RECLAMATION

Managing Water in the West

St. Mary River-
Milk River Basin
Study *Draft* Report

U.S. Department of the Interior
Bureau of Reclamation

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Executive Summary

The U.S. Bureau of Reclamation (Reclamation) and the Montana Department of Natural Resources and Conservation (DNRC) conducted a Basin Study of the St. Mary River and Milk River basins in north-central Montana. The purpose was to develop build a river system model of the St. Mary River-Milk River watershed to assess the ability of the existing infrastructure to meet future water needs under a changing climate; to evaluate alternative ways of reducing future water shortages; and for future planning and reserved water rights settlement needs. The basins examined in this study supply water to Reclamation's Milk River Project, municipalities, Indian reservations, and to fish, wildlife, and recreational uses.

The river system model was developed with RiverWare ™ software. This software simulates operations of the upper St. Mary River system to meet the goals of diverting water through the St. Mary Canal for 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. 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 various irrigation districts, contract users, and the Tribes of the Fort Belknap Reservation using the reservoirs and irrigation canals on the Milk River. The model was used to simulate the operations of the St. Mary River-Milk River system under baseline conditions and for five future climate scenarios.

Findings

To develop future climate input files for the river system model, Reclamation analyzed projected changes to temperature and precipitation in the basin for five future scenarios. Models were also developed by Reclamation to translate these changes in temperature and precipitation to changes in streamflow and crop irrigation requirements. Under all future scenarios, basin temperatures are predicted to warm, with the rate of warming varying but averaging about 5° F for a climate centered on the year 2050. A moderate increase in precipitation was predicted for most but not all of the scenarios, with a trend towards greater variability between wet and dry years. Hydrologic simulations conducted using a calibrated *SAC-SMA/SNOW 17* model for the basins indicated these changes in precipitation and temperature should produce modest streamflow increases in the basins under most scenarios, but with generally lower streamflow during the driest years. The centroid of the annual streamflow runoff volume for most sub-watersheds in the basins is expected to shift towards earlier in the year, with the runoff centroid for snowmelt-dominated streams on the St. Mary River side projected to be 7-to-9 days earlier. On the demand side, crop irrigation requirements in the Milk River Basin are projected to increase by about 24-29 percent.

Assuming the capacity of the St. Mary Canal could be maintained at about the current 650 cubic feet per second (cfs) into the future, the U. S. might be able to divert about 5 percent more St. Mary River water across to the Milk River in the future than under baseline conditions, except during the driest years when about 8 percent less water might be diverted. The increase in diversion during most years would be due to a combination of an assumed earlier St. Mary Canal start date with a warmer climate and the slightly higher share of St. Mary River flow available to the U.S. under most climate change scenarios. Similarly, the volume of combined St. Mary water and Milk River natural flow that reaches Fresno Reservoir in the future is projected to be similar to or slightly higher than under baseline climate conditions, except during the driest years.

Fresno Reservoir has been steadily losing storage capacity due to sedimentation, and is expected to continue to lose more capacity into the future. By 2050, the estimated storage available is projected to be only 62,000 acre-feet (AF), which is less than half of the capacity of about 130,000 AF when the reservoir was completed in 1939. In addition, the climate change scenarios all project a substantial increase in crop irrigation requirements for the about 140,000 acres of Milk River irrigated lands downstream. The combination of higher release needs for downstream demands and less available storage would result in overall decreased Fresno reservoir levels in the future.

Because water supplies wouldn't increase enough to meet demands, shortages were modeled to increase under all future climate scenarios, with the greatest relative increase during drier years. Total Milk River shortages to crop depletion requirements were modeled to increase by an average of about 36,000 AF per year, to a total of 104,000 AF for the climate expected by 2050 under the middle climate change *Scenario S5*. Although shortages are modeled to increase, the total volume of water consumed by crops and overall crop production on irrigated lands is likely to increase. The exception would be during the driest years when the supply of water in the future is expected to be less than under baseline conditions.

Alternatives that might help to decrease water shortages were simulated with the river system model under baseline and historic conditions. Although none of the alternatives alone would reduce shortages to below baseline levels, several had the potential to make significant reductions. The single most effective alternative might be to increase the efficiencies of irrigation on the Milk River Project which might reduce average future irrigation depletion requirement shortages by about 20,000 AF. Raising the full pool elevation of Fresno Reservoir by 5 feet might result in an average shortage reduction of about 8,000 AF on average. And increasing the capacity of the St. Mary Canal was modeled to reduce average shortages by about 5,000 AF. Rebuilding DNRC's Frenchman River Reservoir to a much larger 50,000 AF could eliminate shortages for Frenchman River irrigators with State Contracts during all but the driest years and might reduce shortages for lower Milk River irrigators by about 4,000 AF per year on average.

In the future the Tribes of the Blackfeet and Fort Belknap reservations might develop more of their Federal Reserved water rights for Milk River flow. This would add further demand to the limited water supplies in the Milk River Basin. The Blackfeet Tribe has reserved water rights to St. Mary River water, and it has yet to be determined how these rights might be developed and what effect there might be on available flow. To use more of the Canadian share of Milk River natural flow, Alberta could construct a reservoir on the Milk River and expand its irrigation along the river. This might reduce the average annual flow of the Milk River at the Eastern Crossing of the International Boundary by about 25,000-30,000 AF and result in increased shortages for Milk River irrigators in the United States.

Recommendations

Although it is not the intent of this report to make recommendations for future feasibility level studies, some alternatives for reducing future water shortages were examined in the Basin Study. The river system model could be used to further analyze these alternatives, to analyze combinations of these alternatives, or to analyze other alternatives. To keep the river system model up to date and to ensure that future stakeholders could use the model for evaluating water resource alternatives or plans, DNRC and Reclamation recommend the following:

- Update the model on an annual basis including annual updates to streamflow and water use information, and keeping the model current with software updates

- Explore groundwater/surface water interaction in the Milk River valley and update the model to better simulate groundwater return flow

- Continue joint efforts with Federal, Tribal, State, and water users on collecting and monitoring canal diversions. With this additional data, the model's calibration and predictive capabilities could be improved

- Explore expanding the river system model to explicitly model water supplies and water uses on the larger Milk River tributaries

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

- Add accounting capabilities to the model that track the current semi-monthly balancing of the U.S. and Canadian shares of St. Mary River and Milk River natural flow

- Annually update DNRC management and the Federal Negotiating Teams on the river system model status so they are informed of the ability of the model to simulate proposed projects by the Tribes to move Reserved Water Rights settlements forward

- Explore using the river system model to model water quality in the St. Mary and Milk rivers

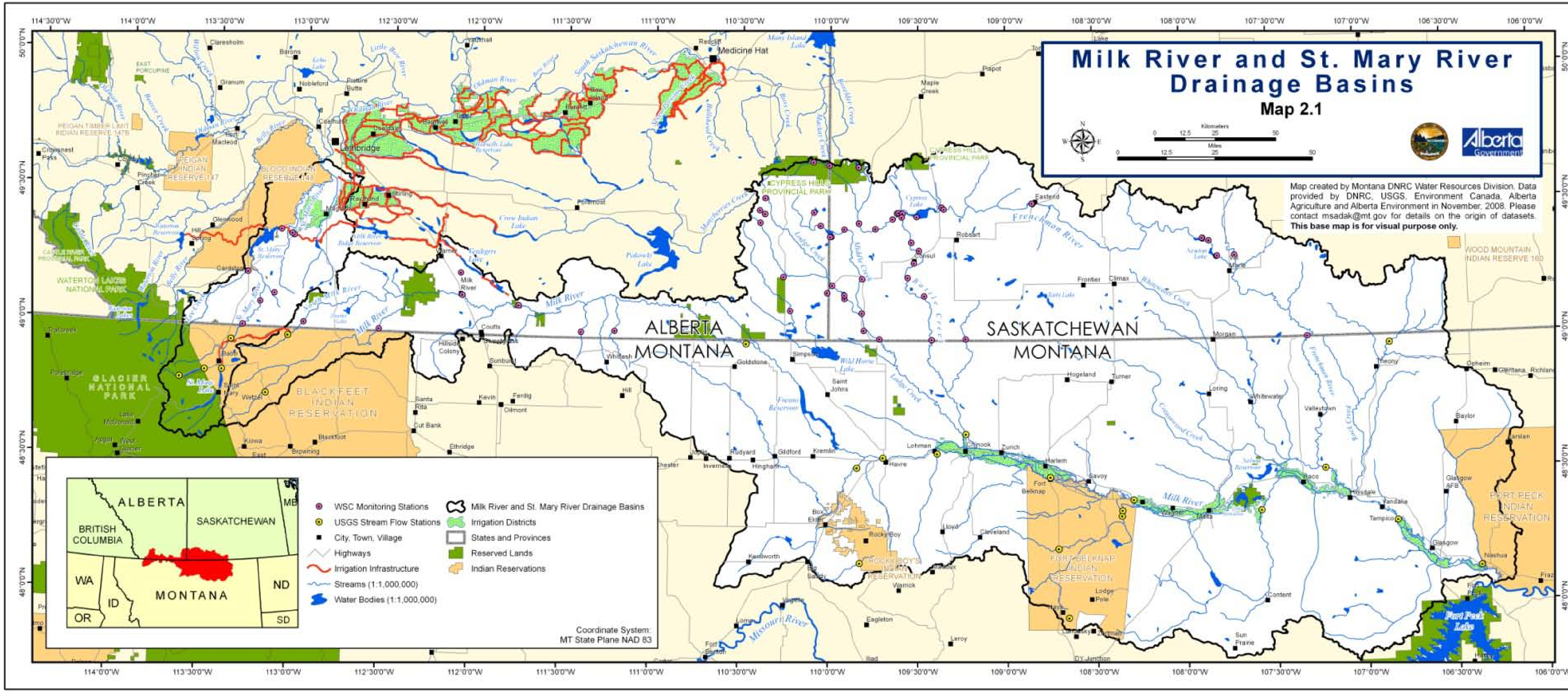
- Update the model to include any refinements in the climate change projections.

Table ES.1:
WaterSmart Program Basin Study Framework
Study Requirements Summary (§ 4.4.5)

Study Requirement	Location in Report
1. Projections of water supply and demand, including risks posed by climate change	Increases in runoff by 2050 due to climate change is expected to only make up for between 33 and 37 percent of the expected increase in crop irrigation depletions. *Chapter 2, Summary of Present and Future Water Supplies and Demands.*
a. Changes in snowpack	Change in snowpack accumulation wasn't determined directly. The precipitation and temperature for the climate change scenarios considered together in the surface water runoff model would indirectly account for changes in streamflow as a result of changes in snowpack. The surface water runoff model determined if precipitation was likely to be rain or snow. A snowmelt component of that model was used to simulate the melt and subsequent runoff. *Chapter 2, Future Water Supplies.*
b. Changes in timing and volume of runoff	Over half of the subbasins in the study area are projected to have the centroid of the annual volume shift up to 4 days earlier. The streams in the St. Mary River watershed are all predicted to have annual volume centroid shifts of 7-9 days earlier (Figure 2.6). The median streamflow of the St. Mary River is expected to increase 3,700 AF and the median streamflow of the Milk River at the mouth is expected to increase 15,000 AF, for a total increase of 18,700 AF for year 2050. The upper areas of the Milk River Basin are expected to have less runoff locally. *Chapter 2, Future Water Supplies.*
c. Changes in groundwater re-charge and discharge	Groundwater use is limited in the St. Mary River and Milk River basins, primarily for domestic and stock watering purposes. Changes in groundwater due to climate change have not specifically been studied in the Milk River Basin. However, surface water is connected to alluvial aquifers; therefore, effects of climate change on precipitation and/or surface water runoff might affect recharge to and/or discharge from groundwater. *Chapter 2, Changes is Groundwater Recharge and Discharge*
d. Increase in demands from rising temperatures or reservoir evap-oration	Average annual net reservoir evaporation for Fresno Reservoir might increase by up to about 3 inches for the future projected climate. A similar increase would occur at Nelson Reservoir and from the river surface of the Milk River. The net irrigation requirement for the climate expected to exist in 2050 is about four and one-half inches greater than the net irrigation requirement for the present condition or between 24-29 percent increase in the net irrigation

		requirement depending on the location in the basin. *Chapter 2, Future Water Demands, Evaporation.*
2.	**How water and power infra-structure and operations would do in face of future population growth and climate change, including how changes in water supply will affect Reclamation operations and facilities**	Water shortages occur for Milk River irrigators every year with the present climate. Irrigation shortages would increase on both a volume basis and on a percentage of demand basis for the future climate *S5* when compared to the existing climate (Table 4.3). The average shortage would increase by 36,000 AF. *Chapter 4.*
a.	Reclamation's ability to deliver water	St. Mary Canal diversion under the existing and future climate would be the same on average (Table 4.4). However, during higher streamflow years under the future climate S5, canal diversions will be about 18,000 AF greater than under the existing climate. During lower streamflow years under the future climate, modeled canal diversion were about 14,000 AF less than under the existing climate. Irrigation water shortages would increase. Water levels at Fresno Reservoir are expected to be lower. *Chapter 4, Meeting Future Demands* Construction of the Rocky Boy/North Central Montana Rural Water System (RB/NCMRWS) may potentially reduce the contracted volume of water used from the Milk River for municipal purpose *Chapter 2, Future Water Demands – Municipal Water Demands.*
b.	Hydropower generation	There is currently no hydropower generating facilities in the St. Mary or Milk River basins in the U.S. at the present time. There are four potential sites that have been identified through other studies that may be viable. 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. *Chapter 4, Present System Reliability – Hydropower.*
c.	Recreation at Reclamation facil-ities	Fresno Reservoir elevations generally would be lower under future climate scenarios than under the baseline. This suggests recreation opportunities will be more limited as compared to the present. *Chapter 4, Meeting Future Demands*
d.	Fish and wildlife habitat	The overall modeled changes to Bowdoin National Wildlife Refuge water levels are modest, with a possible reduction in habitat. *Chapter 2, Future Water Demands – Other Water Demands*
e.	Threatened, endangered, and candidate species under ESA	Bull trout and pallid sturgeon flow requirements might be quantified in the future. Current water operations to benefit the piping plover are expected to continue into the future. *Chapter 2, Future Water Demands – Other Water Demands.*
f.	Water quality issues (including	It is anticipated that water demand and minimum releases

	salinity)	would remain similar to present so water quality is assumed to remain about the same. Minimum releases during the non-irrigation season are provided under contract. *Chapter 2, Future Water Demands – Other Water Demands*.
g.	**Water flow and water dependent ecological resiliency**	Climate change would impact water dependent ecological resiliency for fish and wildlife populations. Species would need to adapt to changing habitat conditions such as water temperatures and flow patterns, all of which are anticipated to occur under predicated climate change scenarios.
h.	Flood control management	Lake Sherburne and Fresno Reservoir provide flood control benefits by storing water during the peak runoff period. More information is needed about designated flood control space in Fresno Reservoir considering the future loss of storage due to sedimentation. Variability of streamflow is expected to increase and it is anticipated that peak streamflows will also increase. Flood control benefits are expected to continue at about the same level since Reclamation has an adaptive management approach to flood control at Fresno Reservoir. *Chapter 4, Meeting Future Demands.*
3.	**Development of options to improve infrastructure and operations to supply water in the future**	Three alternatives related to improvement of Reclamation related facilities were evaluated to test the river system model and to access each alternatives potential for providing water supply to meet demands in year 2050. One alternative was evaluated for a Montana owned tributary reservoir in the lower basin. One alternative was evaluation for a proposed dam in Alberta, Canada that would allow Alberta to more fully use Canada's share of the Milk River and has some potential or storage of US water. *Chapter 5.*
4.	**Comparison of the options, findings, and recommendations (including costs, environmental effects, risks, stakeholders' opinions, and other aspects)**	The primary purpose of this Basin Study was to develop a river system model with the capability to analyze wide range of potential alternatives that could address present and future water needs in the St. Mary and Milk River basins. No feasibility study is currently recommended because the time in not 'ripe' to thoroughly evaluate potential alternatives. Water compacts for two Indian reservations have been agreed upon with Montana, but are not yet approved through Congress. Thus, the water needs for these to large, important uses are not yet fully known. The river system model could be a useful tool for helping the Tribes, Montana, and the United States make informed decisions about implantation of these two water settlements. The Basin Study recommends updates and refinements to the river system model and periodic status updates to managers involved in water related issues in the basins.



Milk River and St. Mary River Drainage Basins
Map 2.1
Kilometers
Miles
Map created by Montana DNRC Water Resources Division. Data provided by DNRC, USGS, Environment Canada, Alberta Agriculture and Alberta Environment in November, 2008. Please contact msadak@mt.gov for details on the origin of datasets.
This base map is for visual purpose only.
ALBERTA
MONTANA
SASKATCHEWAN
MONTANA
GLACIER NATIONAL PARK
BLACKFEET INDIAN RESERVATION
FORT BELKNAP INDIAN RESERVATION
FORT PECK INDIAN RESERVATION
CYPRESS HILLS PROVINCIAL PARK
WATERTON LAKES NATIONAL PARK
Medicine Hat
Lethbridge
Milk River
WSC Monitoring Stations
USGS Stream Flow Stations
City, Town, Village
Highways
Irrigation Infrastructure
Streams (1:1,000,000)
Water Bodies (1:1,000,000)
Milk River and St. Mary River Drainage Basins
Irrigation Districts
States and Provinces
Reserved Lands
Indian Reservations
ALBERTA
SASKATCHEWAN
BRITISH COLUMBIA
MONTANA
WA
ID
OR
ND
SD
MB
Coordinate System:
MT State Plane NAD 83

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Chapter 1: Introduction

The *Basin Study Program*, part of the 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, Reclamation and the Montana Department of Natural Resource 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. This study examines these basins in northern Montana (shown in map and described in "Setting" below) where water shortages are presently experienced and expected grow more acute in the future. The study has incorporated the latest science, engineering technology, and climate models currently available.

