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St. Mary River and Milk River Basins Study Technical Report

Milk River Project, Montana
Great Plains Region

U.S. Department of the Interior
Bureau of Reclamation

State of Montana
Department of Natural Resources
and Conservation

March 2012

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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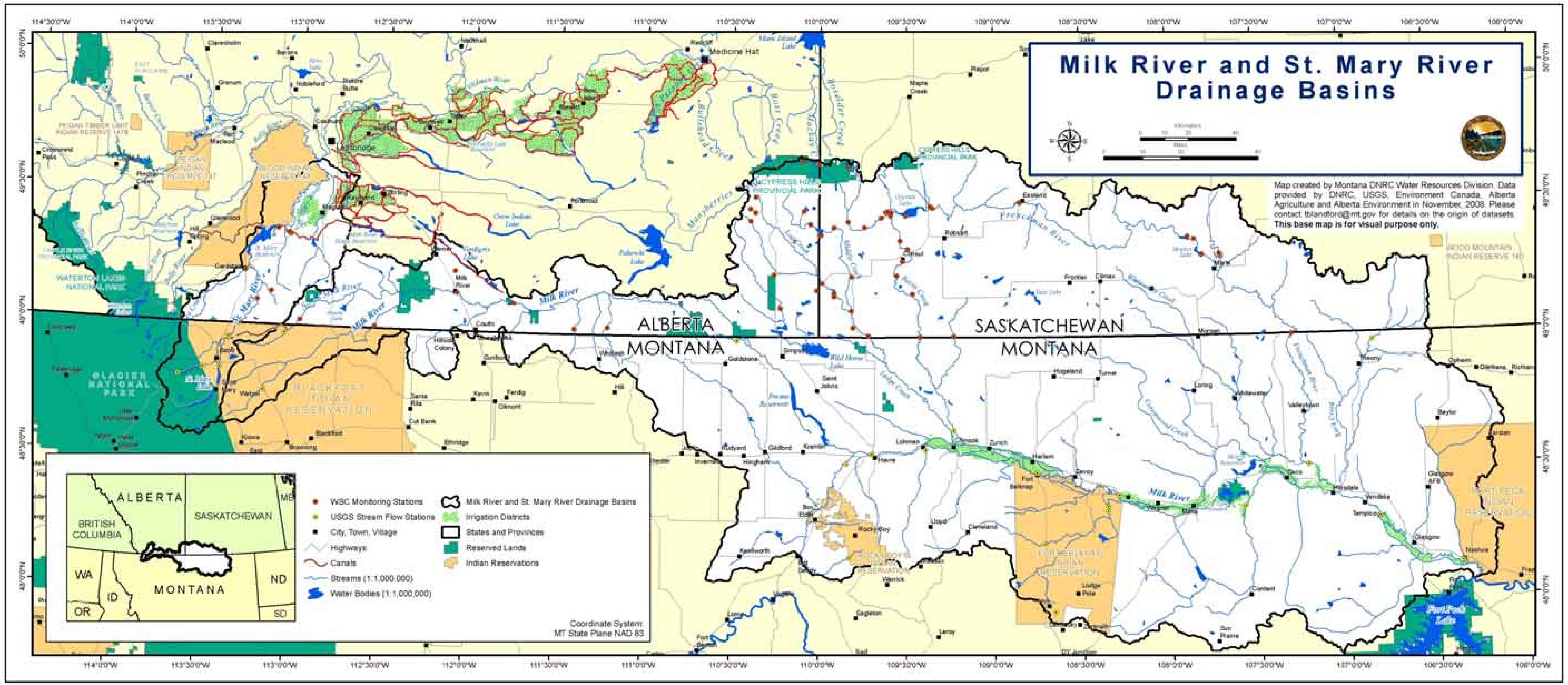
Acronyms and Abbreviations

°F	degrees Fahrenheit
AF	acre-feet
CFS	cubic feet per second
DEQ	Montana Department of Environmental Quality
DNRC	Montana Department of Natural Resources and Conservation
Eastern Crossing	Milk River at the Eastern Crossing of the International Boundary
ESA	Endangered Species Act
FW&P	Montana Department of Fish, Wildlife & Parks
GCM	General Circulation Model
HDe	Period Change Hybrid Delta Ensemble
IJC	International Joint Commission
MR&I	municipal, rural, and industrial
MSL	mean sea level
NRCS	U.S. Natural Resources Conservation Service
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RB/NCMRWS	Rocky Boy's/North Central Montana Rural Water System
SAC-SMA	Sacramento Soil Moisture Accounting Model
SAC-SMA/SNOW-17	Combined use of the Sacramento Soil Moisture Accounting and Snow Accumulation and Ablation hydrologic models
SNOW-17	Snow Accumulation and Ablation Model
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Western Crossing	Milk River at the Western Crossing of the International Boundary



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Chapter 1: Introduction

The Basin Study Program, part of the U.S. Department of the Interior's WaterSMART Program, addresses 21st century water supply challenges such as increased competition for water supplies and climate change. Through this program, the U.S. Department of the Interior's Bureau of Reclamation (Reclamation) and the Montana Department of Natural Resources and Conservation (DNRC) cooperated to create a river system model that can help stakeholders evaluate solutions to water supply issues of the St. Mary River and Milk River basins. The river system model was used to characterize existing and projected future water shortages and to evaluate alternatives for meeting future demands. An important component of the study was developing flow and water demand input data for future climate change scenarios. Potential impacts of climate change were also evaluated using the river system model.

This study examines St. Mary and Milk River basins in northern Montana (shown on the frontispiece, figure 1.8 at the end of this chapter, and described in the "Setting" section later in this chapter) where water shortages are presently experienced and expected to grow more acute in the future. The study has incorporated the latest science, engineering technology, and climate projections available. The accompanying summary report contains the consultation and coordination information.

In this report:

- Chapter 1 introduces the Basin Study, including the study purpose.
- Chapter 2 details present and future water supplies and demands in the basins.
- Chapter 3 explains how the river system model was developed.
- Chapter 4 discusses the baseline condition (existing system and present water supply and demands) and the ability to meet future water demands under the baseline.
- Chapter 5 presents and evaluates alternatives to meet future water demands.
- Chapter 6 presents findings and recommendations.

Purpose

The *St. Mary River and Milk River Basins Study* purpose was to analyze current and future supply and demand imbalances and potential adaptation strategies, with a focus on the development of a daily time step river system model. This tool could be used to assist in analyzing a range of alternatives to address present and future water needs in the basins. In the Milk River basin, water shortages have been well documented. Securing an adequate supply of water to support municipalities; rural water users; fish, wildlife, and recreation; along with the region's agricultural economy in the face of competing demands for a limited resource is a major challenge.

The Basin Study also provides a first look into what future water supplies and demands might be under a warming climate and how the existing, aging infrastructure would perform when attempting to meet future demands. The study evaluates how changes to the system, including modifications or replacements to existing facilities and non-structural changes, might be used to ease imbalances between supply and demand to meet future water needs.

The *North Central Montana Regional Feasibility Report* (Reclamation, 2004b) documented existing water needs, water shortages, issues, and alternatives to address shortages in the Milk River basin. As that study stated:

> Water is crucially short in north central Montana. Irrigation, municipal, rural, and industrial (MR&I) water supplies, threatened and endangered species, water quality, Federal reserved water rights, fish and wildlife species, recreation, and hydro-power needs in the region must be met by Reclamation facilities built, in many cases, a century ago. As a result, competing demands are increasingly at odds over a finite supply of water (p.1).

The *St. Mary River and Milk River Basins Study* does not attempt to duplicate that report, but builds on previous work by developing a more powerful tool for evaluating alternatives and the effects of climate change. This Basin Study report does not include cost/benefit analysis of alternatives, nor does it recommend specific alternatives or feasibility studies.

Planning Objectives

Several planning objectives guided the study:

- To provide a river system model commonly accepted by all stakeholders in the basins that could be used for present and future water resource planning

- To analyze how climate change might affect water supplies, demands, and shortages in the future
- To model a range of alternatives and analyze their capability to ease imbalances between water supply and demand

Authority

This study is authorized by Title IX, Subtitle F, of Public Law 111-11 (Secure Water Act).

Setting

The headwaters of the St. Mary River and Milk River basins run from the Rocky Mountains in the west to the Milk River confluence with the Missouri River below Fort Peck Dam in the east. The St. Mary River rises in Glacier National Park, flowing northeast through the Blackfeet Reservation into Canada to its confluence with Oldman River near Lethbridge, Alberta. The Milk River originates in the foothills of the Rocky Mountains on the Blackfeet Reservation, flowing northeasterly into Alberta for about 200 river miles before crossing the border again into Hill County, Montana. Thereafter, the river flows in an easterly direction for 490 river miles until joining the Missouri River near Fort Peck, Montana.

Climate

The historic climate of the region is typical of the northern Great Plains, with wide variations in temperature from season to season. Summers are cooler and wetter in the higher elevations of the western part of the region near Glacier National Park where snow is reported in every month of the year. The Babb, Montana, weather station is closest to the St. Mary River with a period of record from 1948 to 2005. Near the center of the region, the Havre, Montana, station (WSO AP) has a period of record from 1961 to 2005. The Glasgow, Montana, weather station (Glasgow WSO Airport) is on the eastern edge of the region with a period of record from 1955 to 2005. Weather information is summarized in table 1.1 (Western Regional Climate Center, 2012).

Water

The St. Mary River produces a relatively dependable flow in the summer due to its higher elevation snowmelt and rainfall in Glacier National Park. The Milk River is a foothills and prairie stream and produces less water because it has far less high-elevation drainage area than the St. Mary

Table 1.1: Weather Data from Selected Sites in the Region

	Babb (1948–2011)	Havre (1961–2005)	Glasgow (1955–2005)
Average maximum temperature	53 °F[1]	56.2 °F	54.3 °F
Average minimum temperature	26.8 °F	30.1 °F	30.8 °F
Average annual temperature	40 °F	43 °F	42.5° F
Highest maximum temperature	99 °F (8/24/1969)	111 °F (8/5/1961)	108 °F (8/6/1983 and 6/5/1988)
Lowest minimum temperature	-43 °F (12/8/1977)	-52 °F (1/24/69)	-47 °F (1/25/1969)
Average annual precipitation	18.04 inches	11.16 inches	10.99 inches
Average annual snowfall	49.7 inches	42.5 inches	30.1 inches
Average frost-free days	66	128	138

[1] Degrees Fahrenheit.

River. For part of its length, the St. Mary flows near the North Fork of the Milk River, offering the opportunity for a transbasin diversion. Congress authorized construction of the St. Mary facilities in 1905 to take advantage of St. Mary River flows to supplement flows in the Milk River for irrigation. Water is diverted from the St. Mary River by the St. Mary Diversion Dam just downstream from the outlet of Lower St. Mary Lake and is conveyed to the North Fork of the Milk River through a 29-mile canal, siphon, and drop system. Lake Sherburne on Swiftcurrent Creek, a tributary of the St. Mary River, stores winter and high spring flows for later release to keep the St. Mary Canal running near full longer through the irrigation season.

The Milk River flows into Canada near the Del Bonita Border Station on the Blackfeet Reservation at the Western Crossing of the International Boundary (Western Crossing). Shortly after flowing into Canada, the North Fork of the Milk River, which conveys imported water from the St. Mary Canal, joins with the Milk River main stem. The Milk River then flows through southern Alberta before turning south and re-entering the U.S. at what is referred to as the Eastern Crossing of the International Boundary (Eastern Crossing) just upstream of Fresno Reservoir. Milk River flows, which now include the transported St. Mary Canal water, are stored and regulated in Fresno Reservoir near Havre. Nelson Reservoir, an off-stream reservoir about midway on the system near Malta, captures and re-regulates surplus flow in the river. St. Mary River water and Milk River natural flow is used to irrigate about 140,000 acres in Hill, Blaine, Phillips, and Valley Counties. These reservoirs also provide recreation, flood control, and fish and wildlife benefits to the region. Water supplies in the region are described in more detail in chapter 2.

Water Quality

Under the Clean Water Act, the Montana Department of Environmental Quality (DEQ) classifies water quality by water use, with Montana standards equal to or exceeding United States Environmental Protection Agency water quality standards. Classes run from A-closed (the highest water quality) through A-1, B, C, to I (the lowest quality). These classes characterize the suitability of the water for drinking; processing food; bathing; swimming; propagation and growth of fish and aquatic life, waterfowl, and furbearers; and agricultural and industrial use.

The St. Mary River outside Glacier National Park is classified B-1, suitable for drinking and food processing after conventional treatment, as well as all other uses. The St. Mary River in Glacier National Park is classified A-1, suitable for all water uses. From Glacier National Park to the Canadian border, it is classified as B-1. From the Eastern Crossing to where the Milk River joins with the Missouri River, the Milk River is classified B-3, suitable for drinking and food processing after conventional treatment, as well as for all uses except propagation of salmonid fish.

Water quality problems on the Milk River become more pronounced during droughts when dissolved chemical concentrations and water temperatures are highest, although suspended sediments are higher during high-flow events such as spring runoff. Irrigation can contribute to water quality degradation. Problems typically occur when irrigation diversions result in low riverflows and when return flows from fields contain higher concentrations of salts, nutrients, suspended solids, and pesticides.

Lands

Northern Montana's geology consists of unconsolidated and consolidated deposits ranging from Cambrian to Quaternary in age. Unconsolidated deposits mantling much of the region include Quaternary alluvium and glacially deposited silt, sand, and gravel. Part of the region is in the Glaciated Central Region, which has been covered several times by continental glaciers.

Retreating glaciers left behind unconsolidated till, glacial lake deposits, and outwash deposits. Underlying unconsolidated deposits are Cretaceous sedimentary bedrock formations consisting of sandstone and shale. Pre-Cretaceous deposits exposed near the surface are generally found near mountain uplifts where they were thrust upward and overlying younger formations were eroded away.

Most of the irrigated lands in the Milk River valley are east of Havre. While soils in the uplands of the basins are predominately derived from glacial till, the irrigated lands in the valley primarily have alluvial soils. Irrigated lands also include soils derived from windblown deposits, old lake plains, and glacial outwash.

Plants, Wildlife, and Fish

For most of its distance, the Milk River runs through short grass prairie: vast, rolling, high plains grasslands, interrupted by island mountain ranges like the Bears Paw and Little Rocky Mountains, and valleys like the Milk River basin and Missouri River basin. Potholes—remnants of glaciers—pock the prairie, providing grassland-wetland habitat. Other important wetland habitat is provided by the river's oxbows and sloughs. Plants along the waterways are a grass-forb mixture, with occasional concentrations of rose, willow, buffaloberry, and scattered cottonwoods. Upland areas away from the river are largely rangeland and dryland cropland.

Habitat diversity in the region allows for a great number of wildlife and bird species. Big game species include elk, whitetail and mule deer, and pronghorn antelope. Bison can be found on Indian reservations. Many predatory species exist in the region, including grizzly and black bear, mountain lion, lynx, coyote, red fox, and badger. Small mammals, like beaver, muskrat, cottontail and jack rabbit, black-tailed prairie dog, mink, weasel, raccoon, porcupine, skunk, and several bat species can be found.

The region is a haven for birds: over 150 songbirds; shorebirds (stilt, avocet, willet, and curlew); waterbirds (pelican, loon, goose, and duck); raptors (eagle, falcon, hawk, and owl); and upland game birds (pheasant, partridge, turkey, and grouse) exist in the region.

Many reptile and amphibian species also inhabit the region, including the western painted turtle, soft-shelled turtle, prairie rattlesnake, bull snake, short-horned lizard, and garter snake. Amphibians in the abundant wetlands and riparian areas include the western chorus frog, leopard frog, and Woodhouse's toad.

There are 10 Montana Wildlife Management Areas in the Milk River basin. Several of them are associated with Milk River Project facilities, including Fresno Reservoir, Dodson Diversion Dam, Dodson South Canal, Nelson Reservoir, and Vandalia Diversion Dam. Bowdoin National Wildlife Refuge is also located in the Milk River Basin near Malta, Montana.

Fish species native to the St. Mary River include bull trout, westslope cutthroat trout, mountain whitefish, lake trout, northern pike, burbot, white sucker, longnose sucker, lake chub, trout-perch, longnose dace, pearl dace, mottled sculpin, and spoonhead sculpin. Lakes in the St. Mary drainage also contain native populations of northern pike and sucker species. This habitat is shared with non-native populations of Yellowstone cutthroat trout, rainbow trout, brook trout, kokanee, and lake whitefish. Lakes in the St. Mary drainage also contain the only known population of trout-perch in Montana.

A study of the Milk River fishery found about 40 species of fish. Flathead chub, river carpsucker, shovelnose sturgeon, and stonecat are most common in spring, with emerald shiner, flathead chub, goldeye, and shorthead redhorse the most common in fall (Stash et al., 2001).

Threatened and Endangered Species

A number of species listed under the Endangered Species Act (ESA) can be found in the St. Mary River and Milk River region (table 1.2).

Table 1.2: Threatened and Endangered Species

Endangered Species	Threatened Species
Black-footed ferret	Grizzly bear
Whooping crane	Piping plover
Pallid sturgeon	Bull trout
Interior least tern	Canada lynx

Bull trout population east of the Continental Divide can be found in the St. Mary River basin. Grizzly bears have been reported near Swiftcurrent Creek on the Blackfeet Reservation, as well as using the St. Mary Canal as a travel corridor. Black-footed ferrets have been found on lands near the Milk River residing in abandoned prairie dog towns. Whooping cranes are migratory birds that have been documented to migrate through the Milk River in the spring and fall each year. Canada lynx use the St. Mary River basin as a main traveling corridor, and it is thought to be the strongest population of lynx within the U.S.. Least terns can be found nesting along the banks of the Milk River. Piping plover can be found in the Milk River basin, nesting on the shore and islands in Nelson Reservoir, and at Bowdoin National Wildlife Refuge (figure 1.1).

Figure 1.1: Piping plover.

Montana Species of Special Concern

Montana Department of Fish, Wildlife & Parks (FW&P) has identified 27 Species of Special Concern in the St. Mary River and Milk River region (table 1.3).

Table 1.3: Montana Species of Special Concern

Arctic grayling	Western glacier stonefly	Townsend's big-eared bat
Western toad	Yellowstone cutthroat trout	Westslope cutthroat trout
Trout-perch	Lake trout	Black-tailed prairie dog
Paddlefish	Greater sage grouse	Western hog-nosed snake
Pearl dace	Sauger	Sicklefin chub
Eastern ringtail	Great plains toad	Chestnut collared longspur
Mountain plover	Blue sucker	Sturgeon chub
Black-footed ferret	Milksnake	Caspian tern
Bull sucker	Shortnose gar	Hoary bat

Cultural Resources

Humans have occupied northern Montana for at least 11,900 years, evidenced by finds of distinctive stone artifacts. Early people depended on hunting and gathering during this period. Climatic and technological changes occurred in the years before 1,300 before present: smaller projectile points associated with light darts or atlatls have been excavated in the region, used on species including big game. During the final stages of prehistory, arrow points became dominant. Contact with Euro-Americans led to use of the horse and trade goods, which transformed the native culture.

Although fur trappers had been in the region for a number of years prior to the Lewis and Clark Expedition, little was known about its resources. A string of trading posts and forts were established along the Missouri River during the fur trapping period. In 1855, the Federal Government, in a treaty with the Blackfeet Tribe, established the "territory of the Blackfoot Nation," which included the present Blackfeet Reservation and the St. Mary River and Milk River Project area. The Federal Government established forts specifically for distribution of annuities and other goods to the Tribes. Fort Belknap, for instance, was first built in 1871, abandoned in 1876, and then re-established in 1878. The Treaty of 1888 established separate reservations for the various Tribes in the territory, including the Sioux and Assiniboines of the Fort Peck Reservation, the Gros Ventres and Asssiniboines of the Fort Belknap Reservation, and the Blackfeet Reservation. The Rocky Boy's Indian Reservation was created September 7, 1916, by Executive order.

The discovery of gold in the 1860s drew people to Montana. Wagon traffic on the Fisk Trail and other trails and steamboat traffic to Fort Benton on the Missouri River became common. The Federal Government began issuing grazing permits to the region in 1883. Congress authorized the Great Northern Railroad in 1887, and parts were completed throughout the region within a year. Shortly thereafter, homesteading of the area followed as lands were made available for settlement. A few private irrigation systems were developed along the Milk River and its tributaries; however, water supplies were unreliable until the Federal Government constructed the Milk River Project facilities.

Northern Montana is rich in prehistoric and historic resources. Cultural resources include prehistoric archeological sites, Indian sacred sites, and other traditional and historic sites important to Native Americans. Many of the facilities of the Milk River Project itself are considered eligible for the National Register of Historic Places.

Social and Economic Characteristics

Mainly rural and agricultural, the St. Mary River and Milk River basins have three small cities (Havre, Malta, and Glasgow) and numerous small towns scattered throughout. The region includes the Blackfeet Reservation in Glacier County, the Rocky Boy's Indian Reservation in Hill County, and the Fort Belknap Reservation in Blaine and a small part of Phillips County.

Population

According to the 2010 Census, the five-county region had a total population of 47,608 people, compared to 49,902 in 1990, an overall decrease of 4.8 percent. Population declined in four of the five counties, with the largest decline being in the county with the sparsest population, Phillips County.

Table 1.4 shows regional population by county (U.S. Census Bureau, 2010). Native Americans make up a considerable part of the population. In 2010, the populations of the reservations were: Blackfeet Reservation: 10,405, Rocky Boy's Indian Reservation: 3,323, and Fort Belknap Indian Reservation: 2,851.

Table 1.4: Population by County

County	1990	2000	2010	Percent Change (1990–2010)
Glacier[1]	12,121	13,246	13,399	+10
Hill[2]	17,651	16,651	16,096	-10
Blaine[3]	6,728	7,006	6,491	-3
Phillips[3]	5,163	4,601	4,253	-21
Valley	8,239	7,675	7,369	-12
Totals	49,902	49,179	47,608	

[1] Includes the Blackfeet Reservation.
[2] Includes the Rocky Boy's Indian Reservation.
[3] Includes the Fort Belknap Indian Reservation (a small part in Phillips County).

Income

The average income per person in the region (in 2009 dollars) was:

- Glacier County: $16,904
- Hill County: $21,760
- Blaine County: $16,858
- Phillips County: $22,538
- Valley County: $23,246

This compares to $22,881 for the State of Montana and $27,041 for the U.S. Only one county (Valley County) exceeded the Montana per capita income, and none approached the national per capita income.

Phillips and Valley Counties have the highest per capita income in the region. The pattern of per capita income distribution has been roughly the same since 1990 as shown below on figure 1.2 (U.S. Census Bureau, 2012).

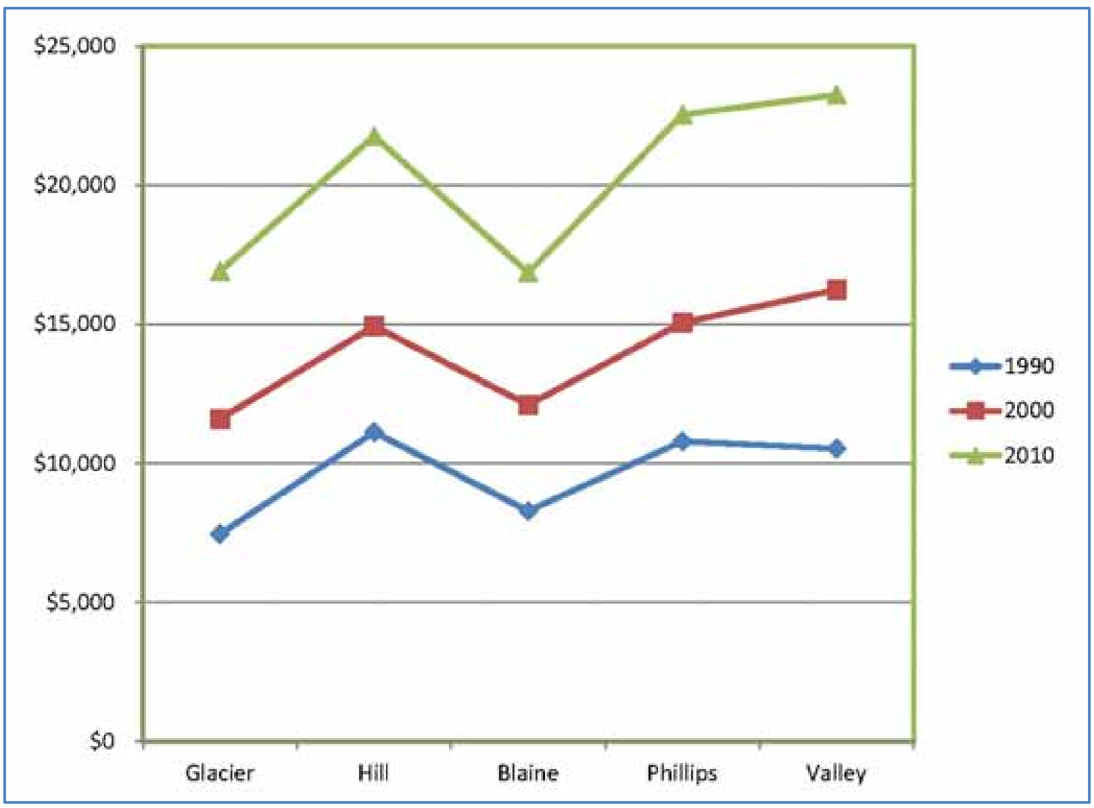

Figure 1.2: Per capita income in the region: 1990, 2000, and 2010.

Agriculture

Agriculture forms the underpinning of the region's economy. Table 1.4 shows the 2007 value of agricultural products sold, the number of farms in the five counties, and the number of these farms with irrigated acres. More than one-fifth of the farms (22 percent) were irrigated (U.S. Department of Agriculture [USDA], 2007).

Table 1.5: Number of Farms and Value of Agricultural Products, 2007

	Glacier	Hill	Blaine	Phillips	Valley	Total
Number of Farms	625	854	655	556	770	3,460
Irrigated Farms	116	42	218	201	185	762
Value ($ million)	$55.4	$86.6	$71.6	$60.9	$80.4	$354.9

Major Economic Activities other than Agriculture

The U.S. Census Bureau ranked economic activities in the region by annual payroll and number of employees as of 2007 (U.S. Census Bureau, 2012). The top four activities were the same in all five counties (table 1.5—the first figure is the payroll in $1,000s; the second is the number of employees.). Retail trade paid the highest payroll and employed the most people in 2007. The second activity, Information, includes newspapers and periodicals, television and radio broadcasting, libraries, movie theatres, telecommunications and wireless, cable, data processing, and software production. Real Estate is the third activity, which also includes rentals and leasing of buildings, vehicles, and equipment. The last of the four activities listed in table 1.5, Professional, includes professional, technical, and scientific services; legal services; accounting and bookkeeping; public relations; photography; administrative management; advertising; graphic design; computer systems; architectural and engineering services; surveying and mapping; environmental consultation; and scientific consultation and research.

Table 1.6: Major Economic Activities in the Region (Other than Agriculture) (in $1,000s and Number of People Employed)

	Glacier	Hill	Blaine	Phillips	Valley
Retail Trade	$9,548 449	$19,552 1,020	$3,213 174	$3,123 161	$6,761 331
Information	$468 19	$6,957 185	*	*	$525 37
Real Estate	$193 16	$977 49	$72 10	$41 4	*
Professional	$1,254 26	*	$494 21	*	*

* Information is not available.

Unemployment and Poverty

The unemployment rates (percent) in 2009 were:

- Glacier County: 13.4
- Hill County: 4.7
- Blaine County: 7.1
- Phillips County: 10.8
- Valley County: 3.6

Unemployment rates in the region are skewed by the extremely high rates on the reservations, estimated to be over 60 percent (Montana State University, 2011). Despite limited job opportunities, the unemployment rate is lower in two of the counties than the 5.6 percent Montana rate. In three of the counties, it is lower than the 9.2 percent national rate.

The poverty rates (percent) in 2009 were:

- Glacier County: 21.6
- Hill County: 10.5
- Blaine County: 25.1
- Phillips County: 8.7
- Valley County: 10.6

Except for Phillips County, all of the region's 2009 poverty rates (poverty level is $22,050 for a family of four) were higher than the Montana rate of 9.8 percent and the national rate of 9.9 percent.

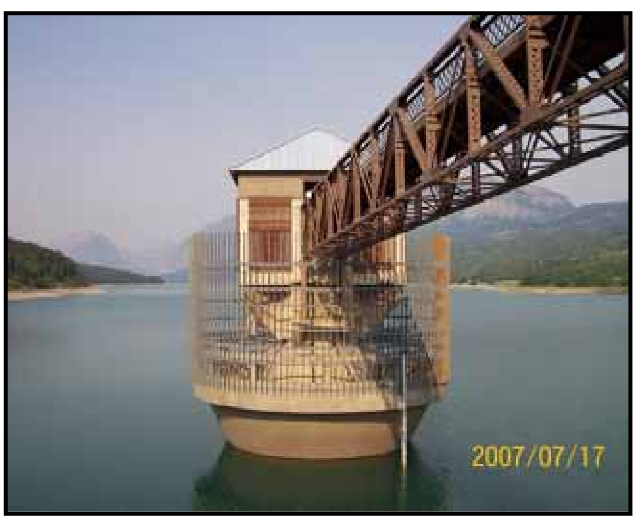

Figure 1.3: Lake Sherburne outlet works.

Milk River Project

Spanning both the St. Mary River and the Milk River basins, Reclamation's Milk River Project facilities in both basins are presently operated as a synchronized system.

St. Mary Storage and Conveyance Facilities are entirely on the Blackfeet Reservation near the Canadian border in north-central Montana. The St. Mary Canal and Lake Sherburne (figure 1.3) are used together to capture and divert the U.S. share of water from the St. Mary River to the North Fork of the Milk River (see figure 1.8 at the end of this chapter). When the U.S. share is insufficient to meet St. Mary Canal diversion needs, stored U.S. share water is released from Lake Sherburne to make up the difference. When there is a U.S. share surplus, water from the Swiftcurrent drainage is stored in Lake Sherburne. In most years, the St. Mary Canal begins diversions in March or April, continuing until September or October. Lake Sherburne generally stores water from October–March, releasing in April and May to transfer water that was stored during the winter to Fresno Reservoir, storing again in June and July during the peak snowpack runoff, and finally releasing again in August and September to keep the St. Mary Canal full later in the irrigation season.

Project storage is provided by:

- **Lake Sherburne**. This reservoir forms behind Sherburne Dam, an earth-filled dam that is 1,086 feet long, and is located about 6 miles west of Babb, Montana, and stores water from Swiftcurrent Creek, the largest St. Mary River tributary. The total storage capacity is 68,080 acre-feet (AF).

- **Fresno Reservoir**. This reservoir forms behind an earth-filled dam that is 2,070 feet long and is located on the Milk River 14 miles west of Havre. Based on a sedimentation survey in 1999, the total storage capacity is 93,000 AF. The reservoir provides flood control benefits, keeping 30,000 AF of storage space available for spring runoff. Fresno Reservoir stores and releases combined Milk River natural flow and St. Mary River water diverted into the Milk River.

- **Nelson Reservoir**. The Nelson South Unit of the Malta Irrigation District diverts water directly from Nelson Reservoir. Nelson Reservoir is an off-stream reservoir that is 19 miles northeast of Malta and receives Milk River water through the Dodson South Canal. About 9,900 feet of dikes form the reservoir, which stores 79,224 AF of water. Releases from Nelson Reservoir back to the Milk River, via the Nelson North Canal, are made for Glasgow Irrigation District.

Lake Sherburne and Fresno Reservoir also provide flood control benefits by storing water during the peak runoff period. Some of these benefits are derived by reducing local damages; for Fresno Reservoir, other benefits are derived by storing water that would have contributed to flooding downstream on the main stem of the Missouri River below Fort Peck Reservoir. Between 1950 and 2010, Lake Sherburne has prevented $7,946,000 in flood damages, while Fresno Reservoir has prevented $14,245,000 in flood damages according to the U.S. Army Corps of Engineers' (USACE) estimates.

Lake Sherburne, Fresno Reservoir, and Nelson Reservoir also provide recreation to the region. The 1,601surface-acre Lake Sherburne on Swiftcurrent Creek lies mainly within Glacier National Park where recreation is managed by the National Park Service. The 7,388 surface-acre Fresno Reservoir and its 65 miles of shoreline are available for recreation. Fishing, boating, and water-borne sports are popular. Reclamation manages 2 swimming beaches, 11 vault toilets, 2 boat launching ramps, and 3 picnic areas with 1 shelter, numerous tables, and 24 leased cabin sites. Many other recreational opportunities are available through various sports groups.

The 4,320 surface-acre Nelson Reservoir and its 30 miles of shoreline are also available for recreation. Reclamation manages 9 campsites, 5 vault toilets, 2 boat launching ramps, and 3 picnic areas with 3 shelters and 16 tables. There are also 106 leased cabin sites around the reservoir.

