bureau of Land & Water Quality. In 2004, the MEDEP released the data to the Maine Emergency Management Agency for use in emergency planning.

Appendix E presents the database of dams sorted by primary drainage basin within Maine. For each dam, the table in Appendix E presents the unique dam identification number, the official and common name of the dam, the name of the river on which the dam is located, the name of the dam owner, and the primary purpose(s) of the dam. Dams may be classified for use in the following categories: irrigation, hydroelectric power generation, flood control and stormwater management, navigation, water supply, recreation, fire protection, fish and wildlife habitat, debris control, tailings management (mining), and “other”. The database also includes the storage capacity of the dam and the maximum discharge capacity from the impoundment.

9.5 Population

MEGIS distributes the U.S. Census population data in a geo-spatial database for the census data gathered between 1950 and 2000. This geo-spatial data was used to estimate the population in the Maine River Basins for the corresponding census years. For towns falling along the watershed divide between two drainage basins, the population in each drainage basin was estimated using the area-weighting method.

Appendix F presents the historical population data for each of the six drainage basins presented in this study. The communities within each drainage basin are also included. For communities falling within two or more drainage basins, the proportion of the total population assigned to each drainage basin is proportional to the total land area falling within each drainage basin.

9.6 Ice Jam Data

The CRREL Program at the US Army Corps of Engineers specializes in applying science and engineering to complex environments, materials, and processes with unique competencies related to the Earth's cold regions. The Ice Engineering Research Division of CRREL maintains a database of ice jams across the United States with records from 1896 to the present day. The database is populated with information obtained through personal knowledge via site visit, phone conversation, detailed study, or literature reference. The database is heavily populated with ice jam events occurring at USGS water-stage gages, which often maintain a record of the stage and discharge during the ice jam event, but do not maintain a record of ice thickness, extent, likely causes, and damages associated with the event.

Appendix G presents the CRREL ice jam database for all jams observed in Maine from 1970 to the present (2007). The table contains information on the jam date, type, location (in latitude and longitude), the associated USGS stream gage, a detailed description of the jam, a comment on damages, the availability of supplemental visual observations (photos), and the availability of supplemental reports.

9.7 Snow Pack Data

The Maine Geological Survey (MGS) maintains raw and summary data of snow pack information within Maine. The snowpack database includes survey stations and locations, date of observation, elevation of station, depth of snow, water content, and snow density. Data for the year 2007 is available via the MEMA internet site.

Marc Loiselle of the MGS has provided the historical data in a personal geodatabase format. The database is included in Appendix H on a compact disk.

9.8 Disaster Declarations

The Federal Emergency Management Agency publishes and distributes a list of disasters and supporting information via the FEMA internet website. Disaster declarations may be made for any type of natural hazard including flooding, mudslides, ice jams, fire, hurricane, high winds, ice storms, etc… Appendix I contains a list of all 45 disaster declarations made on behalf of the State of Maine between 1954 and 2007.

9.9 Digital Floodplain Mapping

The Federal Emergency Management Agency publishes Flood Insurance Rate Maps (FIRMs) for communities participating in the National Flood Insurance Program. Within Maine, some but not all of the paper based FIRMS have been converted to geospatial data sets called Q3 floodplain boundaries. Geospatial Q3 data has been created on a county-wide basis for communities within Cumberland, Hancock, Kennebec, Oxford, Penobscot, Sagadahoc, Waldo, Washington, and York Counties. The digital Q3 floodplain boundary data, originally published in 1996/1997, is available through MEGIS. Although Q3 data is available at the county-wide level, some communities within the county may not have floodplain boundary information. FEMA is currently implementing a Map Modernization Program, which will ultimately result in the production of native digital flood insurance rate maps for a large portion of the United States. Appendix J presents the availability of Q3 digital floodplain boundary data organized by drainage basin and county.