Report Organization:

- 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 ability to meet present and future water demands
- Chapter 5 presents and evaluates alternatives to meet future water demands
- Chapter 6 presents findings and recommendations, and
- Chapter 7 details coordination and consultation.

Purpose

The purpose of the *St. Mary River-Milk River Basin Study* was to create and test a "daily time step" river system model that could be used by Reclamation and DNRC as a planning tool. This tool could be used to assist stakeholders 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 and the primary challenge facing residents is 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 these competing demands for a limited water resource.

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

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

> Water is crucially short in north central Montana. Irrigation, MR&I (municipal, rural, and industrial) water supplies, threatened and endangered species, water quality, Federal reserved water rights, fish and wildlife species, recreation, land hydro-power needs in the region must be met by U.S. Bureau of 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 Basin Study* doesn't 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 doesn't include cost/benefit analysis of alternatives nor 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 may 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 Indian 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 re-crossing the border 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 was reported in every month of the year. The Babb, Montana, weather station is closest to the St. Mary River with period of record from 1948-2005. The weather statistics are summarized in Table 1-1 (http://www.wrcc.dri.edu/summary/climsmmt.html).

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.

Table 1.1: Weather Data from Selected Sites in the Region over the Respective Period of Record

Weather Statistic	Babb (1948-2011)	Havre (1961-2005)	Glasgow (1955-2005)
Average Max. Temp	53° F	56.2° F	54.3° F
Average Min. Temp	26.8° F	30.1° F	30.8° F
Average Annual Temp	40° F	43° F	42.5° F
Highest Max. Temp	99° F (8/24/1969)	111° F (8/5/1961)	108° F (8/6/1983 & 6/5/1988)
Lowest Min. Temp	-43° F (12/8/1977)	-52° F (1/24/69)	-47° F (1/25/1969)
Average Annual Precip.	18.04 in.	11.16 in.	10.99 in.
Average Annual Snowfall	49.7 in.	42.5 in.	30.1 in.
Average Frost Free Days	66	128	138

Water

The St. Mary River produces a relatively dependable flow in the summer due to its higher elevation snowmelt and rainfall sources in Glacier National Park. The Milk primarily is a foothills and prairie stream and has far less high-elevation drainage area than the St. Mary River. For part of its length, the St. Mary flows near the North Fork of the Milk River. Reclamation added the St. Mary facilities to the Milk River Project in 1917 to take advantage of dependable St. Mary River flows to supplement flows in the Milk River. Water is diverted from the St. Mary River by the St. Mary Diversion Dam, just downstream of the outlet of Lower St. Mary Lake. St. Mary water is conveyed to the North Fork of the Milk River through a 29 mile canal, siphon and drop system. Lake Sherburne on the 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.

Milk River flows are stored and regulated in Fresno Reservoir near Havre, and Nelson Reservoir, an off-stream reservoir near Malta. Most of the stored water is used by Reclamation's Milk River Project to irrigate about 140,000 acres in 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 classifies water quality by water use, with Montana standards equal to or exceeding EPA water quality standards. Classes run from *A-closed* (the highest water quality) through *A-1*, *B*, *C*, to *I* (the lowest quality). Water uses are by suitability for drinking; processing food; bathing; swimming; propagation and growth of fish and aquatic life, waterfowl and furbearers; and agricultural and industrial use.

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

The St. Mary River outside Glacier National Park is classified B-1, suitable for drinking and food processing after conventional treatment and 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 B-1. From the Eastern Crossing to the joining with the Missouri River, the Milk River is classified B-3, suitable for drinking and food processing after conventional treatment and for all uses except propagation of salmonid fish.

Lands

Northern Montana's geology consists of unconsolidated and consolidated deposits ranging from Cambrian to Quaternary. 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 (U.S. Bureau of Reclamation, 2004).

Retreating glaciers left behind unconsolidated till, glacial lake deposits, and outwash deposits. Underlying unconsolidated deposits are Cretaceous sedimentary 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. Soils in the region are predominately derived from glacial till. Many of these lands are alluvial soils, but irrigated lands also include soils derived from wind-blown deposits, old lake plains, and glacial outwash. Much of the till was derived from mixed rock sources, but a few soils have formed in till from specific rock sources.

Plants, Wildlife, and Fish

For most of its distance, the Milk River runs through short grass prairie: vast, rolling, high plains grasslands, uprooted by "island" mountain ranges like the Bears Paw and Little Rocky

Mountains, and split by river valleys like the Milk and Missouri. Potholes—remnants of glaciers—pock the prairie, providing grassland-wetland habitat. Other important wetland habitat is provided by the river's oxbows, sloughs, and the extensive canal system. 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 the beaver; muskrat; cottontail and jack rabbit; black-tailed prairie dog; mink; weasel; raccoon; porcupines; skunk; and several bat species can be found (U.S. Bureau of Reclamation, 2004).

The region is a haven for birds: over 150 songbirds (sparrows, woodpeckers, and kingfisher); shorebirds (stilt, avocet, willet, and curlew); waterfowl (pelican, loon, goose, teal, and duck); raptors (eagles, falcon, hawks, and owls); 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.

The region (and area to the south) contains three Montana Wildlife Management Areas: Blackleaf (northwest of Great Falls), Milk River (northeast of Malta), and Freezeout Lake (west of Great Falls). The region also contains two National Wildlife Refuges: Benton Lake (northeast of Great Falls) and Bowdoin (east of Malta).

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). Natural 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 (U.S. Bureau of Reclamation, 2004).

A study of the Milk River fishery completed for Reclamation's 2004 report included flathead chub, river carpsucker, shovelnose sturgeon, and stonecat the most common in spring, with emerald shiner, flathead chub, goldeye, and shorthead redhorse being the most common in fall (Stash, et al., 2001). About 40 species were found during the study.

Threatened and Endangered Species

A number of threatened or endangered species listed under the Endangered Species Act can be found in the region. Candidate species (those for which sufficient information is available to support a proposal to list) include the black-tailed prairie dog. In addition to threatened and endangered species, Montana Department of Fish, Wildlife and Parks has identified the westslope cutthroat trout, sauger, pearl dace, paddlefish, and the blue sucker as *Species of Special Concern* that occur in the region.

The only Bull trout population east of the Continental Divide can be found in the St. Mary River Basin. Grizzly bears use the St. Mary Canal as a travel corridor (U.S. Bureau of Reclamation, 2004). Bald eagles and gray wolves occupy areas around Reclamation's St. Mary facilities. 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. Bald eagles, peregrine falcons, mountain plovers, and swift foxes can also be found. Black-tailed prairie dogs provide unique habitat for many wildlife species, including the black-footed ferret, burrowing owl, mountain plover, and ferruginous hawk, all except the first are Species of Special Concern.

Piping Plover

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 BP (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. Impacts from epidemics such as smallpox, reported as early as 1732, resulted in population shifts and cultural disruption (U.S. Bureau of Reclamation, 2004).

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 region was designated as common hunting grounds for Indian Tribes. 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 reestablished in 1878. In 1888, 17,500,000 acres of the common hunting grounds were ceded back to the Federal government, reducing Indian settlements to the boundaries of three reservations: Blackfeet, Fort Belknap, and Fort Peck. 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 later. 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: 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 Reservation in Hill County, and the Ft. 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 1.2 shows regional population by county (http://quickfacts.census.gov/qfd/index.html). Native Americans make up a considerable part of the total population of the region. In 2010, the population of the Blackfeet Reservation was 10,405; Rocky Boy's 3,323; and Fort Belknap 2,851.

Table 1.2: 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 Reservation.
[3] Includes the Fort Belknap Reservation (a small part in the case of Phillips).

Income

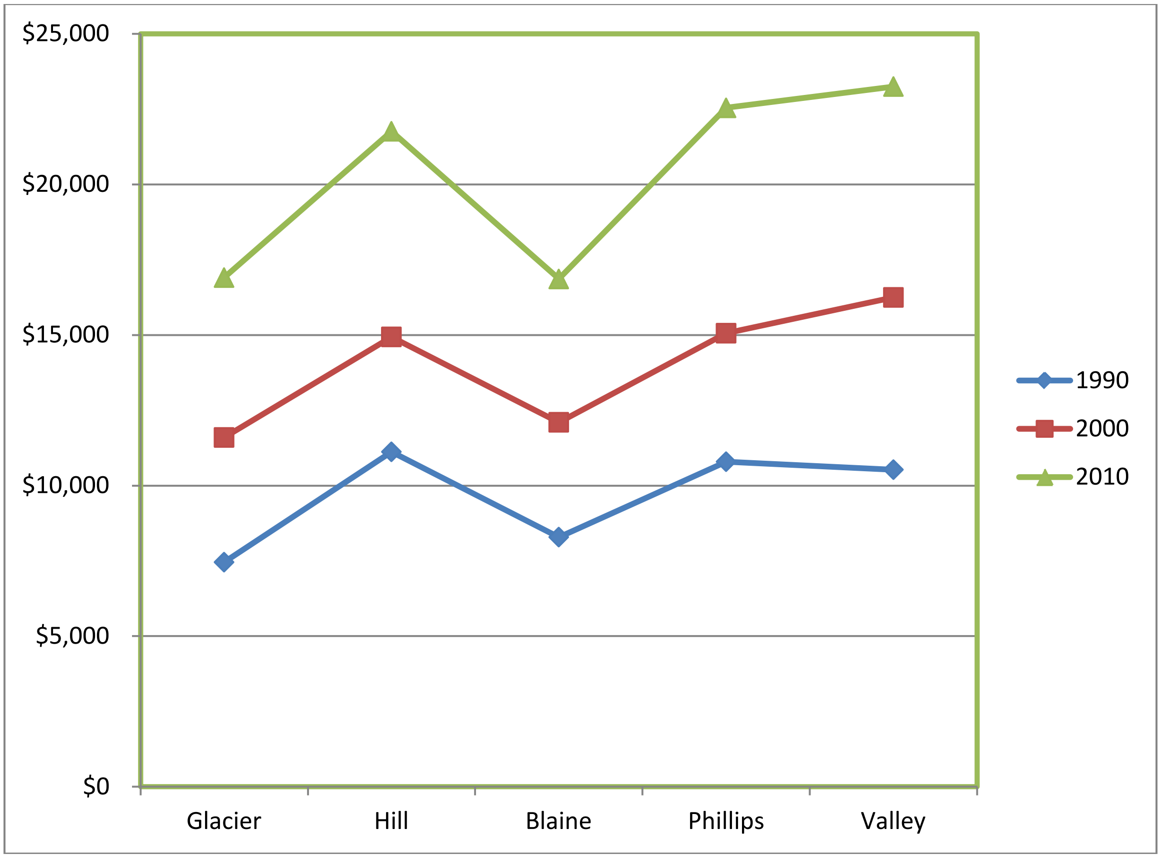
Income per person in the region (in 2009 dollars) was:

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

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

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 in Figure 1.1. (http://factfinder.census.gov/staff/main.hmtl).

Figure 1.1: Per Capita Income in the Region 1990, 2000, and 2010



Agriculture

Agriculture forms the underpinning of the region's economy. Table 1.3 shows the 2007 value of agricultural products sold, number of farms in the five counties, and the number of these farms with irrigated acres. More than a fifth of the farms (22 percent) were irrigated. (http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Montana/index.asp).

Table 1.3: 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 (millions)	$55.4	$86.6	$71.6	$60.9	$80.4	$354.9

Major Economic Activities

The U.S. Census ranked economic activities in the region by annual payroll and number of employees as of 2007 (http://factfinder.census.gov/servlet/SAFFEconFacts). The top four activities were the same in all five counties (Table 1.4—the first figure is the payroll in $1,000; 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; TV 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 1.4, *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 1.4: Major Economic Activities in the Region
(in $1,000)

	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 withheld from Census to avoid disclosing data.

Unemployment and Poverty

Despite limited job opportunities, the unemployment rate is lower in two of the counties than the 5.6 percent Montana rate and in three of the counties lower than the 9.2 percent national rate. The unemployment rates in 2009 were: Glacier County 13.4 percent; Hill County 4.7 percent; Blaine County 7.1 percent; Phillips County 10.8 percent; and Valley County 3.6 percent. Unemployment rates in the region are skewed by the extremely high rates on the reservations, estimated to be over 60 percent (http://www.montana.edu/extensionecon/countydata/allreservation.pdf).

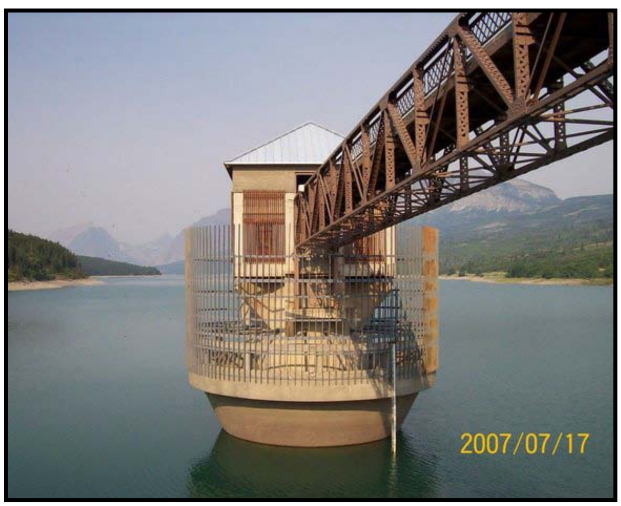
Except for Phillips County, the region's 2009 poverty rate (Poverty level is $22,050 for a family of four) was higher than the Montana rate of 9.8 percent and the national rate of 9.9 percent.

Glacier County had a rate of 21.6 percent; Hill County 10.5 percent; Blaine County 25.1 percent; Phillips County 8.7 percent; and Valley County 10.6 percent.

Milk River Project

Spanning both the St. Mary and the Milk River basins, Reclamation's Milk River Project facilities are operated as one system. The St. Mary Canal diverts the U.S. share of the St. Mary River to the North Fork of the Milk River (Map 2 at the end of this chapter). When U.S. share is insufficient to meet diversion needs, stored water is released from Lake Sherburne to make up the difference. When there is surplus, water from the Swiftcurrent drainage is stored in Lake Sherburne.

Project storage is provided by Lake Sherburne, Fresno Reservoir, and Nelson Reservoir. Lake Sherburne forms behind an earth-filled dam 1,086 feet long, is located about six miles west of Babb, Montana, and stores water from Swift Current Creek, the largest St. Mary River tributary. Total storage capacity is 68,080 AF. 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.



Sherburne Reservoir Outlet Works

Fresno Reservoir, forms behind an earth-filled dam 2,070 feet long, is located on the Milk River 14 miles west of Havre. 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 Milk River natural flow and St. Mary River water diverted to the Milk River.

Nelson Reservoir is an off stream reservoir 19 miles northeast of Malta that 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. Water is released directly out of Nelson Reservoir for the Nelson

South Canal acreage. Releases from Nelson Reservoir back to the Milk River, via the Nelson North Canal, are made for Glasgow Irrigation District. The Nelson South Unit of the Malta Irrigation District diverts water directly from Nelson Reservoir.

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

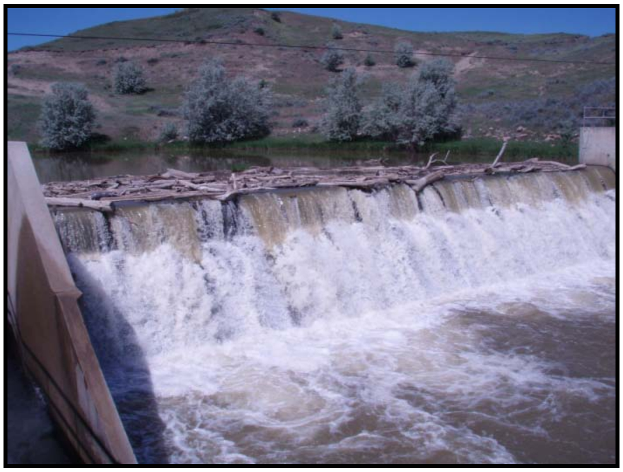
Lake Sherburne, Fresno, and Nelson Reservoirs provide recreation to the region. The 1,601surface-acre Lake Sherburne on Swiftcurrent Creek lies mainly within Glacier National Park, so the U.S. National Park Service manages recreation. The 7,388 surface-acre Fresno Reservoir and its 65 miles of shoreline are available for recreation. Fishing, boating, and water-borne sports are popular. Reclamation manages two swimming beaches, 11 vault toilets, two 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 available for recreation. Reclamation manages 9 campsites, 5 vault toilets, two boat launching ramps, 3 picnic areas with 3 shelters and sixteen tables. There are also 106 leased cabin sites around the reservoir.

The project contains three divisions and eight irrigation districts with two pumping units as shown in Table 1.5.