The Milk River Project contains three divisions and eight irrigation districts with two pumping units as shown in table 1.6 and on figures 1.4 and 1.5.

Table 1.7: Organization of the Milk River Project

Division	District	Diversion Structure	Canals
Chinook	Fort Belknap Alfalfa Valley Zurich Paradise Valley Harlem	Lohman Diversion Dam Lohman Diversion Dam Lohman Diversion Dam Paradise Valley Diversion Dam Two pumping plants	Fort Belknap Fort Belknap Fort Belknap Paradise Valley Harlem
Malta	Malta	Dodson Diversion Dam	Dodson North Dodson South Nelson South
	Dodson	Dodson Diversion Dam	Dodson North
Glasgow	Glasgow	Vandalia Diversion Dam	Vandalia

Figure 1.4: Paradise Valley Irrigation District Diversion Dam.

Figure 1.5: Harlem Irrigation District main pump station.

Authorized for irrigation, the Milk River Project irrigates about 121,000 contracted acres in the Milk River basin. Principal crops are alfalfa, hay, oats, wheat, and barley. The populations in the study area (approximately 50,000 people) depend on the Milk River Project for an MR&I supply, including the communities of Havre, Chinook, and Harlem. The Fort Belknap Indian Reservation receives water from Fresno Reservoir storage of Milk River natural flows.

Basin Planning Considerations

The river system model developed for this Basin Study has the capability to evaluate potential solutions to basin needs. Some of the issues in the St. Mary River and Milk River basins that the river system model is capable of evaluating are described in more detail below.

Boundary Waters Treaty[1]

The U.S. and Canada share the waters of the St. Mary and Milk Rivers in accordance with the Boundary Waters Treaty of 1909, the International Joint Commission (IJC) 1921 Order, and subsequent Letter of Intent.

Canada's share of the St. Mary River at the International Boundary, as stipulated by the IJC 1921 Order, is three-fourths of the natural flow when the flow is 666 cubic feet per second (CFS) or less during the irrigation season (April 1 to October 31). Flow in excess of that quantity is divided equally between Canada and the U.S. The flow is divided equally between the two countries during the non-irrigation season (November 1 to March 31). The division of the Milk River is similar to the division of waters of the St. Mary River, except the U.S. receives the larger fraction. The U.S.'s share of the Milk River at the Eastern Crossing, as stipulated by the IJC 1921 Order, is three-fourths of the natural flow when the flow is 666 CFS or less during the irrigation season. Flow in excess of that quantity is divided equally between Canada and the U.S. The flow is divided equally between the two countries during the non-irrigation season.

To comply with the IJC 1921 Order, representatives of both countries make twice-monthly computations of the daily natural flow of each river to determine the flow apportionment during the irrigation season. These 15- or 16-day periods are termed "division periods," serving to provide an opportunity of each country to respond to varying use and flow conditions. For example, if use by the U.S. is in excess of its share during a division period, then a surplus of an equivalent volume of water is normally delivered to Canada at the earliest opportunity (Goos and Ethridge, 2008).

[1] The Compact is a "treaty between the United States and Great negotiated water rights."

Current administration of the Treaty, combined with infrastructure limitations, result in the U.S. receiving less than its share of St. Mary River flow and Canada receiving less than its share of Milk River flow. The State of Montana and the Province of Alberta meet to explore options for both nations to better use their shares of the rivers. The parties were still having discussions at the time of this report.

Endangered Species Act Compliance on the St. Mary River

Reclamation is working with the U.S. Fish and Wildlife Service (USFWS) on operations in the St. Mary River drainage. USFWS listed bull trout (figure 1.6) as threatened under the ESA in 1999. USFWS identified three areas where Reclamation structures and operations may have adverse impacts on bull trout: lack of winter flows in Swiftcurrent Creek below Sherburne Dam, entrainment into the St. Mary Canal, and passage at the St. Mary Diversion Dam. Reclamation is required to comply with ESA as it relates to bull trout in its operations of these facilities.

Figure 1.6: Bull trout.

In March 2011, Reclamation, in cooperation with the Blackfeet Tribe, National Park Service, USFWS, Milk River Joint Board of Control, St. Mary Rehabilitation Working Group, DNRC, and Bureau of Indian Affairs, completed a value planning study on fish passage and entrainment for the St. Mary Diversion Dam. Reclamation is also completing designs and specifications and associated environmental documents for fish passage and entrainment for the St. Mary Diversion Dam.

Tribal Compacts

A Water Rights Compact between the State of Montana and the Gros Ventre and Assiniboine Tribes of the Fort Belknap Indian Reservation was ratified by the Montana State Legislature and signed by the Governor in 2001. The compact entitles the Tribes to divert up to 645 CFS from the U.S. share of the natural flow of the Milk River. In the historic 1908 *Winters* vs. *United States* decision, the U.S. Supreme Court ruled that when Congress reserves land, sufficient water is also reserved to fulfill the purpose of the reservation. When the Fort Belknap Reservation was created, 125 CFS were reserved, which established the reserved water rights doctrine.

The compact negotiated between the Blackfeet Tribe and the State of Montana was approved by the Montana Legislature and recommended for further action by the Blackfeet Tribal Business Council in 2009. The Compact gives the Tribe the right to 50,000 AF per year from the St. Mary drainage, other that Lee Creek and Willow Creek, subject to the Boundary Waters Treaty and all groundwater in the St. Mary River drainage not subject to the Boundary Waters Treaty. In the Milk River basin, the Tribe has a water right to all natural flow and groundwater available to the U.S. under the Boundary Waters Treaty and all groundwater not subject to the Boundary Waters Treaty in "Basin 40F" (i.e., the Milk River basin) within the Blackfeet Reservation, with the exception of those waters subject to the water rights arising under state law on the Reservation. More specific details regarding the Compact can be found in Section 85-20-1501 of the Montana Code Annotated.

Montana Water Rights Adjudication—St. Mary and Milk Rivers

In 1973, the State of Montana began a state-wide adjudication of all water right claims that existed prior to July 1, 1973. This included reserved water rights associated with Indian and other federal reservations. Claims on the St. Mary and Milk Rivers are being examined by DNRC or being adjudicated by the Montana Water Court. Some subbasins have temporary or preliminary decrees; however, no final decrees have been issued in the St. Mary River basin or the Milk River basin. The DNRC is required to complete all examinations by June 30, 2015.

Rehabilitation of St. Mary Canal

Reclamation began construction of the St. Mary Storage and Conveyance Facilities shortly after project authorization in 1905 and diverting water from the St. Mary River to the Milk River in 1915. Diverted St. Mary River water supplements Milk River flows to irrigate about 140,000 acres and provides water supplies to cities and irrigation districts and the Bowdoin National Wildlife Refuge. St. Mary facilities include Sherburne Dam, Swiftcurrent Dike, St. Mary Diversion Dam and Intake (figure 1.7), and St. Mary Canal. St. Mary Canal was designed to divert up to 850 CFS. Since construction was completed, only routine maintenance and extraordinary repairs have been done. The St. Mary Diversion Dam and Intake and Canal have severely deteriorated and now are at risk of catastrophic failure. Reclamation and the irrigation districts perform replacement and extraordinary maintenance on

Figure 1.7: St. Mary Diversion Dam at low flow.

St. Mary facilities dependent on funding availability. The actual conveyance capacity of the St. Mary Canal has been reduced from 850 CFS to about 650 CFS at the St. Mary's siphon as a result of seepage, slides, and canal bank slumping.

Sedimentation of Fresno Reservoir

Fine-grained sediments are transported by the Milk River downstream to Fresno Reservoir where they settle and reduce the storage capacity of the reservoir. Reclamation estimated that the reservoir has lost 36,200 AF (as of May 1999) from its original 129,062 AF storage capacity from sedimentation since it was completed in 1939. Similar rates of sedimentation are expected to continue into the future.

Swiftcurrent/Boulder Creek Bank Bed Stabilization

The Federal Highway Administration provided funding through Reclamation to work with the Blackfeet Tribe on the Swiftcurrent/Boulder Creek Bank and Bed Stabilization Project. The project addresses Tribal concerns with Reclamation facilities and operations and how they affect Tribal resources by diverting water from Swiftcurrent Creek into Lower St. Mary Lake. Reclamation and the Blackfeet Tribe formed a working group in 2009 to investigate and evaluate alternatives to address these concerns.

Figure 1.8 shows the Upper St. Mary River basin diversion and conveyance system.

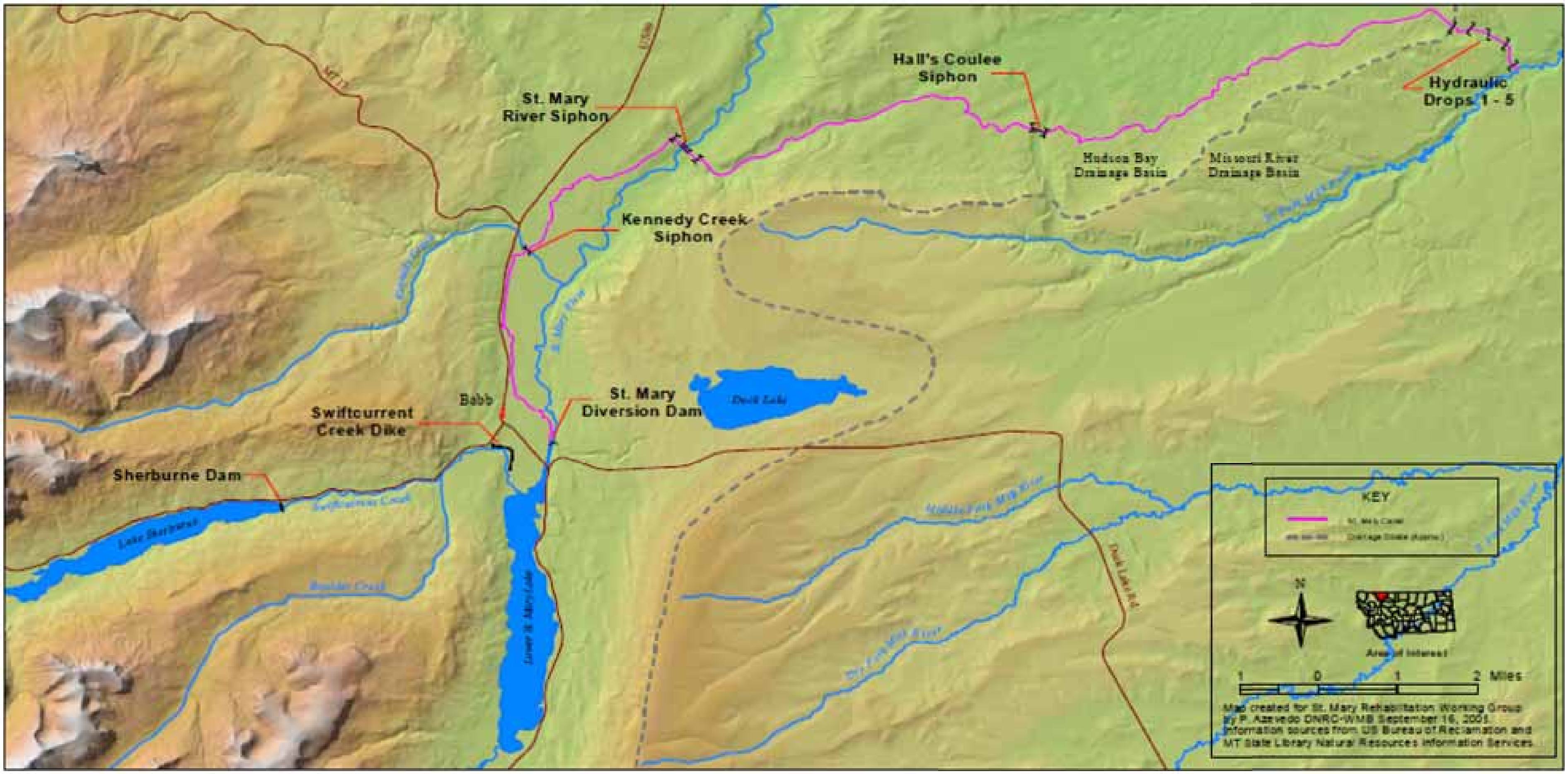

Figure 1.8: Upper St. Mary River basin diversion and conveyance system.

Chapter 2: St. Mary River and Milk River Basins Water Supplies and Demands

Chapter 2 details present water supplies and demands in the St. Mary River and Milk River basins of Montana and supplies and demands estimated for 2050.

Present Water Supplies

Water supplies for the region come from the St. Mary River and the Milk River basins. The St. Mary River produces more water and is a more predictable and reliable water supply, typical of headwater, mountain streams with a large snowmelt component. The Milk River does not produce as much water and is less predictable from year to year, typical of plains streams in the region.

St. Mary River

The St. Mary River, originating along the Continental Divide in Glacier National Park, is in the Hudson Bay drainage, flowing north into Canada. Streamflow is divided between Canada and the U.S., with Canada receiving the larger share. The IJC has determined the median natural flow volume at the Canadian-U.S. boundary for the April through October irrigation season during 1959–2008 to be about 549,000 AF (Goos and Ethridge, 2008).

Historically, most of the U.S. share of streamflow has been captured by the St. Mary Canal and Sherburne Dam on Swiftcurrent Creek. The U.S. median share of the St. Mary River for April through October during 1959–2008 was about 217,000 AF. The St. Mary Canal during 1959–2008 diverted a median annual volume of 178,500 AF from the St. Mary River to the Milk River. Typically, 38,500 AF have been surplused to Canada due to canal capacity, available storage, and apportionment procedure constraints. During dry years, these constraints are not so limiting and the entire U.S. share can be diverted. Figure 2.1 shows the natural flow of the St. Mary River, the U.S. share, and the U.S. share diverted by the St. Mary Canal from 1989–2008. In very dry years, annual canal diversions can exceed the U.S. share when Lake Sherburne water carried over from the previous water accounting years is diverted to the Milk River.

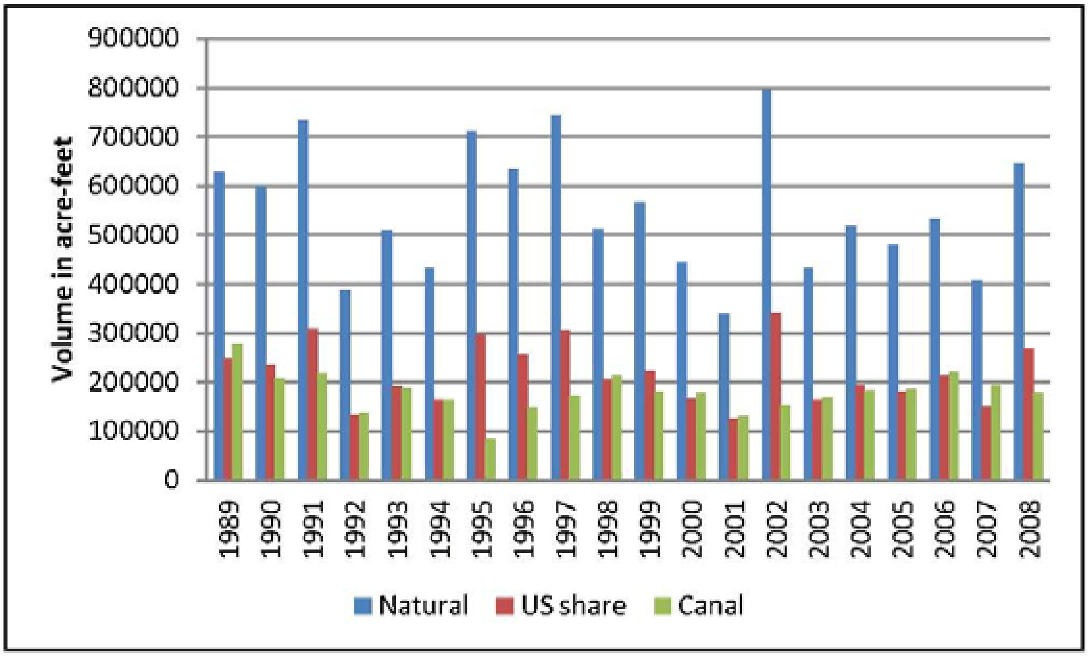

Figure 2.1: Comparison of April through October natural flow of the St. Mary River at the International Boundary, the U.S. share, and St. Mary Canal diversions.

The U.S. Natural Resources Conservation Service (NRCS) prepares seasonal April through July runoff forecasts and coordinates these forecasts with their counterparts in Alberta. Forecasts are made for Lake Sherburne inflow and for the natural flow of the St. Mary River at the International Boundary. Reclamation also produces its own forecasts for inflows to Sherburne Reservoir. These forecasts are very reliable. Having these forecasts allows Reclamation to efficiently operate the St. Mary River system to maximize capture of the U.S. share.

Milk River

For this report, the present water supply of the Milk River is divided into three geographic areas:

- Milk River at the Eastern Crossing upstream of Fresno Reservoir (figure 2.2)
- Tributaries downstream from Fresno Reservoir entering the Milk River from the north
- Tributaries downstream from Fresno Reservoir entering the Milk River from the south

Figure 2.2: Milk River at the Eastern Crossing.

Streamflow from the Milk River at the Eastern Crossing is divided between Canada and the U.S. The IJC has determined the median natural flow of the Milk River at the Eastern Crossing for March through October during 1959–2008 to be about 94,900 AF (Goos and Ethridge, 2008). The median U.S. share of the Milk River at this location is 63,900 AF. Evaluation of gauging station records indicates that the median volume of Canada's share that flows into the U.S. is about 20,000 AF. Therefore, the total volume of Milk River flow typically available for use to the U.S. at the Eastern Crossing is about 83,900 AF, which is a combination of the U.S. share plus the unused portion of Canada's share. The snowmelt runoff of the Milk River upstream of Fresno Reservoir typically occurs during March, April, and May, and the rainfall-generated runoff typically occurs in May and June. The flow of the Milk River at the Eastern Crossing, which also includes imported St. Mary Canal water, is regulated by Fresno Reservoir.

Because Canada does not have storage facilities on the Milk River, they are not able to capture and use their entire share of the Milk River's natural flow. Present Canadian water use is primarily for about 8,000 acres of mostly sprinkler irrigation. Figure 2.3 shows the 2008 monthly natural streamflow of the Milk River upstream of Fresno Reservoir, the U.S. share, and the volume received by the U.S. (2008 was a near average water year). During 2008, the March through October natural flow volume was about 88,100 AF. The U.S. share was about 60,000 AF, and the volume received by the U.S. about 83,900 AF. Natural streamflow in July and August, some of the peak use times in the U.S. and Canada, was very low.

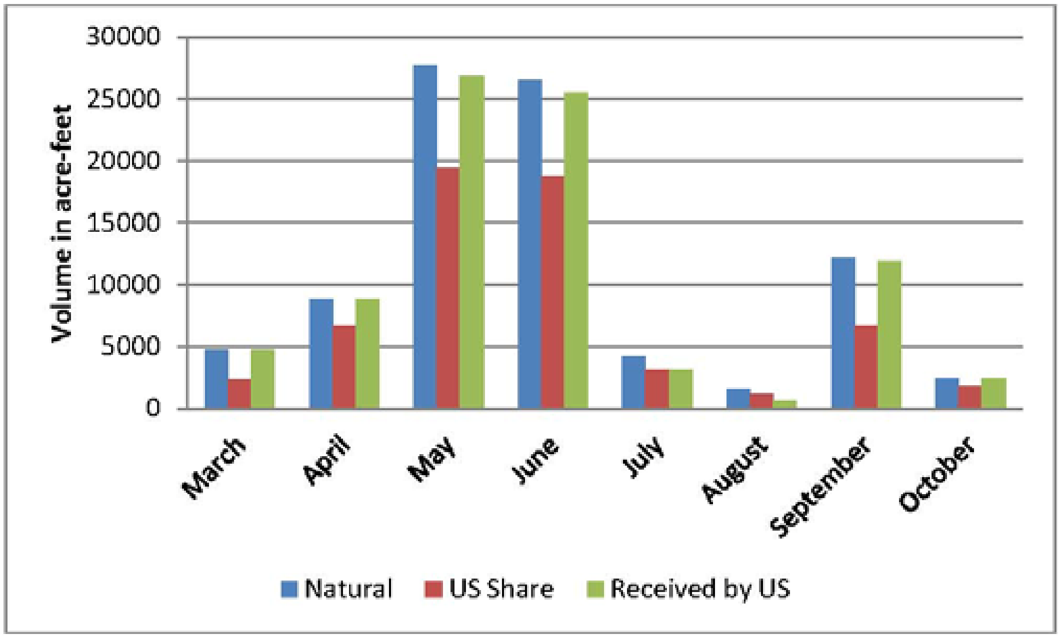

Figure 2.3: Natural streamflow of the Milk River at the Eastern Crossing, the U.S. share, and the volume received by the U.S. during 2008.

The NRCS prepares seasonal March through July runoff volume forecasts for the Milk River at the Eastern Crossing, coordinating these forecasts with the National Weather Service and their counterparts in Alberta. These forecasts, though helpful, are not as reliable as those in the St. Mary River basin.

Three major tributaries, (Lodge Creek, Battle Creek, and Frenchman Creek) also known as the “northern tributaries,” begin in Canada and flow south to join the Milk River. The flow of these tributaries at the International Boundary is divided equally between Canada and the U.S.. The median U.S. share of Lodge Creek is 7,100 AF; the median share of Battle Creek is 8,300 AF; and the median share of Frenchman Creek is 23,600 AF. Historically, the total median flow of the northern tributaries available to the U.S. is about 49,300 AF, which includes the unused Canadian share. Although there is considerable water development in Canada on these streams, flow that crosses the International Boundary typically exceeds the U.S. share annually. There is a considerable drainage area that contributes runoff to these tributaries between the International Boundary as well as their confluences with the Milk River. Gauges have been operated at times near the mouths of these streams, but the record is incomplete.

Peak runoff for Milk River tributaries typically occurs during March and April. Because evapotranspiration and crop demand during March and April are low, much of the runoff water reaches the Milk River. During the irrigation season (when crop demands are high and flows are typically low), very little flow reaches the Milk River.

The larger, gauged tributaries entering the Milk River from the south (listed from west to east) are Big Sandy Creek, Clear Creek, Peoples Creek, and Beaver Creek (near Hinsdale). These streams have gauging stations with discontinuous periods of record. Based on gauging records, the available median annual streamflow from tributaries entering the Milk River from the south is at least 68,970 AF. As with the northern tributaries, flow in these streams generally peaks in March and April, and tributary irrigation consumes most of the flow later in the summer. The Milk River also receives inflow at times from smaller, ungauged southern tributaries. However, these flows are not measured and are difficult to estimate.

In summary, the median combined historic water supply above Fresno Reservoir from St. Mary River diversions and the Milk River flow is about 262,400 AF at the Eastern Crossing. This upstream supply is heavily managed by Reclamation facilities, and most of the U.S. share can be captured and put to beneficial use during low-to-median flow years. The water supply downstream from Fresno Reservoir from gauged tributaries is about 118,270 AF. This water supply can be used by direct diversion when it occurs during the irrigation season and when it is within the capacity of the diversion facilities. Part of this supply upstream of Dodson Diversion Dam can be diverted to Nelson Reservoir. The water from Lodge Creek, Battle Creek, Big Sandy Creek, Clear Creek, and Peoples Creek (a median of about 38,870 AF) might be diverted though Dodson South Canal (figure 2.4) and stored in Nelson Reservoir if the runoff occurs when the canal is operating and at a rate that does not exceed canal capacity.

Figure 2.4: Dodson South Canal headworks.

The water supply from the tributaries below Fresno Dam is much less reliable than the upstream water supply; during dry years, there is very little water that can be captured by the Milk River Project from these tributaries. Additionally, the water supply from Frenchman and Beaver Creeks, about 79,400 AF, occurs at lower elevations in the basin. This water can only be used by direct diversion from individual pumpers and at Vandalia Diversion Dam, which serves about 18,000 acres of the Glasgow Irrigation District. Frenchman and Beaver Creeks are not presently considered water supplies that water users can rely on.

Total median annual water supply, which includes St. Mary River and Milk River water, is at least 380,000 AF, but the water contributed by tributaries below Fresno Dam varies considerably from year to year. Table 2.1 lists median annual volume for the major Milk River tributaries and volumes available for direct diversion use or storage.

Table 2.1: Median Annual or Seasonal Water Supply for Selected Locations in the Milk River Basin (AF)

Location in Basin with Stream/Source	Available Flow	Available for Direct Diversion Only	Available for Direct Diversion or Storage
Upstream of Fresno Reservoir			
St. Mary Canal	178,500		178,500
Milk River Flow	83,900		83,900
Subtotal	262,400		262,400
Tributaries from the North			
Lodge Creek	7,150		7,150
Battle Creek	9,450		9,450
Frenchman Creek	32,700	32,700	—
Subtotal	49,300	32,700	16,600
Tributaries from the South			
Big Sandy Creek near Havre[1]	4,470		4,470
Clear Creek near Chinook[2]	3,850		3,850
Peoples Creek near Dodson[3]	13,950		13,950
Beaver Creek near Hinsdale[4]	46,700	46,700	—
Subtotal	68,970	46,700	22,270
Total	380,670	79,400	301,270

[1] U.S. Geological Survey (USGS) station 06139500, period of record of 1984–2010, April through September.
[2] USGS station 06142400, period of record of 1985–2010, April through September.
[3] USGS station 06154500, period of record of 1952–73 and 1982–87, January through December.
[4] USGS station 06167500, period of record of 2006–2010, March through October.

Figure 2.5 shows the median water supply available for diversion in the Milk River basin by source. During dry years, the importance of St. Mary Canal water is greater because there is little Milk River natural flow available during these years. To illustrate this, figure 2.6 depicts the usable water supply by source during 2001, which was a very dry year. Even though St. Mary Canal diversions were much less than average during 2001, the imported water accounted for 75 percent of the water available for diversion by Milk River irrigators that year.

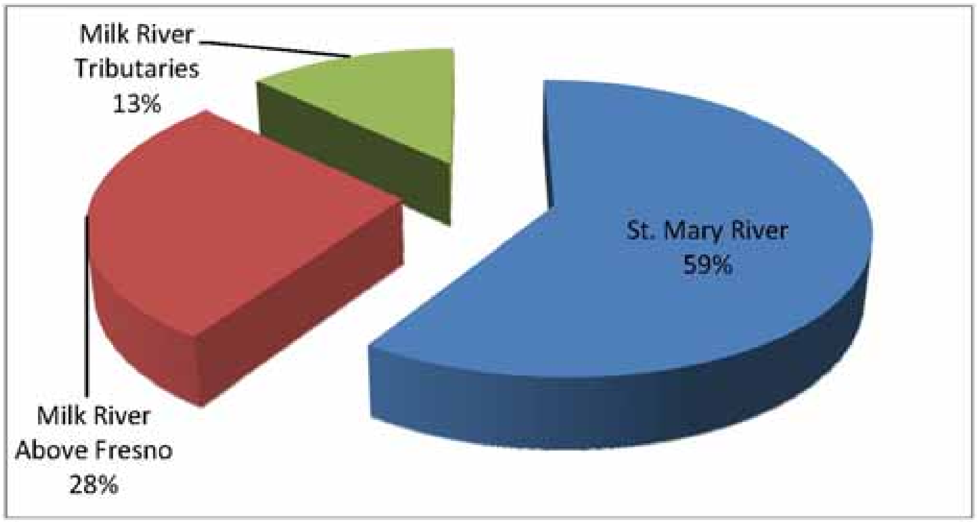

Figure 2.5: Milk River irrigation season median water supply available for direct diversion in AF (April 1–October 1). The total water supply is 301,207 AF.

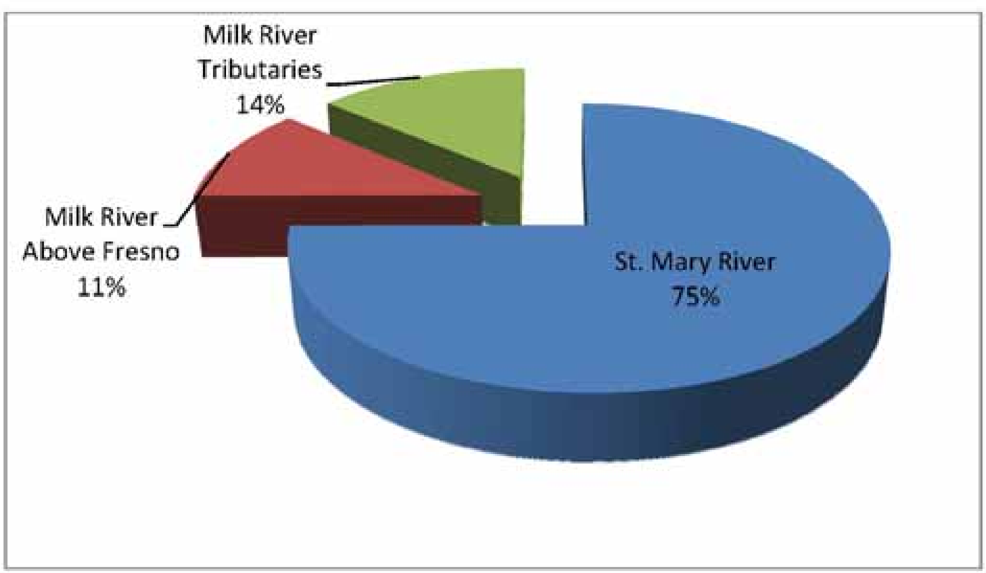

Figure 2.6: Milk River 2001 irrigation season water supply available for direct diversion in AF (April 1–October 1). The total water supply is 168,100 AF.

A considerable volume of water leaves the Milk River basin and flows into the Missouri River especially during high flow years. Much of this water, which is natural flow that arises in the basin, cannot be captured with existing facilities. The Milk River at the Nashua gauging station is located near the mouth of the Milk River downstream from almost all of the irrigation diversion in the basin.

The median annual flow for 1959–2008 is 337,600 AF; the median streamflow during the May through September irrigation season is 129,400 AF. Although some of this water represents tributary inflows that cannot be captured with existing facilities, some of the flows could be made available through infrastructure and water management improvements.

Future Water Supplies

The ability of water supplies for the region to meet the demand is expected to change in the future. Demand increases are discussed in detail in the next section, "Future Water Demands." This Basin Study examined potential changes to the water supply due to climate changes.

Warming has been experienced over much of the U.S. during the 20th century, and this general warming of the global climate is likely to continue in the 21st century. In response, global and continental climate simulation projections have been developed using models that were calibrated to reproduce temperature trends during the 20th century. Success in these efforts has increased confidence in using these models in combination with developing statistical methods using historical data to project future climate conditions (Reclamation, 2010).

Reclamation examined climate change in eight western river basins in the 21st century in the *SECURE Water Act Section 9503 (c) - Reclamation Climate Change and Water 2011* (Reclamation, 2011a). One of the eight basins examined was the Missouri River basin, of which the Milk River basin is a part. The report indicated that the annual temperature is projected to increase by about 5 °F, and annual precipitation would gradually increase over the western upper reaches of the Missouri River basin in the 21st century. Warmer temperatures would affect accumulation of snow in the mountains during the cool season and, thus, availability of snowmelt to sustain runoff in the spring and summer. Increased precipitation during the cool season would offset increased temperatures somewhat. Increased variability between wetter and drier years is projected.

Two 30-year climate "look-ahead" period data sets—centered on 2030 and 2050—were developed for this study. The projected climate change for the two look-ahead periods were based on hydrologic and meteorological patterns for the 1950–1999 base period, with climate change superimposed. The 2030 period consisted of the years 2015 to 2044, and the 2050 period consisted of the years

2035 to 2064. The Basin Study Team decided to place the focus of this report on the period centered on 2050, which better corresponds with Reclamation's planning horizon.

Reclamation analyzed climate change for the St. Mary River and Milk River basins, producing hydrologic data sets centered on 2030 and 2050 using the Period Change Method. (The findings are summarized in the report *Climate Change Analysis for the St. Mary and Milk River Systems in Montana* [Reclamation, 2010].) There are 16 General Circulation Models (GCM), 3 emission scenarios, and multiple initial conditions, resulting in 112 projections. For the climate change analysis, Reclamation started with the future climate data sets produced by 112 projections that simulate future climate changes that affect weather patterns (by assuming various rates of some physical parameter such as greenhouse gas concentrations). A problem with the results from the GCMs is that the spatial scale of the output data is too coarse for use in basin studies. Statistical downscaling was used to translate the global-scale output data from the GCMs to the finer-scale climate differences applicable at the level of a basin study.

The consensus message of all of these projections was that temperatures in the St. Mary River and Milk River basins are likely to follow a warming trend in the future. However, the rate of warming projected varies among the different GCMs. Projections for precipitation ranged from drier to wetter, but most of the predications were for overall wetter conditions in the basins, with increasing year-to-year variability. Figure 2.7 contains plots of modeled annual temperatures and precipitation trends. The solid line represents the median change while the shaded band represents the variability for the 112 climate projections.