9.10 Storm Event Database

The National Climatic Data Center (NCDC) of NOAA distributes a description of extreme weather events in a searchable database via the World Wide Web. The data in the Storm Event database originates from National Weather Service publications based information obtained from county, state, and federal emergency management officials, local law enforcement officials, skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry, and the general public. The event record within the database includes the dates of the beginning and end of the event, the location of the event, magnitude, fatalities, injuries, property damage, and crop damage. The description of the event often includes the weather conditions leading to the event. The Storm Event database includes information for events dating from April 1993 to the present. Three hundred and nine events are identified between April 4, 1993 and October 10, 2007. Future efforts for expanding this report may include adding the narrative text included in the Storm Event database. The web address to the searchable storm event database is included here.

http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

10.0 Future Work and Annual Updates

This report provides a synthesis of data relevant to riverine flooding within the State of Maine. This data supports the State Hazard Mitigation Plan to provide detailed flood data in an accessible format to the public, local governments, and state and federal agencies. This report includes all data that was identified, collected, and synthesized prior to publication; however, new data sources continue to be identified. Future work may include expanding this report to contain:

- Flood information on the small coastal rivers in the Eastern and Western Coastal Drainage Basins
- An expanded list of flood events including flood events that date after the publication of this report
- An expanded list of flood events including flood events that date prior to 1970
- Discussion of the response and/or action taken as a result of a particular flood event, which may include mitigation such as acquisition of land or levee construction
- A description of the weather event that caused the flooding as described in the Storm Event database
- Incorporation of data on high-water marks and monuments available at the community level
- An expanded newspaper record including text and photos of flooding
- Expanded table in each section of the report indicating peak USGS flow recorded at streamgaging stations. Include all historical and short-record streamgages in this table (not just long-record and active gages) identify the contributing area and the flood stage at each gage.

The Maine State Planning Office and the Maine Emergency Management Agency will review this report on an annual basis to determine whether the report is meeting the intended goals. A minor effort to continue to identify sources of relevant data shall be ongoing throughout the year. When reason and funding allow, the additional data shall be incorporated into the report.

11.0 References

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12.0 Draft Framework for a Web-Based Geographic Database

[Consider this section a draft/outline only]

The grant application requesting funding for this study indicates that the purpose of this report is *"to provide detailed information in a useable format… to be migrated to a webbased system for wider use by local governments and state agencies for preparing grant applications, implementing projects, and managing the State's floodplains. "*

This section of the report outlines a framework that may be used to develop a geo-spatial database that would logically correlate the data described in Section 1.4 for use in querying historical flood data. Production of this geospatial database will not be completed within the scope of this study. However, the plan presented below may be useful going forward for developing a relational database in the future.

12.1 GIS Data Inventory

Towns (metwp24, MEGIS)

Counties (metwp24, MEGIS)

Watersheds (wbdme6_a, MEGIS)

USGS gages (USGS, NWIS)

Dams (impound, MEGIS),

Bridges (bridges, MEDOT),

Rivers and Tributaries (USGS, NHD),

NOAA stations (NOAA, NWS, Tom Hawley).

Snowpack Stations (MGS, Marc Loiselle)

Q3 Digital Floodplain Boundaries (MEGIS, FIRM)

Storm Event Locations (NWS, NCDC)

12.2 Plan for linking data

Each flood event will be given a single day date.

Each flood event will be located at a specific point.

If the flood event spans several days, there will be as many records (points) as days in the flood.

A flood can be located at a USGS gaging station on a day where the instantaneous stage is greater than the flood stage or at an Ice Jam location where the description of the flood jam includes notes on flooding or damages. At gaging stations and ice jam locations, coordinates are given in latitude and longitude. A flood event may also occur at address as reported by word-of-mouth or in a newspaper article.

Each flood event date is located in a town, a county, and a/many drainage basin(s) (Huc 6, 8, 10, 12).

Each flood event date should be linked by date to the daily stage and daily discharge if it is located at a USGS gaging station.

Each flood event date should have a unique ID that correlates multi-date floods to one distinct event

A flood event can be linked by unique ID to the precipitation records and the snowpack records

A flood event can link to a photograph or a newspaper article, if available.

If a county is declared a disaster area, the disaster declaration should be combed for reference to flood source.

A flood event can contain a field for: structures damaged (qty), lives lost (qty), injuries (qty), total losses ($), disaster funds ($), Notes (text field).

Flood event points database (not yet created, will contain a subset of USGS gages, Ice Jam locations, and notable flooding in newspapers, etc…)

Appendix A

Historical Flood Events, USGS

Appendix B

Streamgage Inventory, USGS

Appendix C

Streamgage Data: Peak Annual Discharge with Stage, USGS

Appendix D

Weather Data for Storm Events, NOAA, NWS

Appendix E

Dams, ACOE, BL&WQ, MEDEP, MEMA

Appendix F

Population, US Census

Appendix G

CRREL Ice Jam Database, ACOE

Appendix H

Snowpack Data, MGS

Appendix I

Disaster Declarations in Maine, FEMA/MEMA

Appendix J

Digital Floodplain Data (Q3) Inventory, FEMA