Table 1.5: Organization of the Milk River Project

DIVISION	DISTRICT	DIVERSION STRUCTURE	CANALS
Chinook			
	Fort Belknap	Fort Belknap Diversion Dam	Fort Belknap
	Alfalfa Valley	Fort Belknap Diversion Dam	Fort Belknap
	Zurich	Fort Belknap Diversion Dam	Fort Belknap
	Paradise Valley	Paradise Valley Diversion Dam	Paradise Valley
	Harlem	Two Pumping Plants	Harlem Canal
Malta	Malta	Dodson Diversion Dam	Dodson North Dodson South Nelson South
	Dodson	Dodson Diversion Dam	Dodson North
Glasgow	Glasgow	Vandalia Diversion Dam	Vandalia



Paradise Valley Irrigation District Diversion Dam
Harlem Irrigation District Pump Station

Authorized for irrigation, the project irrigates about 121,000 acres in the Milk River Basin. Principal crops are alfalfa, hay, oats, wheat, and barley. Many people depend on the project for a municipal, rural, or industrial (MR&I) supply. The project supplies towns along the river like Havre, Chinook, and Harlem with MR&I water. The Ft. Belknap Reservation receives water from Fresno Reservoir storage of Milk River natural flows.

Basin Planning Considerations

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

Boundary Waters Treaty

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 1921 Order and subsequent Letter of Intent Current administration of the Treaty and the available infrastructure result in the United States 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 Providence of Alberta have been meeting to explore potential options for both nations to better utilize their respective shares of the two rivers. The parties were still negotiating at the time of this report.

Canada's share of the St. Mary River at the International Boundary, as stipulated by the 1921 Order, is three-fourth s of the natural flow when the flow is 666 cubic feet per second or less during the April 1 to October 31 irrigation season. Flow in excess of that quantity is divided equally between Canada and the United States. The flow is divided equally between the two countries during the non-irrigation season of 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 percentage. The United State's share of the Milk River at the Eastern Crossing of the International Boundary, as stipulated by the 1921 Order, is three-fourth s of the natural flow when the flow is 666 cubic feet per second or less during the April 1 to October 31 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 of November 1-March 31.

To comply with the 1921 Order, representatives of both countries make twice-monthly computation 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” and serve to provide an opportunity of each country to respond to varying use and flow conditions. For example, if use by the United States is in excess of its share during a division period, then a surplus delivered of an equivalent quantity of water is normally made to Canada at the earliest opportunity (Goos and Ethridge, 2008).

Endangered Species Act - Bull Trout

The U. S. Fish and Wildlife Service (USFWS) listed bull trout in the St. Mary River drainage as threatened under the Endangered Species Act (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. The river system model developed under this study will allow Reclamation to evaluate operation and facilities modifications to comply with the ESA as it relates to bull trout and quantify impacts on water deliveries.

Bull Trout

Reserved Water Rights

A 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 2001. The compact entitles the Tribes to divert up to 645 cfs from the natural flow of the Milk River. In the historic 1908 *Winters v. United States*, the U.S. Supreme Court ruled that when Congress reserves land, sufficient water is also reserved to fulfill the purpose of the reservation. 125 cfs was reserved to the Fort Belknap Indian Reservation, which established the reserved water rights doctrine.

The Blackfeet Tribe of the Blackfeet Indian Reservation and the State of Montana negotiated a reserved water rights compact that was approved by the Montana State Legislature in and recommended for further action by the Blackfeet Tribal Business Council in 2009. The compact allocates 50,000 acre-feet of surface water and all groundwater in the St. Mary River Basin to the Blackfeet Tribe. The Blackfeet Tribe also has reserved rights to all natural and groundwater in the Milk River Basin arising on the Reservation subject to the Boundary Waters Treaty and state based water rights.

More detail on the reserved water rights is included in Chapter 2.

Montana Water Rights Adjudication—St. Mary and Milk Rivers

In 1973, the State of Montana began a state-wide adjudication of all water rights claims that exist prior to July 1, 1973. This includes 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 or Milk River basins. The DNRC is required to complete all examinations by July 30, 2015.

Rehabilitation of St. Mary Canal

Reclamation began construction of the St. Mary Storage and Conveyance structures in 1906 and started diverting water from the St. Mary River to the Milk River Project in 1915. Diverted St. Mary water supplements the Milk River flows to irrigate approximately 140,000 acres in the Milk River Valley, provides water supplies to cities and water districts and the Bowdoin National Wildlife Refuge. The St. Mary facilities include Sherburne Dam, Swiftcurrent Dike, St. Mary Diversion Dam and Intake, and St. Mary Canal. The St. Mary Canal was designed to divert up to 850 cfs. Since construction was completed, only routine maintenance and extraordinary repairs have been performed. The St. Mary Diversion Dam, Intake and Canal have deteriorated severely and are at risk of catastrophic failure. Reclamation and the irrigation districts perform replacement and extra ordinary maintenance on the St. Mary facilities contingent upon funding availability. The actual diversion capacity of the St. Mary Canal has been reduced to approximately 650 cfs as a result of slides and slumping of canal banks.

St. Mary Diversion Dam

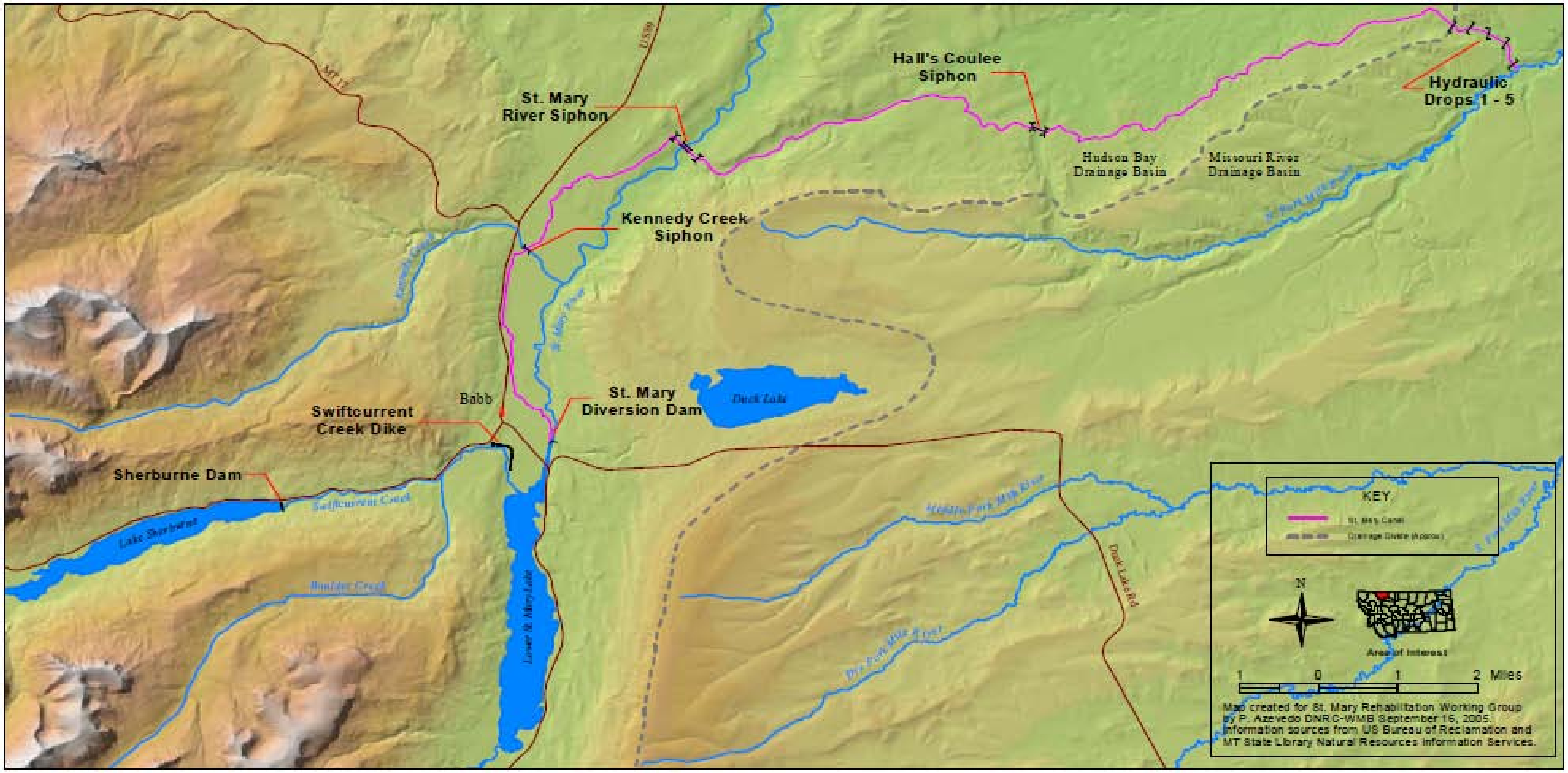
Sedimentation of Fresno Dam

Fine grained sediments are transported downstream to Fresno Reservoir where they settle and reduce the storage capacity of the reservoir. As of May 1999, Reclamation estimates that the reservoir has lost 36,200 acre-feet of storage capacity since 1939 as a result of sedimentation. Similar rates of sedimentation are expected to occur 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 impact Tribal resources by diverting water into Lower St. Mary Lake. Reclamation and the Blackfeet Tribe formed a working group in 2009 to investigate and evaluate alternatives to address concerns.

St. Mary Lake



Hall's Coulee Siphon
Hydraulic Drops 1 - 5
St. Mary River Siphon
Hudson Bay Drainage Basin
Missouri River Drainage Basin
Kennedy Creek Siphon
Duck Lake
St. Mary Diversion Dam
Babb
Swiftcurrent Creek Dike
Sherburne Dam
Lake Sherburne
Swiftcurrent Creek
Boulder Creek
Lower St. Mary Lake
Middle Fork Milk River
Dry Fork Milk River
Duck Lake Rd
KEY
N
Area of Interest
1 0 1 2 Miles
Map created for St. Mary Rehabilitation Working Group
by P. Azevedo DNRC-WMB September 16, 2005.
Information sources from US Bureau of Reclamation and
MT State Library Natural Resources Information Services.

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

Chapter 2 details the present water supplies and demands of northern Montana and supplies and demands estimated for 2050.

Present Water Supplies

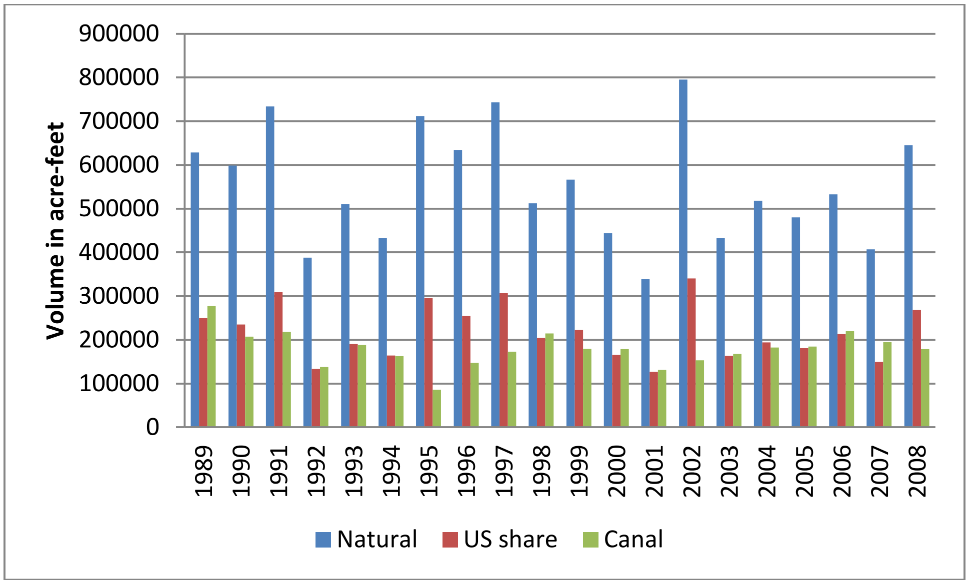
Water supplies for the region come from the St. Mary and the Milk rivers. The St. Mary River is a predictable, reliable water supply, typical of headwater, mountain streams. The Milk River is unpredictable and less reliable from year-to-year, which is typical of plains streams in the region.

St. Mary River

The St. Mary River originates along the Continental Divide in Glacier National Park, with runoff typical of mountain streams with snowmelt and baseflow. The St. Mary River is in the Hudson Bay drainage, flowing north into Canada. The streamflow is divided between Canada and the U. S. The International Joint Commission (IJC) has determined the median (middle year in a high to low sequence) natural flow at the Canadian-United States Boundary for the April through October irrigation season during 1959-2008 to be about 549,000 AF, (Goos and Ethridge, 2008)

The U.S. share of streamflow is controlled by Sherburne Dam on Swiftcurrent Creek which contributes about 25 percent of the flow of the St. Mary River and diverted into the St. Mary Canal. 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. The U.S. has been unable to use the remaining 38,500 AF due to canal capacity, available storage, and apportionment procedure constraints. During dry years, these constraints are not so limiting and the U.S. is able to divert nearly its entire share. 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, canal diversions can exceed the U.S. share when Lake Sherburne water is carried over from the previous water accounting years.

Figure 2.1: April through October Natural Flow of the St. Mary River at the International Boundary, the U.S. share, and St. Mary Canal Diversions Compared



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 system to maximize and capture the U.S. share.

Milk River

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

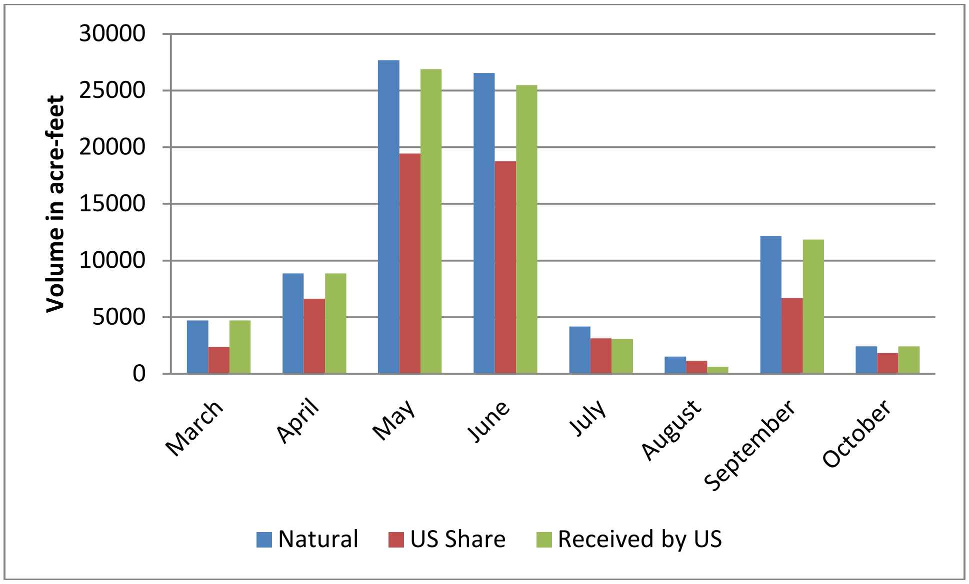
- Milk River upstream of Fresno Reservoir
- Tributaries entering the Milk River from the north
- Tributaries entering the Milk River from the south.

The streamflow of the Milk River at the Eastern Crossing of the International Boundary (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 at the Canadian-U.S. Boundary 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 amount of Canada's share that flows into the U.S. is about 20,000. Therefore, the total amount of Milk River flow typically available for use in the U.S. is about 83,900 AF. 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 U.S. share is stored and regulated at Fresno Reservoir.


Milk River at Eastern Crossing of International Boundary

Because Canada doesn't have storage facilities on the Milk River; Canadian's aren't able to use their entire share of the Milk River natural flow. Present Canadian water use is primarily for irrigation of about 8,000 acres of mostly sprinkler irrigation Figure 2.2 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 normal 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 2.2: 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 of the International Boundary and coordinates these forecasts with the National Weather Service and counterparts in Alberta. These forecasts, though helpful, are not as reliable as those in the St. Mary River Basin, which can use mountain snowpack data sets with strong correlations to historic streamflow records.

Three major tributaries, also known as the "Northern tributaries," begin in Canada and flow south to join the Milk River: Lodge Creek, Battle Creek, and Frenchman 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 the Frenchman River 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, typically, flow that crosses the International Boundary exceeds the U.S. share on an annual basis.

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, very little flow reaches the Milk River. Runoff in the tributaries that occurs downsteam of the boundary gauging stations and flow from other ungauged tributaries have not been quantified; thus, there are no dependable volume forecasts, either.

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. The footnote to Table 2.1 lists the period of record and median annual or seasonal streamflow for these streams.
Based on gauging records, the 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 inflows from smaller, ungauged southern tributaries; thus, no dependable volume forecasts exist.

In summary, the median historic water supply above Fresno Reservoir from the St. Mary River and the Milk River 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 of 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 (or about 38,870 AF) can be taken though Dodson South Canal to Nelson Reservoir.


Dodson South Canal Headworks

The water supply from the tributaries 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 the Frenchman River and Beaver Creek near Hinsdale, about 79,400 AF, occurs low in the basin and 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. The Frenchman River and Beaver Creek are not presently considered water supplies that users can count on. The total median annual water supply 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 flows for the major Milk River tributaries and the volumes of flow that might typically be available for direct diversion use or storage.

Table 2.1: Median Annual or Seasonal Water Supply for Selected Locations in the Milk River Basin, in 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
Sub-total	262,400		262,400
Tributaries from the North			
Lodge Creek	7,150		7,150
Battle Creek	9,450		9,450
Frenchman River	32,700	32,700	------
Sub-total	49,300	32,700	16,600
Tributaries from the South			
Big Sandy Creek nr Havre [1]	4,470		4,470
Clear Creek nr Chinook [2]	3,850		3,850
Peoples Creek nr Dodson [3]	13,950		13,950
Beaver Creek nr Hinsdale [4]	46,700	46,700	--------
Sub-total	68,970	46,700	22,270
Total	380,670	79,400	301,270

[1] USGS station 06139500, period of record of 1984-2010, April thru September.
[2] USGS station 06142400, period of record of 1985- 2010, April thru September.
[3] USGS station 06154500, period of record of 1952-73 and 1982-87, January thru December.
[4] USGS station 06167500, period of record of 2006-2010, March thru October.