To account for the uncertainty in the climate change projections while keeping the number of scenarios manageable, Reclamation grouped the climate change scenarios into four quadrants (i.e., groups of similar scenarios). Mean annual temperature and precipitation changes were used to define these four groups as depicted on figure 2.8. There are four climate change scenario groups that represent the range of projected changes from less to more warming, paired with drier to wetter conditions.

A fifth climate change scenario also was defined, representing the central tendency group of the projected changes. For easier reading, these climate change scenario groups will be referred to in this report as "climate change scenarios."[2]

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[2] Note that the climate change scenario names are italicized to differentiate them from the alternatives for easier reading.

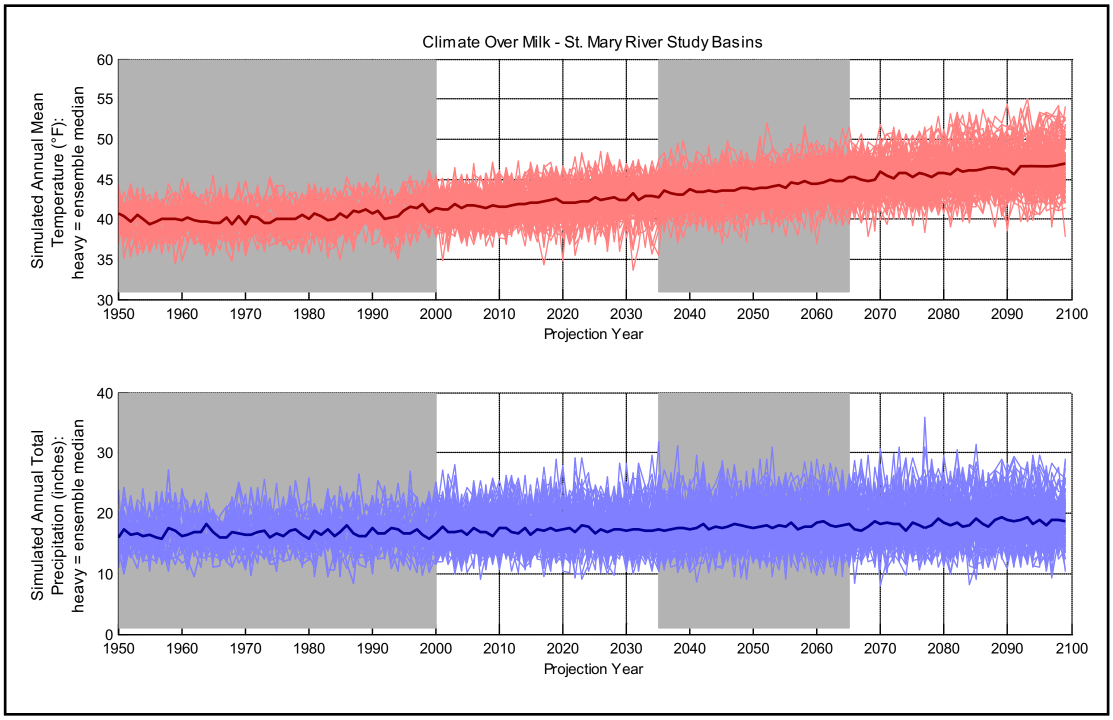


Figure 2.7: Average annual climate temperature and precipitation projections for the region.

Note that we also have a climate change scenario, *S0: Historic Climate Conditions.* This scenario assumes that there will be no climate changes and is based on historic climate.

- *S1: Less Warming/Dryer*
- *S2: Less Warming/Wetter*
- *S3: More Warming/Dryer*
- *S4: More Warming/Wetter*
- *S5: Central Tendency*

These scenarios are further defined in table 2.2.

A surface water hydrology model was used to translate temperature and precipitation data to streamflow in the region's subbasins. The hydrologic simulation was run using a calibrated version of the National Weather Service River Forecasting Center's SAC-SMA/SNOW-17[3] model of the St. Mary River and Milk River basins. The Sacramento Soil Moisture Accounting (SAC-SMA)

[3] Combined use of the Sacramento Soil Moisture Accounting and Snow Accumulation and Ablation hydrologic models.

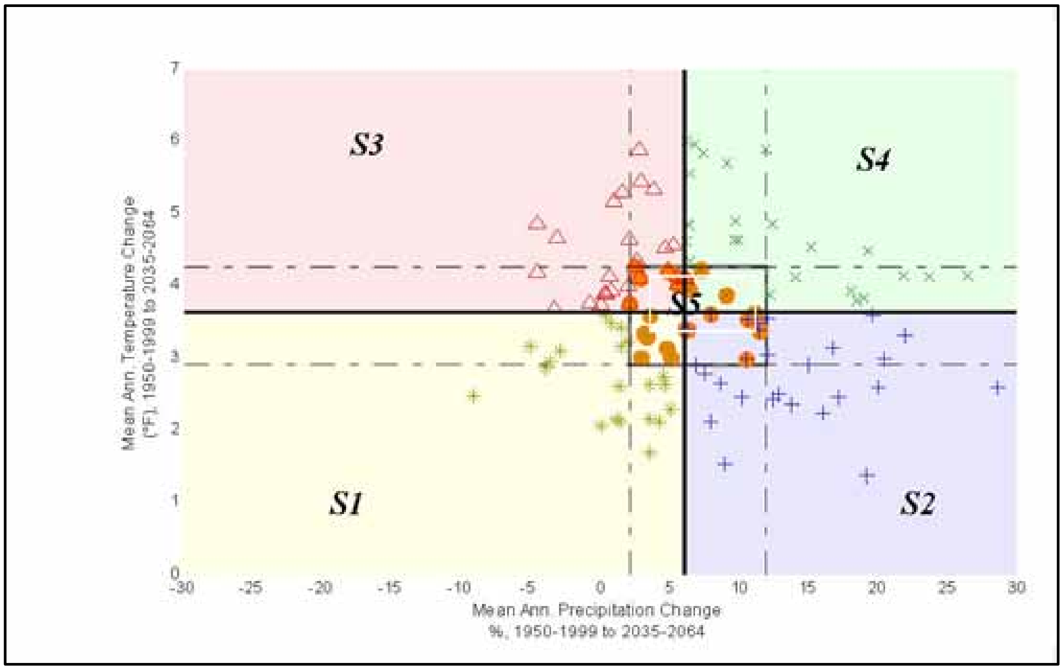


Figure 2.8: Climate change scenarios showing modeled changes in mean annual temperature and precipitation in the region for four quadrant groupings and a central tendency grouping (note that *S5: Central Tendency* is in the center).

Table 2.2: Climate Change Scenarios

Climate Change Scenario	Climate Change Scenario Groups from Climate Change August 2010 Report
S0: Historic Climate Conditions	—
S1: Less Warming/Dryer	q4
S2: Less Warming/Wetter	q2
S3: More Warming/Dryer	q3
S4: More Warming/Wetter	q1
S5: Central Tendency	q5

and Snow Accumulation and Ablation (SNOW-17) applications use precipitation and temperature on a 6-hour time series as inputs for computing a runoff time series. The SAC-SMA model simulates physical mechanisms that drive water movement through the soil column (infiltration, percolation, storage, evapotranspiration, baseflow, etc.) while preserving the water balance. The

SNOW-17 model simulates physical processes that affect snow runoff data sets from accumulation and snowmelt. Once the projections corresponding to each of the five climate change scenarios were identified, the Period Change Hybrid Delta Ensemble (*HDe*) method was used to generate temperature and precipitation data to run the SAC-SMA/SNOW-17 hydrology model for each climate change scenario.

The streamflows generated by the SAC-SMA/SNOW-17 surface water runoff hydrology model using temperature and precipitation of the base period 1950–1999 did not always adequately match the historical gauging station-based data in annual and seasonal volume. This required adjustment of the streamflows developed for the five climate change scenarios to correct the bias between the surface water runoff model historic climate baseline streamflows and the historical flows used in the river system model. The adjustment method is described in *Milk-St. Mary River System Basin Study* (Reclamation, 2011b).

Information on change in streamflow in the basin was projected for two future look-ahead periods centered on 2030 and 2050; again, only the 2050 climate model results are presented in this report. The predicted change in the median annual streamflow for the five climate change scenarios for 2050 and for four key locations in the region are listed in table 2.3.

Table 2.3: Change from *S0: Historic Climate Conditions* in Median Annual Streamflow at Selected Locations for the 2050 Climate Change Scenarios *(*AF)

Climate Change Scenarios	St. Mary River at the International Boundary	Milk River at the Western Crossing	Milk River at the Eastern Crossing	Milk River near Harlem	Milk River at Nashua (Mouth of Milk River)
S1: Less Warming/Dryer	-19,000	-7,000	-21,000	-22,000	-67,000
S2: Less Warming/Wetter	59,000	1,800	2,000	49,000	166,000
S3: More Warming/Dryer	-18,000	-7,000	-28,000	-32,000	-64,000
S4: More Warming/Wetter	63,000	-1,300	-11,000	25,000	105,000
S5: Central Tendency	3,700	-4,700	-17,000	-8,000	15,000

As shown in table 2.3, median annual streamflow would decrease in the St. Mary River at the International Boundary in 2050 and in the Milk River at the Eastern Crossing, near Harlem, and at the mouth for both scenarios *S1: Less Warming/Dryer* and *S3: More Warming/Dryer*. Median annual streamflow would increase in 2050 in the St. Mary River at the International Boundary and in the

Milk River, near Harlem, and at Nashua, the mouth of the St. Mary River for scenarios *S2: Less Warming/Wetter* and *S4: More Warming/Wetter*. Milk River flows at the Eastern Crossing are predicted to decline under scenario *S4: More Warming/Wetter*. Median annual streamflow for 2050 is projected to increase slightly in the St. Mary River at the International Boundary for climate change scenario *S5: Central Tendency*, with decreases in the Milk River at the Eastern Crossing and near Harlem.

Overall, earlier runoff in the St. Mary River and Milk River basins is projected. The earlier shift in runoff timing is more predominant in warmer scenarios (*S3* and *S4*), especially for snowmelt dominated runoff. The surface water hydrology model used for the climate change projections of streamflow divided the St. Mary River and Milk River basins into 42 subbasins.

Under Scenario *S5: Central Tendency*, six of the subbasins are projected to have the centroid (or halfway date for total annual streamflow runoff volume) of the annual runoff volume shifted later, while 36 of the subbasins are projected to be shifted earlier. Over one-half the subbasins are projected to have the centroid of the annual volume shifted earlier by 3 days or more as shown on figure 2.9. The streams in the St. Mary River watershed, which are snowmelt dominated, are all predicted to have annual volume centroid shifts of 7–9 days earlier.

Figure 2.10 compares the median St. Mary River flow that would be available to the U.S. under *S0: Historic Climate Conditions* and future climate change scenarios *S1 – S5*. Overall, the future volume available to the U.S. might be similar to the past, but with an earlier shift in the runoff peak. The abrupt drops and rises in the flow available to the U.S. on April 1 and November 1 reflect the provisions of the flow apportionment with Canada that allow the U.S. a greater percentage of St. Mary River flow (50 percent of the natural flow) during November–March.

Changes in Groundwater Recharge and Discharge

Groundwater is a limited resource in the St. Mary River and Milk River basins, used primarily for domestic and stock water purposes. Wells used for these two purposes generally pump less than about 1.5 AF per year per well. Groundwater is also used to supplement the surface water supply for Havre and is the main supply for Malta. The only widespread groundwater use for agricultural irrigation is in the Turner, Montana, area, near the U.S.-Canadian border. Manifolding (joining) two to four wells for sprinkler irrigation systems to serve about 125 acres is a common practice in this area.

Changes in groundwater due to climate change have not been specifically studied in the St. Mary River basin or the Milk River basin. However, surface water is connected to alluvial aquifers, which includes alluvium of the ancestral Missouri River throughout the basin. The Milk River is also a regional discharge area for

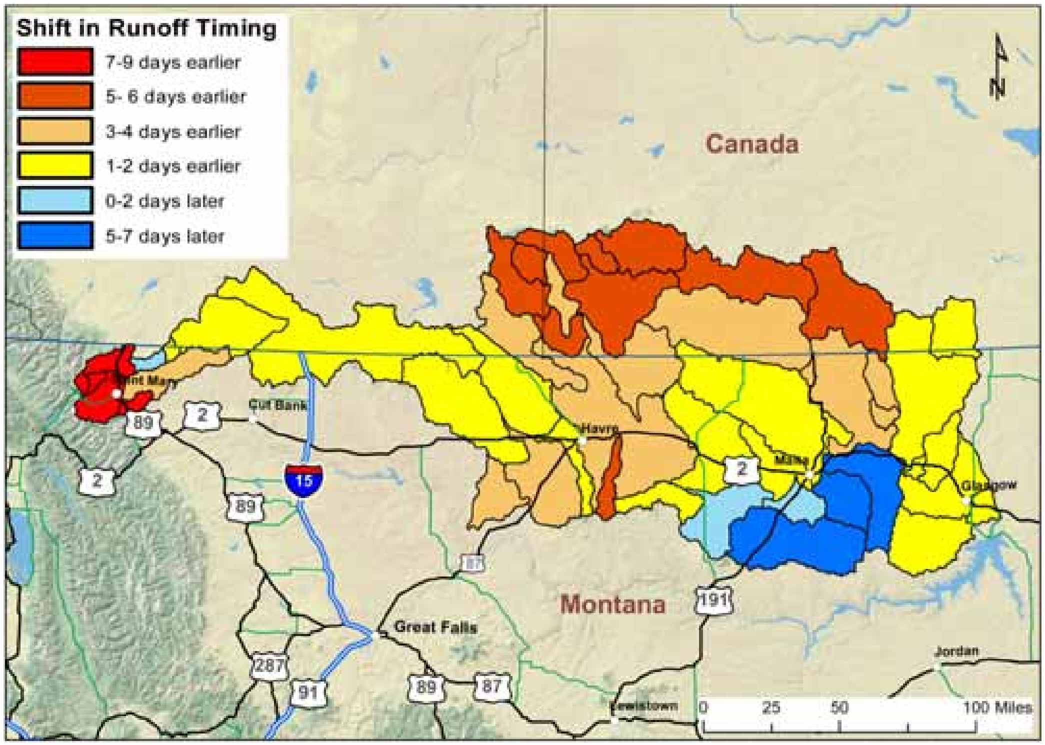


Figure 2.9: Shift in timing (days) of annual runoff volumes per subbasin.

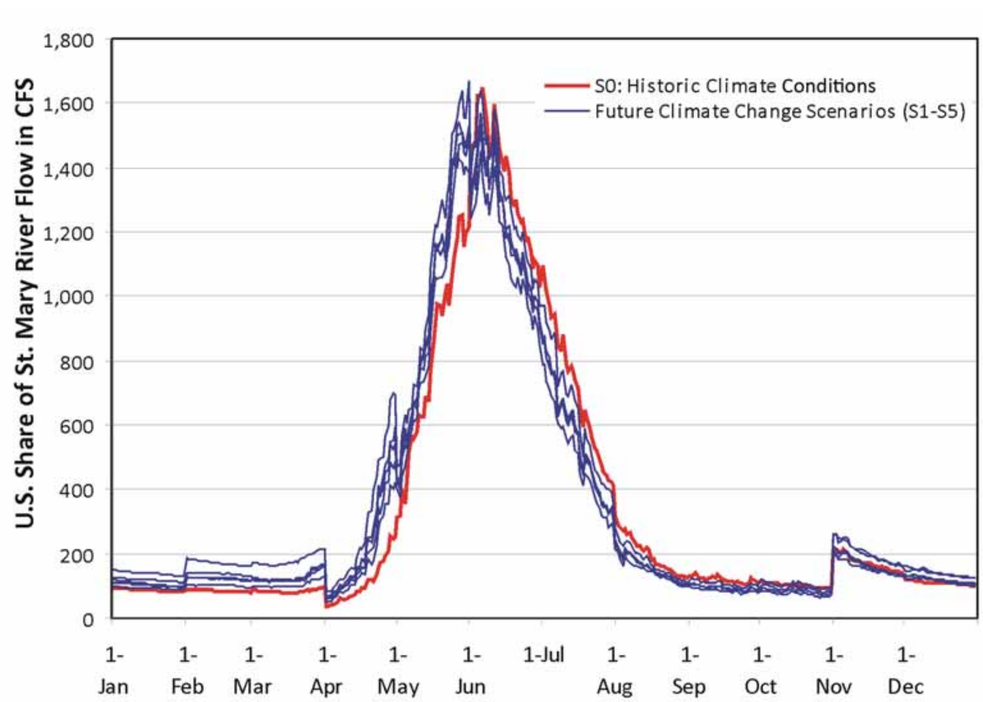


Figure 2.10: Median modeled U.S. share of the St. Mary River flow under *S0: Historic Climate Conditions* and future climate change scenarios *S1 – S5*.

bedrock aquifers such as the Judith River and Eagle formations. Therefore, effects of climate change on precipitation and surface water runoff could affect both recharge to and discharge from groundwater. Warmer climate conditions could reduce groundwater recharge. Increased evapotranspiration would result in more water consumed by plants, thereby reducing groundwater recharge through surface soils. Less precipitation and possibly fewer irrigation return flows due to direct evaporation from the soil also might reduce recharge to groundwater. In addition, riparian areas might consume more water due to increased evapotranspiration, thereby reducing groundwater flows to surface water or recharge to groundwater. Increased evapotranspiration is dependent on temperature and changes to riparian vegetation and might be offset by increased precipitation, with the timing of precipitation being an important factor. A reduction in volume and change in timing of surface water runoff could reduce recharge to groundwater via return flows from application of surface water to farmland. Less water available for irrigated agriculture could result in less recharge, thereby reducing groundwater availability and discharge to surface water bodies such as the Milk River.

Evaporation

Evaporation from open water surfaces, such as reservoirs and stream channels, is expected to increase with warming temperatures. Table 2.4 compares annual net reservoir evaporation for Fresno Reservoir for various climate change scenarios (Reclamation, 2011b). The "net" evaporation is the evaporation from the reservoir surface minus precipitation that falls on the water surface. The wetter conditions projected for most of the climate change scenarios would at least partially offset the effects of more warming on evaporation rates. Average annual net reservoir evaporation for Fresno Reservoir might increase by up to 3 inches for the future projected climate. A similar increase would occur at Nelson Reservoir and from the river surface of the Milk River.

Table 2.4: Average Annual Net Evaporation for Fresno Reservoir under *S0: Historic Climate Conditions* and Climate Change Scenarios *S1 – S5*

Climate Change Scenario	Net Reservoir Evaporation (Inches per Year)
S0: Historic Climate Conditions	22.0
S1: Less Warming/Dryer	24.0
S2: Less Warming/Wetter	22.2
S3: More Warming/Dryer	25.1
S4: More Warming/Wetter	23.6
S5: Central Tendency	23.8

Present Water Demands

Water demands in the Milk River basin are dominated by agricultural irrigation. Municipal demands are much smaller in comparison. There are non-consumptive water demands for recreation and fish and wildlife purposes associated with the Milk River Project, but these generally are not quantified and historically have been considered by Reclamation as incidental uses of project water.

Agricultural Water Demands

Present irrigation water users generally can be categorized into five groups:

- Water users upstream of the Eastern Crossing
- Water users diverting from tributaries of the Milk River main stem
- Non-project water users diverting from the Milk River main stem
- Tribal water users
- Milk River Project irrigation districts
- Milk River Project contract water users

Water users in the Milk River basin upstream of the Eastern Crossing include U.S. and Canadian irrigators. In the Milk River headwaters on the Blackfeet Reservation in the U.S., irrigation varies from year to year, depending on available water and economic factors. This study assumed that 200 acres from the North Fork of the Milk River, and 2,000 acres in the Milk River watershed upstream of the Western Crossing, were irrigated. For the Milk River in Alberta, Canada, between the Western and Eastern Crossings, 8,000 acres were considered irrigated.

Water users diverting from Milk River tributaries generally have limited irrigation opportunities because of tributary runoff patterns. The tributary streams usually have water available during the snowmelt runoff, which usually is during March and April. Although crop demands are very low during this period, irrigators still apply water to fill the soil profile for later use by the crop. Tributaries may also flow and have water available from spring and early summer rains in May and June. Approximately 40,000 acres are irrigated from tributary streams in the Milk River basin, although very little of this irrigation approaches full service. There are a few storage reservoirs for irrigation on the tributary streams, the largest being the DNRC's Frenchman Reservoir on Frenchman Creek.

For lands irrigated from the Milk River main stem, the study team reviewed mapping of irrigated lands previously completed by the DNRC. The Geographic Information Systems (GIS) analysis indicated that there are 140,200 acres of land that can be irrigated from the Milk River downstream from the Eastern Crossing. The Fort Belknap Indian Reservation water users presently irrigate about 6,200 acres from the main stem of the Milk River. The Fort Belknap Indian Irrigation Project area has a total of 10,500 acres, but some of this land is currently not being irrigated. There are 110,300 acres authorized to receive Milk River Project water. The mapping indicates that there may be 122,400 acres irrigated as part of the Milk River Project. The 12,100 acres that appear to be irrigated from project facilities that are not authorized may have overlapping state-based water rights presently being adjudicated by the Montana Water Court.

The remaining 11,600 acres are irrigated by private irrigation systems along the Milk River. The water for these systems is usually pumped from the Milk River. Previous studies indicated that there are about 25,000 acres of privately irrigated land in the basin below Fresno Reservoir. With the 12,100 acres being served by project facilities but not authorized, private irrigation could total 23,700 acres. Milk River irrigated acres below Fresno Reservoir are summarized in table 2.5.

Table 2.5: Milk River Irrigated Acres Below Fresno Reservoir

Description	Acres
Milk River Project Irrigation Districts	104,700
Lands with Project Contracts	17,700
Fort Belknap Indian Reservation	6,200
Private, Non-contract	11,600
Total	140,200

The net irrigation requirement for the crop distribution grown in the Milk River basin downstream from Fresno Reservoir ranges from an average of about 18.3 inches per acre in the Chinook area to an average of about 19.8 inches per acre in the Glasgow area. Thus, the total depletion requirement for land irrigated from the main stem of the Milk River without water shortages averages about 210,000 AF per irrigation season. When overall basin irrigation efficiencies of about 33 percent are factored in, the total diversion requirement for the 140,200 acres irrigated is about 630,000 AF (Reclamation, 2011b). The system would not need to produce the entire 630,000 AF to meet diversion requirements because return flows are recycled downstream.

Municipal Water Demands

The communities of Havre, Chinook, Harlem, Hill County, and North Havre Water District have water supply contracts with Reclamation for municipal water. The current annual average water use, the maximum annual water use since 2001, the total water volume of contracts, and the expiration date of the contracts is listed in table 2.6. The cities deplete part of this water, especially during the summer for lawn and garden use, but much of the diverted flow eventually returns to the Milk River.

Table 2.6: Current Average Water Use, Maximum Water Use, Contract Volumes, and Contract Expiration for Municipal Water

	Average (AF)	Maximum since 2001 (AF)	Contract Volumes	Contract Expiration
Havre	1,825	2,040	2,800	March 2033
Chinook	360	825	700	September 2016
Harlem	130	140	500	May 2043
Hill County	250	340	500	August 2046
North Havre	35	—	100	August 2046
Total	2,600	—	4,600	—

The communities are presently using an average of about 2,600 AF annually. The combined contracted amount of water is up to 4,600 AF annually, so they are presently using considerably less than the contracted volume. Municipal use represents less than 1 percent of total Milk River diversions.

Other Water Demands

Fish, Wildlife, and Recreation

The St. Mary River, Milk River, and associated storage reservoirs (Sherburne Lake, Fresno Reservoir, and Nelson Reservoir) provide habitat for many fish and aquatic species. These reservoirs, rivers, and surrounding lands also offer hunting and fishing opportunities; water-borne recreation like boating, water skiing, and swimming; as well as camping, picnicking, and wildlife observation.

FW&P established guidelines in 1998 for reservoir and river operations for fish, wildlife, and recreation. Recommendations for Fresno Reservoir include maintaining a conservation pool above elevation 2,560 feet mean sea level (MSL) to provide maximum benefit to the fishery and recreation, and a minimum pool of elevation 2,551 feet MSL. Recommendations for Nelson Reservoir include maintaining a conservation pool above elevation 2,215 feet to provide maximum benefit to fishery and recreation, and a minimum pool of elevation 2,210 feet. A gradual drawdown of both reservoirs after mid-May is recommended to allow for walleye and perch eggs to hatch.

The Bowdoin National Wildlife Refuge (figure 2.11) provides food and habitat for migratory birds (including the endangered piping plover and interior least tern), upland birds, and many species of waterfowl. The refuge has a reserved water right from Beaver Creek and a contract with Reclamation for Milk River Project water. Up to 3,500 AF of project water annually is diverted to the refuge from the Dodson South Canal under the contract. The refuge also receives return flow from the Malta Irrigation District.

Figure 2.11: Bowdoin National Wildlife Refuge.

Water Quality

The communities of Havre, Chinook, and Harlem have wastewater discharge permits from the DEQ. A minimum release of 25 CFS from Fresno Reservoir is provided under contract by Reclamation during the non-irrigation season to provide mixing flows for treated wastewater into the Milk River. This also allows the communities downstream to have water of suitable quality to divert from the Milk River. This flow rate in the winter typically is exceeded because the outlet works at Fresno Reservoir would be damaged by cavitations at lower flows. Current operation procedures are that the flow from Fresno Reservoir during the non-irrigation season not be reduced below approximately 45 CFS. The 45 CFS flow requirement will continue to be met in the future.

Threatened and Endangered Species

Currently, water is managed in the area for bull trout, piping plover, and pallid sturgeon.

Bull trout are found in the St. Mary River drainage. Studies by Reclamation, USFWS, and the Blackfeet Tribe are underway to determine how to best manage the St. Mary Diversion Dam and Canal facilities to provide fish passage and to prevent canal entrainment. The USFWS and the Blackfeet Tribe also have identified the need to maintain instream flows in Swiftcurrent Creek below Sherburne Dam during the non-irrigation season. Reclamation anticipates entering formal ESA consultation with the USFWS in the near future to address these identified impacts to bull trout.

The piping plover is found in the Milk River basin at Bowdoin National Wildlife Refuge and Nelson Reservoir. When gravel shoreline habitat is available, the plover can use the reservoir's shore as nesting habitat. Reclamation consulted with USFWS on operations of Nelson Reservoir in 1990. In 1991, the USFWS issued a non-jeopardy opinion under ESA. An agreement among Reclamation, USFWS, and the irrigation districts to reduce effects on nests allowed the designation of the reservoir as critical habitat to be avoided. The agreement outlines operational guidelines that attempts to fill Nelson Reservoir by mid-May and maintain water levels at or below the mid-May level to prevent nest inundation.

Pallid sturgeon, found in the Missouri River, have also been documented to use the lower Milk River. Studies are underway to analyze if they are using warmer waters of the lower Milk River and if a more natural hydrograph triggers the fish to move upstream to spawn.

Montana Species of Special Concern

There are over 27 Species of Special Concern in the region. Currently, water is not managed in the area for these species.

Future Water Demands

Climate Change

Most of the 112 GCMs used for climate change projections indicate increased temperature and precipitation in the St. Mary River and Milk River basins, although some show modest precipitation decreases. The increase in temperature, predicted under all future climate change scenarios, would result in increased water demands, especially for irrigation. The baseline conditions (i.e., existing infrastructure and present water supply and demands) were compared under all scenarios. The climate change scenario *S0: Historic Climate Conditions* assumes that there would be no change in the future and uses the historical climate records. This climate change scenario serves as a basis for comparison. To illustrate the relative range of effects, we used the future climate change scenarios with the least demand increase *S2: Less Warming/Wetter*, the greatest demand increase scenario *S3: More Warming/Dryer*, and *S5: Central Tendency.* The demand increases for scenarios *S1: Less Warming/Dryer* and *S4: More Warming/Wetter* fall in between *S2: Less Warming/Wetter* and *S3: More Warming/Dryer.*

Agricultural Water Demands

Modeling the impacts of climate change as part of this Basin Study included estimates of net irrigation requirements for the period centered on year 2050. Water Use for a discussion of methods used to estimate evapotranspiration requirements in the model. Table 2.7 lists the annual net irrigation requirement for four locations across the Milk River basin for *S0: Historic Climate Conditions*

Table 2.7: Annual Net Irrigation Requirement in the Milk River Basin for Current Climate and the Range of Climate Change Scenarios (in inches per acre)

Climate Condition	Milk River Headwaters Area	Chinook Area	Malta Area	Glasgow Area
S0: Historic Climate Conditions	16.0	18.3	19.1	19.8
Year 2050 Climate				
S5: Central Tendency	20.6	22.8	23.5	24.5
S2: Less Warming/Wetter	18.5	20.6	21.1	21.8
S3: More Warming/Dryer	22.5	24.5	25.3	26.2

and *S5: Central Tendency* and the two climate change scenarios *S2: Less Warming/Wetter* and *S3: More Warming/Dryer* that define the upper and lower limits of anticipated crop irrigation requirement changes.

The net irrigation requirement for the year 2050 for *S5: Central Tendency* is about 4.5 inches greater than the historic net irrigation requirement. This is because a warmer temperature and long growing season would result in more crop growth and increased evapotranspiration. This represents a 24–29 percent increase in the net irrigation requirement, depending on the location in the basin. The 2050 climate projection for *S2: Less Warming/Wetter* shows the smallest increase in net irrigation requirement of about 2 inches. The 2050 climate projection for *S3: More Warming/Dryer* shows the greatest increase in net irrigation requirement, with an increase of about 6 inches more than historic climate baseline crop requirements.

The projections under the 2050 for *S5: Central Tendency* indicate an annual crop requirement of 266,000 AF for the 140,000 acres irrigated along the Milk River, an increase of 56,000 AF more than the present requirements of 210,000 AF. This estimate assumes that the basin's crop distribution would not change from *S0: Historic Climate Conditions.* If efficiencies remained the same as today, this would translate into an increased annual diversion requirement of about 170,000 AF.

The net irrigation requirement projected increase of about 4.5 inches per acre suggests that there could be an increase in crop production if the increased water demand could be satisfied. In the Milk River valley, a significant amount of the irrigated acres is in alfalfa hay. Increases in alfalfa production can serve as an indicator of total agricultural crop production in the basin. Considerable research has been conducted in the western U.S., and alfalfa yield can be estimated by production functions based on the volume of water used by the crop. On average, about 0.19 ton of alfalfa is produced with each applied inch of water. Thus, alfalfa production could increase by about 0.85 ton of alfalfa per acre if the 4.5 inches of extra water were always available.

Municipal Water Demands

The Rocky Boy's/North Central Montana Rural Water System (RB/NCMRWS) is currently being constructed. At the current funding levels, completion of the project is more than 50 years away. As the water supply for this system is from Tiber Reservoir, this system might reduce the contracted volume of municipal water currently used from the Milk River. Havre, Hill County Water District, and North Havre Water District are all within the Milk River Project boundary and have signed Letters of Intent to be served by the rural water system. Once each of these areas started to receive water, Hill County Water District and North Havre Water District would significantly reduce or possibly eliminate their contracts for water from the Milk River. Havre might keep their water contract and use the treated water to serve areas on the eastern side of the project boundary. Because of these factors, future water uses of these communities are expected to remain within the current contracted volume.

St. Mary River and Milk River Aquatic Species Demands

Instream flow amounts and temperatures need to be considered for aquatic species. Climate change in northern Montana is generally projected to increase annual mean temperatures, modifying streamflow volumes both positively and negatively, and shifting the peak of the hydrograph both forward and backward. These effects are localized in different regions of the two basins and have potential to affect ecological resiliency for aquatic species in these basins, primarily the ability of invertebrate and fish species to adapt to changing habitat conditions.

An "ecologically resilient" aquatic ecosystem can be defined as possessing the capability to recover from either stochastic natural disturbances, such as extreme drought or flooding, or from anthropogenic disturbances, such as river channelization, dam construction, or water storage and diversion. The concept of ecological resiliency encompasses both the time required for the ecosystem to recover and an endpoint in the recovery process. A resilient ecosystem is able to withstand short-term disturbances and return to more normal conditions once the disturbance subsides or is eliminated. It is important to note that ecosystem resiliency is not equivalent to ecosystem health. For example, an ecosystem that is developed in response to a disturbance might contain monotypic stands of invasive species, be inhospitable to native species, and may be highly resilient and, therefore, difficult to return to its native condition. In addition, it is generally considered that a threshold of disturbance exists that prohibits ecosystems from returning to the same dynamic-equilibrium paradigm.

Reclamation has not yet adopted a common definition for ecological resiliency, nor have methodologies been developed to quantify impacts to ecological resiliency. It is anticipated that such information may be available in late 2012 or early 2013. Therefore, the treatment of ecological resiliency and potential effects of climate change on aquatic species are presented qualitatively for this report.