A considerable volume of water leaves the Milk River Basin, especially during high flow years. Much of this water, which is natural flow that arises in the basin, can't be captured with existing facilities. The Milk River at Nashua gauging station is located near the mouth of the Milk River downstream of almost all of the irrigation diversion in the Milk River Project. The median annual flow here 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 can't be captured with existing facilities, some of the flows might be made available through infrastructure and water management improvements.

Future Water Supplies

Water supplies for the region are expected to change in the future due to increased demands and climate change. Warming has been experienced over much of the U.S. during the 20th century according to the U.S. Global Change Research Program in 2009. The *Intergovernmental Panel on Climate Change* in 2007 concluded that general warming of the global climate observed in the 20th century was likely to continue in the 21st century. In response, global and continental climate simulation models have been developed and applied to reproduce temperature trends during the 20th century. Success in these efforts have built confidence in using these models in combination with developing statistical methods using historical data to project future climate conditions.

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*. One of the eight basins examined was the Missouri River Basin, of which the Milk River region is a part. The report indicated that the median temperature is projected to increase by about 5 degrees F. and mean 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 Basin Study Team decided to place the focus of this report on the period centered on 2050, which better corresponded 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 *Climate Change Analysis for the St. Mary and Milk River Systems in Montana* [U.S. Bureau of Reclamation, 2010]). In the Period Change method, Reclamation started with future climate data sets produced by 112 global climate circulation models that predict future changes in temperature and precipitation assuming various rates of greenhouse gas emissions into the future. A problem with the results from these global-scale models is that the output data are too coarse spatial scale for use in basin studies. Statistical downscaling was used to translate the global-scale output data from the climate models to the finer scale climate differences that is more meaningful at the level of a basin study.

A consensus message of all of these projections was that temperatures in the St. Mary River-Milk River basins are likely to follow a warming trend into the future. However, the rate of warming projected varies among the different climate projections models. Projections for precipitation ranged from drier to wetter, but the majority of the predications were for overall wetter conditions in the basins, with increasing year-to-year variability. Figure 2.3 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 to analyze manageable, Reclamation grouped the climate-change scenarios into four quadrants. Median temperature and precipitation changes were used to define these four groupings as depicted in Figure 2.4. The four climate change scenarios represent the range of projected changes from less to more warming, paired with drier to wetter conditions. A fifth scenario also was defined to represent the central tendency of the projected changes. These climate change scenarios will be referred to in this report as *S1* through *S5*, and are further defined in Table 2.2.

Figure 2.3: Average Annual Climate Temperature and Precipitation Projections for the Region

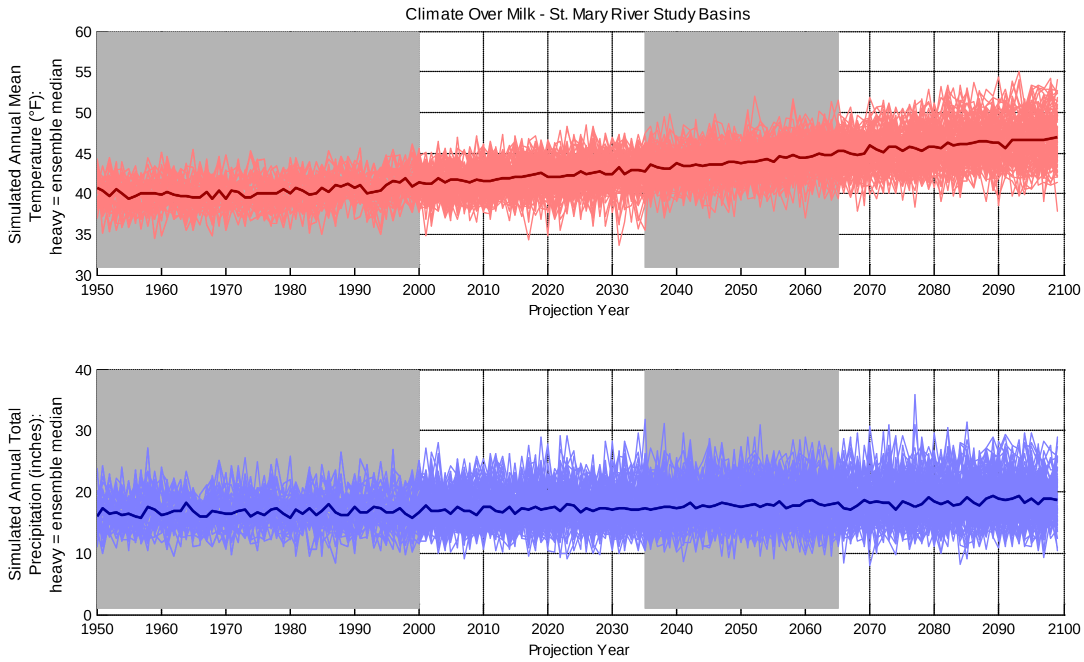


Figure 2.4: Climate Change Scenarios, Showing Mean Annual Temperature and Precipitation in the Region

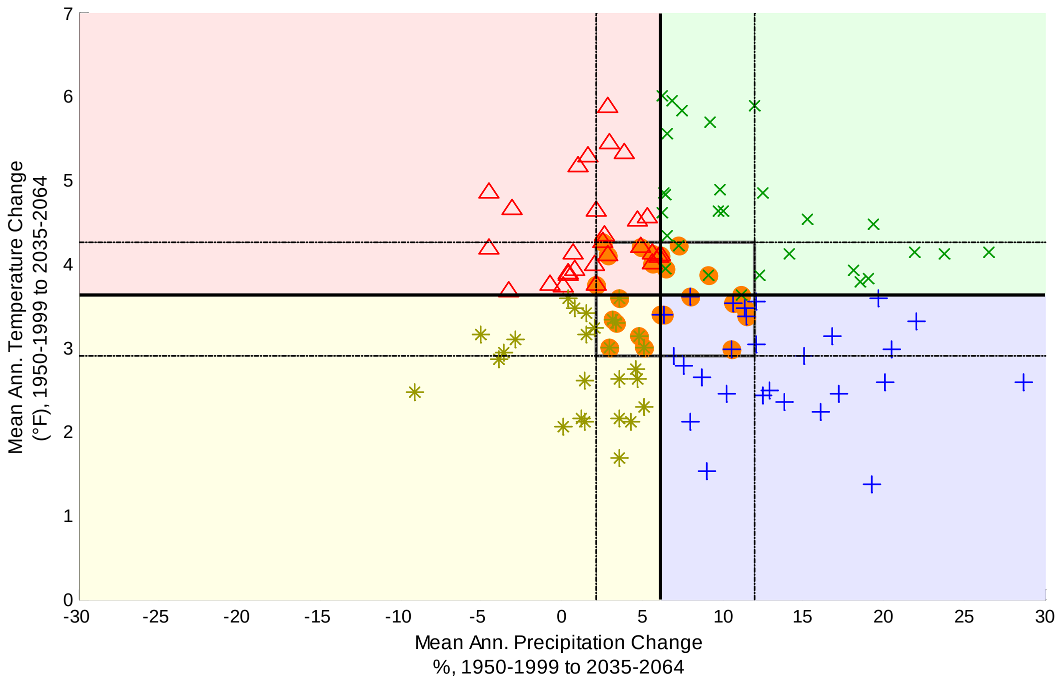


Table 2.2 Climate Change Scenarios

Climate Change Scenario Number	Climate Change Scenario Description	Climate Change Scenario Number from Climate Change August 2010 Report
S0	Historic Climate Baseline	Scenario not in Report
S1	Less Warming and Dryer Conditions	q4
S2	Less Warming and Wetter Conditions	q2
S3	More Warming and Dryer Conditions	q3
S4	More Warming and Wetter Conditions	q1
S5	Central Tendency	q5

Once the projections corresponding to each of the five climate scenarios were identified, the Period Change *HDe* (Hybrid Delta) method was used to generate weather forcings on the *SAC-SMA/SNOW-17* hydrology model. The *HDe* method reflects change in the monthly distribution of temperature and precipitation over the region, sampled from an ensemble of climate projections corresponding to each of the climate change scenarios shown in Table 2.2.

A surface water hydrology model was used to translate temperature and precipitation to streamflow at the selected locations in the region. The hydrologic simulation was run using a calibrated version of the National Weather Service River Forecasting Center's *SAC-SMA/SNOW-17* model of the St. Mary and Milk River basins. The SAC-SMA (Sacramento Soil Moisture Accounting) and SNOW-17 (Snow Accumulation and Ablation) applications use precipitation and temperature on a six 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. The SAC-SMA and SNOW-17 work together to generate temperature and precipitation.

The projected climate change for the two look ahead periods centered on 2030 and 2050 were based on hydrologic and meteorological patterns for the 1950-1999 base period with climate change superimposed. The 2030 period consisted of the years 2015-2044 and the 2050 period included the years 2035-2064. Projected streamflow for those years was based on weather patterns for the 1950-1999 period with climate change superimposed.

The streamflows generated from the calibrated surface water runoff hydrology model using temperature and precipitation of the base period 1950-1999 didn't 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 present climate streamflows and the historical flows used in the river system model. The adjustment method is described in *Milk-St. Mary River System Basin Study, Technical Service Center Support* (U.S. Bureau of Reclamation, 2011b).

Information on change in streamflow in the basin was projected for two future look-ahead periods centered on 2030 and 2050, but, to repeat, only the 2050 climate model results are presented in this report. The year 2050 is used because this time better correlates with Reclamation's planning study time frames. 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 below.

Table 2.3: Change in Median Annual Streamflow for Selected Locations in the Basins, Climate Change Scenarios for 2050

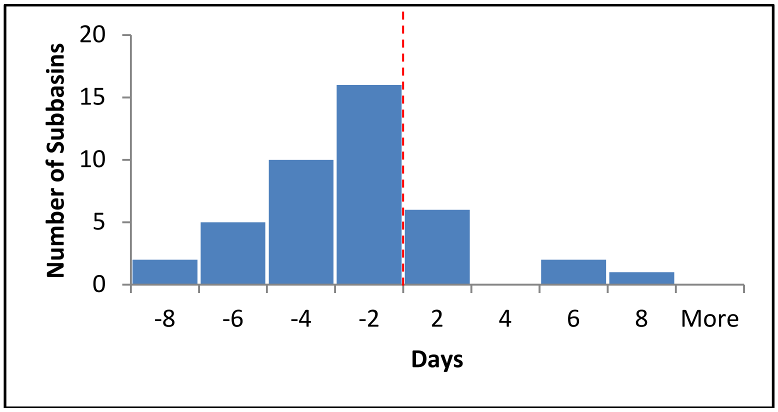
Climate Change Scenarios	St. Mary River at the International Boundary	Milk River at the Eastern Crossing of International Boundary	Milk River near Harlem	Milk River at the Mouth
	Change from Observed Data, in AF			
S1	-19,000	-21,000	-22,000	-67,000
S2	59,000	2,000	49,000	166,000
S3	-18,000	-28,000	-32,000	-64,000
S4	63,000	-11,000	25,000	105,000
S5	3,700	-17,000	-8,000	15,000

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 *S1* and *S3*. Median annual streamflow would increase in 2050 in the St. Mary River at the International Boundary and in the Milk River at the Eastern Crossing, near Harlem, and at the mouth for *S2* and *S4*. Median annual streamflow for 2050 is projected to increase slightly in the St. Mary River at the International Boundary for the central tendency climate change scenario (*S5*), with decreases in the Milk River at the Eastern Crossing and near Harlem. Streamflow would increase at the mouth.

Streamflow for the region is projected to increase for the central tendency climate change scenario for 2050. The median streamflow of the St. Mary River at the International Boundary is expected to increase 3,700 AF and the median streamflow of the Milk River at the mouth is expected to increase 15,000 AF, for a total increase of 18,700 AF. The exception is the upper areas of the Milk River Basin which are expected to have less runoff locally.

Overall, earlier runoff in the St. Mary and Milk River basins is projected. The earlier shift in runoff timing is more predominant in warmer scenarios; especially for snowmelt dominated runoff. The surface water hydrology model used for the climate change projections of streamflow for 42 subbasins that comprise the St. Mary River and Milk River basins. Figure 2.5 shows the change in runoff timing for these subbasins.

Figure 2.5: Shift in Timing (Days) of Annual Runoff Volumes for 42 Subbasins for the 2050 Central Tendency Climate Projection

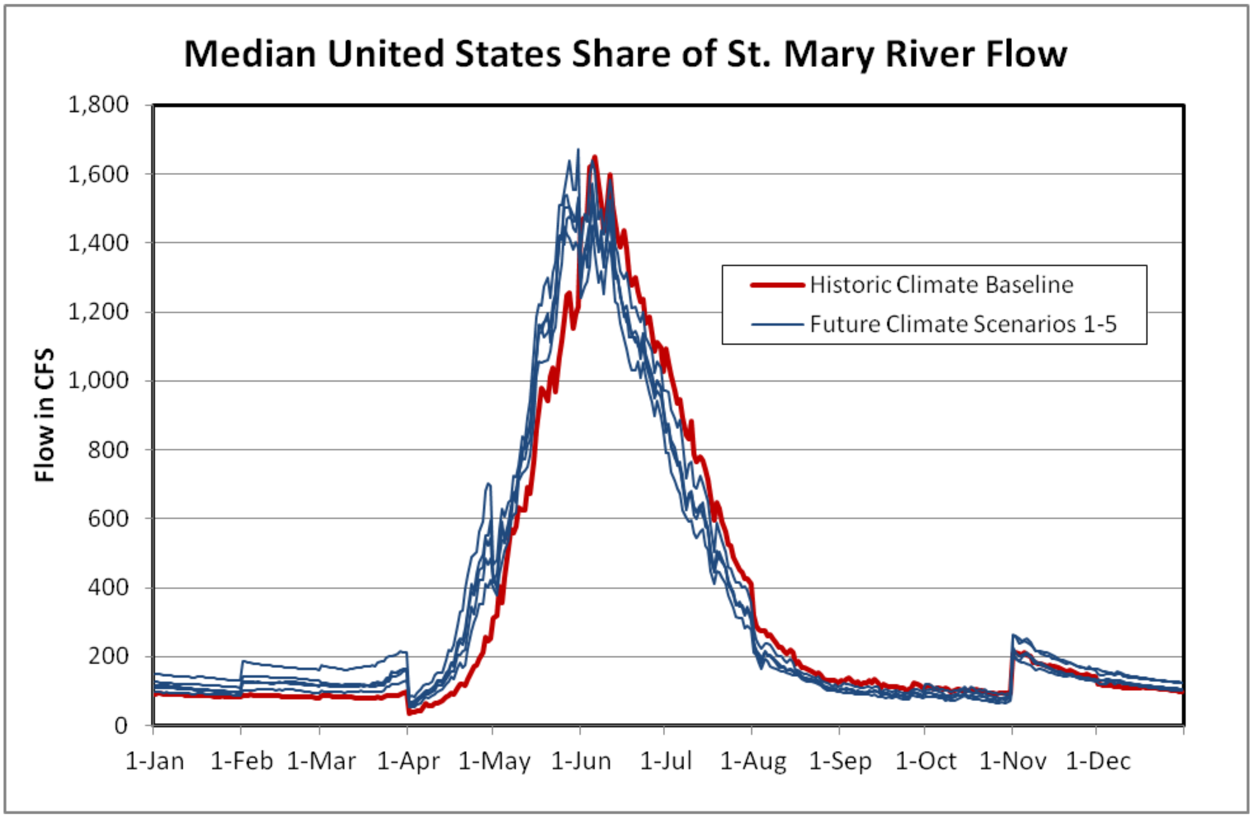


Note: Negative day values represent earlier runoff.

Nine of the subbasins are projected to have the centroid of the annual runoff volume shifted later and 33 of the subbasins are projected to be shifted earlier. Over half of the subbasins are projected to have the centroid of the annual volume shifted earlier by up to four days. The streams in the St. Mary River watershed are all predicted to have annual volume centroid shifts of 7-9 days earlier.

Figure 2.6 compares the median St. Mary River flow that would be available to the U.S. under historic conditions and future climate *Scenarios S1-5*. Overall, the future volume available to the U.S. might be similar to the past but with a 7-9 day 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, which allow the U.S. a greater percentage of St. Mary River flow (50 percent of the natural flow) during November-March.

Figure 2.6: Median Modeled U.S. Share of the St. Mary River under Historic Climate Baseline and Future Climate Conditions



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 US-Canadian Border. Manifolding 2-4 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 specifically been studied in the St. Mary or Milk River basins. 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 bedrock aquifers such as the Judith River and Eagle formations. Therefore, effects of climate change on precipitation and/or surface water runoff might affect recharge to and/or 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 evapotranspiration. Less precipitation and possibly less 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 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 generated by 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, in inches, for Fresno Reservoir for various climate change scenarios (U.S. Bureau of 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 three 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 Evaporation for Fresno Reservoir under Historic Baseline and Climate Change *Scenarios S1-5*

Climate Change Scenario Number	Net Reservoir Evaporation Inches Per Year
S0	22.0
S1	24.0
S2	22.2
S3	25.1
S4	23.6
S5	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 water demands for recreation and fish and wildlife purposes associated with the Milk River Project, but these are generally 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 diverting from tributaries of the Milk River main stem
- Non-project water users diverting from the main stem Milk River
- Tribal water users
- Milk River Project irrigation districts
- Milk River Project contract water users.

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 River Reservoir.

For lands irrigated from the Milk River main stem, the study team reviewed mapping of irrigated lands previously completed by the DNRC. The mapping indicated that there are 140,200 acres of land irrigated from the Milk River downstream of the Eastern Crossing. The Ft. Belknap Tribal water users on the reservation 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 10,400 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 aren't authorized may have private, state based water rights, which are presently being adjudicated by the Montana Water Court.

Table 2.5: Milk River Basin Irrigated Acres

	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 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.

The net irrigation requirement for the crop distribution grown in the Milk River Basin downstream of 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 is about 630,000 AF (U.S. Bureau of Reclamation, 2011b). The system would not need to produce the entire 630,000 AF diversion requirement 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

	Present Use (AF)		**Contract Amount (AF)**	
Community	Average	Max since 2001		**Contract Expiration Date**
Havre	1825	2040	2800	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	2600	---	4600	---

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 the communities are presently using considerably less than the contracted volume. Municipal use represents approximately one percent of total Milk River diversions.

Other Water Demands

Fish, Wildlife, and Recreation

The St. Mary River, Milk River, and associated storage reservoirs Sherburne, Fresno, and Nelson 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.

The Montana Department of Fish, Wildlife and Parks established guidelines in 1998 for reservoir and river operations for fish, wildlife, and recreation. Recommendations for Fresno include maintaining a conservation pool above elevation 2560 feet to provide maximum benefit to the fishery and recreation, and a minimum pool of elevation 2551 feet. Recommendations for Nelson Reservoir include maintaining conservation pool above elevation 2215 feet to provide maximum benefit to fishery and recreation, and a minimum pool of elevation 2210 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 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. Project water is diverted by Dodson Diversion Dam to the Refuge from the Dodson South Canal. The refuge can receive up to 3,500 AF annually of project water. The refuge also receives return flow from the Malta Irrigation District.

Bowdoin National Wildlife Refuge

Water Quality

Havre, Chinook, and Harlem all have wastewater discharge permits from the Montana Department of Environment Quality. 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 suitable water quality which can be diverted from the Milk River. Because the outlet works would be damaged by cavatation at lower flows, the flow from Fresno during the non-irrigation season cannot be reduced below approximately 45 cfs.

Threatened and Endangered Species

There are five species on the Federal *Threatened and Endangered Species* list that are found in the St. Mary River–Milk River region: bull trout, piping plover, grizzly bear, pallid sturgeon, and interior least tern. Currently, water is not managed in the area for pallid sturgeon, grizzly bear or interior least tern.

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 St. Mary Diversion Dam and Canal facilities that provide fish passage and to prevent canal entrainment. The USFWS and the Blackfeet Tribe also identify 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 allows the reservoir to avoid designation as critical habitat. 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 minimize nest inundation.

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

Montana Species of Special Concern

Sauger, pearl dace, paddlefish, and blue suckers are identified on the Montana *Species of Special Concern* list. Species of special concern have been found in the Milk River near the Canadian border to the confluence with the Missouri River. Currently, water is not managed in the area for these species

Future Water Demands

Climate Change

Climate change trends in the St. Mary River and Milk River basins indicate increased temperature and precipitation, although some scenarios show modest precipitation decreases. The increase in temperature would result in increased water demands, especially for irrigation.

Agricultural Water Demands

Climate change modeling done as part of this Basin Study included estimates of net irrigation requirements for the period centered on year 2050. Table 2.7 lists the annual net irrigation requirement for four locations across the Milk River Basin for the historic climate condition and several climate change projections.

The net irrigation requirement for the year 2050 climate projection is about four and one-half 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 in 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 less warming and wetter conditions results in the smallest increase in net irrigation requirement, but even this climate projection indicates an increase in net irrigation requirement of about two inches. The 2050 climate projection for more warming and dryer conditions results in the greatest increase in net irrigation requirement, with an increase of about 6 inches more than the current crop requirements.

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

Climate Condition	Milk River Headwaters Area	Chinook Area	Malta Area	Glasgow Area
S0	16.0	18.3	19.1	19.8
		Year 2050 Climate		
S5	20.6	22.8	23.5	24.5
S2	18.5	20.6	21.1	21.8
S3	22.5	24.5	25.3	26.2

Irrigation depletion requirements for 140,180 acres along the Milk River main stem are projected to increase by 51,000 AF above present conditions. The 2050 central tendency climate projection indicates an annual depletion requirement of 266,000 AF. This estimate assumes that the basin's crop distribution will not change from present conditions. If efficiencies remain the same as today, this translates into an increased annual diversion requirement of 170,000 AF.

The projected increase in net irrigation requirement for the year 2050 of about 4.5 inches suggests that there could be an increase in crop production if this 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 (*Personal*

Communication, Dr. Jim Bauder, Montana State University Extension Service, 2002). Bauder indicates that on average about 0.19 tons of alfalfa is produced with each applied inch of water. Thus, alfalfa production would increase by about 0.85 tons of alfalfa per acre, if only the 4.5 inches of extra water were always available.

Municipal Water Demands

Construction of the Rocky Boy/North Central Montana Rural Water System might reduce the contracted volume of municipal water used from the Milk River. Havre, Hill County Water District, and North Havre Water District are all within the project boundary and have signed letters of intent to be served by the project. At the current funding levels, completion of the project is more than 50 years away. Once each of these areas starts to receive water, Hill County Water District and North Havre Water District would significantly reduce or possibly eliminate their contract for water from the Milk River. Havre might keep the water contract in place and use the treated water to serve areas on the eastern side of the project boundary. Because of these factors the future water uses of these cities are expected to remain within the current contracted amount.

Other Water Demands

Fish, Wildlife, and Recreation
With warming temperatures and higher evaporation rates in the future, lower overall water levels at the Bowdoin National Wildlife Refuge could be a concern.

Water Quality
Water demand and minimum releases from Fresno Reservoir are not anticipated from present releases.

Threatened and Endangered Species
Bull trout flow requirements might be quantified in the future. Current water operations to benefit the piping plover are expected to continue into the future. Pallid sturgeon flow requirements might be quantified in the future.

Montana Species of Special Concern
Water requirements for these species might be quantified in the future.

Future Canadian Use from the Milk River

On average, the U.S. receives about 36,000 AF per year of Canada's share 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. The evaluation of a reservoir storage alternative is detailed in Chapter 5.

Northern tributaries to the Milk River also arise in Canada, primarily in Saskatchewan. The largest and most important to Saskatchewan for irrigation are Lodge Creek, Battle Creek, and the

Frenchman River. 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 Ft. 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 Ft. 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 where 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, was ratified by the Montana Legislature and signed by the governor, all 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 of the developments related to the compact have already been implemented. The water right priority date of this reserved right is September 7, 1916. This priority is junior in priority to many uses on the main stem Milk River and junior to the downstream federally reserved rights of the Ft. Belknap Reservation.

The Ft. Belknap Indian Community of the Ft. Belknap Indian Reservation and the State of Montana reached a compact agreement in 2001. This compact has not been ratified by Congress. The compact recognized the original 125 cfs provided in the Winters reserved right from the Milk River for use on the existing Ft. Belknap Indian Irrigation Project. In addition, the Fort Belknap Indian Reservation received 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 reserved water right is 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 acknowledges that the St. Mary diversion facilities must continue to be viable for the Tribes to exercise its 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.

Fort Belknap Indian Irrigation Project Diversion Dam

In addition to the main stem Milk River water right, the Ft. 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 has a right to use up to 8,024 AF per year from Beaver Creek, which flows into the Milk River near Hinsdale.

The Blackfeet Tribe and the State of Montana entered into a compact agreement in 2009. This compact has not been ratified by Congress. The reservation is located in the headwaters of the St. Mary and Milk rivers; therefore, the Tribe has federally reserved water rights in both the St. Mary and Milk River basins. For the St. Mary River, the Tribe has a right to use 50,000 AF per year from the river, other than Lee Creek and Willow Creek, 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 reserved water right is October 17, 1855, the same priority as the Ft. Belknap Indian Community water rights.

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 shall defer new development of the Milk River water for a period of 10 years after the effective date of the compact for irrigation uses not relying on stored water.

Basin Water Use 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 Endangered Species Act and Clean Water Act in response to shifts in social values. If the past is any indicator of the future, unforeseen new uses, increased resource protection, and socioeconomic changes are likely to continue. Below are some areas that look beyond familiar and customary uses and existing water management practices.

Irrigation

In order for the irrigation 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 DNRC-issued basin closure, implementation of compacts, and the existing Reclamation water contracts are formal sideboards that limit the likelihood of new, non-Tribal irrigation development. 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.

Industry

Due to the intensive-use nature of irrigation, chronic water shortages are frequently incurred. However, the Milk River Project facilities generally ensure reliable flows in the Milk River. Reliable supplemental water, storage facilities, and flood control are attractive features that could draw other water-intensive industry into the area.

Energy

Extractive energy development is taking place in the basin, but has 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 unfeasible to exploit, which 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.

Environmental

Enforcement of water quality standards is likely to become more stringent in the future. Achieving *Total Maximum Daily Loads* (TMDLs) may 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 water management in the basins in the future.

Water Exports

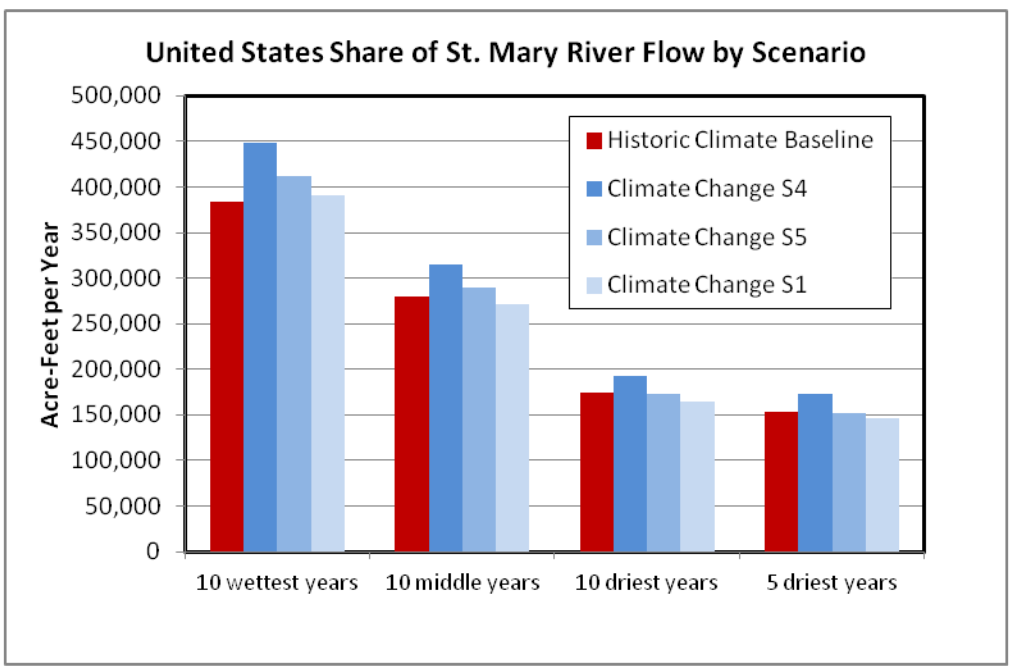
During drought, the value of a trans-basin water supply becomes apparent. Water-short basins have often evaluated the feasibility of transferring water from basins of abundance and reliability to supplement their water supplies, such as the transfer of water from the St. Mary River to the Milk River. If future water shortages in some regions became chronic, construction of a “water grid” could be considered as a means to manage the State’s water more effectively.

Summary of Present and Future Water Supplies and Demands

The present average St. Mary and Milk rivers' 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 has not been quantified and is highly variable from year-to-year. The central tendency climate change scenario projects that runoff would increase by 18,700 AF annually above the 1950-1999 base period. Another consideration is that most of the future climate scenarios are predicting an increase in the variability of the water supply.

The U.S. share of St. Mary River flow in the future might be relatively similar to what it is today, with some increases in variability between wetter and drier years (Figure 2.7). 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 shares in the future as during the past, although the timing of those diversions is expected to shift towards the early portions of the season. Table 4.4 in Chapter 4 summarizes modeled St. Mary Canal diversions under future climate *Scenario S5*—the central tendency scenario. During average and median years, future climate diversions were modeled to be about the same as under the historic climate. Modeled future *S5* diversions were somewhat higher than historic conditions for wetter years and lower for drier years, reflecting the increased year-to-year variability anticipated under the future climate scenarios.

Figure 2.7: U.S. Share of St. Mary Flow under Historic Climate Baseline and Future Climate Scenarios



The theoretical total annual irrigation depletion for land presently irrigated from the Milk River, if water were always available to meet all crop requirements, would be about 210,000 AF. The theoretical irrigation depletion is expected to increase to 266,000 AF by 2050. This represents an increase of 56,000 AF annually from the current irrigation depletion.

Previous studies have indicated that significant irrigation shortages already occur in the basin. Increases in runoff by 2050, if it can all be captured and used, is expected to only make up for between 33-37 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 2.9 presents a summary of present and future demands by water use.

Table 2.9: Summary of Present and Future Demands

Beneficial Use	Water Body	Management Objective	Present Demand	Consumptive	Future Demand (2050 Look-Ahead Period)	Impact
Irrigation	Milk River	140180 ac	210000 af	Yes	266000 af	Increased crop prod but less return flows
Municipal	Milk River	Havre, Chinook & Harlem	2600 af	Yes	Possible Reduction	Negligible improvement to flows
Water Quality	Milk River	Mixing	25 cfs (45 cfs is released	No	If facilities are modified, may be reduce to 25 cfs	Less stream flow, more reservoir winter carryover
Fisheries & Recreation	Fresno Reservoir	Preferred/ Minimum Pool	Pool Target Elev. 2560/min 2551 ft; gradual drawdown after Mid-May for walleye & Perch Hatch	No	Storage reduction due to sedimentation and increased evaporation	Less water available for releases as sedimentation continues to reduce reservoir storage capacity
	Nelson Reservoir	Preferred/ Minimum Pool	Pool Target Elev. 2215/min 2210 ft; gradual drawdown after Mid-May for walleye & Perch Hatch	No	No changes anticipated	Irrigation constraints in dry years
	Milk River	Minimum Flows	No minimum flow identified	No	No changes anticipated	Water not available for other uses
	St. Mary River	Minimum Flows	No minimum flow identified (Canadian Apportionment ensures flows)	No	No changes anticipated	No impact
Wildlife	Bowdoin NWR Lakes	Migratory Birds	3500 AF Milk, 5000 AF irrigation return flows, Beaver Creek Floods, 14-16KAF needed	Yes	Increased	Possible reduction in habitat
Endangered Species Act	St. Mary River	Bull Trout (Threatened)	Canal Entrainment, Fish Passage and lack of winter flows on Swiftcurrent Cr are identified as affecting bull trout, but currently not managed for this Species	No	Possible winter flow release from Sherburne Reservoir into Swiftcurrent Cr. Diversion Facility Modifications to address entrainment and passage, which should have little or no impact on water availability	Less winter carryover in Sherburne Reservoir
	Nelson Reservoir	Piping Plover (Endangered)	Stop filling Nelson Reservoir by May 15 to prevent nest inundation	No	No changes anticipated	No Impact
	St. Mary and Milk Rivers	Pallid Sturgeon, Grizzly Bear & Least Tern (Endangered)	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	Water not available for other uses
Montana Species of Special Concern	Milk River	Sauger, Pearl Dace, Paddlefish and blue sucker	Water currently not managed for these species	No	Possible instream flow	Water not available for other uses

Chapter 3: The River System Model

One of the main purposes of this Basin Study 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 of the basin have relied on revising older models or constructing new models to address specific goals. These older generation models no longer have the robustness or resolution to evaluate complex river system issues faced by water managers, planners, decision makers or users. Additionally, previous models have been constructed on a monthly time step which does not always provide information to capture operations that are changed more frequently and even daily to meet apportionment requirements, irrigation demands, and other goals. The new model also incorporates operations of the system, and irrigation diversion data for more recent years.

Knowledge gained from previous models developed for the basin was used in development of 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 International Joint Commission 1921 Order. The apportionment procedure also includes the Letter of Intent allowing temporary deficit deliveries

- Accounting routines to track the amount of water in two storage accounts in Fresno Reservoir, and

- Performs calculations on a daily time step

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

The model with this new capability will allow Montana and the U.S. to better; evaluate water developments that might be proposed on implementation of the reserved water rights compacts of Blackfeet Tribe and Ft. Belknap Indian Community; evaluate alternatives for replacement and rehabilitation of aging water infrastructure; evaluate proposed water apportionment/sharing alternatives being considered by the Montana and Alberta St. Mary and Milk River Water Management Initiative, and the effects of climate change on water supply and demands.

The Model

RiverWare ™, a newer generalized river basin modeling tool, was selected as the model software for this study. RiverWare™ was developed by CADSWES of Boulder, Colorado, with substantial support from Reclamation. The software provides a construction kit for developing and running detailed, site-specific models without the need to develop or maintain the supporting software within a water management agency. It includes an extensible library of modeling algorithms, several solvers, and a language for the expression of operating policy. Its point-and-click graphical interface facilitates model construction and execution, and presentation quality outputs formats for communicating output results. Models have been developed with RiverWare™ by both federal and state agencies across the west to resolve a wide range of operational and planning problems.

The St. Mary-Milk river 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 simulated St. Mary Canal. 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 Tribes using the reservoirs and irrigation canals on the Milk River.