St. Mary River

The St. Mary River basin lies mostly within Glacier National Park and is largely unencumbered by development. The construction and operation of Sherburne Dam and the St. Mary Diversion Dam represent the most significant alterations to temperature and flow patterns in the basin. In addition, a reach of Swiftcurrent Creek below Sherburne Dam has been relocated to permit flow into Lower St. Mary Lake.

Fish species native to the St. Mary River include bull trout, westslope cutthroat trout, mountain whitefish, lake trout, northern pike, burbot, white sucker, longnose sucker, lake chub, trout-perch, longnose dace, pearl dace, mottled sculpins, and spoonhead sculpins (Brown, 1971). Lakes in the basin also contain native populations of northern pike and sucker species. These habitats also support non-native Yellowstone cutthroat trout, rainbow trout, brook trout, kokanee, and lake whitefish. The only known population of trout-perch in Montana is found in the basin (Reclamation, 2004a). The only known east-slope population of bull trout is found in streams and lakes throughout the upper basin and is listed as threatened under the ESA.

Aquatic invertebrates in the basin are typical of streams and lakes dominated by a snow-melt hydrograph. Stoneflies, mayflies, and caddisflies are common along with other invertebrates. A few invertebrates, such as the western glacier stonefly, have limited distribution and are restricted to the coldest reaches of some headwater streams in the basin.

By 2050, the climate change scenario *S5: Central Tendency* is likely to increase annual streamflow in the St. Mary River at the Canadian border (see table 2.3 earlier in this chapter). Some flow increase might result from melting glaciers responding to higher air temperatures. Air temperatures are projected to increase in the basin with a probable corresponding increase in water temperatures.

Bull trout and endemic aquatic invertebrates, such as the western glacier stonefly, are particularly sensitive to water temperature. Migratory bull trout begin to spawn with falling water temperatures in late summer and early fall and move to the coldest reaches of the basin. Bull trout might be able to react to increasing water temperatures by migrating and spawning higher in the basin, provided access is not restricted by barriers. The altered timing of the hydrograph results in reduced flows (and possibly higher water temperatures) occurring earlier in the summer, limiting bull trout spawning habitat and possibly affecting the species' ability to adapt to a changing climate. Other salmonids and native fish are less sensitive to increased water temperatures and might have less difficulty reacting to a changing climate and its effect on streamflows and water temperatures. However, salmonids and other native species with spawning strategies that cue off the timing of hydrograph characteristics may experience reproductive limitations. The indirect effects of spawning earlier or higher in the watershed are not well understood.

The western glacier stonefly's entire aquatic life cycle is restricted to high-elevation reaches of the basin that receive water from melting glaciers and snowfields. The greatest impact from a changing climate for this and similar species in the basin would be increased air temperatures that cause glaciers and large snowfields to melt faster and ultimately disappear. The absence of these features from the alpine landscape would ultimately increase water temperatures.

Milk River

Compared to the St. Mary River basin, this basin is highly altered. Transbasin imports, reservoir construction, irrigation diversions, and non-point source pollution have altered streamflows, water temperatures, and other aquatic habitat parameters over the last century. Bi-national management strategies have also contributed to changes in streamflow volume and temperature both in Canada and the U.S..

Projected median annual streamflow for the climate change scenario *S5: Central Tendency* is inconsistent across the Milk River basin. Streamflows are projected to decrease at the Eastern Crossing and at Harlem, but they are projected to increase in the lower basin and at the confluence with the Missouri River (see table 2.3 earlier in this chapter).

Changes to the peak of the hydrograph are also inconsistent across the basin. Most of the subbasins are projected to experience earlier peaks in the hydrograph; however, there are a few subbasins projected to shift to a later peak. Air temperatures are projected to increase across the basin.

Composition of the Milk River fishery is dynamic with flathead chub, river carpsucker, shovelnose sturgeon, and stonecat most common in spring and emerald shiner, flathead chub, goldeye, and shorthead redhorse most common in fall (Stash, et al., 2001). Pallid sturgeon, blue sucker, shovelnose sturgeon, and other native fish from the Missouri River are attracted by increased water temperatures and sediment load in the lower reaches of the Milk River under some high-flow conditions and move into the Milk River presumably to spawn. Upstream movement is limited by the Vandalia Diversion Dam. With increased flows and warmer water temperatures, the lower Milk River may become significant habitat for fish migrating out of the Missouri River to spawn, especially pallid sturgeon.

Above the Vandalia Diversion Dam, streamflows, water temperatures, and sediment loads are highly modified. The composition of the fish community is reflective of such modification. With the projected increase in water temperatures and decreased streamflow, the composition of the aquatic community is likely to shift further from its natural state. Aquatic species inhabiting the Milk River in the future would have to be able to withstand wide fluctuations in both streamflow and temperature. Such a strategy would likely produce a more resilient aquatic community; however, species diversity would decrease, and community composition may be dominated by non-native species.

Alterations to streamflow and water temperatures due to water management, in addition to habitat disturbance, loss, and fragmentation, have negatively impacted the spatial distribution, productivity, abundance, and diversity of aquatic communities that inhabit much of the basin. It is anticipated that the effects associated with a potential change in climate would further reduce these indicators of population health.

Fish, Wildlife, and Recreation Demands

With warming temperatures and higher evaporation rates in the future, lower overall water levels at the Bowdoin National Wildlife Refuge could be a concern. Recreational use of Fresno, Nelson, and Sherburne, as well as Glacier National Park, is expected to increase, so emphasis on water surface elevations might be a public concern.

Water Quality Demands

Minimum releases from Fresno Reservoir are not anticipated to increase in the future. The communities of Havre, Chinook, and Harlem have wastewater discharge permits from the DEQ. A minimum release of 25 CFS from Fresno Reservoir is provided under contract by Reclamation during the non-irrigation season to provide mixing flows for treated wastewater into the Milk River. This also allows the communities downstream to have water of suitable quality to divert from the Milk River. This flow rate in the winter typically is exceeded because the outlet works at Fresno Reservoir would be damaged by cavitations at lower flows. Current operation procedures are that the flow from Fresno Reservoir during the non-irrigation season not be reduced below approximately 45 CFS. The 45 CFS will continue to be met into the future. If releases are reduced, water temperatures will increase, dissolved oxygen will decrease, and good and bad constituents will increase.

Threatened and Endangered Species and Montana Species of Special Concern Demands

Reclamation will be entering into ESA consultation with the USFWS to continue to study bull trout needs. Bull trout flow requirements on Swiftcurrent Creek and the St. Mary River might be quantified in the future once more information has been obtained. Current water operations to benefit the piping plover are not expected to change in the foreseeable future. Pallid sturgeon flow requirements might be quantified in the future. Water demands for Species of Special Concern are not anticipated to change.

Future Canadian Use from the Milk River

The median surplus Canadian share that the U.S. receives is 20,000 AF per year of the Milk River natural flow. Alberta has explored building a reservoir on the Milk River to capture a greater share of the Canadian apportionment. The preferred site would be an on-stream reservoir just below the junction of the North Fork of the Milk River on the Milk River proper. (Evaluation of an alternative to provide reservoir storage in Canada is detailed in chapter 5.)

Northern tributaries to the Milk River also arise in Canada, primarily in Saskatchewan. The largest and most important tributaries to Saskatchewan for irrigation are Lodge Creek, Battle Creek, and Frenchman Creek. On average, the U.S. receives about 10,300 AF per year of Canada’s share of these tributaries, primarily during the spring in wet years. Saskatchewan has investigated building additional infrastructure on the northern tributaries to capture more of the Canadian share, but there are no definitive plans to build new reservoirs at this time.

Tribal Implementation of Federal Reserved Water Rights

The Rocky Boy’s and Fort Belknap Indian Reservations have federally reserved water rights in the Milk River basin. The Blackfeet Reservation has federally reserved water rights in both the St. Mary River and Milk River basins. The Fort Peck Indian Reservation has some reservation land in the Milk River basin; however, in 1985 the Tribes and the State of Montana reached a Compact Agreement in which the Tribe’s relinquished all claims from the Milk River in exchange for water in the Missouri River.

The Chippewa Cree Tribe of the Rocky Boy’s Indian Reservation and the State of Montana reached a Compact Agreement ratified by the Montana Legislature and signed by the Governor in early 1997. The Compact quantified a total of approximately 10,000 AF of water that the Tribe has a right to use from various water sources tributary to the main stem Milk River. Some of this volume is for existing uses and some for new uses. Some Compact-related developments have already been implemented. The water right priority date of this Compact right is September 7, 1916, junior to many uses on the main stem Milk River and junior to the downstream Compact rights of the Fort Belknap Indian Reservation.

The Fort Belknap Indian Community of the Fort Belknap Indian Reservation and the State of Montana reached a Compact Agreement in 2001. At the time of this report, this Compact has not been ratified by Congress. The Compact recognizes the original 125 CFS provided in the *Winters* reserved right from the Milk River for use on the existing Fort Belknap Indian Irrigation Project. In addition, the Fort Belknap Indian Community receives another 520 CFS from the Milk River for use by the Tribes. The Compact recognizes that the Tribes' water rights are from the U.S. share of the Milk River under the Boundary Waters Treaty. The priority date for this Compact water right was October 17, 1855. The Compact acknowledges that additional water will be required to mitigate the impacts on state-based water rights from the Tribal development of the reserved water rights. The Compact specifies that the St. Mary diversion facilities must continue to be viable for the Tribes to exercise their water rights under the Compact. It also provides for construction of a reservoir on Peoples Creek and rehabilitation and improvement of the Tribes' Milk River irrigation system (figure 2.12).

Figure 2.12: Fort Belknap Indian Irrigation Project Diversion Dam.

In addition to the main stem Milk River water right, the Fort Belknap Indian Community has a water right from Peoples Creek for water in the stream on the reservation after upstream, off-reservation water uses are satisfied. The Tribes have a right to use up to 8,024 AF per year from Beaver Creek, which flows into the Milk River near Hinsdale, Montana.

The Blackfeet Tribe and the State of Montana entered into a Compact Agreement in 2009. It has not been ratified by Congress. The reservation is located in the headwaters of the St. Mary and Milk Rivers; therefore, the Tribe has water rights in both the St. Mary and Milk River basins. For the St. Mary River, the Compact defines a right for the Tribe to 50,000 AF per year from the river, other than the Lee Creek and Willow Creek tributaries, subject to the Boundary Waters Treaty. The Tribe also has a right to use all the natural flow available to the U.S. under the Boundary Waters Treaty within the reservation from Lee Creek and Willow Creek, subject to certain conditions. The priority date for this water right was October 17, 1855.

The Blackfeet Tribe also has a right to use all the natural flow available to the U.S. under the Boundary Waters Treaty within the reservation from the Milk River, subject to certain conditions. Additionally, the Tribe will defer new development of Milk River water for a period of 10 years after the effective date of the Compact for irrigation uses not relying on stored water.

Potential Factors that could Affect Demands in the Future

Economic opportunities, legal requirements, and social values are continually shifting and evolving. Increased awareness and interests related to water quality, riparian health, recreation, aesthetics, and fish and wildlife represent good examples and are reflected in legislation such as the ESA and Clean Water Act in response to shifts in social values. If the past is any indicator, unforeseen new uses, increased resource protection, and socioeconomic changes are likely to continue into the future. Below are some areas that look beyond familiar and customary uses and existing water management practices.

Irrigation

For the Milk River Project to remain viable, water users will likely have to incorporate new technologies, forge new partnerships, and improve overall management of the water supply. The basin closures, implementing compacts, and the existing Reclamation water contracts are formal sideboards that limit the likelihood of new, non-Tribal irrigation expansion in the St. Mary River and Milk River basins. However, advancements in irrigation technologies and efficiencies might present opportunities to move irrigated lands from the river valley to more productive adjacent lands. Partnerships between project water users and non-project water users could allow for those acres to be contractually incorporated into the Milk River Project. Modifications to irrigation would need to be done within the framework of Montana water law, which might require water rights changes for some types of irrigation improvements.

Industry

Due to the intensive-use nature of irrigation, chronic water shortages are frequently incurred. The Milk River Project facilities generally ensure reliable flows in the Milk River to support irrigated crops during the irrigation season and municipal needs year round, but there is little unappropriated water in the basins. If water were needed for new industry in the area, it would probably need to come from early-season tributary storage or through changes to existing water rights.

Energy

Extractive energy development is taking place in the basin, but these developments have yet to place measureable stresses on the water supply. Resource extractive industry technologies and capabilities are expanding, providing access to nonrenewable resources that were previously uneconomical or technically infeasible. This might lead to more extraction activity in the area, placing more demand on the water supply.

Milk River Project facilities could be upgraded to accommodate hydropower generation capabilities, possibly coupled with other renewable energy development such as wind power generation. A power plant requiring large volumes of water for cooling could conceivably be built in the area, but it probably would need to obtain water through tributary storage or through purchase and changes to existing water rights.

Environmental

Enforcement of water quality standards is likely to become more stringent in the future. Achieving Total Maximum Daily Loads might become mandatory at some future time as methods and technologies for management, monitoring, and enforcement of non-point source pollution become technically feasible. Additionally, unidentified future uses might introduce new impairments to the stream. Instream flow also might be a required part of future water management in the basins.

Summary of Present and Future Water Supplies and Demands

The present average St. Mary River and Milk River water supplies are estimated to be about 380,000 AF annually for the U.S.. Some additional water may be available from ungauged tributaries, but the usable flow is difficult to quantify and is highly variable from year to year. The climate change scenario *S5: Central Tendency* shows a runoff increase of 18,700 AF annually above that for climate change scenario *S0: Historic Climate Conditions.* Another important consideration is that an increase in the variability of the water supply is expected in the future.

The U.S. share of St. Mary River flow in the future might be similar to what it is today, with some increases in variability between wetter and drier years. Figure 2.13 shows the U.S. share of the St. Mary River flow for the high and low range of future flows (i.e., under the climate change scenarios *S0: Historic Climate Conditions*, *S5: Central Tendency*, *S1: Less Warming/Dryer,* and *S4: More Warming/Wetter*). Model results show that, with the existing infrastructure, the U.S. should be able to capture and divert a similar volume of St. Mary River share in the future as during the past, although the timing of those diversions is expected to shift towards the early portions of the season.

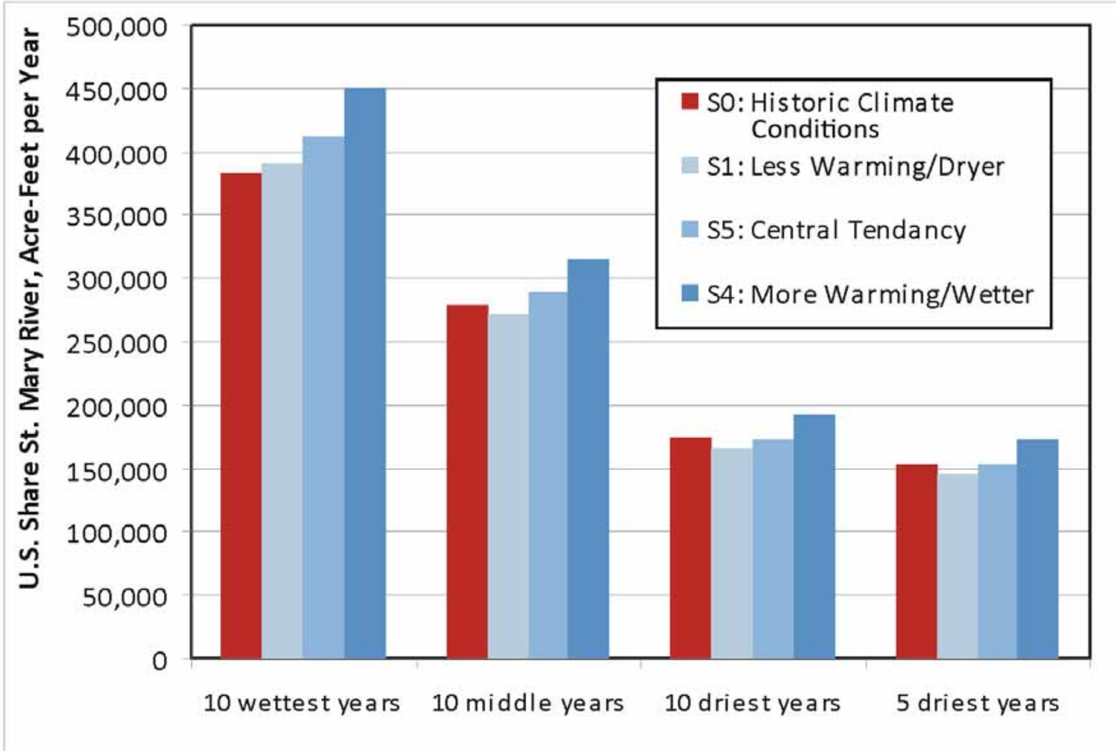


Figure 2.13: U.S. share of St. Mary flow under historic climate baseline and climate change scenarios.[4]

Table 4.2 in chapter 4 summarizes simulated St. Mary Canal diversions under *S5: Central Tendency*. During average and median years, model results indicate that future diversions would be similar to historic diversions. *S5: Central Tendency* diversions were about 10 percent higher than historic conditions for wetter years and about 6 percent lower for drier years, reflecting the increased year-to-year variability anticipated under the future climate change scenarios.

For this report, irrigation depletion shortages are the volume of unmet crop water demand. The historic theoretical total annual depletion of irrigation water by crops for land presently irrigated from the Milk River, if water were always available to meet all crop requirements, is about 210,000 AF. The theoretical irrigation depletion shortage is expected to increase to 266,000 AF by 2050. This represents an increase of 56,000 AF, or 27 percent annually, from the current irrigation depletion requirements.

Previous studies have indicated that significant water shortages already occur in the basin. Increases in runoff by 2050, if it can all be captured and used, is

[4] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

expected to only make up for between 33 to 37 percent of the expected increase in crop irrigation depletions. A more detailed analysis on meeting future demands using the river system model is presented in chapter 3.

Table 2.8 presents a summary of present and future demands by water use. This table is general and does not explicitly include all uses.

Table 2.8: Summary of Present and Future Demands

Water Use	Water Body	Present Demand (2012)	Consumptive	Future Demand (2050)
Irrigation 140,000 acres	Milk River	210,000 AF	Yes	266,000 AF
Municipal (Havre, Chinook, and Harlem)	Milk River	2,600 AF	Yes	Possible reduction
Water Quality Mixing	Milk River	25 CFS (45 CFS is currently released from Fresno Reservoir)	No	If facilities are modified, releases may reduce to 25 CFS
Fisheries and Recreation Preferred/Minimum Pool	Fresno Reservoir	Pool target elev. 2,551 feet, preferred 2,560 feet minimum pool, and gradual drawdown after mid-May for walleye and perch hatch	No	Storage reduction due to sedimentation and increased evaporation and releases for increased crop demands
Preferred/Minimum Pool	Nelson Reservoir	Pool target elev. 2,215 feet, preferred 2,210 feet minimum pool, and gradual drawdown after mid-May for walleye and perch hatch	No	No changes anticipated
Minimum Flows	Milk River	No minimum flow identified	No	No changes anticipated
Minimum Flows	St. Mary River	No minimum flow identified (Canadian apportionment ensures flows)	No	No changes anticipated

Table 2.8: Summary of Present and Future Demands

Water Use	Water Body	Present Demand (2012)	Consumptive	Future Demand (2050)
Wildlife Migratory Birds	Bowdoin NWR Lakes	3,500 AF Milk River, 5,000 AF irrigation return flows, Beaver Creek floods, 14–16 thousand AF needed	Yes	Increased evaporation
ESA Bull Trout (Threatened)	St. Mary River	Canal entrainment, fish passage, and lack of winter flows on Swiftcurrent Creek are identified as affecting bull trout, but currently not managed for this species	No	Possible low flow releases from Sherburne Reservoir into Swiftcurrent Creek. St. Mary diversion facility modifications to address entrainment and passage should have little or no impact on water availability
Piping Plover (Endangered)	Nelson Reservoir	Stop filling Nelson Reservoir by May 15 to prevent nest inundation	No	No changes anticipated
Pallid Sturgeon, Grizzly Bear, and Least Tern (Endangered)	St. Mary and Milk Rivers	Water currently not managed for these species	No	May require minimum flows in lowest reach (Vandalia Diversion Dam to confluence of the Milk and Missouri Rivers)
Montana Species of Special Concern: Sauger, Pearl Dace, Paddlefish and Blue Sucker	Milk River	Water currently not managed for these species	No	Possible instream flow

Chapter 3: The River System Model

One of this Basin Study's main purposes is to develop, refine, and test a river system model to be used to evaluate current and future activities and conditions in the St. Mary River and Milk River basins. Previous studies have relied on revising older models or constructing new models to address specific goals. These older models no longer have the robustness or resolution to evaluate complex river system issues faced by water managers, planners, decisionmakers, or users. Additionally, previous models have been constructed on a monthly time step, which does not always provide enough information to capture operations changed more frequently to meet apportionment requirements, irrigation demands, and other goals. The new river system model also incorporates operations of the system and irrigation diversion data for more recent years.

Knowledge gained from previous models was used to help develop the model for this study. Notable improvements and additions to this model were:

- Procedures to apportion water according to the Boundary Waters Treaty and the IJC 1921 Order. The apportionment procedure also includes the Letter of Intent, allowing temporary deficit deliveries.

- Two storage accounts in Fresno Reservoir—one for the Fort Belknap Indian Irrigation Project and the other for Milk River Project users.

- Performs calculations on a daily time step.

- Incorporates data that have only recently been collected on irrigation district canal diversions and surface return flows.

This river system model, with its new capabilities, will allow the State of Montana and the U.S. to better evaluate:

- Water developments that might be proposed with implementation of the Water Rights Compacts of the Blackfeet Tribe and Fort Belknap Indian Community

- Alternatives for replacement and rehabilitation of aging water infrastructure

- Proposed water apportionment/sharing alternatives being considered by the State of Montana and Province of Alberta through the St. Mary and Milk Rivers Joint Water Management Initiative

- The effects of climate change on water supply and demands

The River System Model

RiverWare ™, an up-to-date, generalized river basin modeling tool, was selected as the model software for this study. RiverWare ™ was developed by the Center for Advanced Decision Support for Water and Environmental Systems of Boulder, Colorado, with substantial support from Reclamation. The software provides a construction kit for developing and running detailed, site-specific simulations without the need to develop or maintain the supporting software within a water management agency. It includes an extensive library of modeling algorithms, several solvers, and a language for the expression of operating policy. Its point-and-click graphical interface facilitates model construction, execution, and preparing quality outputs for communicating results. Models have been developed with RiverWare ™ by both federal and state agencies across the Western U.S. to resolve a wide range of operational and planning problems.

The St. Mary and Milk Rivers system model is a simulation model composed of objects such as reservoirs, canals, and river reaches; hydrologic and water use data; and "rules" that specify how the system is to be operated. The model simulates operations of the upper St. Mary River system to meet the goals of diverting water through the St. Mary Canal for the water needs of the Milk River Project while meeting international apportionment requirements with Canada. The St. Mary River is linked to the Milk River in the model through the St. Mary Canal object. Operations of the Milk River system in the model are simulated to distribute the imported St. Mary River water and Milk River natural flow to the various irrigation districts, contract users, and the Fort Belknap Indian Community of the Fort Belknap Indian Reservation using the reservoirs and irrigation canals on the Milk River.

Major Milk River Project operations modeled for this study include:

- Sherburne Dam and Lake, Fresno Dam and Reservoir, and Nelson dikes and Reservoir
- St. Mary Canal
- Dodson Diversion Dam (figure 3.1) and Dodson South Canal system, including the Bowdoin National Wildlife Refuge
- Major canals and pumping stations for the other Milk River irrigation districts

The most recent reservoir attributes, such as available storage, surface areas, outlet and spillway capacities, and target elevations, were obtained from Reclamation. Up-to-date canal capacities and other canal operational constraints were obtained from Reclamation or the irrigation districts.

Figure 3.1: Dodson Diversion Dam.

The basic operations of the St. Mary and Milk Rivers system were modeled using guidelines set forth in the *Reservoir and River Operation Guidelines for the Milk River Project, A Practical Guide to Operating the Milk River Project* (Reclamation, 2008). This guide sets out general reservoir target elevations, release rates, filling procedures, irrigation releases and deliveries, and river flows through the system. Information compiled by Reclamation from the previous system models (Reclamation, 2004a) were also used extensively in developing the rules and methods for simulating system operations.

A schematic of the river system model is shown in appendix A at the end of this report. The *St. Mary River and Milk River Basins Study Model Documentation* (DNRC et al., 2012) includes specific information about each river reach, including streamflow, demand, and rules related to operation of the reservoir and river system. Because the Milk River Project has the predominate water supply facilities and demands in the basin, in many ways the operating criteria for the project define the “rules of the river” for the *St. Mary River and Milk River Basins Study* model.

Summary of Model Input Data

Model simulations during initial development and calibration were based on streamflow, climate, and operations data from 1959 to 2009. Data from this period were used to:

(1) Include streamflow and water use data for a representative sequence of years, with wetter and drier periods, to capture the year-to-year and decadal patterns of variability that might be expected to occur in the future

(2) Incorporate the most recent years’ data so the model could be calibrated to current operational procedures and level of water development that reflect present conditions

The model was developed to simulate operations of the system with the 1959 to 2009 input data for each day, or what hydrologists refer to as a "daily time step." The initial analysis period was extended back only to 1959 because an accurate, comprehensive daily set of historic gauged streamflow data for the Milk River tributaries below Fresno Dam could not be developed for years before 1959.

Hydrologists usually try to select a period of study that includes the lowest streamflow years on record. Future users of the model should be aware that the study period does not include the lowest streamflow period for the St. Mary River basin, which occurred during 1939 to 1941, when streamflow averaged 367,000 AF about 65 percent of normal as characterized by the natural streamflow of the St. Mary River at the International Boundary gauging station. However, there were a series of low flow periods for the St. Mary River included in the study period (1959 to 2009), and one of the 3-year periods ranks just behind the 1939 to 1941 period. The years 1986 to 1988 were the lowest on record for the Milk River as characterized by the streamflow of the Milk River at the Eastern Crossing.

The model documentation and Milk River Project operating criteria adequately describe the hydrology model inputs. Streamflow and agricultural irrigation demand data for the hydrology model are the two most significant input items; therefore, they are summarized below.

Streamflow for Model Development and Calibration

Historic streamflow data for 1959 to 2009 were used as the basis for the initial development and calibration of the RiverWare ™ model. Two different types of streamflow data were developed for the model, depending on the location of the stream reach in the basin: natural and available flow. In both cases, U.S. Geological Survey (USGS) streamflow gauging station data were used as the basis for developing the flow input data to the St. Mary River and Milk River basins model.

- **Natural flow**. Natural flow is flow that would have occurred in the stream if there were not human influences. Natural flow data were developed for the St. Mary River and for the Milk River upstream of Fresno Reservoir. The U.S. and Canada have been cooperatively calculating natural flow for the St. Mary River at the International Boundary and for the Milk River at the Eastern Crossing (above Fresno Reservoir) pursuant to the Boundary Waters Treaty since the early 1900s. However, the hydrology model needed streamflow information at more points than these two boundary locations. The natural flow computational procedure for the Boundary Waters Treaty accounts for the removal of regulation by Lake Sherburne, depletions by the St. Mary Canal on the St. Mary River side, depletions by irrigation in both the U.S. and Canada, and increased evaporation from the Milk River due to the addition of St. Mary River water. The model takes all of these factors into account. For the St. Mary River basin and for the Milk River basin upstream of Fresno Reservoir, there was relatively complete streamflow gauging data for the entire 1959 to 2009 model base and calibration period. These data needed to be adjusted by the appropriate depletion amounts depending upon the stream reach location before the streamflow data could be used as input to the model. For instance, streamflow data from the Swiftcurrent Creek at Many Glacier gauge were used as the basis for developing daily inflows to Lake Sherburne for the period of study. This gauging station is located above Lake Sherburne and measures most of the inflow to Lake Sherburne, but not all. To estimate the entire natural inflow, the raw USGS gauge data were adjusted based on Reclamation's measured daily changes in the storage contents of Lake Sherburne and outflows at the gauging station below Lake Sherburne.

- **Available flow**. Available flow is flow that occurs in the stream at specific locations and represents natural flow that has been depleted by human activities. Available flow data were developed for the tributary inflow to the Milk River below Fresno Reservoir. In the Milk River basin below Fresno Reservoir, the primary depletion historically has been from agricultural irrigation in the U.S., irrigation reservoir storage, and direct diversion for irrigation in Canada. The study team assumed that water use on the tributaries downstream from Fresno Reservoir would continue in a similar way as it has in the past.

There is a much less complete record for Milk River tributary inflows below Fresno Reservoir than for the St. Mary River system and the Milk River upstream of the Eastern Crossing. USGS gauged streamflow data for tributaries were used whenever available for input to the model. Few of the lower Milk River tributaries were gauged for the entire modeling period. Most of the gauging records were seasonal; that is, the gauges operated only during late spring, summer, and early fall. Where streamflow records for a gauge location were unavailable for the entire modeling period, the missing values were filled in by statistical correlation to other active stream gauging stations in the region. The *Maintenance of Variance Extension* Type 1 (MOVE.1) method and associated FILLIN computer program were used to fill in missing values and to extend the streamflow records at sites that did not have a complete streamflow record. The FILLIN program and MOVE.1 method were used to estimate missing streamflow data on a monthly time step. Hirsch (1982) showed that the MOVE.1 method, which is similar to regression methods, preserves the statistical characteristics of the actual record better than traditional regression methods.

MOVE.1 results in preserving sample estimates of the mean and of the variance from the historical record. Additionally, using the MOVE.1 FILLIN program allows selection of different base stations to fill in missing records for the site of interest. For instance, data from several nearby stations could be used to fill in various parts of missing records for a station rather than having all of the missing values based on those of a single gauge. This preserves some of the variability for the station with missing data.

The missing monthly flows that were produced with the FILLIN program were disaggregated to daily values using the daily flow distributions from nearby active gages. For instance, the Rock Creek at International Boundary gauge was operational during the entire base period, and its daily flow distributions could be used to distribute missing monthly flows for a station like the Whitewater River gauge, which was not operational during much of the period. The process in this example would be to:

(1) Compute what percent of the monthly flow of Rock Creek that occurred during each day of a month

(2) Then apply those daily percentages to each day of the month for the monthly total flow computed for the Whitewater River with the FILLIN program

The station used to estimate the daily flow distributions for a station could have been the same or a different station from that used to estimate the monthly flows.

Most Milk River reaches in the model downstream from Fresno Reservoir have some ungauged tributary inflow (because many smaller tributaries have never been gauged or gauging stations are located a distance upstream from where the stream discharges into the Milk River). Drainage area adjustments were made to account for flow from the ungauged areas. This was done by multiplying the flow at the gauge by a factor to account for the ungauged areas. The adjustment factors were based on the volume of gauged-to-ungauged area but are not strict ratios. This is because most of the ungauged areas are drier lands closer to the Milk River where the volume of runoff generated per unit area typically is less than that produced in areas like the Bear Paw Mountains or the higher, prairie areas upstream of the gauges in Canada.

Streamflow for Climate Change Scenarios and Alternatives

Future streamflows under all climate change scenarios, including *S0: Historic Climate Conditions*, were estimated using the SAC-SMA/SNOW-17 model. *S0: Historic Climate Conditions* flows that were initially computed with the SAC-SMA/SNOW-17 model were adjusted (bias corrected) so that they more closely matched the actual historic flow data derived from the gauging station records described in the section above. These same adjustment ratios were then applied to bias correct the streamflow data for the climate change scenarios (*S1 – S5*). The period of record used for the SAC-SMA/SNOW-17 model was 1950–2001, and this same period was used in the river system model to simulate climate change scenarios *S1 – S5* for the various alternatives. For more information on the SAC-SMA/SNOW-17 model used to develop streamflows, see the “Climate Change” section in chapter 2.

Water Use

Water use in the St. Mary and Milk Rivers system includes irrigation, municipal and industrial demands, recreation, fish and wildlife, and water quality. Recreation and fish and wildlife use are primarily incidental uses in the Milk River basin that depend on the irrigation water supply. Municipal and industrial uses and for water quality are relatively minor uses compared to irrigation. While all of these uses are considered in the model, irrigation is the dominant use, and it is explained in more detail below.

Irrigation water demands are determined by the number of acres irrigated, the kinds of crops irrigated, the weather during the year, and the canal and on-farm delivery efficiencies. The number of acres irrigated and the efficiencies are presented in chapter 2 and in the model documentation in more detail.

The kinds of crops irrigated and the weather during the year determines the net irrigation requirement for the irrigated area. The kinds of crops irrigated in the basin are summarized in table 3.1.