The operations of major Milk River Project facilities were modeled for this study. These facilities include:

- Sherburne, Fresno, and Nelson Reservoirs
- St. Mary Canal
- Dodson South Canal system, including the Bowdoin National Wildlife Refuge, and
- Major canals and pumping stations for the other Milk River irrigation districts.

Dodson Diversion Dam

Reservoir attributes, such as available storage, surface areas, outlet and spillway capacities, and target elevations, were obtained from Reclamation. Canal capacities and other canal operational constraints were obtained from Reclamation or the irrigation districts.

The basic operations of the St. Mary River-Milk River system were modeled using guidelines set forth in the *Reservoir and River Operation Guidelines for 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 modeling of the system for Reclamation's 2004 report also were used extensively in developing the model rules and methods for simulating operations of the system.

A schematic of the river system model is included in the Appendix. The *St. Mary River-Milk River Basin Study Model Documentation* 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 Basin Study* model.

Summary of Model Input Data

Model simulations during initial development and calibration were based on streamflow, climate, and operations data from 1959-2009. 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 which might be expected to occur in the future, and
>
> (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 1959-2009 input data for each day or for what hydrologists refer to as a daily time-step. The initial analysis period only was extended back as far as 1959 because a comprehensive daily set of historic gauged streamflow data for the Milk River tributaries below Fresno Dam that 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 hydrology model should be aware that the study period doesn't include the lowest streamflow period for the St. Mary River Basin, which occurred during 1939-41, 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 included in the study period, and one of the 3-year periods ranks just behind the 1939-41 period. The lowest streamflow for the period of record for this study for the Milk River was 1986-88 as characterized by the natural streamflow of the Milk River at the Eastern Crossing of the International Boundary.

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; hence, they are summarized below.

Streamflow

Two different types of streamflow data were developed for the model, depending on the location of the stream reach in the basin. *Natural flow* data were developed for the St. Mary River and for the Milk River upstream of Fresno Reservoir. *Available flow* data were developed for the tributary inflow to the Milk River below Fresno Reservoir. 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 model.

Natural flow is flow that would have occurred in the stream if there were not human influences. 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 1900's. 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, and 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 1959-2009 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 the reservoir and measures most of the inflow to the reservoir, but not all. To estimate the entire natural inflow, the raw USGS gauge data were adjusted based on the Reclamation's measured daily changes in the storage contents of Lake Sherburne, and outflows at the gauging station below the Reservoir.

Available flow is flow that occurs in the stream at specific locations and represents natural flow that has been depleted by human activities. In the Milk River Basin below Fresno Reservoir, the primary depletion historically has been from agricultural irrigation in the U.S. and irrigation reservoir storage and direct diversion for irrigation in Canada. The study team made the assumption that water use on the tributaries downstream of Fresno Reservoir would continue in a similar way as it has historically occurred.

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, and most of the gauging records were seasonal; that is, the gauges were not operated during the late fall, winter, and early spring. 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 was used to fill in missing values and to extend the streamflow records at sites that didn't have a complete streamflow record. MOVE.1 was used to estimate monthly values. 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 preservation of sample estimates of the mean and of the variance from the historical record. Additionally, use of MOVE.1 allows selection of different base stations to fill in missing record for the site of interest. For instance, the Rock Creek at International Boundary USGS gauge was operational during the entire base period and its daily flow distributions could be used to estimate missing flows for a gauging station like that on the nearby Whitewater River, which wasn’t operational during much of the base period. In some cases, MOVE.1 was used to estimate the missing monthly values for the station of interest, but a different station was used to estimate the daily distribution of flows for the month.

Most Milk River reaches in the model downstream of 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 aren’t 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.

Future Climate Scenario and Baseline Flow Input Data

Historic streamflow data for 1959-2009 were used as the basis for the initial development and calibration of the RiverWare ™ model. For the future climate conditions and corresponding historic baseline condition, streamflow inputs were estimated using a calibrated rainfall/snowmelt runoff model (*SAC-SMA/SNOW-17*). The *SAC-SMA/SNOW-17* was developed to predict streamflow for the St. Mary River, Milk River, and their various tributaries based on precipitation and temperature data (Riverside Technology, 2006).

For baseline conditions (*Scenario S0*), the *SAC-SMA/SNOW-17* model was used to produce estimated streamflow based on historic climate data. These data were then adjusted (bias-corrected) so that they more closely matched the historic flow data derived from the gauging station records. For the future climate scenarios (*S1- S5*), predicted future daily temperature and precipitation values were used to run the *SAC-SMA/SNOW-17* model. These data were then bias-corrected using the adjustment factors developed for *Scenario S0* to produce the future climate streamflow input files for use in the RiverWare ™ model.

Adequate information was not available to the *SAC-SMA/SNOW-17* model to estimate flow based on the more recent 2001-2009 period. To compensate for not being able to use the flow input data corresponding to the most recent years, the early part of the modeling period was extended to start in 1950, because adequate climate data to run the *SAC-SMA/SNOW-17* hydrology model were available for these earlier years. These flow input data were used in the RiverWare ™ model, along with the water use data described below to run *Scenarios 1-5*.

Water Use

Water use in the St. Mary River-Milk River system include irrigation, municipal and industrial demands, recreation, fish and wildlife, and for water quality. Recreation and fish and wildlife use are primarily incidental uses in the Milk River Basin dependent on the irrigation water supply. Municipal and industrial uses and for water quality are relatively minor uses in comparison 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 of this report and in more detail in the model documentation.

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, Province of Alberta, June 2011.
[2] Source of data: Personal knowledge, Larry Dolan, Montana DNRC.
[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.

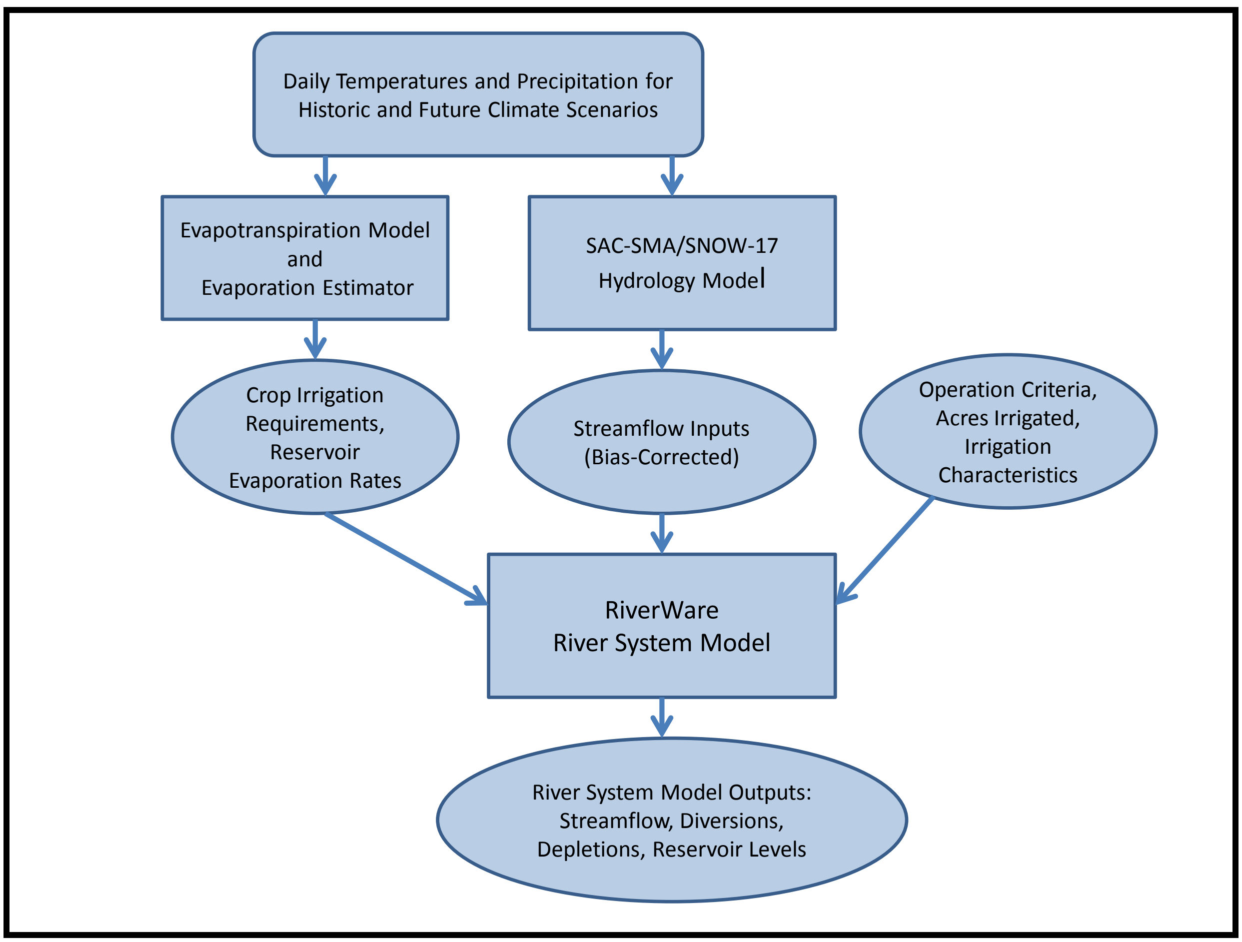
Temperature and precipitation data for the observed climate, a part of the climate change component of this study, was used with evapotranspiration models and with the above crop mix to estimate the net irrigation requirements for 45 subbasins in the region. The crop mix for each sub-basin was dependent upon 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 fractions based on the

Hargreaves-Samani evapotranspiration model was then computed and applied to the monthly Blaney-Criddle values to arrive at daily values used in the hydrology model to estimate irrigation demands, *Milk-St. Mary River System Basin Study Technical Service Center Support, Bureau of Reclamation, September, 2011*. 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 1950-2009.

In summary, the daily temperature and precipitation data for historic and future climate scenarios were used in the hydrology model to predict future streamflow for the St. Mary and Milk rivers. The data was also used in an evaporation estimator and evapotranspiration model to estimate daily net irrigation requirements and reservoir evaporates 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 3.1 is a flow diagram which describes this process.

Figure 3.1: St. Mary River– Milk River Models and Input Files



Calibration

Hydros Consulting, Inc. evaluated the river system model to quantify and improve the model's ability to simulate irrigation water use and to replicate historical river flows (Hydros Consulting, Inc., 2011). The calibration focused on physical parameters, such as irrigation efficiencies, surface and groundwater return flows, and water losses. The ability of the model to replicate downstream Milk River flows at the following gauging stations was tested:

- The Eastern Crossing
- Harlem
- Dodson (below the Dodson Diversion Dam)
- Bjornburg Bridge
- Nashua (mouth).

To better isolate how the model simulates irrigation use, the model temporarily was modified during calibration to use historic St. Mary Canal, Fresno Reservoir, 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 which 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) didn't 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.

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.

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 river flow, the calibration for the river below Fresno Dam focused on matching modeled irrigation season and monthly flow volumes to measured historic data. For each station, statistical analyses were conducted, modeled versus historical volumes were plotted and compared, and mass balance difference between modeled and historic data were computed. Modeled flows at the Harlem and Dodson gauge locations initially were greater than historic, implying that the model was underestimating depletions 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 dams. The result was a better mass balance in comparison to historic for the Harlem and Dodson gauges. Figure 3.2 is a plot of the irrigation season volume at the Harlem gauge for historic flow and model simulated flow.

Overall the model appeared to be well calibrated, properly estimating river depletions and reasonably able to replicate historic conditions at the river gauges. The Nashua gauging station near the mouth of the Milk River was an exception. There are several high flow events that the model significantly underestimates. It is believed that these discrepancies resulted from actual ungauged tributary inflows being higher than those estimated for model input. 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.

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

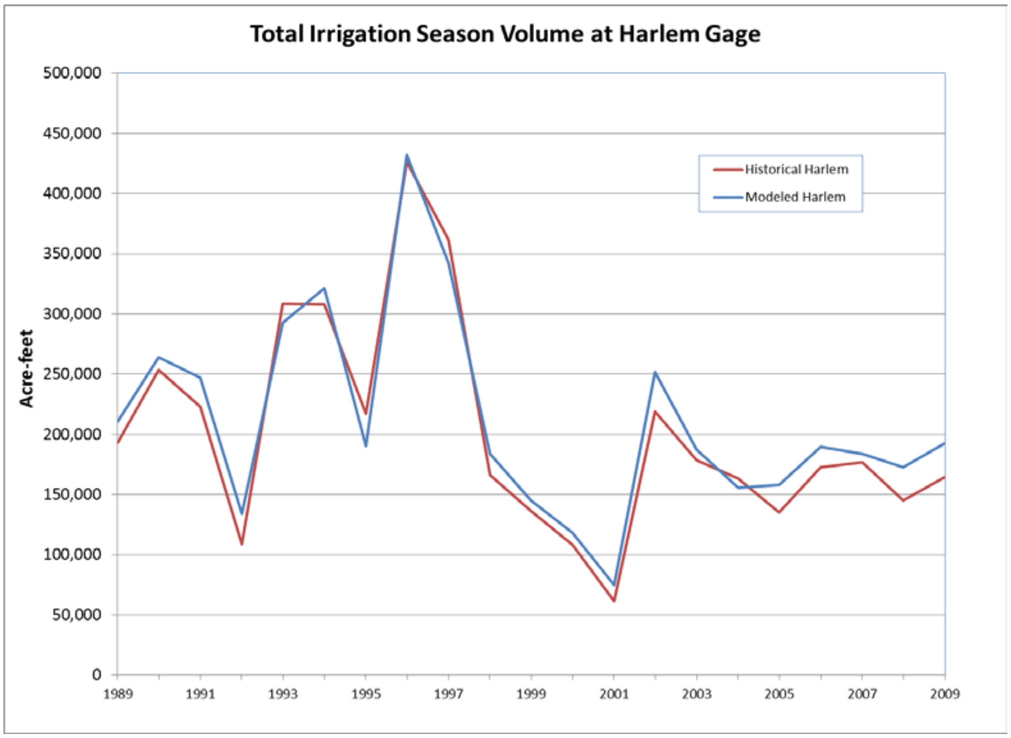


Figure 3.2: Example Plot for Milk River at Harlem Gauging Station after Simulated Groundwater Returns to the Milk River were reduced during Calibration.

Chapter 4: Ability to Meet Baseline and Future Water Demands

This chapter describes the ability of currently existing facilities to meet present and future water demands of the region. “Baseline” represents existing water demands. In the next chapter, alternatives are evaluated and compared against baseline to measure their mitigative benefits and impacts.

Baseline Conditions

A baseline condition needs to be established to evaluate hydrologic modeling results. Baseline provides the datum from which to measure things such as impacts from climate change, operational and/or facilities modifications, and changes in water use. For purposes of this report, the baseline condition was defined as the water supply, water facilities, water use, and irrigated land base in the St. Mary River-Milk River basin as it currently exists, but with adjustments made to recognize continual losses in Fresno storage. This represents the river system under historic climate conditions. The assumptions for the river system model for the baseline condition are:

- Streamflows and demands are defined by the historic climate as described in the *S0* climate scenario

- There are about 140,000 acres that can be served by the irrigation system from the main stem of the Milk River downstream of Fresno Reservoir. Some of this land is fallowed each year, and only about 127,000 acres are actually irrigated each year. Water rights are not administered along the Milk River, and junior water users have the same opportunity to irrigate as senior water users

- There are about 8,600 acres of phreatophytes (vegetation that consumes lots of water, such as cottonwood trees, willows, and wetland plants) in the basin that 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 20-40 percent for irrigation district lands and from 45-50 percent for lands served by private irrigation systems, with efficiencies generally higher later in the season and when water shortages are highest

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

- The St. Mary Canal has an average annual maximum operating capacity of 650 cfs, with an operating season varying from year-to-year based on historic St. Mary Canal start dates

- The Boundary Waters Treaty is administered according to the 1921 Order. Water apportionment is done on a daily time frame. The Letter of Intent which allows for deficit deliveries to the downstream country and a repayment process is included in the baseline conditions model

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

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

- 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 non-irrigation season release from Fresno Reservoir is 45 cfs

- The non-irrigation season release from Lake Sherburne is 0 cfs

- The Ft. Belknap Indian Irrigation Project uses its 125 cfs Winter's reserved water right for irrigation and up to 1/7 of the Milk River natural flow stored in Fresno Reservoir.

Present System Reliability

Irrigation

The volume of water that crops might consume with a full water supply on Milk River lands is about 210,000 AF per year on average. This equates to about 1.5 AF of water per acre irrigated, or about 18 inches. As modeled under the historic climate and baseline conditions, the Milk River Project and Tribal water rights have the potential to supply only about 127,000 AF of water per year on average that would directly support crop irrigation requirements within project and reservation lands. This is about 1 AF per acre (about 12 inches), and about 60 percent of the annual crop needs. Water shortages occur for Milk River irrigators every year. These shortages can be due to infrastructure limitations, low water supplies, or a combination of these two factors. During wetter years, shortages can be relatively small. In the driest years, when flow is low and crop demands are high, shortages can be quite large. For instance, during the two worst years in the 1950-2001 data series (1988 and 2001), the modeled supply was only a little over half of the crop irrigation needs. Table 4.1 summarizes modeled shortages for the Milk River irrigation by annual volume and as a percentage of the total demand.