Table 3.1: Irrigated Crops as a Percent of Total Irrigated Acres in the Milk River Basin by Geographic Area

Crop	Canada[1]	Glacier County[2]	Blaine County[3]	Phillips County (Not Including Nelson Reservoir Lands)[3]	Valley County (Not Including Nelson Reservoir Lands)[3]	Nelson Reservoir Lands[4]
Alfalfa	10	25	54	56	55	15
Grass	80	60	25	28	17	80
Small Grains	10	15	21	15	24	5
Corn	0	0	0	1	4	0

[1] Source of data: Personal communication, Bob Riewe, Province of Alberta, June 2011.
[2] Source of data: Dolan, 2009.
[3] Source of data: Average of data for 2002 and 2007, Census of Agriculture – County Data, USDA, National Agricultural Statistics Service, Phillips and Valley County data adjusted for Nelson Reservoir lands data.
[4] Source of data: Personal communication, Malta Irrigation District, April 2011.

Temperature and precipitation data for the observed climate, a part of the climate change component of this study, were used with evapotranspiration models and with the above crop mix to estimate the net irrigation requirements for 42 subbasins in the region. The crop mix for each subbasin depends on which geographic area the subbasin was located.

The Blaney-Criddle evapotranspiration model was used to estimate monthly net irrigation requirement for each month in the study period, as this evapotranspiration model was the preferred method and used previously in the basin.

Next, the Hargreaves-Samani evapotranspiration model was used with the temperature, effective precipitation, and crop mix to estimate the daily net irrigation requirement for each subbasin. A daily fraction based on the Hargreaves-Samani evapotranspiration model was then computed and applied to the monthly Blaney-Criddle values to arrive at daily values for irrigation demands. The net irrigation requirements estimated by this procedure are the basis for those summarized in chapter 2. These net irrigation requirements were developed for the period 1950 to 2009. These methods are further summarized in the *Milk-St. Mary River System Basin Study* (Reclamation, 2011b). These evapotranspiration computation methods are used for both model development and calibration and used when modeling climate change scenarios and alternatives.

Total diversion requests were computed for each irrigation water user in the river system model using crop irrigation requirements described above, along with acres irrigated, irrecoverable loss rates, and irrigation efficiency. For instance, if the irrigation efficiency were assumed to be 50 percent, then at least twice as much water as the crop required would be diverted from the river.

Flows tracked in the river system model included return flow (i.e., water that is diverted for irrigation but eventually returns to the stream, either as surface flow or through the shallow groundwater system). Surface return flow could include water that runs off the end of a field during flood irrigation (tail water) or water that spills back to the stream after reaching the end of a ditch (wastewater). Surface return flow was simulated in the model to come back to the stream the same day the water was diverted. Groundwater return flow could include water that seeps from canals or applied irrigation water that percolates through the soil profile and to the water table. Groundwater return flow was simulated to come back to the stream over a 1-year period, with the bulk of the water returning within the first few months following irrigation.

Irrecoverable losses represent water diverted for irrigation but lost to surface evaporation, use by non-target plants, or seepage to deeper groundwater aquifers. Irrecoverable loss rates used in the model ranged from about 10 to 30 percent of the water diverted.

Figure 3.2 is a schematic that depicts how irrigation diversions, crop consumption, return flow, and irrecoverable losses were simulated in the river system model.

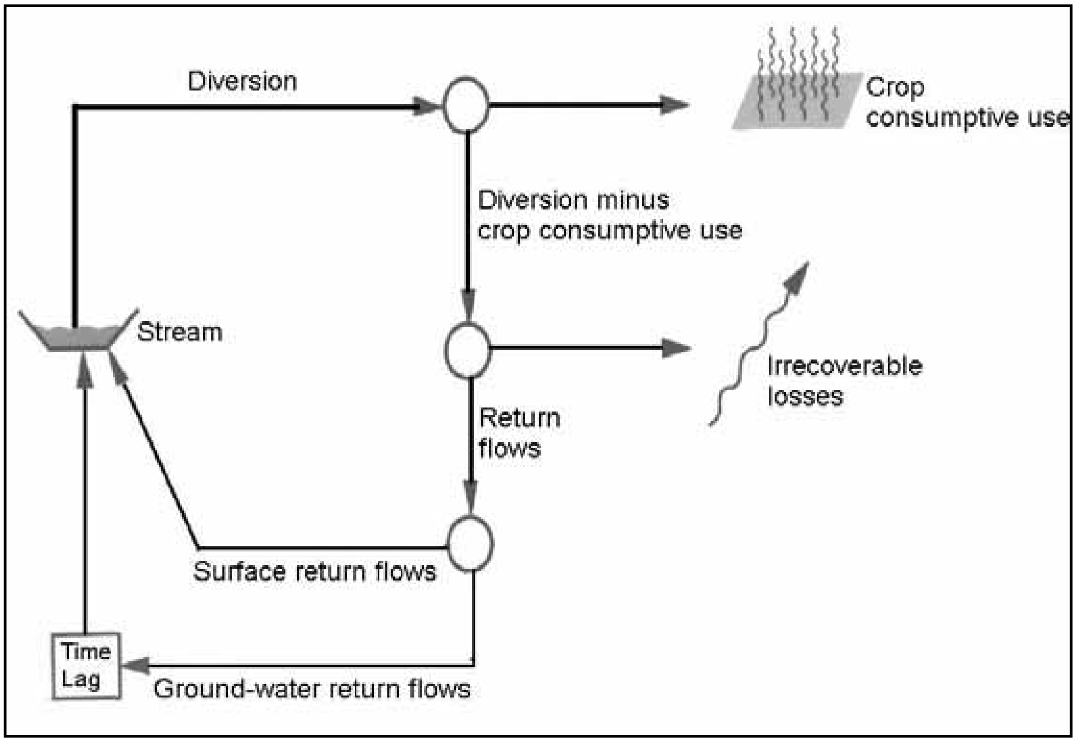


Figure 3.2: Schematic describing how irrigation is simulated in the river system model.

In summary, daily temperature and precipitation data for historic and future climate change scenarios were used in the hydrology model to predict future streamflow for the St. Mary and Milk Rivers. The data were also used in an evaporation estimator and evapotranspiration model to estimate daily net irrigation requirements and reservoir evaporation rates. The outputs from these models, plus the data to delineate operational criteria, acres irrigated, and irrigation characteristics, were the final inputs into the river system model. Finally, the river system model was able to run alternatives and give outputs related to—but not limited to—streamflow, diversions, depletions, and reservoir levels. Figure 3.3 is a flow diagram that describes this process.

Calibration

Before a model can be used to analyze alternatives or simulate future conditions, it must be tested and calibrated so that it can reasonably replicate historic conditions. Hydros Consulting, Inc., evaluated the river system model to quantify and improve its ability to simulate irrigation water use and to replicate historical riverflows (Hydros Consulting, Inc., 2011). The calibration focused on physical

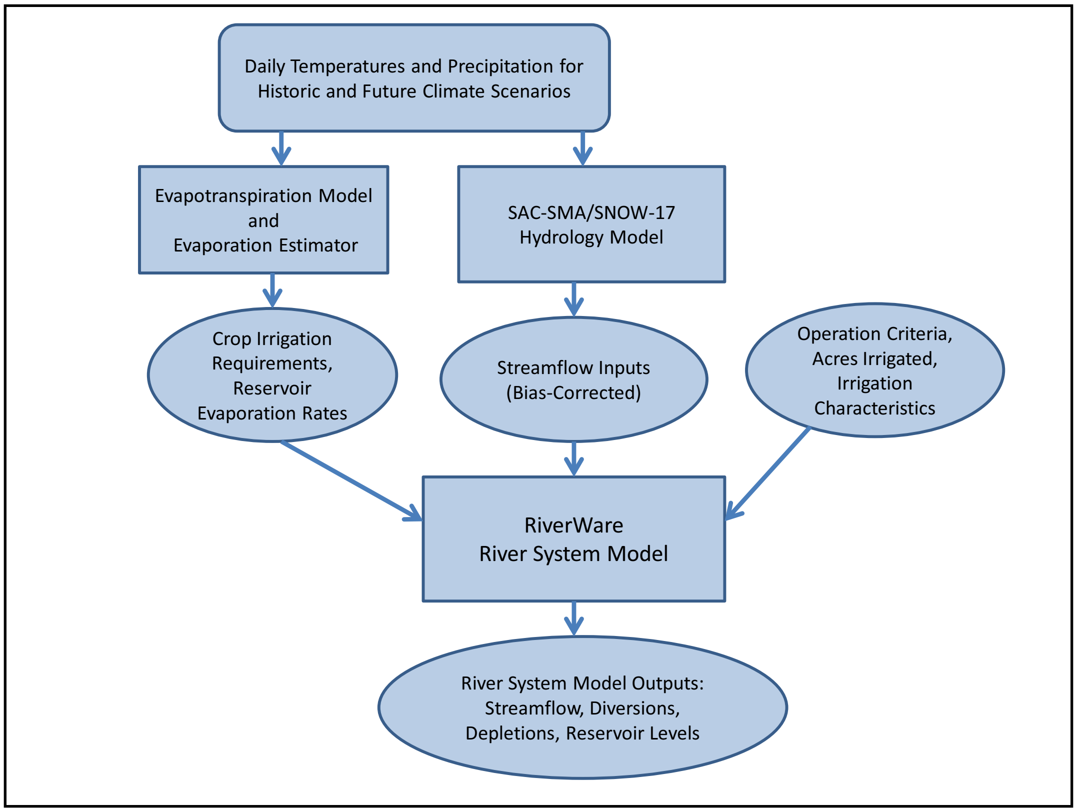


Figure 3.3: St. Mary and Milk Rivers models and input files.

parameters, such as irrigation efficiencies, surface and groundwater return flows, and water losses. The calibration tested the ability of the model to replicate downstream Milk River flows at the following gauging stations:

- Eastern Crossing
- Harlem
- Dodson (below the Dodson Diversion Dam)
- Juneberg Bridge
- Nashua (mouth of the Milk River)

To better isolate how the model simulates irrigation use, the model temporarily was modified during calibration to use historic St. Mary Canal operations, Fresno Reservoir releases, and irrigation district canal diversion data. Modeled diversions also were visually compared to historic measured diversions and to historic measured surface return flows for the Paradise Valley and Glasgow Irrigation Districts.

An important part of the calibration analysis was to identify parameters that have the most effect on model results. For instance, adjusting modeled losses due to evaporation from the river channel and evapotranspiration by non-target plants (phreatophytes) did not have a significant effect on model output. The model appeared to be most sensitive to changes in the irrigation district diversions and return flows. As such, calibration efforts were focused on these parameters.

Due to the seasonal nature of the data collection at some of the streamflow gauging stations and the difficulty of exactly matching day-to-day changes in riverflow, the calibration for the Milk River below Fresno Dam focused on matching modeled irrigation season and monthly flow volumes to measured historic data. For selected stations, we:

- Conducted statistical analyses
- Plotted and compared modeled versus historical volumes
- Computed mass balance difference between modeled and historic data

Table 3.2 lists the percentage of difference between modeled and historic total flow volumes and the coefficient of determination for stations on the Milk River after calibration. The coefficient of determination is a measure of how well the model predicts actual flows, with a value of 1.0 indicating perfect prediction.

Table 3.2: Model Calibration Results

Station	Percent Volume Difference (for all data)	Coefficient of Determination (R^2) (based on monthly values)
Milk River at the Eastern Crossing	-3%	.99
Milk River at Harlem	+5%	.97
Milk River at Dodson	+5%	.89
Milk River at Juneberg Bridge	-6.5%	.83
Milk River at Nashua	-25% (-5%)[1]	.75

[1] Volume difference after data for high-flow months were removed.

The model results for the Milk River at the Eastern Crossing compare very well with the historical data. This part of the model was considered calibrated with no further adjustment.

Modeled flows at the Harlem and Dodson gauge locations initially were about 10 to 20 percent greater than historic flows, implying that the model was underestimating depletions (and overestimating flow) in this reach of the river. To account for this, groundwater return flows reaching the river were reduced for all simulated irrigation diversions between Fresno and Dodson Diversion Dams. The result was a much better mass balance in comparison to historic conditions for the Harlem and Dodson gauges. Figure 3.4 is a plot of the irrigation season volume at the Harlem gauge for historic flow and model simulated flow.

Progressing downstream from the Dodson Diversion Dam, modeled riverflows were found to be up to 20 percent lower than historic flows. It was determined that about 75 percent of the discrepancy was from underestimating the peak flows from the lower, ungauged tributaries. Because these peak flows cannot be captured and stored and usually are not usable for irrigation, adjusting the irrigation and storage components of the model would have little effect on the calibration. With better estimates of inflows from the lower tributaries, the model calibration could be improved. After the effects of ungauged inflows were removed from the mass balance calculations, the differences between modeled and historical flows at the Nashua gauge were reduced substantially.[5] Figure 3.5 compares modeled to historic monthly flows for the Milk River at the Juneberg Bridge just downstream from the confluence of the Frenchman Creek tributary with the Milk River and upstream of most of the ungauged lower Milk River tributaries.

Further improvements could be made to the model as more tributary inflow and irrigation diversion and return flow data become available. A better understanding of surface water and groundwater exchanges and losses in the Milk River valley would also allow for a better calibration.

[5] Note that for this calculation, data for high-flow months were removed.

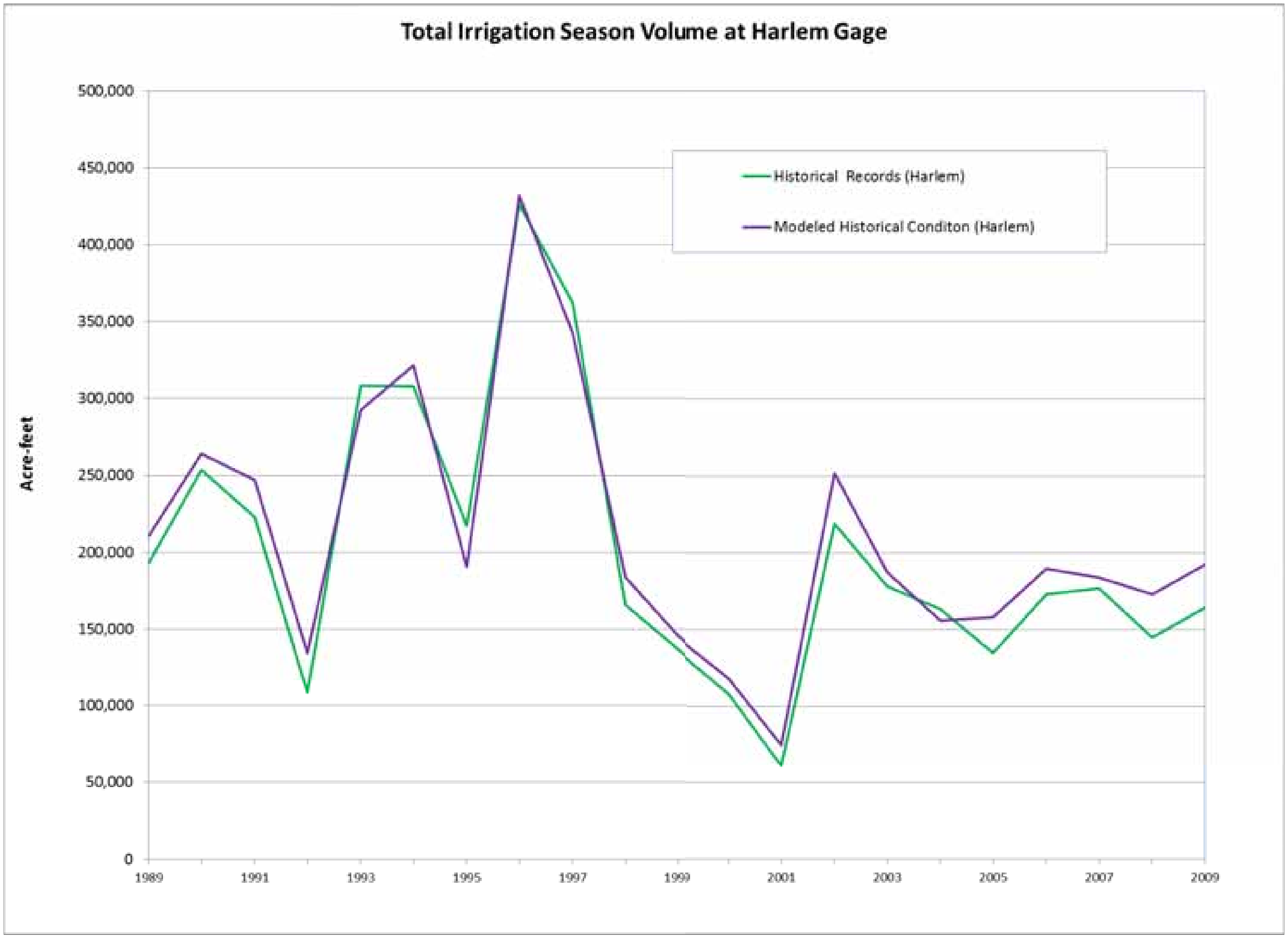


Figure 3.4: Example plot for Milk River at Harlem gauging station after simulated groundwater returns to the Milk River were reduced during calibration.

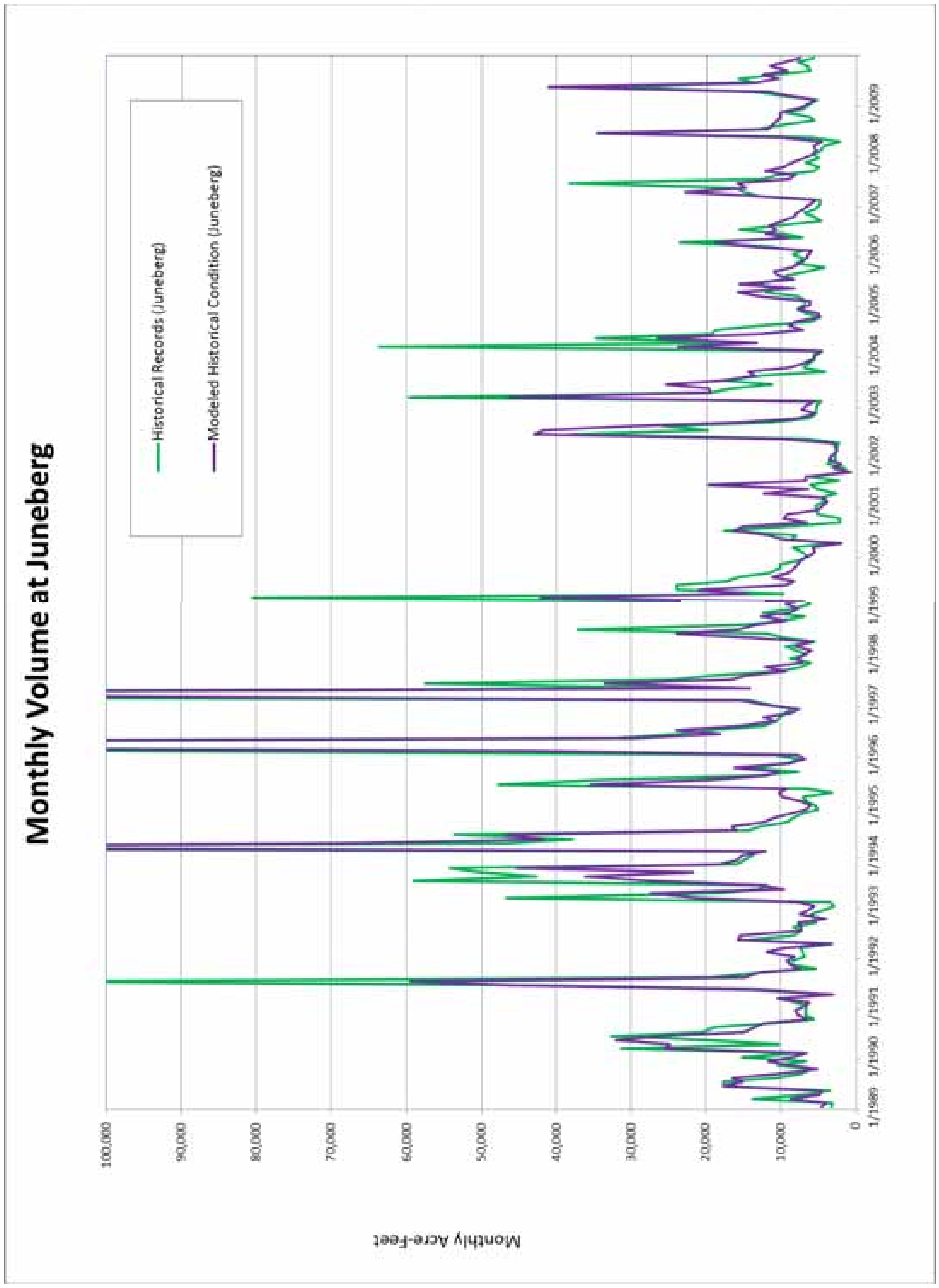


Figure 3.5: Plot for Milk River at Juneberg Bridge gauging station after model calibration.

Chapter 4: Baseline Condition and the Ability to Meet Future Water Demands

The baseline conditions represent present water supplies and demands and existing infrastructure. This chapter describes the baseline condition and its ability to meet present and future water demands in the basins. Chapter 5 describes potential alternatives and compared these against baseline to measure their mitigative benefits and impacts.

Baseline Condition

A baseline condition needs to be described and established to provide the data to compare impacts from climate change, operational and/or facility modifications, and changes in water use. For this report, the baseline condition was defined as the water supply, water facilities, water use, and irrigated land base in the St. Mary River and Milk River basins as it currently exists, but with adjustments made to recognize continual losses in Fresno Reservoir storage.

River Model Assumptions

The river system model assumptions for the baseline condition are:

- Streamflows and demands are defined by the historic climate as described in *S0: Historic Climate Conditions.*

- About 140,000 acres can be served by the irrigation system from the main stem of the Milk River downstream from Fresno Reservoir. Some of this land is fallowed each year, and only about 127,000 acres are assumed to be irrigated each year.

- Water rights are not strictly administered by priority along the Milk River, although junior water users will have less water available to them during times of shortage than senior water users.

- About 8,600 acres of phreatophytes (vegetation that consumes lots of water, such as cottonwood trees, willows, and wetland plants) in the basin deplete water directly from the Milk River.

- A maximum of 3,500 AF per year of Milk River water is diverted to Bowdoin National Wildlife Refuge.

- Irrigation efficiencies range from 20 to 40 percent for irrigation district lands and from 45 to 50 percent for lands served by private irrigation systems. Efficiencies vary by season and are modeled to be up to 50 percent higher for some irrigation districts later in the season and when water shortages are highest. These are combined field and delivery efficiencies.

- Havre, Hill County, Chinook, and Harlem use a combined volume of 2,600 AF of municipal water per year.

- The St. Mary Canal has an average annual maximum operating capacity of 650 CFS at St. Mary's siphon, with the operating season varying from year to year based on historic St. Mary Canal start dates, available flow, and Lake Sherburne storage.

- The Boundary Waters Treaty is administered according to the IJC 1921 Order. For the purposes of the river system model, water apportionment is performed daily. The Letter of Intent that allows for deficit deliveries to the downstream country and a repayment process is included in the baseline condition.

- Canada will continue to irrigate about 8,000 acres with Milk River water and to make surplus deliveries to the U.S. on the Milk River.

- The full-pool storage for Fresno Reservoir has been set at 62,000 AF to account for losses in storage to sedimentation that are expected to occur by 2050.

- The normal full pool at Lake Sherburne is 66,147 AF, and at Nelson Reservoir it is 78,950 AF.

- The non-irrigation season release from Fresno Reservoir is 45 CFS.

- The non-irrigation season release from Lake Sherburne is 0 CFS.

- The Fort Belknap Indian Irrigation Project uses the 125 CFS *Winter's* reserved water right for irrigation and up to one-seventh of the Milk River natural flow stored in Fresno Reservoir.

Present Irrigation Demands and Shortages

With a full water supply on 127,000 acres of Milk River lands assumed to be irrigated under baseline conditions, crops might consume (through the evapotranspiration process) an average of about 191,000 AF per year. This equates to about 1.6 AF of water consumed per acre irrigated or about 18 inches per acre. As modeled under *S0: Historic Climate Conditions*, the Milk River

Project and Tribal water rights have the potential to supply only about 120,000 AF of water per year on average that would directly support crop consumption within project and reservation lands. This is just under 1 AF per acre irrigated (about 11 inches per acre) that is being used by the crop and is about 60 percent of what the annual crop actually needs. Thus, irrigated crops are not getting the amount of water needed for optimal growth. This is calculated in terms of "irrigation depletion shortage." Irrigation depletion shortages are computed by taking the amount of water the crops would need to deplete, through the process of evapotranspiration, for optimal growth and production, minus the amount of water that the crops are modeled to deplete. In the remainder of this report, irrigation depletion shortages will be used as a measure of how irrigation shortages might increase in the future and of how alternatives might be used to reduce irrigation shortages. A reduction in irrigation depletion shortages translates into an improvement in crop production.

Water shortages occur for Milk River irrigators every year. These shortages can be due to either infrastructure limitations or low water supplies or a combination of these two factors. During wetter years, shortages can be relatively small and result more from the infrastructure's inability to deliver all the water that is needed to the crop at peak times. In the driest years, when flow is low and crop demands are high, shortages can be quite large and result more from the lack of available water. During the driest years, the water that the crop receives is less than one-half of the crop irrigation need. During the spring, the Milk River Project irrigation districts meet with Reclamation to set water allotments for the upcoming season. In years that water shortages are anticipated, allotments for all project water users are reduced so that shortages are equitably shared.

Irrigators often do not receive a full allocation of water, undermining their ability to maximize crop production. Being accustomed to frequent water shortages, the irrigators routinely do not apply the full crop irrigation requirement even when water is available. In this way, frequent water shortages affect the irrigators' willingness to invest in necessary equipment and infrastructure to diversify crops. The lack of crop diversity contributes to water shortages, as project facilities were not designed to meet current peak irrigation demands (Reclamation, 2004a).

Diversions from the St. Mary River to the Milk River are critical for meeting crop demands for the Milk River Project. These diversions are especially important during dry years when there is little available Milk River natural flow. Years are characterized depending on the combined annual natural flow of the St. Mary and Milk Rivers:

- **Wet years**. Diversions are lower than average during wet years because there is more Milk River natural flow available, and irrigation demands typically are not as high.

- **Middle years**. Diversions generally are highest during the middle years when St. Mary River water is available, Milk River natural flows are moderately low, and crop demands are relatively high.

- **Dry years**. Diversions are lower than average during dry years when the U.S. share of St. Mary River is not sufficient to keep the canal running full during much of the irrigation season.

Hydropower

There are no hydropower generating facilities in either the St. Mary River basin or the Milk River basin in the U.S.. Since the early 1980s, there have been Federal Energy Regulatory Commission preliminary permits at Lake Sherburne Dam and Fresno Dam by various parties, but project construction has never progressed primarily for economic reasons. Reclamation completed a hydropower resource assessment at existing Reclamation facilities in 2011 (Reclamation, 2011c). This assessment identified nine sites in the region with hydropower production potential, but only four of these sites have a benefit-cost ratio greater than 0.75. These sites are Fresno Dam; Vandalia Diversion Dam, which diverts water to Glasgow Irrigation District and is the last diversion dam on the Milk River; and both St. Mary Canal Drops 4 and 5, where the St. Mary Canal water is dropped to the North Fork of the Milk River. The Blackfeet Tribe has also studied hydropower at the St. Mary Drops for non-consumptive use of water (HKM Engineering, 2007). Future hydropower development in the two river basins should be based on the hydrology expected in the future, which could include the future streamflow information developed as part of this study.

Meeting Future Demands

Until recently, river system modeling was done by selecting a base period, such as the 1950 to 2001 period for this study, running and calibrating the model to historic conditions, and then using the calibrated model to run future scenarios. Historic period input data would be used to model future scenarios under the assumption that the future would resemble the past. Although it is always been recognized that the exact sequence of past weather and flow events would not recur in the future, it was assumed that similar patterns and magnitudes of weather and flow conditions would recur.

The potential effects of climate change cannot be adequately modeled using the assumption that mostly unaltered past data could be used to model the future. Therefore, to evaluate the ability of the baseline condition (i.e., existing facilities and present water supply and demands) to meet future demands, the river system model was run for each of the climate change scenarios discussed in chapter 2. These scenarios were compared with the system as modeled under *S0: Historic Climate Conditions.*

Irrigation depletion shortages would increase under all year types on both a volume basis and on a percentage of demand basis for climate change scenario *S5: Central Tendency* when compared to *S0: Historic Climate Conditions* (table 4.1). The average irrigation depletion shortage would increase to be more than 35,000 AF under *S5: Central Tendency* than under *S0: Historic Climate Conditions.* This increase in irrigation depletion shortages would primarily be from increased crop demands.

Table 4.1: Modeled Irrigation Depletion Shortages for all Milk River Irrigation Downstream From Fresno Reservoir Under the Climate Change Scenarios *S0: Historic Climate Conditions* and *S5: Central Tendency*

	S0: Historic Climate Conditions		*S5: Central Tendency*		Change
Year Category	Shortage Volume (AF)	Shortage as Percent of Demand	Shortage Volume (AF)	Shortage as Percent of Demand	Shortage Volume (AF)
Average	71,000	36	106,000	43	35,000
Wettest Ten Years	53,000	29	77,000	34	24,000
Middle Ten Years	66,000	35	96,000	41	30,000
Driest Ten Years	91,000	44	140,000	54	49,000
Maximum	145,000	62	216,000	74	71,000
Minimum	18,000	13	37,000	21	19,000

St. Mary Canal diversions under *S5: Central Tendency* would be 6,000 AF greater than *S0: Historic Climate Conditions* (table 4.2) on average, although there is expected to be more variability from year to year in the future. During higher streamflow years, canal diversions would be about 19,000 AF greater under *S5: Central Tendency* than under *S0: Historic Climate Conditions*. During lower streamflow years under the climate change scenario *S5: Central Tendency*, modeled canal diversions were about 10,000 AF less than under the *S0: Historic Climate Conditions*. When simulating St. Mary Canal diversions for future climate change scenarios, the river system model assumed that the canal start dates in the future would be 7 days earlier in the spring to take into account the earlier shift in runoff due to warmer temperatures.

Because the timing of the St. Mary River's natural flows available to the U.S. is projected to change in the future, the timing on when water is diverted through the canal might change as well. Figure 4.1 shows that more water is modeled to be diverted earlier in the season and less water diverted later in the season compared to *S0: Historic Climate Conditions*. This would be partly due to the assumption that it would be possible to start up the St. Mary Canal earlier in the spring in the future, and partly due to increases in March runoff (when the U.S. receives one-half of the natural flow) under the future climate change scenarios.

Table 4.2: Modeled St. Mary Canal Diversions under Climate Change Scenarios *S0: Historic Climate Conditions* and *S5: Central Tendency*

Year Category	***S0: Historic Climate Conditions*** Annual Volume Diverted (AF)	***S5: Central Tendency*** Annual Volume Diverted (AF)	Change (AF)
Average	192,000	198,000	6,000
Wettest Ten Years	176,000	195,000	19,000
Middle Ten Years	198,000	208,000	10,000
Driest Ten Years	180,000	170,000	-10,000
Maximum	231,000	241,000	10,000
Minimum	126,000	110,000	-16,000

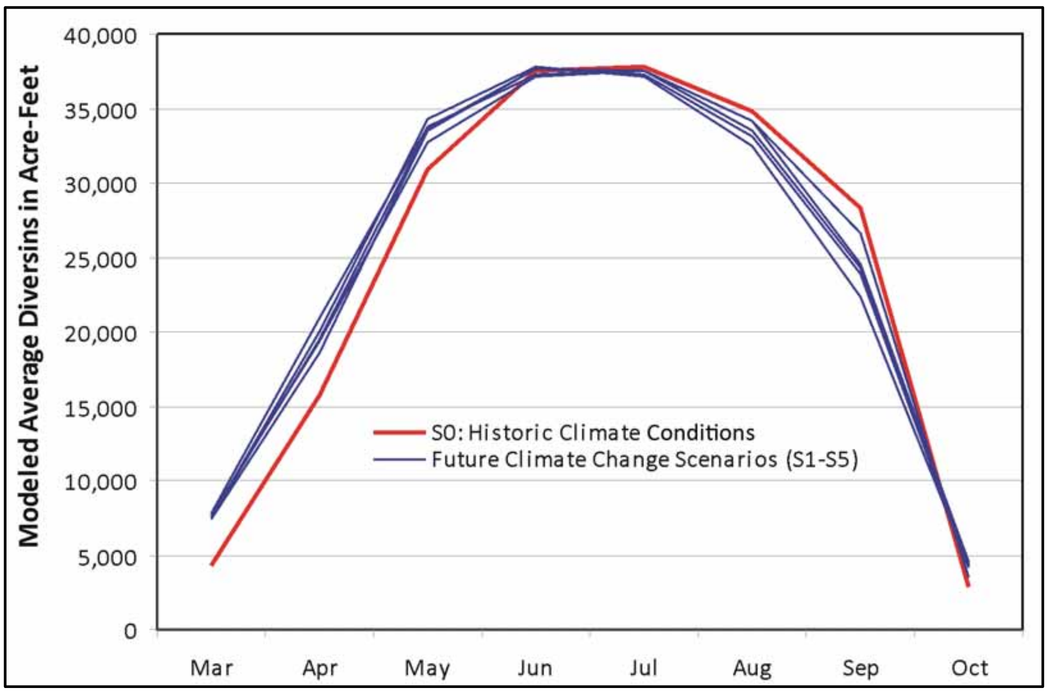


Figure 4.1: Modeled average St. Mary canal diversions for the baseline condition under *S0: Historic Climate Conditions* and future climate change scenarios (*S1 – S5*).

Flow contributions for the upper Milk River watershed are expected to decrease under the future scenarios, but not enough to substantially reduce the volume of water that flows into Fresno Reservoir during median years when considered in combination with St. Mary Canal Diversions to the Milk River (figure 4.2). Below Fresno Reservoir, lower Milk River tributary flow contributions are expected to increase some under most scenarios. Overall, the water supply

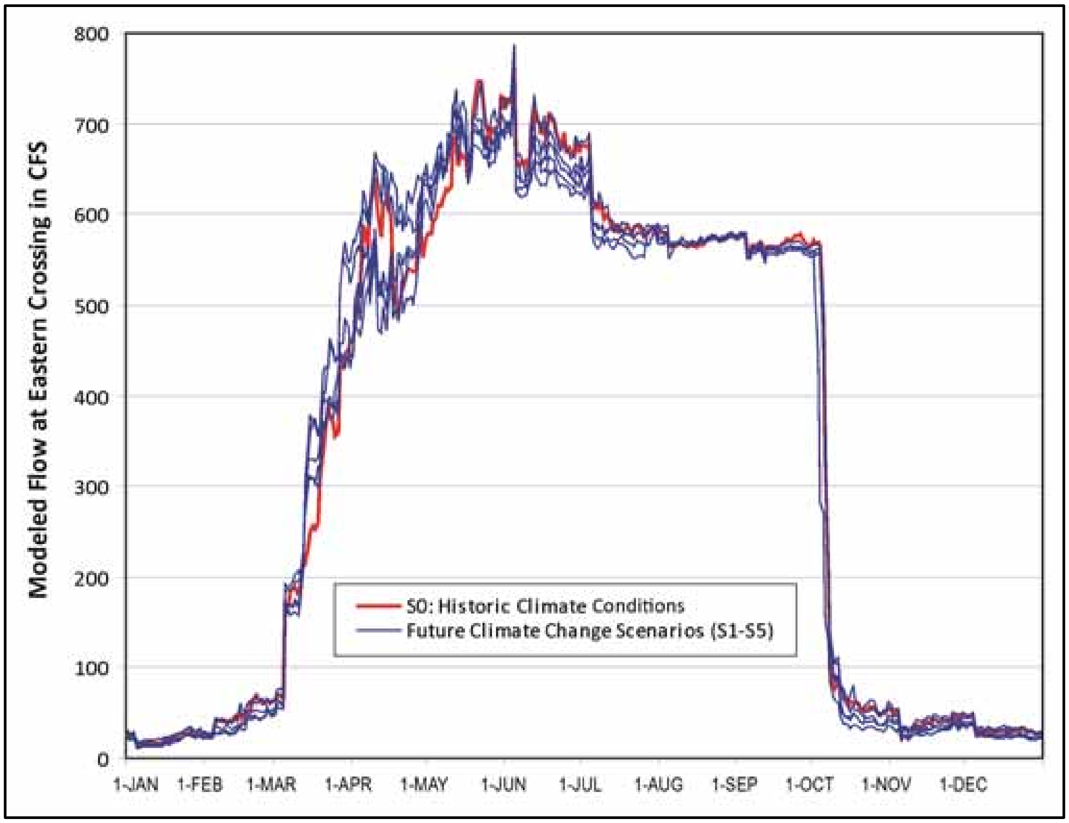


Figure 4.2: Modeled median flow for Milk River at the Eastern Crossing for the baseline condition under *S0: Historic Climate Conditions* and future climate change scenarios (*S1 – S5*). (Note: Graph includes the effect of St. Mary Canal diversions.)

available for Milk River irrigation in the future might be similar to what it has been during the past, but with increased variability resulting in more flow during wetter year and less flow during the driest years.

Due primarily to increases in downstream crop irrigation demands, Fresno Reservoir elevations are projected to be 1 to 6 feet lower on average under future climate change scenarios (*S1 – S5*) than under the future climate change scenario *S0: Historic Climate Conditions*. Figure 4.3 compares average Fresno Reservoir elevations for *S0: Historic Climate Conditions* to those for the climate change scenarios *S1 – S5*. FW&P recommended a minimum reservoir pool level for optimizing fisheries habitat and recreation opportunities of 2,560 feet MSL as represented on figure 4-3. Under future climate change scenarios, the graph shows that pool elevations would be below this recommended level more frequently.

Irrigation depletion shortages are frequent in the Milk River basin. Warmer temperatures and a longer growing season would cause these shortages to increase.

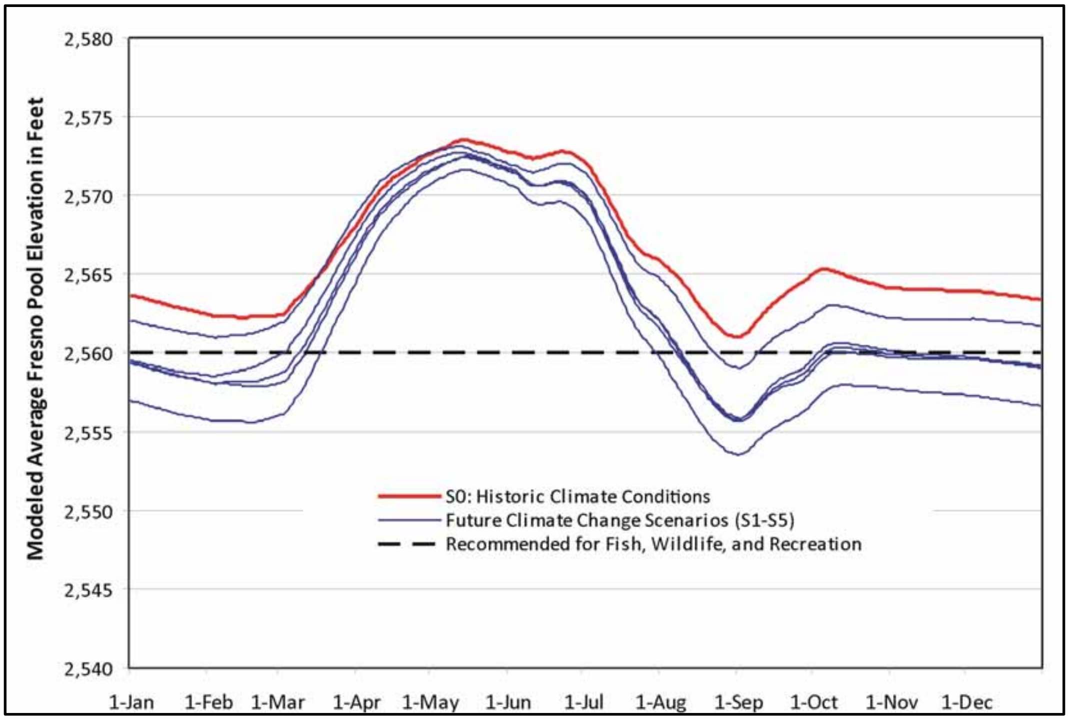


Figure 4.3: Modeled average Fresno Reservoir pool elevations for the baseline condition under *S0: Historic Climate Conditions* and future climate change scenarios (*S1 – S5*).

The USACE and Reclamation jointly identified the storage space volume needed in Fresno Reservoir for flood control in 1957. Fresno Reservoir provides flood control benefits when operated with about 30,000 AF of storage space available on March 1 to store the natural flow of the Milk River (which generally peaks about this time). Fresno Reservoir is expected to continue to lose storage space in the future due to sedimentation as previously discussed. More information is needed about future designated flood control space in Fresno Reservoir considering the future loss of storage due to sedimentation. Therefore, at this time, no additional analysis was made related to future flood control management.

Variability of streamflow is expected to increase in the future due to climate change, and it is anticipated that peak streamflows during wetter years would also increase. Currrent flood control benefits are expected to continue into the future, as Reclamation has an adaptive management approach to flood control at Fresno Reservoir.

Lower lake levels at the Bowdoin National Wildlife Refuge in the future might also be a concern for aquatic organisms. Habitat for shoreline nesting birds would be expected to increase. Table 4.3 compares modeled average Lake Bowdoin water levels under *S0: Historic Climate Conditions* and the climate change scenarios *S1 – S5*. Annual diversions to the reservoir of 3,500 AF per year were assumed to continue during the future in the model. Irrigation returns from the Malta Irrigation District were also assumed to continue into the future. The overall modeled changes to refuge water levels are modest, ranging from a projected 0.2-foot average increase to a 7-foot decrease in average level. However, as air temperatures warm and evaporation rates increase, lower overall water levels at the Bowdoin National Wildlife refuge would reduce available aquatic habitat, increase water temperatures, and reduce dissolved oxygen, which are all detrimental to native aquatic organisms. The wetter conditions associated with most of the climate change scenarios might offset some of the effects of increased evaporation; however, wetter conditions in random years is not likely to mitigate effects of increased evaporation in most years.

Table 4.3: Average Modeled Level for Lake Bowdoin under *S0: Historic Climate Conditions* and Future Climate Change Scenarios (*S1 – S5*)

Climate Change Scenario	Average Modeled Lake Level (feet MSL)
S0: Historic Climate Conditions	2,212.3
S1: Less Warming/Dryer	2,211.9
S2: Less Warming/Wetter	2,212.5
S3: More Warming/Dryer	2,211.6
S4: More Warming/Wetter	2,212.2
S5: Central Tendency	2,212.1

Irrigation depletion shortages are frequent in the Milk River basin. Warmer temperatures and a longer growing season would cause these shortages to increase. Figure 4.4 depicts the magnitude and frequency of irrigation depletion shortages (water that crops needs for optimal growth but cannot be supplied) under the baseline condition under the future climate change scenarios *S0: Historic Climate Conditions*, *S2: Less Warming/Wetter*, *S3: More Warming/Dryer*, and *S5: Central Tendency*. These climate change scenarios define the high, middle, and low range of shortages, respectively. Irrigation depletion shortages during drier years are those plotted on the left side of the graph; wetter years are to the right. The markers along the lines represent the individual years in the 52-year series examined based on weather patterns from 1950 to 2001. Note that shortages for the driest 10 percent of the years increase sharply and are particularily severe. These types of shortages would correspond to years like 1984, 1988, and 2001.

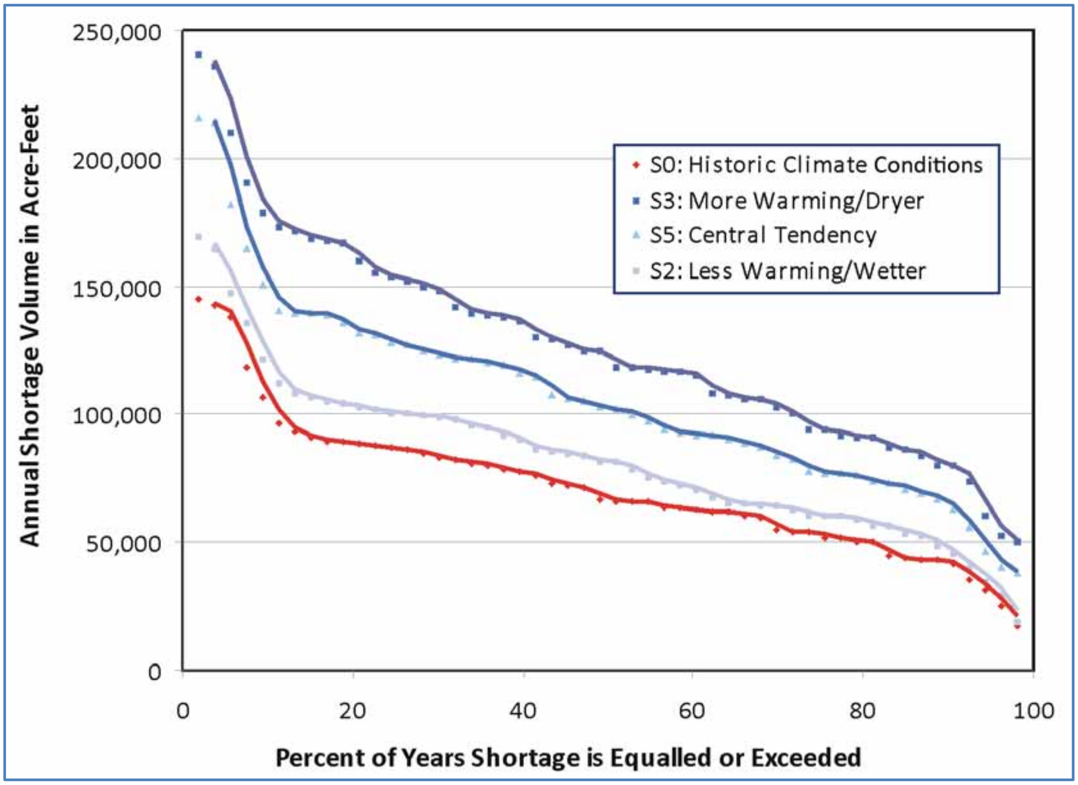


Figure 4.4: Modeled Milk River irrigation depletion shortages for the baseline condition under *S0: Historic Climate Conditions* and Selected Future Climate Change Scenarios.[6]

Figure 4.5 compares modeled median Milk River flows at Nashua for historic conditions and for future climate change scenarios. This represents the flows that would leave the Milk River basin and flow into the Missouri River. Figure 4.5 shows a slight shift in the timing of peak runoff towards earlier in the season. Most of the future climate change scenarios produce higher overall flow peaks, although late spring and summer flows for the future climate change scenarios (*S1– S5*) are lower than *S0: Historic Climate Conditions* under most scenarios. Increased discharge into the Missouri River below the Fort Peck Reservoir may benefit pallid sturgeon and other native fish species by increasing flow volume suspended sediment in both streams and by potentially stimulating increased movement by more native species into the lower Milk River for spawning.

[6] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

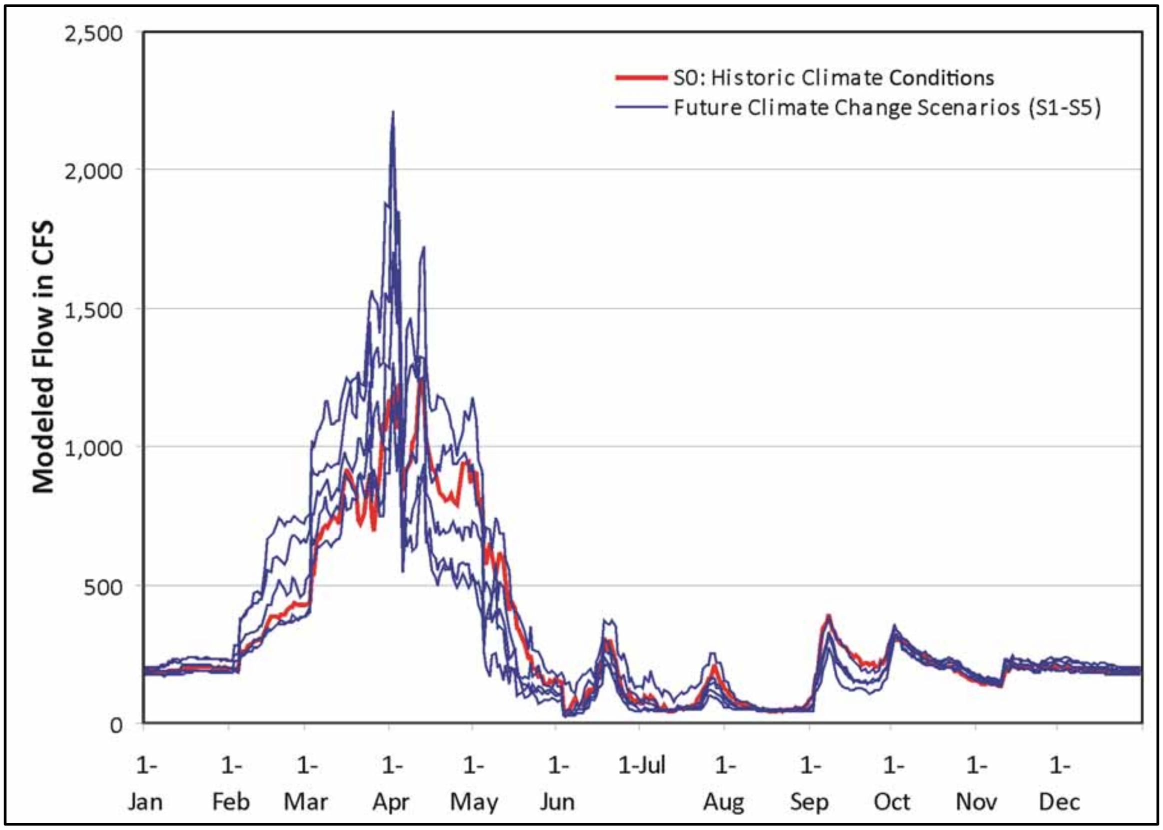


Figure 4.5: Modeled Milk River flows at Nashua under historic climate baseline and future climate change scenarios.

Chapter 5: Alternatives to Meet Water Demands

This Basin Study provides a preliminary evaluation of five alternatives to satisfy increasing water demands in the St. Mary River and Milk River basins. This chapter describes and evaluates the alternatives. The evaluations focused on each alternative's ability to reduce irrigation depletion shortages.[7] This chapter concludes with "Other Potential Alternatives," alternatives that could be analyzed in future studies of the basins.

Canal and On-Farm Water Use Efficiency Improvements Alternative

Description

This alternative would improve the efficiency of canals and ditches that deliver Milk River water and the efficiency of systems that apply the water to irrigated fields:

- **Canal efficiency**. Methods include lining canals and laterals, putting laterals into pipe, reusing spills and return flows, and adding and improving water measurement sites. Ditch efficiencies could be improved by reducing seepage losses and, in some cases, increasing capacities to meet peak demands (figure 5.1).

- **On-farm efficiencies**. Methods include field leveling, more efficient flood irrigation water distribution, converting from flood irrigation to sprinkler, and shorter field runs (figure 5.2).

Improvements to irrigation efficiencies would need to comply with Montana water law and, in some cases, might involve water rights changes.

Specific efficiency improvements were not evaluated in this study; rather, general project-wide improvements were applied above baseline efficiencies for both historic and future conditions.

[7] Irrigation depletion shortages are the amount of irrigation water that the crops would need to use through the process of evapotranspiration for optimal crop production, minus what the model results compute that the crops would actually be able to deplete given the available water supply and other factors.

Figure 5.1: Canal lining.

Figure 5.2: Sprinkler irrigation.

The baseline irrigation efficiencies in the model range from 20 to 40 percent for irrigation districts and 45 to 50 percent for lands served by private irrigation systems. The river system model uses a single efficiency that combined on-farm and conveyance efficiencies. For this alternative, irrigation district total efficiencies were increased by 17 percent (10 percent conveyance and 7 percent on-farm) for an overall efficiency ranging from 37 to 57 percent.

Summary

The Milk River Project area has traditionally relied heavily on the reuse of return flows to meet downstream demands. Improving efficiency in the canals would mean that water users would divert less water overall, and that less return flow would be recycled. Although this would not decrease the amount of water that crops ultimately receive, it would change the way flow and water are distributed throughout the system. To adjust, water managers would have to restructure the way that they divert and deliver water to users, particularly when it comes to sharing shortages. Reduced return flows also could impact other resources that have benefited from these flows in the past.

This alternative provided the single-most potential for decreasing shortages. On average, crop consumptive use shortages might be decreased by about 20,000 AF. For dry years, shortage reductions of about 15,000 AF might be achievable.

Evaluation

Agriculture

Releases from Fresno Reservoir are used to irrigate nearby lands along 300 miles of the Milk River. It may take releases up to 2 weeks to reach the last canal diversion at Vandalia Dam. About 30 percent of irrigation diversions return to the river via surface or groundwater. About 30 percent of return flows are surface returns, and up to 70 percent are groundwater return flows. Because water may be diverted and used several times between Fresno Dam and Vandalia Diversion Dam, improving efficiencies may, in some cases, decrease return flow and not necessarily make more water available to downstream users. Nearly all of the main canals and laterals are earth lined, and most are too small to meet peak irrigation water demands. This restriction in canal capacity is part of the efficiency problem. Another portion is attributable to lack of crop diversity, which leads to a delivery bottleneck because typically, water users need to irrigate at about the same time.

Table 5.1 presents modeled decreases in irrigation depletion shortages for Milk River irrigators with an increase in irrigation efficiencies of 17 percent for the Milk River Irrigation Districts. Figure 5.3 shows model results and includes additional climate change scenarios that represent the high, low, and central range. The level of benefit would be similar across the scenarios.

Table 5.1: Modeled Irrigation Depletion Shortage With and Without the Canal and On-Farm Water Use Efficiency Improvements Alternative Under Climate Change Scenario *S5: Central Tendency*

	Irrigation Depletion Shortages Without the Alternative (AF)	Irrigation Depletion Shortages With the Alternative (AF)	Annual Reduction in Irrigation Depletion Shortages With the Alternative (AF)[1]
Average	106,000	86,000	20,000
Wettest Ten Years	77,000	57,000	20,000
Middle Ten Years	97,000	75,000	22,000
Driest Ten Years	140,000	124,000	16,000
Driest Five Years	173,000	158,000	15,000

[1] Calculated from subtracting the second column from the first column.

The modeled increases in water to crops under this alternative likely are due to a couple of factors. Capacity limitations on the districts' canals do not allow enough water to be diverted from the river to meet all irrigation demands during the warmest part of the summer when demands are highest. With higher efficiencies, less water needs to be diverted per unit of crop demand, so the canal capacity limitations do not become a factor as often. The benefits of improved efficiency might not be as great during dry years because availability of water in the river, rather than canal capacity, is likely more limiting during dry years. Improving efficiencies in some cases might only decrease return flow, and return flow often is reused downstream.

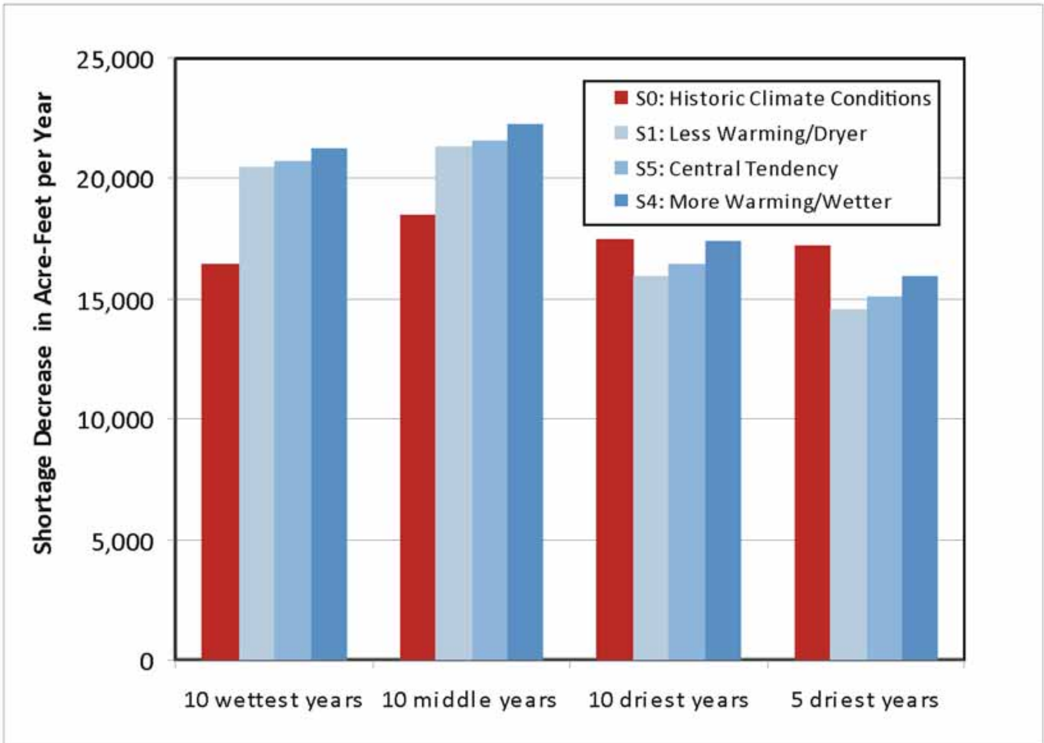


Figure 5.3: Modeled decreases in Milk River irrigation depletion shortages for the Canal and On-Farm Water Use Efficiency Improvements Alternative under *S0: Historic Climate Conditions* and selected climate change scenarios.[8]

The increase in irrigation efficiency would result in less irrigation return flow overall and less water leaving the Milk River at the mouth. These decreases in basin outflow are similar to the overall increases in crop consumption that are listed in table 5.2. Some of these reductions in basin outflows are due to a reduction in groundwater return flow that does not make it back to the river until after the irrigation season.

Fish and Wildlife

Less water would return to the river from canal spills and groundwater returns with potential impacts on the river fishery, wildlife along some river reaches, and riparian and wetland wildlife habitat. There may also be impacts to fish and wildlife caused by the loss of habitats that were once supported by the wastewater runoff and elevated water tables. There might be water quality impacts as well (e.g., increased water temperatures and concentrations of pollutants), which could range from positive to negative. Game species like deer and pheasants might benefit from increased crop production.

[8] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

Table 5.2: Decreases in the Milk River Outflow Near Nashua With and Without the Canal and On-Farm Water Use Efficiency Improvements Alternative Under Climate Change Scenario *S5: Central Tendency*

	Basin Outflow Existing Efficiencies Without the Alternative (AF)	Basin Outflow Increased Efficiencies With the Alternative (AF)	Annual Decrease in Basin Outflow With the Alternative (AF)[1]
Average	477,000	459,000	18,000
Wettest Ten Years	643,000	627,000	16,000
Middle Ten Years	473,000	452,000	21,000
Driest Ten Years	195,000	179,000	16,000
Driest Five Years	131,000	118,000	13,000

[1] Calculated from subtracting the second column from the first column.

Return flows to the Bowdoin National Wildlife Refuge are projected to be reduced by 45 percent on average under Scenario S5 *Central Tendency*. This might affect waterfowl habitat, piping plover nesting, water temperatures, and pollutant concentrations. Average Lake Bowdoin pool elevations were projected to decline by 1.5 feet under climate change scenario *S5: Central Tendency* due to decreased return flow to the lake from the Malta Irrigation District.

Recreation

Model results show that reservoir levels and associated recreational opportunities would probably remain similar at Fresno and Nelson Reservoirs, but might decrease along the lower river corridor.

Hydropower and Flood Control

Not applicable.

Rehabilitate St. Mary Canal for Increased Capacity Alternative

Description

This alternative would increase the capacity of the St. Mary Canal to the original 850 CFS. Canal capacity has dropped from 850 CFS in 1925 to its current 650 CFS at the St. Mary Canal’s siphon. Most of the structures of the 90-year old St. Mary Canal (figure 5.4) have exceeded their design life and need major repairs or replacement.

Figure 5.4: One of 16 documented slides on the St. Mary Canal.

Summary

The larger capacity would allow the U.S. to divert more of its share of the St. Mary River for use in the Milk River basin and help alleviate chronic water shortages in the Milk River. Increasing the capacity from 650 CFS to 850 CFS would result in substantial diversion increases during average to wetter years, but only relatively small increases in drier years.

Water availability and the flow apportionment with Canada would limit the use of that extra capacity during much of the time. The U.S. might be able to bring across an average of 20,000 AF more water with an 850-CFS St. Mary Canal. Some, but not all, of this water would be effective at decreasing irrigation depletion shortages. On average, irrigation depletion shortages might be decreased by about 5,000 AF per year with an 850-CFS canal.

Evaluation

Agriculture

Table 5.3 compares annual modeled St. Mary Canal diversions for canal capacities of 650 and 850 CFS under climate change scenario *S5: Central Tendency*. Note that the annual diversion increase for very dry years is low. During dry years, there is only a very short period of time when the U.S. share of St. Mary River natural flow is higher than what can be captured through a combination of diverting water through the canal at existing capacity and storing water in Lake Sherburne.

In average to wet years, a higher capacity canal could be used to divert more stored water from Lake Sherburne, leaving the reservoir contents lower at the end of the season. However, if the following year turns out to be dry (despite the larger canal capacity), then lower diversions may result from less carryover storage in Lake Sherburne at the start of the season. This explains why modeled diversions during the driest years for *S0: Historic Climate Conditions* were up to 3 percent lower with the 850 CFS capacity canal (figure 5.5).

Table 5.3: Modeled Annual St. Mary Canal Diversions and Diversion Increases With and Without the Rehabilitate St. Mary Canal for Increased Capacity Alternative Under Climate Change Scenario *S5: Central Tendency*

	Annual Diversions Without the Alternative[1] (AF)	Annual Diversions With the Alternative[2] (AF)	Annual Diversion Increase With the Alternative (AF)[3]
Average	198,000	218,000	20,000
Wettest Ten Years	195,000	237,000	42,000
Middle Ten Years	208,000	231,000	23,000
Driest Ten Years	170,000	172,000	2,000
Driest Five Years	148,000	149,000	1,000

[1] That is, St. Mary's Canal with 650 CFS capacity.
[2] That is, St. Mary's Canal with an 850 CFS capacity.
[3] Calculated from subtracting the first column from the second column.

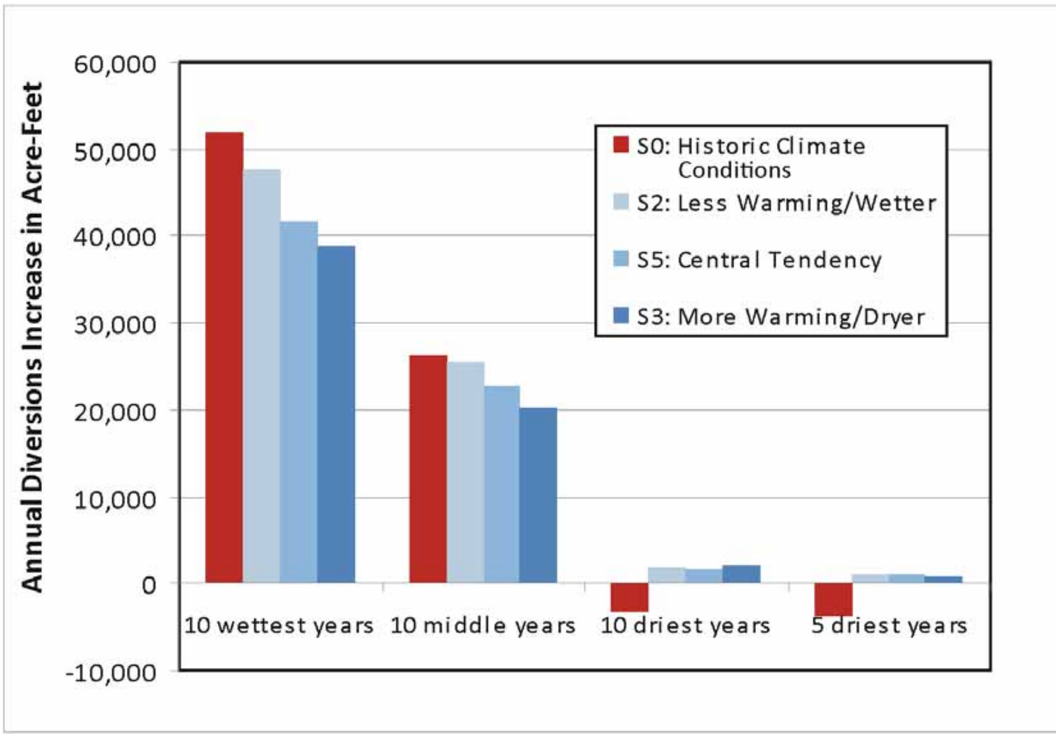


Figure 5.5: Modeled changes in annual St. Mary Canal diversions for the Rehabilitate St. Mary Canal Alternative under selected climate change scenarios.[9]

[9] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

Figure 5.5 shows modeled changes in St. Mary Canal annual diversions for historic conditions and climate change scenarios *S5: Central Tendency*, *S2: Less Warming/Wetter*, and *S3: More Warming/Dryer* by type of year from a water supply standpoint. These results again show that the increased canal capacity would allow substantially more water to be diverted in wetter-to-median years. Under the future climate change scenarios, there is also a modest increase in diversions during drier years.

Not all the extra water diverted through a higher capacity St. Mary Canal could effectively be used by crops. Table 5.4 presents modeled irrigation depletion shortages for climate change scenario *S5: Central Tendency* under this alternative. Figure 5.6 shows these model results and includes other climate change scenarios.