Table 4.1: Milk River Modeled Irrigation Depletion Shortages under Baseline Conditions

Year Category	Shortage Volume in AF	Shortage as Percent of Demand
Average	68,000	35
Wettest Ten Years	53,000	29
Middle Ten Years	63,000	33
Driest Ten Years	86,000	42
Maximum	136,000	59
Minimum	18,000	13

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. Table 4.2 summarizes modeled St. Mary Canal diversions under existing conditions. Years were characterized as wet, middle, or dry depending on the combined annual natural flow of the St. Mary and Milk rivers. Canal diversions generally are highest during the middle years when St. Mary River water is available, when Milk River natural flows are moderately low, and when crop demands are relatively high. Diversions are low 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. Diversions are also modeled to be lower during wet years because—during these years—there is more Milk River natural flow available and irrigation demands typically are not as high.

Table 4.2: Modeled St. Mary Canal Diversions under the Baseline

	Annual Volume Diverted AF
Average	189,000
Wettest Ten Years	170,000
Middle Ten Years	197,000
Driest Ten Years	179,000
Maximum	231,000
Minimum	126,000

Hydropower

There are no hydropower generating facilities in the St. Mary or Milk River basins in the U.S. at the present time. Since the early 1980's 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(U.S. Bureau of Reclamation, 2011c). This assessment identified 9 sites in the region with hydropower production potential, but only 4 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; St. Mary Canal Drop 4; and St. Mary Canal Drop 5. 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, hydrologic modeling was done by selecting a base period 1950-2001, running and calibrating a computer model to historic conditions, and then using the calibrated model with defined baseline conditions 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's 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.

Climate change cannot be adequately modeled using the assumption that mostly unaltered past data could be used to model the future. Recent observations suggest the climate is warming and will likely continue to do so. Therefore, it was necessary to develop input data for the model that would reflect anticipated future conditions with climate change. In doing so, a similar base-period for 1950-2001 was used to define the sequence of year-to-year temperature and precipitation patterns that might occur in the future. These data were then adjusted to the anticipated conditions for a 30-year time period centered on 2050. In other words, the patterns of weather and streamflow variability for the 1950-2001 period were used as a template, and then adjusted to reflect a warmer future climate. In this report, we focused on future climate scenarios centered on 2050.

To evaluate the capability of existing facilities to meet future demands, the baseline condition was modified to include future streamflow and future water demands projected from the changing climate.

In evaluating capability of existing facilities to meet future demands, the river system model was operated with climate change *Scenario S5* streamflow and demand data, the central tendency climate projection, and then compared to baseline conditions. Additionally, the other four climate change scenarios were modeled and the results of two were identified to define the upper and lower limit of changes expected in the basin due to climate change.

Irrigation shortages would increase under all year types on both a volume basis and on a percentage of demand basis for the future climate *S5* when compared to the existing climate (Table 4.3). When compared to baseline, the average shortage would increase by 38,000 AF.

Table 4.3: Modeled Irrigation Depletion Shortages for all Milk River Irrigation Downstream of Fresno Reservoir

	Historic Climate Baseline S0		**Future Climate *S5***		**Change**
Year Category	**Shortage Volume in AF**	**Shortage as Percent of Demand**	**Shortage Volume in AF**	**Shortage as Percent of Demand**	**Shortage Volume in AF**
Average	68,000	35	104,000	42	36,000
Wettest Ten Years	53,000	29	75,000	33	22,000
Middle Ten Years	63,000	33	95,000	40	32,000
Driest Ten Years	86,000	42	137,000	53	51,000
Maximum	136,000	59	208,000	72	72,000
Minimum	18,000	13	36,000	21	3,000

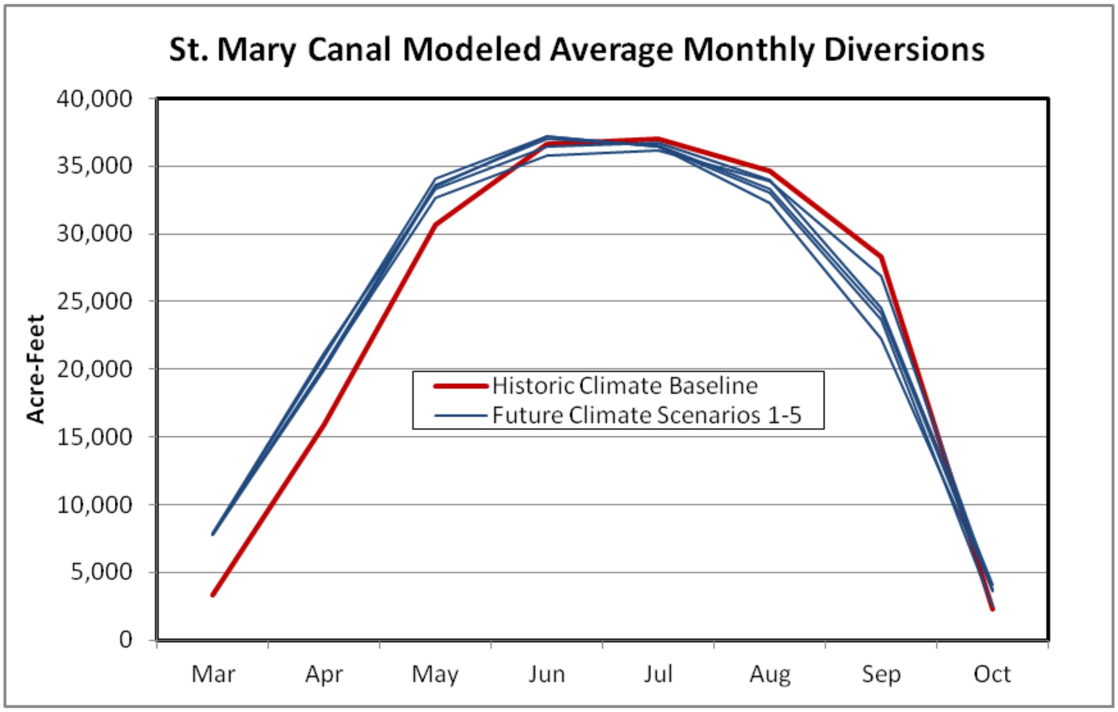
St. Mary Canal diversions under the future climate would be 7,000 AF greater than existing diversions (Table 4.4). However, during higher streamflow years under the future climate S5, canal diversions would be about 18,000 AF greater than under the baseline climate conditions. During lower streamflow years under future climate conditions, modeled canal diversions were about 14,000 AF less than under the baseline climate conditions. When simulating St. Mary Canal diversions for future climate scenarios, the canal start dates in the river system model were advanced 10 days earlier in the spring to take into account the earlier shift in runoff due to warmer temperatures and earlier shift in runoff.

Table 4.4: Modeled St. Mary Canal Diversions under
Historic Climate Baseline and Future Scenario S5 Climate Conditions

	Historic Climate Baseline S0 Annual Volume Diverted, AF	**Future Climate S5 Annual Volume Diverted, AF**	**Change, AF**
Average	189,000	196,000	7,000
Wettest Ten Years	170,000	188,000	18,000
Middle Ten Years	197,000	209,000	12,000
Driest Ten Years	179,000	169,000	-14,000
Maximum	231,000	250,000	19,000
Minimum	126,000	109,000	-17,000

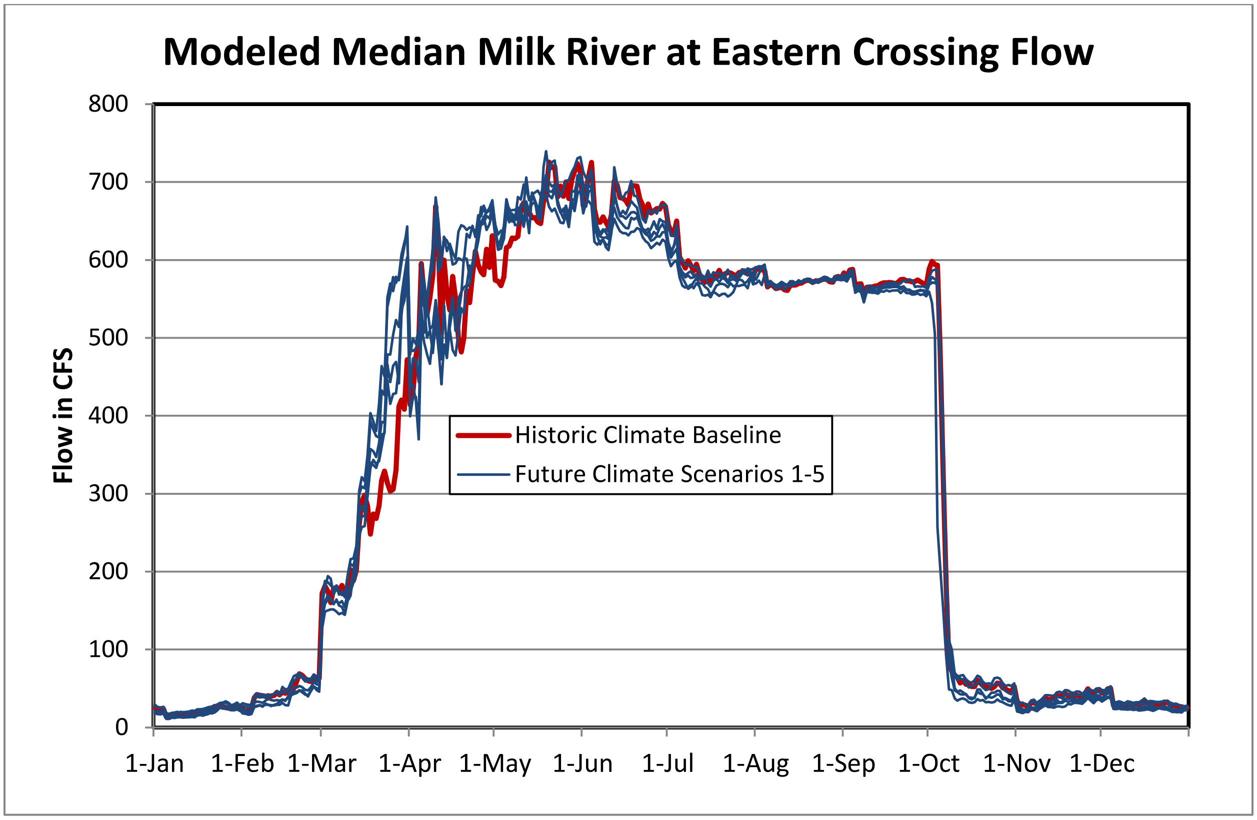
Because the timing of the St. Mary River's natural flows available to the U.S. is projected to change in the future, the timing on when water is diverted through the canal might change. Figure 4.1 shows that more water is diverted earlier in the season and less water diverted later in the season compared to baseline. 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.

Figure 4.1: Modeled Average St. Mary Canal Diversions under Historic Climate Baseline and Future Climate Scenarios 1-5



Flow contributions for the upper Milk River watershed are expected to decrease some under the future scenarios but perhaps 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). Lower Milk River flow contributions are expected to increase some under most scenarios. Overall, the water supply available for Milk River irrigation in the future might be similar to what it has been during the past, but with increased variability and less flow during the driest years.

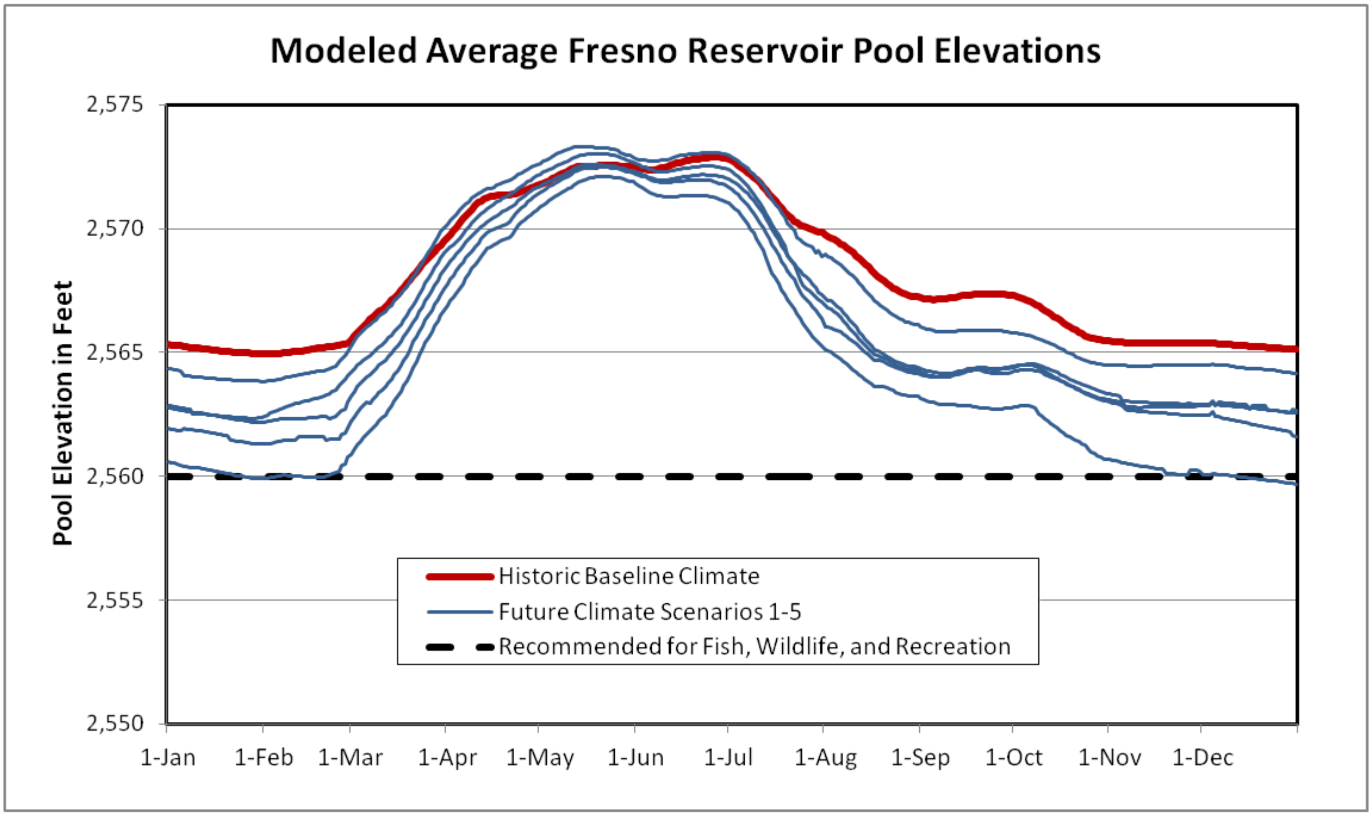
Figure 4.2: Modeled Milk River at Eastern Crossing Median Flow for Historic Climate Baseline and Future Climate Scenarios 1-5 (graph includes the effect of St. Mary Canal diversions)



Due primarily to increases in downstream crop irrigation requirements, Fresno Reservoir elevations generally would be lower under future climate scenarios than under the baseline. Figure 4.3 compares average Fresno Reservoir elevations for baseline conditions to those for future climate *Scenarios S1- S5*. The recommended reservoir pool level by the Montana Department of Fish, Wildlife and Parks also is presented on the graph. Although the average pool levels depicted on the graph generally are higher than the recommended level, it is important to note that pool levels would be lower during drier years and would be below recommended levels more frequently under the future climate scenarios.

Fresno Reservoir provides flood control benefits by storing water during the peak runoff period. Fresno Reservoir provides flood control benefits when operated with about 30,000 AF of storage space available on March 1 to store the high flows. The Corps of Engineers and Reclamation jointly identified the storage space volume needed for flood control in 1957. Fresno Reservoir is expected to continue to lose storage space in the future 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. For this reason, 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 would also increase. Flood control benefits are expected to continue into the future as Reclamation has an adaptive management approach to flood control at Fresno Reservoir.

Figure 4.3: Modeled Average Fresno Reservoir Pool Elevations under Historic Climate Baseline and Future Climate Scenarios



Lower lake levels at the Bowdoin National Wildlife Refuge in the future might also be a concern. Table 4.5 compares modeled average Lake Bowdoin water levels under the baseline and climate change *Scenarios S1-S5*. Annual diversions to the reservoir of 3,500 AF per year were assumed in the model. Irrigation returns from the Malta Irrigation District were also assumed to continue into the future. The overall modeled changes to refuge levels are modest, however, as temperatures warm and evaporation rates increase in the future, lower overall water levels at the Bowdoin National Wildlife Refuge could become an issue. The wetter conditions associated with most of the climate change scenarios might offset some of the effects of increased evaporation.