Table 5.4: Modeled Decreases in Milk River Irrigation Depletion Shortages With and Without the Rehabilitate St. Mary Canal for Increased Capacity Alternative Under Climate Change Scenario *S5: Central Tendency*

	Irrigation Depletion Shortages Without the Alternative[1] (AF)	Irrigation Depletion Shortages With the Alternative[2] (AF)	Annual Reduction in Irrigation Depletion Shortages With the Alternative (AF)[3]
Average	106,000	101,000	5,000
Wettest Ten Years	77,000	71,000	6,000
Middle Ten Years	97,000	90,000	7,000
Driest Ten Years	140,000	139,000	1,000
Driest Five Years	173,000	172,000	1,000

[1] That is, St. Mary's Canal with 650 CFS capacity.
[2] That is, St. Mary's Canal with an 850 CFS capacity.
[3] Calculated from subtracting the second column from the first column.

Fish and Wildlife

St. Mary River basin flows would be reduced under this alternative, as more water would able to be diverted during wetter and median flow years. At this time, it is unknown what the bull trout flow needs are; therefore, the impacts cannot be quantified. In the Milk River basin, the enlarged St. Mary Canal, along with irrigation, would increase the amount of water available for fish and wildlife habitat and municipal and industrial water supplies. The increase in flows may positively impact water quality, such as sustaining or decreasing water temperatures and pollutant concentrations in the Milk River. Assuming irrigation efficiencies remained the same, water available for the Bowdoin National Wildlife Refuge from return flows could increase, which would benefit migratory waterfowl habitat and piping plover nesting.

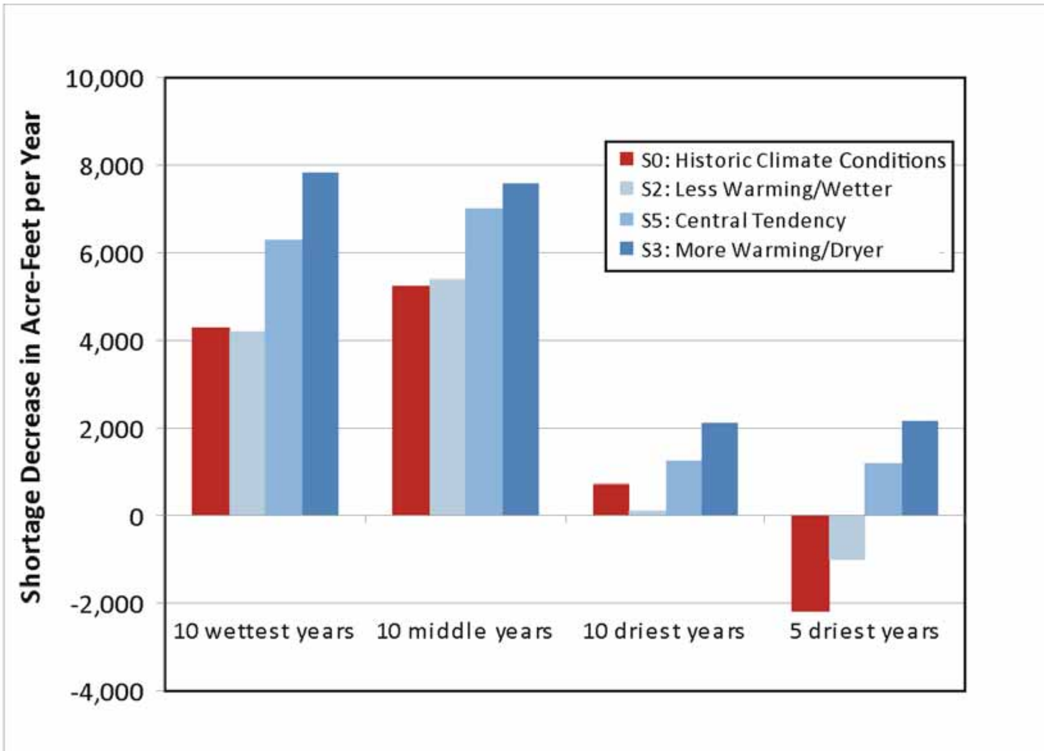


Figure 5.6: Modeled reductions in irrigation depletion shortages for the Rehabilitate St. Mary Canal Alternative under selected climate change scenarios.[10]

Increased flow in the Milk River channel in Alberta could result in increased channel and bank erosion, contributing to sediment loads.

Recreation

This alternative would increase the volume of St. Mary water reaching Fresno Reservoir. However, the projected increase for Fresno Reservoir average levels is only about 0.1 foot. This would have a small, positive effect on associated recreational opportunities.

Hydropower

The increase in capacity might improve the feasibility of developing hydropower on the canal.

Flood Control

Not applicable.

[10] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

Increase Fresno Reservoir Storage Alternative

Description

This alternative would increase Fresno Reservoir storage by raising the spillway crest from elevation 2,575 feet to elevation 2,580 feet MSL (figure 5.7). Fresno Dam was constructed in 1939, with an original storage capacity of 130,000 AF. A 1999 reservoir survey showed that the storage capacity had shrunk from accumulating sediments to 93,000 AF—a loss of 37,000 AF of storage capacity. By 2050, Fresno Reservoir's storage capacity is expected to be reduced further to an estimated 62,000 AF if no action is taken. The decrease in storage capacity will lead to additional shortages in the Milk River Project beyond those that could be attributed to a warmer climate.

Figure 5.7: Fresno Reservoir.

Summary

For the shorter term, losses in storage might be offset with a control structure on the reservoir spillway that could increase the maximum usable water surface elevation by 5 feet. Raising the spillway crest to elevation 2,580 feet would increase the year 2050 storage capacity to 90,000 AF, near the present capacity.

During most years, this extra storage might decrease irrigation depletion shortages by about 4,000 AF. Reductions in irrigation depletion shortages were 50 percent higher than average during wet years and 50 percent lower than the average during dry years. Benefits of the increased storage would be about 3 times greater during wetter years because extra water would be available to store during wet years. During drier years, especially if the drier years occur in sequence, there might not be enough water to take advantage of the extra storage capacity, and benefits would be less.

Other benefits include safeguarding water supplies for municipal users. The increase in water surface elevation also would help to maintain the existing reservoir fisheries and recreational values. Water quality along the Milk River would likely remain the same.

Evaluation

Agriculture

Table 5.5 compares estimated total Milk River irrigation depletion shortages for climate change scenario *S5: Central Tendency* with and without a 5-foot raise to Fresno Reservoir. The last column is the anticipated irrigation benefits of a 5-foot raise in the Fresno pool elevation and associated 28,000AF increase in storage.

Table 5.5: Modeled Irrigation Depletion Shortage Comparison With and Without the Increase Fresno Reservoir Storage Alternative Under Future Climate Change Scenario *S5: Central Tendency*

	Irrigation Depletion Shortages Without the Alternative (AF)[1]	Irrigation Depletion Shortages With the Alternative (AF)[2]	Annual Reduction in Irrigation Depletion Shortages With the Alternative (AF)[3]
Average	106,000	101,000	5,000
Wettest Ten Years	77,000	70,000	7,000
Middle Ten Years	96,000	92,000	4,000
Driest Ten Years	140,000	138,000	2,000
Driest Five Years	173,000	171,000	2,000

[1] That is, Fresno Reservoir Storage = 62,000 AF.
[2] That is, Fresno Reservoir Storage = 90,000 AF.
[3] Calculated from subtracting the second column from the first column.

Figure 5.8 compares decreases in irrigation depletion shortages under this alternative under *S0: Historic Climate Conditions* and under several climate change scenarios to show the central tendency and high and low range.

Even if the reservoir elevation were raised 5 feet to recapture lost storage, increased irrigation demands associated with warmer temperatures would result in greater fluctuations in pool elevation than in the past. Figure 5.9 compares modeled Fresno Reservoir storage for *S5: Central Tendency* with and without

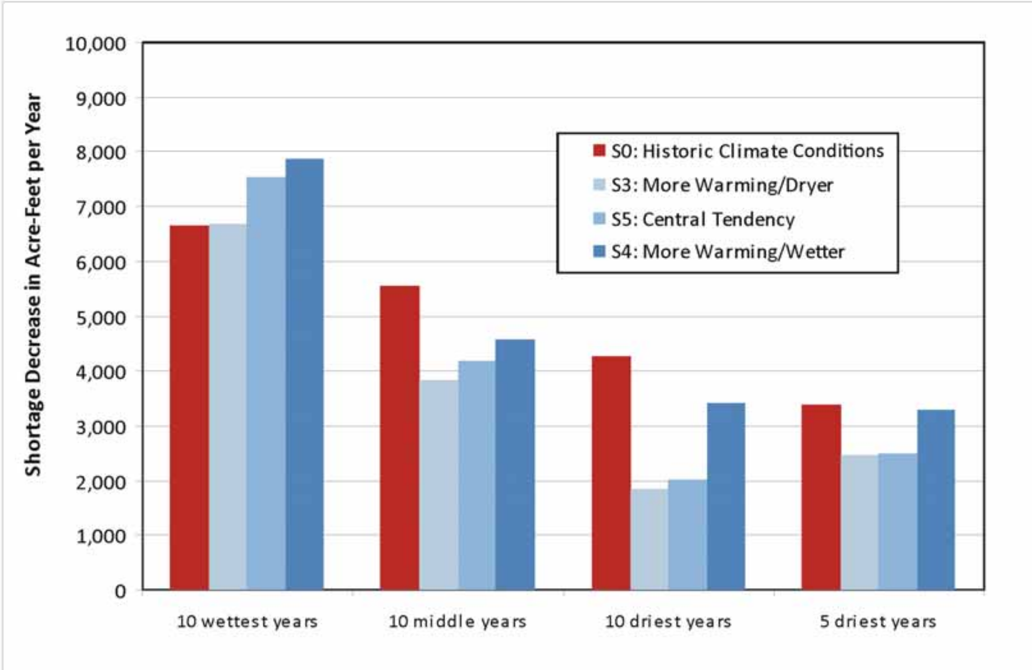


Figure 5.8: Modeled decreases in irrigation depletion shortages for the Increase Fresno Reservoir Storage Alternative under *S0: Historic Climate Conditions* and selected climate change scenarios.[11]

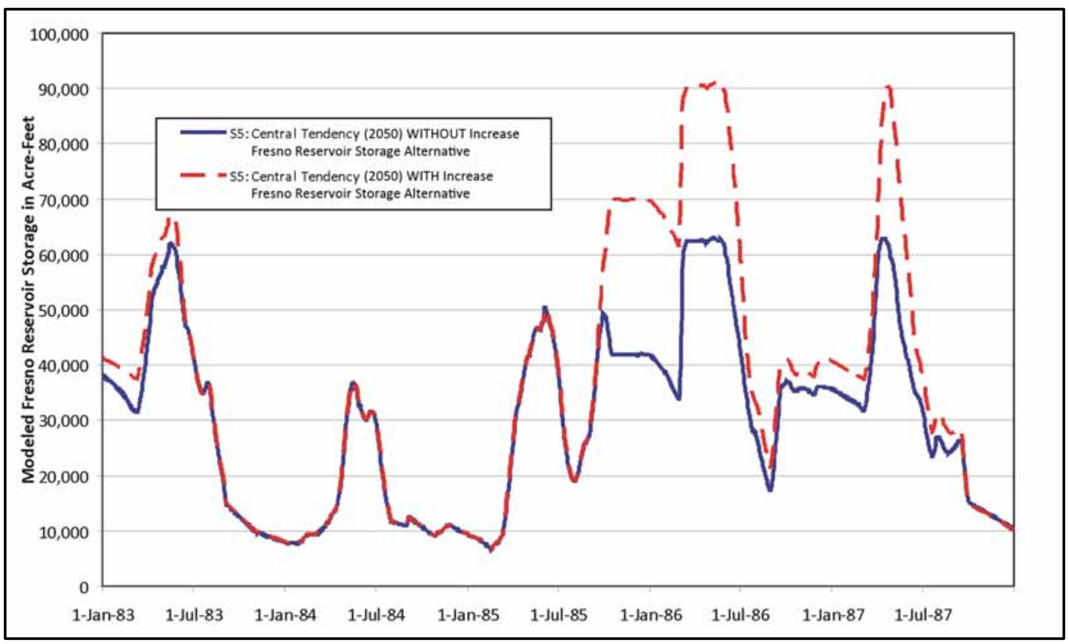


Figure 5.9: Modeled Fresno Reservoir storage with and without the increase Fresno Reservoir Storage Alternative under Climate Change Scenario *S5: Central Tendency*.

[11] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

this alternative. The plot is based on weather patterns for the 1983 to 1987 period, which included wet and dry years. Note that the increase in storage does result in benefits during the 1984 to 1985 sequence of dry years.

Fish and Wildlife

Continued storage loss to sedimentation is a long-term problem that threatens to diminish all of the benefits of Fresno Reservoir. Even though this alternative allows for more frequently meeting FW&P minimum pool recommendations to benefit the fishery and recreation, the higher fluctuations would result in less fish production. Another effect of this alternative would result in more frequent inundation of surrounding reservoir lands, which decreases the historic wildlife habitat areas. Water available for the Bowdoin National Wildlife Refuge might increase through higher return flows, which would benefit migratory and nesting waterfowl habitat. The increase in water available for storage may positively impact water quality, such as sustaining water temperatures in the Milk River.

Recreation

Some recreational facilities (e.g., cabins, docks, and picnic areas) might need to be relocated.

Hydropower

Not applicable.

Flood Control

The increase in storage would not impact the flood storage space and would therefore continue to preserve the benefits associated with flood control.

Expanded Frenchman Reservoir Alternative

Description

Frenchman Reservoir (figure 5.10) has lost about 60 percent of its original capacity of 7,010 AF to sedimentation, substantially decreasing the volume of water it can deliver to irrigators on Frenchman Creek. Frenchman Dam is a state-owned project on Frenchman Creek—a tributary to the Milk River. The dam has experienced severe deterioration since it was built in 1952–1953. Frenchman Dam's spillway also cannot safely pass the 500-year flood as recommended for a dam this size.

Given this small volume of storage and the variability of Frenchman Creek flows, Frenchman Creek irrigators experience substantial irrigation depletion shortages

Figure 5.10: Frenchman Reservoir dewatered during 2011 construction activities.

in most years. To provide a reliable water supply to Frenchman Creek water users and downstream Milk River irrigators, the existing reservoir would need to be raised or a new reservoir constructed.

DNRC is currently considering options for Frenchman Dam to improve the water supply for users on Frenchman Creek and possibly mitigate impacts from Fort Belknap Compact implementation on Milk River irrigators.

The river system model was operated for various reservoir sizes to determine the yield. Raising Frenchman Reservoir to its original capacity of 7,010 AF would greatly improve the water supply for the approximately 3,485 acres of irrigated land receiving water from the reservoir, but it would not provide enough water to meet all demands for these lands. A storage volume of 50,000 AF was modeled because it would meet most irrigation demands on Frenchman Creek and also could store and release some additional water during most years for downstream Milk River irrigators. Figure 5.11 shows that if Frenchman Reservoir were increased to 50,000 AF of storage capacity, it might be able to yield about 18,000 AF reliably every year.

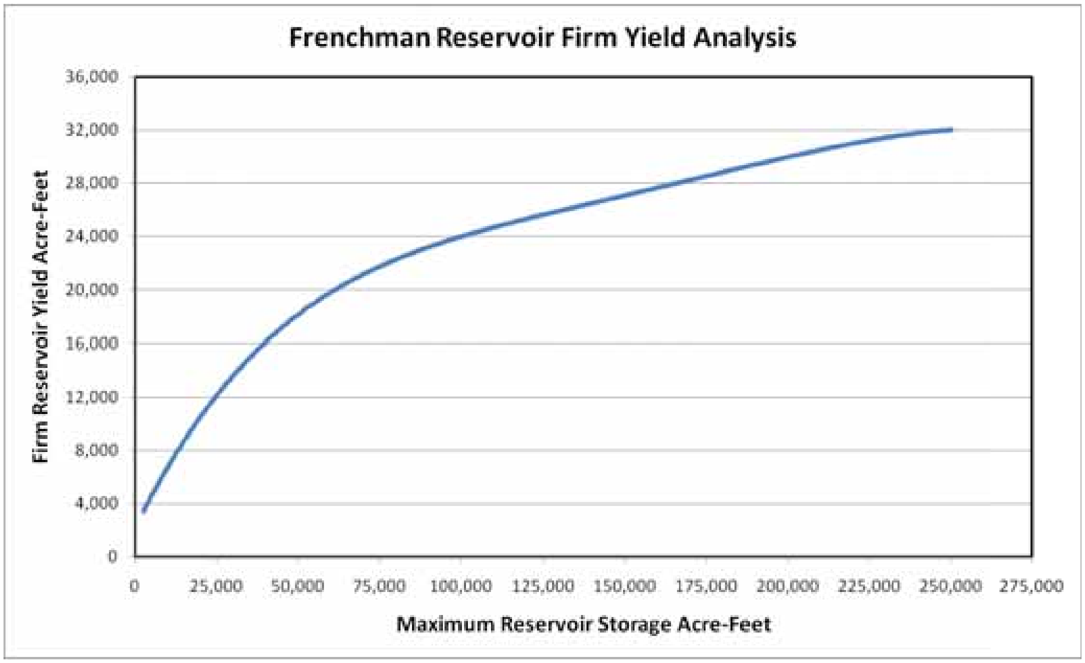


Figure 5.11: Firm yield of 50,000 AF—Frenchman Reservoir.

Summary

The Frenchman Creek basin contains an estimated 3,485 irrigated acres. If the capacity of Frenchman Reservoir were restored to the original capacity of 7,010 AF, it would result in an average increase in crop consumption of 1,200 AF, or 4.1 inches per acre, with the gains typically occurring during the mid-summer months when flows of Frenchman Creek decline.

Similar to most prairie streams, the flow of Frenchman Creek varies substantially from year to year. A reservoir in this environment would need to be large enough to "carry over" storage from wetter to drier years in order to provide a dependable water supply during periods of prolonged drought. Evaporation losses from the larger reservoir surface would be about 2,800 AF per year on average under climate change scenario *S5: Central Tendency*. Because of its downstream position in the Milk River basin, Frenchman Reservoir could only directly benefit the Glasgow Irrigation District and other downstream contract and private water users.

The enlarged Frenchman Reservoir alternative would capture and store flow from a large upstream source area. Model results show that reservoir pool levels would average about 20,000 AF per year under the future climate change scenario *S5: Central Tendency*. About 25 percent of the time, reservoir levels would be below 5,000 AF. The reservoir would be near-full pool (above 40,000 AF) about 20 percent of the time.

A 50,000-AF reservoir was modeled, and shortages for Frenchman Creek water users were significantly reduced in all but the driest years. This size reservoir might also reduce irrigation depletion shortages by about 4,000 to 7,000 AF per year for downstream water users on the Milk River, with the higher range benefits during dry years. Homes near the reservoir might be affected if the existing dam were enlarged.

Evaluation

Agriculture

If water users were willing to accept some shortages during dry years, then the 50,000 AF reservoir could be used to meet most of the needs of irrigators on Frenchman Creek and to provide some additional water for downstream users. The analysis included accounting for the increased evaporation from an expanded reservoir surface area.

Tables 5.6 and 5.7 compare modeled decreases in irrigation depletion shortages for Frenchman Creek irrigators for the climate change scenarios *S0: Historic Climate Conditions* and *S5: Central Tendency* using a 50,000-AF reservoir (with some of the benefits shared with downstream Milk River irrigators). Most of the modeled irrigation depletion shortages that remain under the expanded reservoir alternative would be during dry years that are at the end of a sequence of drought years.

Table 5.6: Frenchman Creek Watershed Irrigation Depletion Shortages With and Without the Expanded Frenchman Reservoir Alternative (i.e., 50,000 AF Storage) Under Climate Change Scenario *S0: Historic Climate Conditions*

	Irrigation Depletion Shortages Without Alternative (AF)	Irrigation Depletion Shortages With the Alternative (AF)	Annual Reduction in Irrigation Depletion Shortages With the Alternative (AF)*
Average	2,900	800	2,100
Wettest Ten Years	2,000	200	1,800
Middle Ten Years	2,200	400	1,800
Driest Ten Years	3,800	1,600	2,200
Driest Five Years	5,000	2,900	2,100

* Calculated from subtracting the second column from the first column.

Table 5.7: Decreases in Frenchman Creek Watershed Irrigation Depletion Shortages With and Without the Expanded Frenchman Reservoir Alternative (i.e., 50,000 AF Storage) Under Climate Change Scenario *S5: Central Tendency*

	Irrigation Depletion Shortages Without Alternative (AF)	Irrigation Depletion Shortages With the Alternative (AF)	Annual Reduction in Irrigation Depletion Shortages With the Alternative (AF)*
Average	3,900	1,500	2,400
Wettest Ten Years	2,600	200	2,400
Middle Ten Years	3,200	600	2,600
Driest Ten Years	5,100	3,000	2,100
Driest 5 Years	6,400	4,800	1,600

* Calculated from subtracting the second column from the first column.

After most of the needs of Frenchman Creek water users are met, additional water could be released to reduce irrigation depletion shortages for downstream Milk River irrigators under this alternative. Table 5.8 shows modeled decreases in irrigation depletion shortages for Milk River irrigators with the 50,000-AF reservoir for climate change scenario *S5: Central Tendency*. The modeled reductions in irrigation depletion shortages result from:

- Releases made from the reservoir during times of low flow and high crop demand
- An increase in return flow from lands irrigated on Frenchman Creek downstream from the reservoir

Table 5.8: Decreases in Milk River Irrigation Depletion Shortages With and Without a Expanded Frenchman Reservoir Alternative (i.e., 50,000 AF Storage) Under Climate Change Scenario *S5: Central Tendency*

	Irrigation Depletion Shortages Without Alternative (AF)	Irrigation Depletion Shortages With the Alternative (AF)	Annual Reduction in Irrigation Depletion Shortages With the Alternative (AF)*
Average	106,000	100,000	6,000
Wettest Ten Years	77,000	73,000	4,000
Middle Ten Years	96,000	90,000	6,000
Driest Ten Years	140,000	133,000	7,000
Driest Five Years	173,000	167,000	6,000

* Calculated from subtracting the second column from the first column.

The irrigation for the land served by Frenchman Reservoir was modeled with 30-percent efficiency.

Figure 5.12 shows the modeled decreases for Milk River irrigation depletion shortages and includes additional future climate change scenarios. Under *S0: Historic Climate Conditions* and future climate change scenarios (*S1 – S5*), the benefits of the reservoir are modeled to be greatest during drier years. Overall, Milk River shortages would be higher with a warmer climate, the need for the stored water would be greater, and Frenchman Creek basin would yield more water under most of the future climate change scenarios due to projected higher average precipitation.

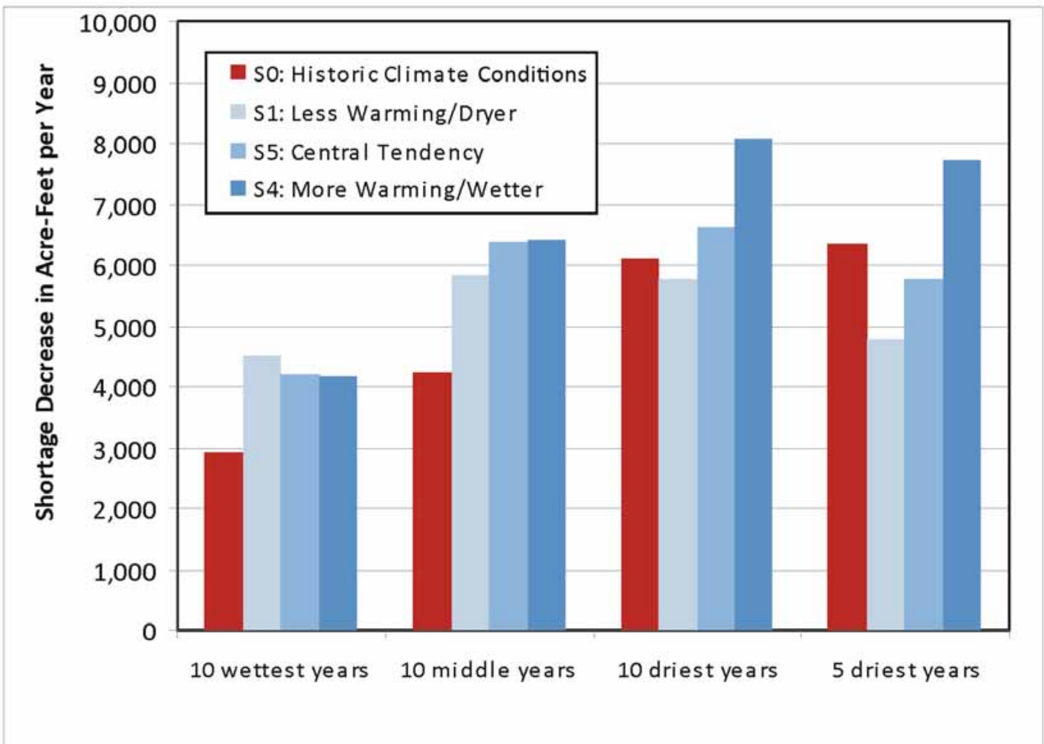


Figure 5.12: Decreases in Milk River irrigation depletion shortages with the Expanded Frenchman Reservoir Alternative (i.e., 50,000 AF Storage) under *S0: Historic Climate Conditions* and selected climate change scenarios.[12]

Fish and Wildlife

In the past, DNRC employees inspecting reservoir facilities at low pool levels observed a healthy gamefish population despite the reservoir's overall shallow depth and low storage capacity. A larger, deeper reservoir would have the

[12] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

potential to support a good fishery along with an associated increase in recreational opportunities. The reservoir could also provide habitat for other wildlife such as migratory waterfowl.

Negative impacts associated with a larger reservoir would be inundated riparian and upland habitat used by existing wildlife populations. Downstream from the reservoir, riparian areas could be affected due to the loss of peak flows that overtop the riverbanks and scour the channel.

Reduced high flows from Frenchman Creek tributary also would lower peak flows downstream, which could have an adverse effect on native fish that spawn in the lower Milk River.

This alternative would have no impact on Bowdoin National Wildlife Refuge.

Recreation

Frenchman Reservoir is in a remote, prairie landscape with some recreation. However, the reservoir is usually drawn down to low water levels by late summer. An expanded reservoir could provide improved recreational opportunities.

Hydropower

Not applicable.

Flood Control

Because a larger Frenchman Reservoir could capture peak flows from a large drainage area, flooding on the lower portion of Frenchman Creek and the Milk River might be reduced, especially if reservoir operations included flood-control criteria.

New Storage on Milk River in Alberta Alternative

Description

Under this alternative, Canada would build a dam and reservoir on the Milk River. Alberta, Canada, has no reservoir to store and regulate Milk River flow, so an average of 20,000 AF per year of Canada's share of the river flows into the U.S.. A new storage reservoir on the Milk River in Alberta, with associated irrigation expansion, could decrease water supplies for U.S. Milk River irrigators. This alternative evaluates a 237,000 AF new reservoir in Alberta, Canada, just below the confluence of the North Fork on the Milk River and the Milk River main stem. The larger reservoir would allow Alberta to capture the entire Canadian share of Milk River natural flow in all but the highest flow years.

About 8,000 acres are currently irrigated from the Milk River in Alberta. Figure 5-13 shows the Milk River in Canada. Because the natural flow of the Milk River is usually far below 666 CFS during the peak summer irrigation season (and often near zero) and because Canada is only entitled to 25 percent of the natural flow below 666 CFS, the flow available for Alberta irrigators typically is less than the irrigation demand. In addition to providing a more reliable water supply to existing Alberta irrigation, a reservoir might allow Alberta to expand its total irrigated land base in the Milk River watershed by about 18,000 acres to a total of 26,000 acres.

Figure 5.13: Milk River in Canada.

Summary

With an Alberta storage reservoir, the U.S. would receive less Milk River natural flow from Canada because the Alberta storage reservoir would allow Canada to use most, but not all, of its share. Alberta could not capture the entire Canadian share primarily because the reservoir would be in the upper part of the Milk River in Canada, where it would not be able to capture tributary inflow between the dam and the Eastern Crossing.

The 237,000-AF reservoir on the Milk River was modeled to provide water to 26,000 acres in Alberta. Reservoir operations were simulated to store only the Canadian share of Milk River natural flow to meet Alberta irrigation demands using the historic climate baseline and future climate change scenarios. The flow of the Milk River at the Eastern Crossing would be reduced by about 24,000–30,000 AF on average; during middle to dry years, reductions would be 3,000–18,000 AF. Because such a reservoir primarily would capture and store higher peak flows, shortages to U.S. irrigation crop depletions might be about 2,000-4,000 AF per year.

Past discussions and investigations with Alberta have indicated that a shared reservoir in Canada could provide joint benefits. The river system model could be used to investigate potential benefits of shared Milk River storage to U.S. Milk River water users.

Evaluation

Agriculture

Table 5.9 compares modeled Milk River flow decreases at the Eastern Crossing, with the Alberta storage reservoir, under *S0: Historic Climate Conditions* and *S5: Central Tendency* climate conditions. Flows would decline due to storage, depletion of water by crops with the expanded Alberta irrigation, and evaporation from the reservoir surface. Reservoir evaporation, which would be charged to the Canadian share, would account for about 15 to 20 percent of the total Canada-share depletions. In addition to declines in flow due to the Alberta reservoir, under most of the future climate scenarios, the U.S. share of Milk River natural flow also is expected to decrease (figure 5.14).

Table 5.9: Annual Flow Volume Decreases for the Milk River at the Eastern Crossing With the New Storage on Milk River in Alberta Alternative Under the Climate Change Scenarios *S0: Historic Climate Conditions* and *S5: Central Tendency*

	***S0: Historic Climate Conditions* (AF)**	***S5: Central Tendency* (AF)**
Average	29,000	24,000
Wettest Ten Years	60,000	51,000
Middle Ten Years	18,000	15,000
Driest Ten Years	3,000	2,500
Driest Five Years	3,500	2,500

Canada would no longer benefit from the Letter of Intent if a reservoir were constructed, and it is unlikely that the Letter of Intent would be kept in place solely for the benefit of the U.S.. Therefore, the Letter of Intent requirements and assumptions were removed from the Alberta reservoir model simulation. The resulting decline in St. Mary Canal diversions also slightly decreases the total flow at the Eastern Crossing.

Because less Milk River natural flow would be available to the U.S., shortages for the U.S. Milk River irrigators would increase somewhat (tables 5.10 to 5.12). The increase in shortages might be smaller than expected because much of the flows that the Alberta storage reservoir would capture are higher spring flows that might otherwise spill from Fresno Reservoir.

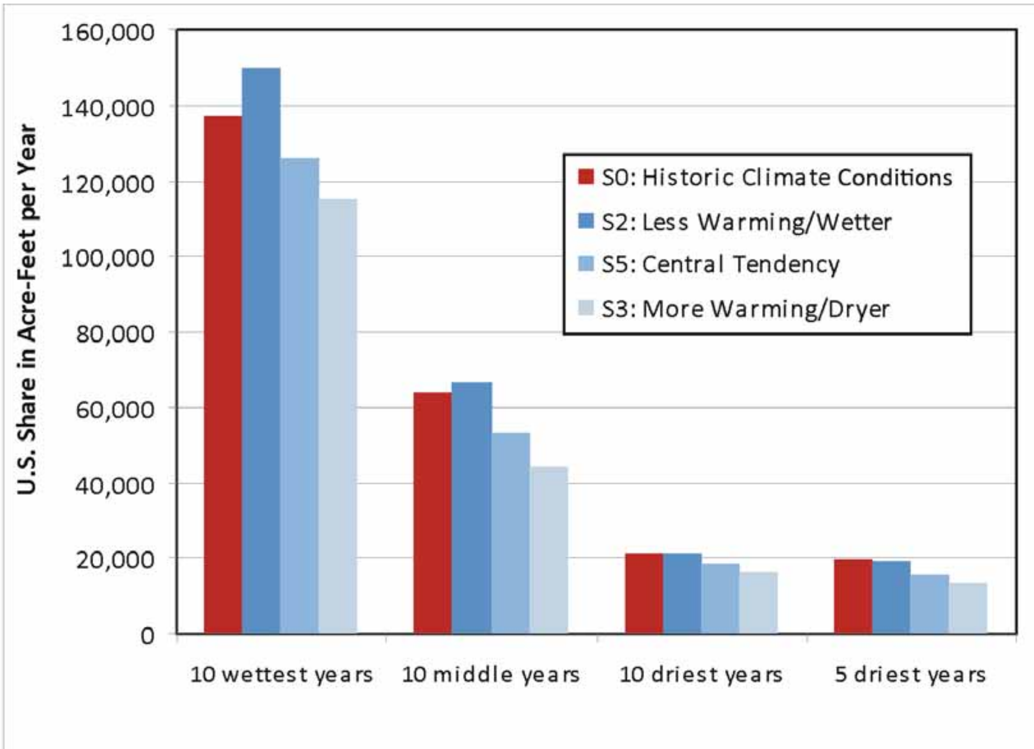


Figure 5.14: Modeled U.S. share of Milk River at the Eastern Crossing with the New Storage on Milk River in Alberta Alternative under *S0: Historic Climate Baseline* and selected climate change scenarios.[13]

Table 5.10: U.S. Share and Natural Flow Delivered to the U.S. at the Milk River at the Eastern Crossing With and Without the New Storage on Milk River in Alberta Alternative Under Future Climate Change Scenario *S0: Historic Climate Conditions*

	U.S. Share of Milk River Natural Flow With the Alternative (AF)	Natural Flow Delivered to U.S. With the Alternative (AF)	Natural Flow Delivered to U.S. With the Alternative (AF)
Average	71,000	104,000	75,000
Wettest Ten Years	121,000	183,000	124,000
Middle Ten Years	54,000	74,000	56,000
Driest Ten Years	24,000	30,000	26,000
Driest Five Years	21,000	27,000	23,500

[13] Please note that this graph does not show results for all of the future climate scenarios. Instead, data are plotted to show the range of potential climate impacts.

Table 5.11: U.S. Share and Natural Flow Delivered to the U.S. at the Milk River at Eastern Crossing With and Without the New Storage on Milk River in Alberta Alternative Under Climate Change Scenario *S5: Central Tendency*

	U.S. Share of Milk River Natural Flow With the Alternative (AF)	Natural Flow Delivered to U.S. Without the Alternative (AF)	Natural Flow Delivered to U.S. With the Alternative (AF)
Average	62,000	89,000	65,000
Wettest Ten Years	110,000	165,000	115,000
Middle Ten Years	47,000	63,000	49,000
Driest Ten Years	21,000	24,000	22,000
Driest Five Years	20,000	23,000	21,000

Table 5.12: Increases in Milk River Irrigation Depletion Shortages for the New Storage on Milk River in Alberta Alternative Under *S0: Historic Climate Conditions* and *S5: Central Tendency*

	S0: Historic Climate Conditions **Increase in Irrigation Depletion Shortages With the Alternative (AF)**	***S5: Central Tendency*** **Increase in Irrigation Depletion Shortages With the Alternative (AF)**
Average	2,500	3,000
Wettest Ten Years	2,500	2,000
Middle Ten Years	1,000	2,500
Driest Ten Years	3,000	4,000
Driest Five Years	3,000	4,000

A dam on the Milk River in Alberta might slow sedimentation rates and subsequent loss of storage in Fresno Reservoir. This would be more due to the way that the reservoir regulated peak flows than due to the dam actually capturing sediment since the primary sediment-producing areas in the Milk River in Canada mostly are downstream from the proposed dam location. Figure 5.15 depicts simulated Fresno Reservoir storage for a selected period with and without the Alberta storage reservoir under conditions projected under climate change scenario *S5: Central Tendency*. The amount of water stored in Fresno Reservoir would be less if the Alberta storage reservoir were built. The decreases in storage for *S5: Central Tendency* result from a combination of decreased natural flow at the Eastern Crossing and storage in the potential reservoir in Alberta.

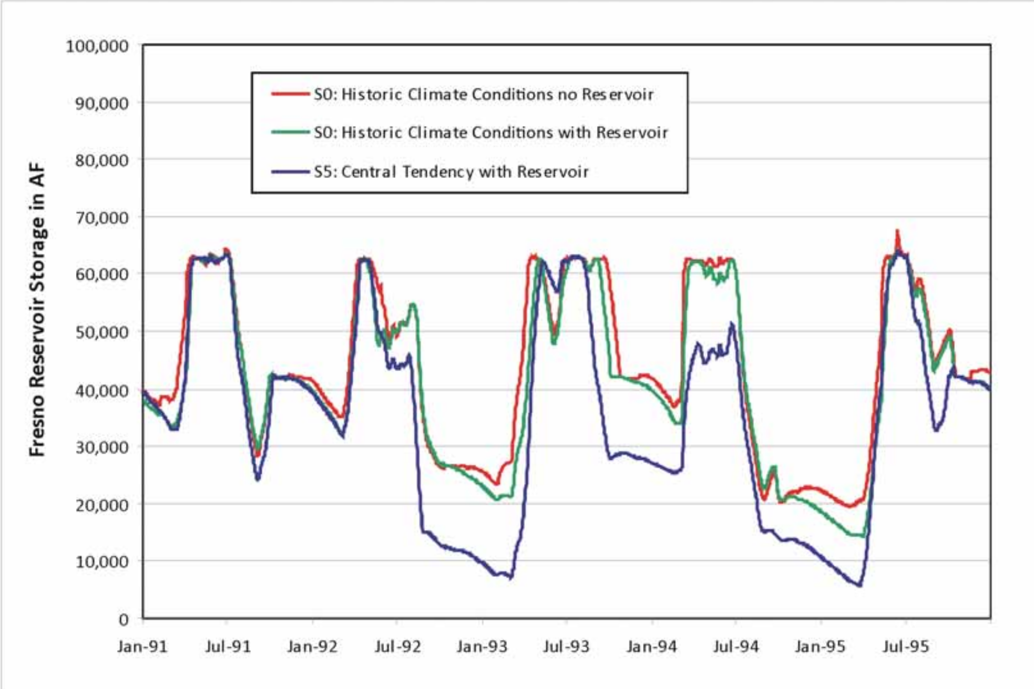


Figure 5.15: Comparison of modeled Fresno Reservoir Storage under *S0: Historic Climate Conditions* with and without the New Storage on Milk River in Alberta Alternative and *S5: Central Tendency* with the Alternative.

If the reservoir and associated increases in irrigation were developed in Alberta, Montana water users would no longer receive the surplus Milk River flows that they are accustomed to. Also, the current Letter of Intent that allows the U.S. to take more early St. Mary water and allows Canada access to St. Mary water in the Milk River basin would no longer be useful to Canada and would likely be dropped. This alone might reduce the total flow of water at the Eastern Crossing by up to 4,000 AF. Because the Alberta reservoir would capture surplus flows that might otherwise be stored in Fresno Reservoir, average lake levels at Fresno would decline.

Fish and Wildlife and Recreation

Lower lake levels would be detrimental to the reservoir fishery and reduce recreational opportunities. Peak flows would be reduced on the Milk River downstream from Fresno Reservoir, resulting in a negative impact to riparian vegetation. The riparian vegetation relies on overbank and scouring flows for rejuvenation. There might be negative impacts to water quality as well (e.g., increased water temperatures and concentrations of pollutants).

The potential Alberta reservoir also might have negative impacts on migratory and nesting waterfowl habitat at Bowdoin National Wildlife Refuge as water levels decrease.

Recreational opportunities and fish and wildlife habitat would be created in Canada by the new reservoir, although riparian and prairie wildlife habitat would be lost. Some local U.S. recreationists might take advantage of nearby recreational opportunities across the border.

Hydropower

Not applicable.

Flood control

An Alberta reservoir would capture peak flow during large runoff events that might otherwise spill over the Fresno Dam spillway. This might result in flood control benefits for property adjacent to the Milk River in the U.S..

Other Potential Alternatives

There are other alternatives for addressing future water demands. Some have been identified and are listed below. The river system model can be used to analyze these and other alternatives although some model modifications may be needed.

- Longer St. Mary Canal diversion period
- Enforcement of water rights
- Water marketing
- Revised Boundary Waters Treaty apportionment procedures
- Changes in crop patterns
- Industrial water demands
- Additional storage at Lower St. Mary Lake
- Sherburne Dam low flow releases/Swiftcurrent Creek low flows
- *Winters* St. Mary Canal diversion capability
- Raised dam crest and spillway at Fresno Reservoir
- New storage at proposed Chain of Lakes Dam on Milk River
- Increased Dodson South Canal size
- New off-stream storage
- Milk River pumping to Nelson Reservoir
- Duck Creek Canal
- Tributary dams
- Hydropower at dams and canal drops
- Fort Belknap Indian Reservation off-stream storage reservoir
- Retiring of irrigated acres
- St. Mary - Milk River minimum streamflows

Summary of Alternatives

Benefits and impacts of the alternatives are summarized in table 5.13. These five alternatives represent a sample of potential ways to address water demands in the future.

Table 5.13: Summary of Alternatives

		Water Shortage (Acre-Feet)					Beneficiary Impact							
	Description	Average	Wettest 10 Years	Middle 10 Years	Driest 10 Years	Driest 5 Years	Irrigation Shortages	MR&I	Bowdoin NWR	Water Quality	ESA	F&W	Recreation	Hydropower
Historic Climate Baseline Model Run	Year 2012 - River system model with no alternative changes	**71,000**	**53,000**	**66,000**	**91,000**	**116,000**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Future Climate Model Run for Central Tendancy	Year 2050 - River system model with no alternative changes	106,000	77,000	97,000	140,000	173,000								
Alternatives - Central Tendency Climate Scenario for Year 2050														
Canal & On-Farm Water Use Efficiency Improvements	Increase of 17% efficiency	86,000	57,000	75,000	124,000	158,000	Positive	No Effect	Likely Negative	Likely Negative, Likely Positive	No Effect	Likely Negative, Likely Positive	Likely Positive	No Effect
Rehabilitatate St. Mary Canal for Increased Capacity	Increase canal capacity from 650 cfs to 850 cfs	101,000	71,000	90,000	139,000	172,000	Likely Positive	Likely Positive	Likely Positive	Likely Positive	Likely Negative, Likely Positive	Likely Positive	Likely Positive	Positive
Increase Fresno Reservior Storage	Increase of 33,400 AF of storage	101,000	70,000	92,000	138,000	171,000	Likely Positive	Likely Positive	Likely Positive	No Effect	Likely Positive	Likely Negative, Likely Positive	Positive	Likely Positive
Expanded Frenchman River Reservior	Increase of 50,000 AF of storage	100,000	73,000	90,000	134,000	166,000	Likely Positive	No Effect	No Effect	No Effect	No Effect	Likely Negative	Positive	Likely Positive
New Storage on Milk River in Alberta	New storage of 237,000 AF and increase of 26,000 irrigated acres	109,000	79,000	99,000	144,000	177,000	Likely Negative	Likely Negative	Likely Negative	Likely Negative	Likely Negative	Likely Negative	Likely Negative	No Effect

Impact Legend

Positive	⇧ (green arrow up)
Likely Positive	● (green)
No Effect	○
Likely Negative	● (red)
Negative	⇩ (red arrow down)

*More than one graphic indicates a range of impacts

Chapter 6: Findings and Recommendations

This chapter summarizes findings and makes recommendations for advancing the model beyond this study to provide the best model for stakeholders to use for future planning activities. This Basin Study does not make recommendations for alternatives.

Findings

Irrigation depletion shortages[14] occur for the Milk River irrigators every year now and in all future climate change scenarios, including *S0: Historic Climate Conditions.* Modeled irrigation depletion shortages average 71,000 AF annually, which is 36 percent of the crop irrigation demand. During the driest years, shortages are modeled to be 44 percent of demand.

Overall, streamflow for the region is projected to increase for the climate change scenario *S5: Central Tendency* and most climate change scenarios for 2050. However, these increases in flow for *S5: Central Tendency* would be modest: the median streamflow of the St. Mary River is expected to increase by 3,700 AF (a less than 1-percent increase), and the median streamflow of the mouth of the Milk River is expected to increase by 15,000 AF (about a 3-percent increase), for a total increase of 18,700 AF (about a 2-percent increase overall). Although streamflow increases are expected under most scenarios for most areas, the upper areas of the Milk River basin are expected to produce somewhat less runoff locally under most scenarios. Increased runoff variability also is predicted for both the St. Mary River and Milk River basins, with wetter years, producing more runoff than in the past, and in drier years, producing disproportionally less runoff. An earlier shift in runoff timing also is projected for most of the subbasins in the St. Mary River and Milk River basins. This is especially true for the higher elevation snow-producing St. Mary River watersheds, which are all predicted to have annual volume centroid[15] shifts of 7–9 days earlier.

Crop irrigation demands are expected to increase with the projected increase in temperatures under all of the future climate change scenarios (*S1 – S5*). The trend toward moderate increases in precipitation will not be enough to offset the increases in crop demands. Crop demands are expected to increase between 24 to 29 percent (or between 51,000 to 56,000 AF) as compared to *S0: Historic Climate Baseline*. By year 2050, increases in runoff are expected to only make up

[14] Irrigation depletion shortages are defined as the unmet crop demand.
[15] Centroid is the halfway date for total annual streamflow runoff volume.

for between 33 and 37 percent of the expected increase in irrigation depletion shortages if it could all be captured and used. The river system model shows that during dry years, runoff will decrease, and shortages will increase.

With the existing infrastructure in the St. Mary River basin, assuming that the current capacity of the St. Mary Canal could be maintained, the U.S. might be able to divert slightly more St. Mary River water to the Milk River on average in the future. However, increased variability between wetter and drier years is anticipated in the future. Although future canal diversions were modeled to be 5 to 12 percent higher during median to wetter years, modeled diversions were 2 to 10 percent lower during the driest years. Because the natural flow of the Milk River might be somewhat less in the future, the future overall volume of flow at the Eastern Crossing might be similar to, or perhaps a little bit higher than, present conditions. On the other hand, losses in storage due to sedimentation in Fresno Reservoir would decrease the Milk River Project's ability to capture and re-regulate this flow to meet downstream irrigation needs.

With the anticipated significant increase in irrigation water demands and a future water supply that might be similar to what it is today, the net result is that shortages for Milk River irrigators are expected to increase substantially. Simulation of the future streamflows and crop irrigation demands indicates that total Milk River irrigation depletion shortages would increase from the present average of about 35,000 AF to a total average irrigation depletion shortage of 106,000 AF for projected 2050 climate conditions under *S5: Central Tendency*.

Recommended Future Improvements to the River System Model

To keep the newly developed river system model up to date and to ensure that future stakeholders could use the model for evaluating water resource alternatives or plans in the future, DNRC and Reclamation recommend:

- Updating the model annually, including annual updates to streamflow and water use information, and software updates.
- Exploring groundwater/surface water interaction in the Milk River valley and updating the model to better simulate groundwater return flow.
- Continuing joint efforts between the federal, Tribal and state agencies, as well as water users on collecting and monitoring canal diversions. With this additional data, the model's calibration and predictive capabilities could be improved.

- Expanding the river system model to explicitly model water supplies and water uses on the larger Milk River tributaries, including improvements in computing naturalized tributary streamflows.

- Expanding the model's capability to analyze irrigation system improvements by accounting for canal efficiencies and irrigation field efficiencies separately.

- Adding accounting capabilities that track the current semimonthly balancing of the U.S. and Canadian shares of St. Mary and Milk Rivers' natural flow.

- Updating DNRC management and the Federal Negotiating Teams annually about the river system model status to keep them informed of the model's ability to simulate proposed projects by the Tribes to implement Water Rights Compacts.

- Exploring using the river system model to analyze water quality in the St. Mary and Milk Rivers.

- Updating the model input files to include any refinements in the climate change projections.

References Cited

Brown, C.J.D., 1971. *Fishes of Montana,* Big Sky Books (Montana State University). Bozeman, Montana.

Dalton, J., 2001. *Milk River Basin Canal Efficiency Study and Water Conservation Planning Demonstration Project.* Reclamation and the Milk River Joint Board of Control. Billings, Montana.

Dolan, Larry, 2009. *Field Surveys of Irrigation Water Use in the Portion of Glacier County in the Milk River Basin,* conducted by Larry Dolan of the Montana DNRC, Helena, during the 2006 through 2009 seasons. DNRC, Helena, Montana.

DNRC, 2011. *St Mary River-Milk River Basin Study Documentation.* Helena, Montana.

DNRC and Reclamation, 2012. *St. Mary River and Milk River Basins Study Model Documentation.* DNRC, Helena, Montana.

Goos and Ethridge, 2008. *Report to the International Joint Commission on the Division of the Waters of the St. Mary and Milk Rivers, 2008.*

Hirsch, R.M., 1982. *A Comparison of Four Streamflow Record Extension Techniques.* Water Resources Research, Vol. 18, No. 4, p. 1081–1088.

HKM Engineering, 2007. *Saint Mary Canal Hydropower Feasibility Report – Final Report*, performed by HKM Engineering for Blackfeet Tribe, March 2007. Billings, Montana.

Hydros Consulting, Inc., 2011. *Memorandum on Historical Model Calibration for the St. Mary River and Milk River Basins Study Model.* Hydros Consulting. Boulder, Colorado, to Larry Dolan, DNRC, Helena, Montana.

Milk River Irrigation District, DNRC, and Reclamation, 1990. *Summarizing the Milk River Water Supply Study: Special Report*. Billings, Montana.

Montana State University, 2011. *Poverty Report Card.* Bozeman, Montana. Accessed February 2012. <http://www.montana.edu/extensionecon/poverty.html>

Reclamation, 2000. Fresno Reservoir 1999 Reservoir Survey. Sediment and River Hydraulics Group, Water Resources Services, Technical Service Center, Denver, Colorado.

_____, 2003. Hydrology Appendix for the Regional Feasibility Report. North Central Montana, Montana Area Office, Billings, Montana.

_____, 2004a. *North Central Montana: Alternatives Scoping Document.* U.S. Department of the Interior, Billings, Montana.

_____, 2004b. *North Central Montana Regional Feasibility Report.* U.S. Department of the Interior, Billings, Montana.

_____, 2008. *Reservoir and River Operation Guidelines for the Milk River Project, A Practical Guide to Operating the Milk River Project*, Supplemental Information to the Standard Operating Procedures. Montana Area Office, Billings, Montana.

_____, 2010. *Climate Change Analysis for the St. Mary and Milk River Systems in Montana,* Technical Memorandum No. 86-68210-2010-04. Technical Service Center, Denver, Colorado.

_____, 2011a. *SECURE Water Act Section 9503 (c) – Reclamation Climate Change and Water 2011*. Technical Service Center, Denver, Colorado.

_____, 2011b. *Milk-St. Mary River System Basin Study.* Technical Service Center, Denver, Colorado.

_____, 2011c. *Hydropower Resource Assessment at Existing Reclamation Facilities*. Technical Service Center, Denver, Colorado.

Riewe, Bob, 2011. Personal communication, Bob Riewe, Irrigation Modeling Specialist, Basin Water Management Section, Ministry of Agriculture and Rural Development. Government of Alberta, Lethbridge Alberta, Canada.

Riverside Technology, Inc. 2006. Calibration of the St. Mary and Milk River Basins for the Missouri Basin River Forecast Center (MBRFC), Task Completion Report, Task 5-0012, Phase 1, 80 pp.

Slade, Bud, 2011. Personal communication, Bud Slade, Manager, Malta Irrigation District, Montana.

Stash, S., R.G. White, and D. Fuller. 2001. *Distribution, Relative Abundance, and Habitat Associations of Milk River Fishes Related to Irrigation Diversion Dams*. USGS Cooperative Fishery Research Unit, Montana State University, Bozeman, Montana.

U.S. Census Bureau, 2010. State and County QuickFacts. Accessed February 2012. <http://quickfacts.census.gov/qfd/index.html>

______, 2012. America FactFinder. Accessed February 2012. <http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml>

USDA, 2007. U.S. Census of Agriculture, Montana. Accessed February 2012. <http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Montana/index.asp>

Western Regional Climate Center, 2012. *Montana Climate Summaries.* Accessed February 2012. <http://www.wrcc.dri.edu/summary/climsmmt.html>

Glossary

Acre Feet: A volumetric measurement of water that would cover 1 acre at a depth of 1 foot (abbreviated AF).

Alternative: Water management and infrastructure changes that were, or could be in the future, evaluated for their effects on basin water supply and demand in response to climate change.

Average (Mean): The sum of a list of values divided by the number of values in a dataset.

Base Period: The historic hydrological period of record used for purposes of this study. The base period for this study is 1959–2009.

Basin Study Team: Montana Department of Natural Resources and Conservation, Bureau of Reclamation, and private consulting personnel involved in carrying out this study.

Bias Correction: A necessary adjustment made on a statistically derived hydrologic dataset to more closely match it to historic data.

Boundary Waters Treaty of 1909: Guides the U.S. and Canada in managing shared waters.

Central Tendency: A climate change scenario that identifies the central cluster of climate change projections for the study area (see figure 2.8).

Centroid: Halfway date for total annual streamflow runoff volume.

Climate Change Projection: A modeled projection of future temperature and precipitation based on varying rates of some physical parameter such as greenhouse gas concentrations.

Climate Change Scenario: Simulations of future temperature and precipitation for the basins based on general circulation model projections.

Daily Time Step: Modeled computations made on a daily basis. This is the time step that was used in the river system model (Riverware™) for this study.

Ecologically Resilient: An aquatic ecosystem can be defined as possessing the capability to recover from either stochastic natural disturbances, such as extreme drought or flooding, or from anthropogenic disturbances, such as river channelization, dam construction, or water storage and diversion.

Evapotranspiration: The sum of evaporation from the soil and plant leaves and transpiration of water through the plant to build plant tissue (abbreviated ET).

General Circulation Model: A model of atmospheric and oceanic circulation to simulate global climate response to some physical parameter such as greenhouse gas concentrations (abbreviated GCM).

Historic Conditions: Climate and hydrologic conditions as they existed over the period of record.

Historical Climate Baseline: A simulation of historic climate conditions that serve as the datum against which to measure the effects of climate change scenarios and selected alternatives.

Hydrologic Model: A model that translates precipitation and temperature data into predicted streamflows. The SAC-SMA/SNOW-17 model was the hydrologic model used for this study.

IJC 1921 Order: Outlines how the U.S. and Canadian allocation of the St. Mary and Milk River are to be apportioned.

International Joint Commission: An independent bi-national organization established by the U.S. and Canada under the Boundary Waters Treaty of 1909 to help prevent and resolve disputes over the boundary waters and advise the respective governments on water resources (abbreviated IJC).

Irrigation Depletion Requirement: The amount of irrigation water that a crop would consume for optimal growth.

Irrigation Depletion Shortage: The amount of water the crops would deplete through the process of evapotranspiration for optimal growth and production minus the amount of water that the crops actually deplete.

Irrigation Efficiency: Expressed as a percentage, the amount of irrigation water consumed by crops divided by irrigation water diverted from a source. For this study, irrigation efficiency is the combined conveyance and on-farm efficiencies.

Letter of Intent: An agreement between the U.S. and Canada and under the authority of the International Joint Commission that allows flexibility in balancing the water between the St. Mary and Milk Rivers by allowing the U.S. to divert more than its share of St. Mary River water early during the spring and allowing Canada to divert more than its share of water from the Milk River later during the irrigation season.

Median: A value that separates the higher half from the lower half of a list of values. The median is the middle value in a series of data values ranked from highest to lowest.

Natural Flow: Flow that would have occurred in the stream if there were not human influences.

Net Evaporation: Evaporation from a water surface minus precipitation that falls on the water surface.

Net Irrigation Requirement: The amount of water that a crop requires for optimal growth minus that supplied by natural precipitation. In the Milk River basin, irrigation is required because the amount of water required by the crop far exceeds the natural precipitation available to it.

Period Change HDe (Delta Hybrid): Statistical method was used to generate temperature and precipitation data from GCMs for use in the hydrologic model.

Phreatophytes: A deep-rooted plant that obtains water from a permanent ground supply or from the water table.

River System Model: The daily time step model used for this study to simulate current and future riverflows, reservoir operations, and water use in the St. Mary and Milk River basins. Riverware™ was the river system modeling software used for this study.

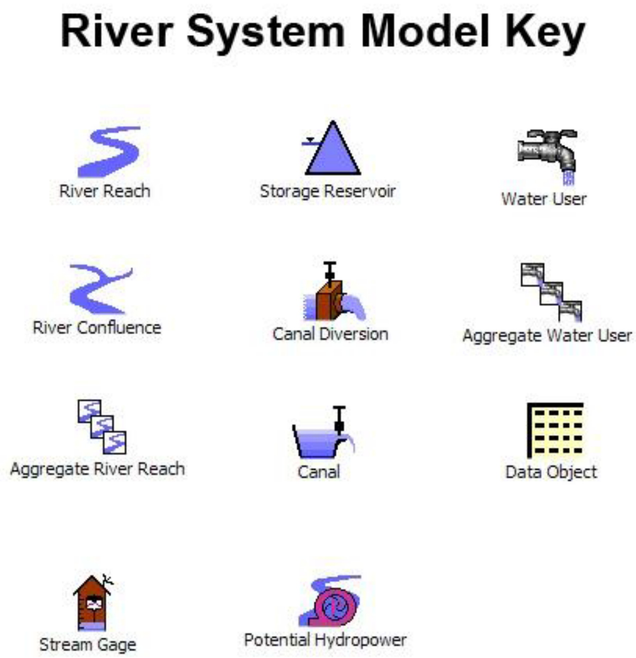
Statistical Downscaling: A statistical method that translates global-scale output data from the General Circulation Models to the finer-scale climate characteristics as they apply at the basin level.

Appendix A

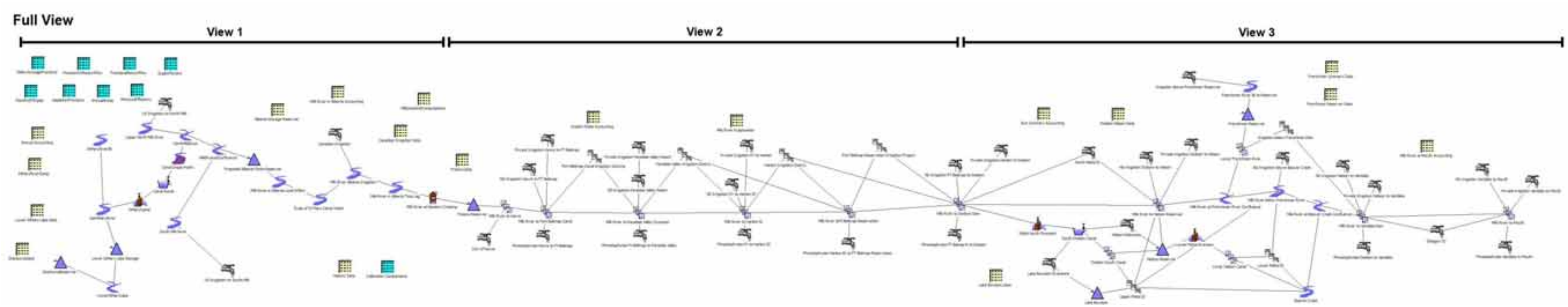
River System Model

Appendix A: River System Model

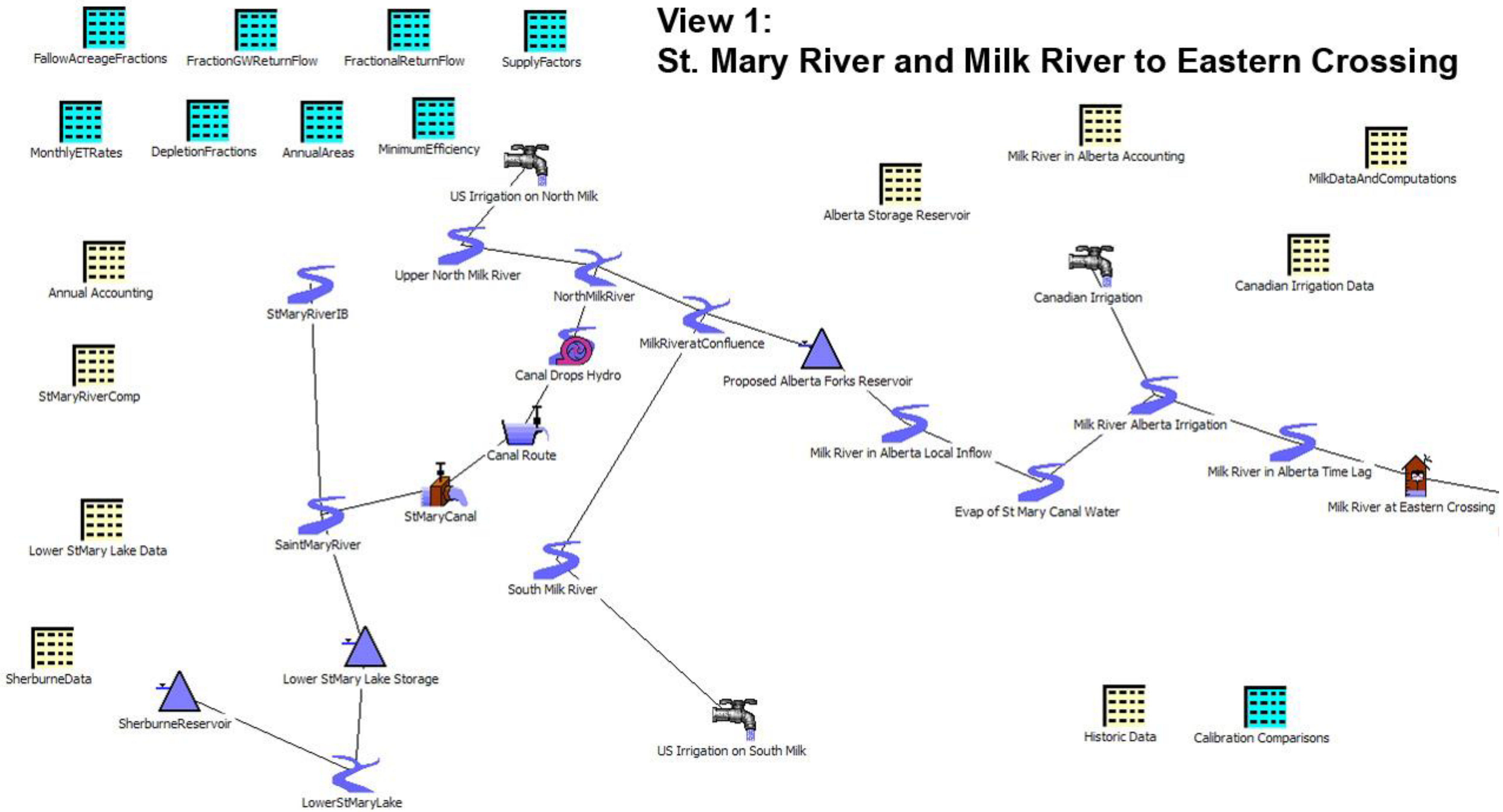
Page A-1 contains a full-view of the River System Model. The model is separated into Views 1 through 3, which are shown as individual close-up views on pages A-2 through A-4. The key to various model components is below:



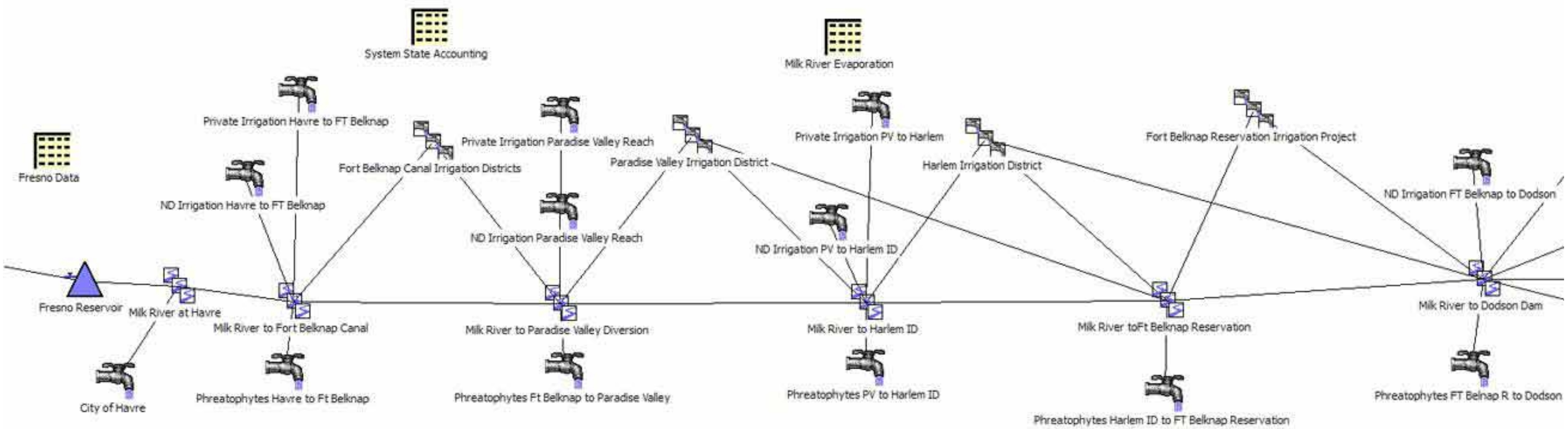
St. Mary River – Milk River Basin
River System Model Schematic



View 1:
St. Mary River and Milk River to Eastern Crossing



View 2:
Fresno Reservoir to Dodson Diversion Dam



View 3: Malta Irrigation District to Mouth