Table 4.5: Average Modeled Level for Bowdoin under Historic Climate Baseline and Future Climate *Scenarios S1-5*

Climate Scenario Number	**Average Modeled Lake Level Feet**
S0 Baseline	2,212.4
S1	2,212.1
S2	2,212.6
S3	2.211.8
S4	2,212.3
S5	2,212.2

Irrigation water shortages are frequent in the Milk River Basin and, with warmer temperatures and a longer growing season, shortages would increase. Figure 4.4 depicts the magnitude and frequency of depletion shortages (water that crops needs for optimal growth but can't be supplied) under historic conditions and future climate *Scenarios S2*, *S3*, and *S5*. These future scenarios define the high, middle, and low range of shortages under the future scenarios. 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 examinded, based on weather patterns from 1950-2001. One thing to note from graph is how 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 under Historic Baseline Climate and Future Climate *Scenarios 1-5*

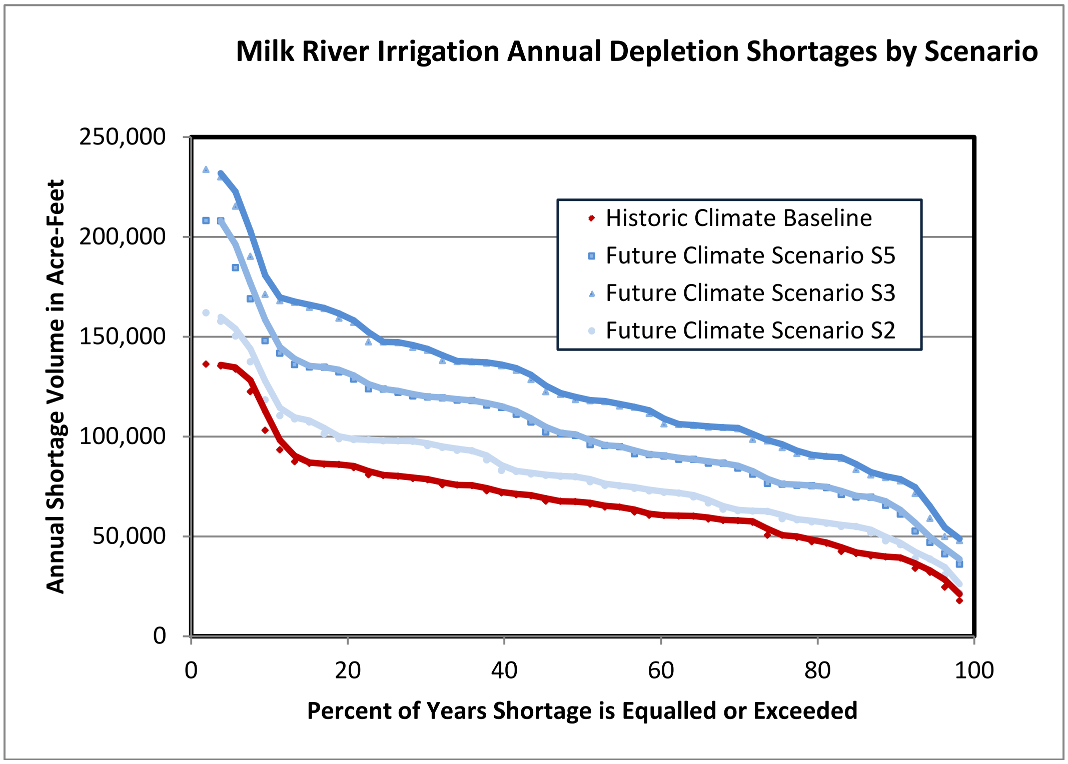
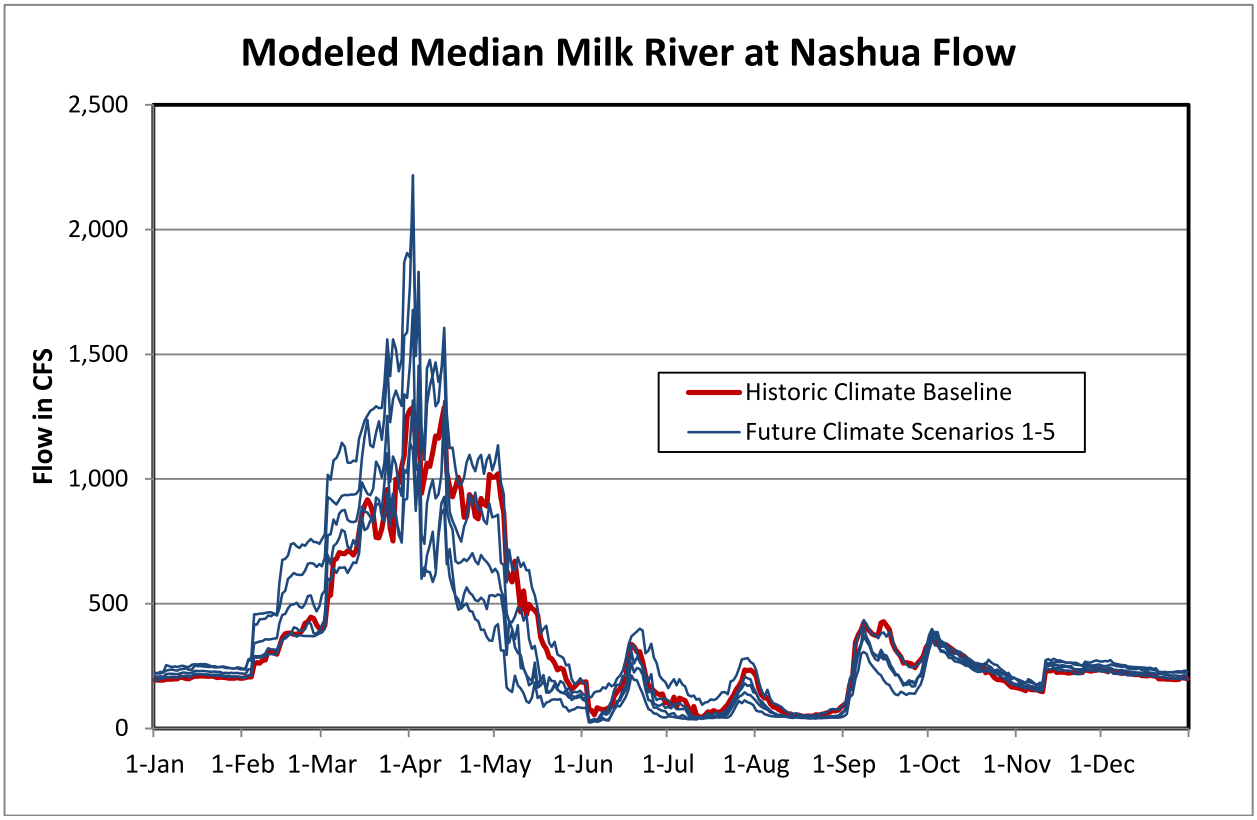


Figure 4.5 compares modeled median Milk River flows at Nashua for historic conditions and for future climate *Scenarios 1-5*. This represents the flows that would leave the Milk River Basin and into the Missouri River. The graph shows a slight shift in runoff timing towards earlier in the season. Most of the future climate scenarios produce higher overall flow peaks, although late spring and summer flows for the future climate scenarios generally are lower than historic.

Figure 4.5: Modeled Milk River Flows under the Historic
Climate Baseline and Future Climate *Scenarios 1-5*



Chapter 5: Alternatives for Meeting Water Demands

Five alternatives to satisfy increasing water demands in the St. Mary River and Milk River basins are evaluated in this chapter. Each alternative is first described; water demands capable of being met by the alternative is compared to the baseline defined in Chapter 4; then, the alternative is evaluated based on the river system model results. The ability of the alternatives to reduce irrigation depletion shortages (the volume of irrigation water supplied to the irrigated crops compared to what is needed for optimal growth) is a focus of this evaluation. This chapter concludes with "Other Potential Alternatives," a section on alternatives that could be analyzed in future studies of the basins.

Canal and On-Farm Water Use Efficiency Improvements Alternative

Description

Canals in the Milk River Project could be modified to deliver water more efficiently to on-farm headgates, and on-farm irrigation system efficiencies could be improved. The baseline irrigation efficiencies in the model range from 20-40 percent for irrigation districts and 45-50 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 37-57 percent for irrigation districts and 62-67 percent for lands served by private irrigation systems.

Methods that would improve canal efficiency include lining canals and laterals; putting laterals into pipe; reusing spills and return flows; and, adding and improving water measurement sites. On-farm efficiencies could be improved by field leveling, converting from flood irrigation to sprinkler, and shorter field runs.


Canal Lining


Sprinkler Irrigation

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.

Releases from Fresno Reservoir are used to irrigate nearby lands along 300 miles of the Milk River. It may take releases up to two weeks to reach the last canal diversion at Vandalia Dam. Approximately 30 percent of the water that becomes return flow flow back to the river via surface returns, and up to 70 percent as 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, only 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 too small to meet peak irrigation water demands. This restriction in capacity is in part an efficiency problem. The other part is attributable to lack of crop diversity, which leads to a bottleneck because typically, everyone needs water at the same time.

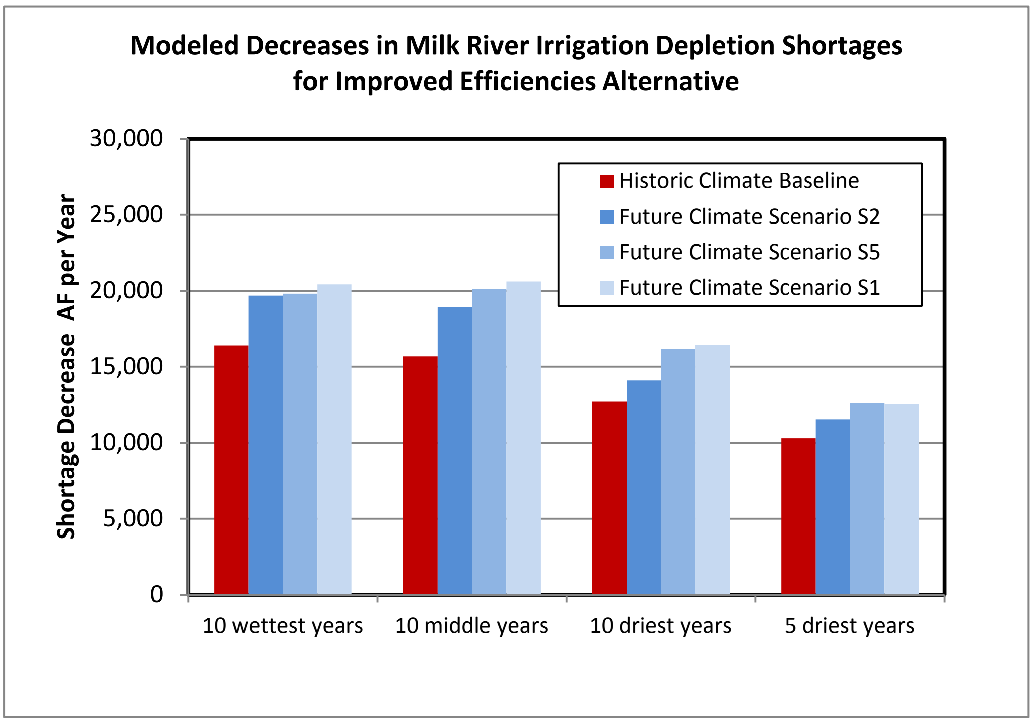
Evaluation

Table 5.1 presents modeled decreases in shortages for Milk River irrigation crop water consumption needs with an increase in irrigation efficiencies of 17 percent for the Milk River Irrigation Districts. Figure 5.1 graphically depicts model results and includes additional future climate scenarios. The level of benefit would be similar across the scenarios.

Table 5.1: Modeled Irrigation Depletion Shortage Comparison, Improved Efficiency Alternative, Future Climate *Scenario S5*

	Scenario S5: Shortages AF	*Scenario S5*: Improved Efficiency Shortages AF	Annual Reduction in Shortages AF
Average	104,000	85,000	19,000
Wettest Ten Years	75,000	55,000	20,000
Middle Ten Years	95,000	75,000	20,000
Driest Ten Years	137,000	121,000	16,000
Driest Five Years	169,000	156,000	13,000

Figure 5.1: Modeled Decreases in Milk River Irrigation Depletion Shortages Due to an Increase in Irrigation Efficiencies for Historic Climate Baseline and Future Climate Scenarios



The modeled increases in water to crops 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. What likely is more limiting to diversions during these years is availability of water in the river rather than canal capacity. Improving efficiencies in some cases will only decrease return flow and return flow often is reused downstream.

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 ground-water return flow that doesn't make it back to the river until after the irrigation season.

Table 5.2: Modeled Decreases in the Outflow of the Milk River near Nashua with an increase in Irrigation Efficiencies of 17 Percent for Future Climate *Scenario S5*

	Climate Change *Scenario S5* Basin Outflow Existing Efficiencies AF	**Climate Change *Scenario S5* Basin Outflow Increased Efficiencies AF**	**Annual Decrease in Basin Outflow AF**
Average	494,000	471,000	23,000
Wettest Ten Years	666,000	642,000	24,000
Middle Ten Years	495,000	468,000	27,000
Driest Ten Years	208,000	190,000	18,000
Driest Five Years	143,000	126,000	17,000

The Milk River Project area has traditionally relied heavily on return flows to meet downstream demands. Improving efficiency in the canals would mean more water available to district irrigators but would possibly reduce return flow available for other users.

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, riparian and wetland wildlife habitat. Recreational opportunities would probably remain similar at Fresno and Nelson reservoirs but might decrease along the lower river corridor. Likewise, increased on-farm efficiency would improve crop production by increasing the volume of water consumed by crops, while reducing the supply available for other uses. There might be water quality impacts as well, which could range from positive to negative. Game species like deer and pheasants might benefit from increased crop production. Water available for the Bowdoin National Wildlife Refuge from return flows would be reduced substantially, which might affect migratory bird habitat and piping plover nesting. Average Lake Bowdoin pool elevations were projected to decline by 1.8 feet under this alternative. Increased diversions to Lake Bowdoin from the Dodson South Canal might be needed to offset these impacts.

Rehabilitate St. Mary Canal for Increased Capacity Alternative

Description

Most of the structures of the 90-year old St. Mary Canal have exceeded their design life and need major repairs or replacement. Canal capacity has dropped from 850 cfs in 1925 to its current 650 cfs. This alternative compares maintaining the St. Mary Canal facilities at the present 650 cfs capacity to upgrading the canal to the original 850 cfs capacity. 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.

St. Mary Canal

Evaluation

Table 5.3 compares annual modeled St. Mary Canal diversions for canal capacities of 650 and 850 cfs under baseline and future climate *Scenario S5*. 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. 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.

Table 5.3: Modeled Annual St. Mary Canal Diversions and Diversion Increases for Increased Canal Capacity Alternative under Future Climate Scenario S5

	Scenario S5 **650 CFS Canal Annual Diversions AF**	***Scenario S5*** **850 CFS Canal Annual Diversions AF**	**Annual Diversion Increase AF**
Average	196,000	214,000	18,000
Wettest Ten Years	188,000	227,000	39,000
Middle Ten Years	209,000	225,000	16,000
Driest Ten Years	169,000	173,000	4,000
Driest Five Years	148,000	150,000	2,000

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 following year turns out to be dry, despite the larger canal capacity, lower diversions may be the result of less carry-over storage in Lake Sherburne at the start of the season. This explains why, for historic baseline conditions, modeled diversions during the driest years were lower with the 850 cfs capacity canal (Figure 5.2).

Figure 5.2 shows modeled changes in St. Mary Canal annual diversions for historic conditions, and future climate Scenarios *S5*, *S2*, and *S1* 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-middle years. Under the future climate scenarios, there also is a modest increase in diversions during moderately dry 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 decreases in shortages for crop water consumption needs associated with an increase in St. Mary Canal capacity from 650 to 850 cfs. Benefits generally are greatest during the wetter and middle years. Figure 5.3 graphically depicts these model results and includes additional future climate scenarios.

Table 5.4: Modeled Decreases in Milk River Irrigation Crop Irrigation Depletion Shortages Due to an Increase in St. Mary Canal Capacity from 650 to 850 cfs for Climate Change *Scenario S5*

	Scenario S5: **650 CFS Canal** Shortages AF	*Scenario S5*: **850 CFS Canal** Shortages AF	Annual Reduction in Shortages AF
Average	104,000	99,000	5,000
Wettest Ten Years	75,000	71,000	4,000
Middle Ten Years	95,000	88,000	7,000
Driest Ten Years	137,000	134,000	3,000
Driest Five Years	169,000	168,000	1,000

Figure 5.2: Changes in Annual St. Mary Canal Diversions for
a Canal Capacity Increase from 650 to 850 cfs

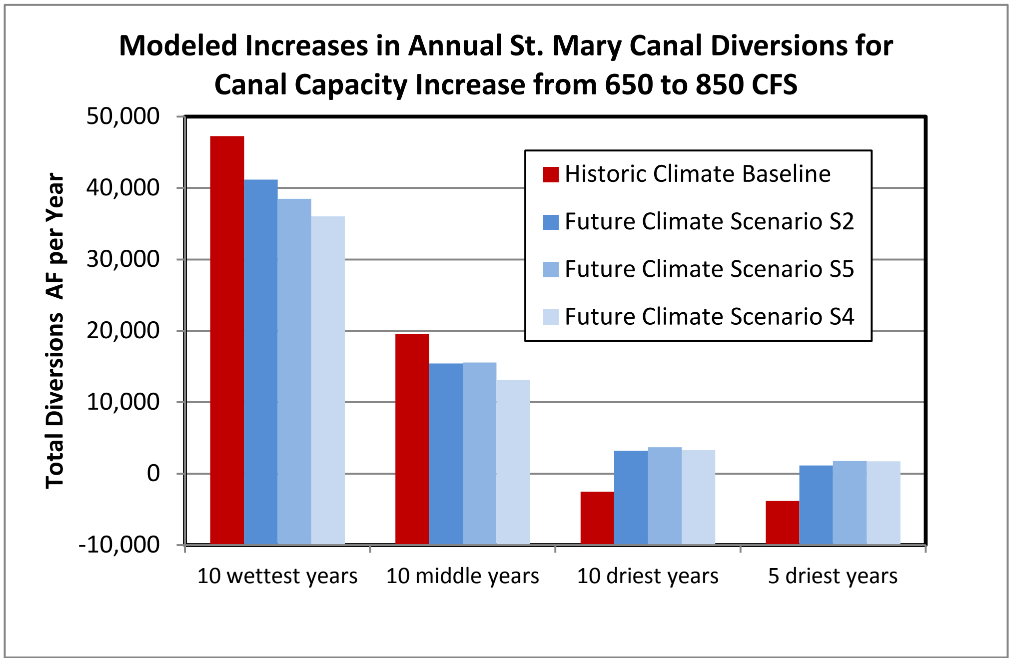
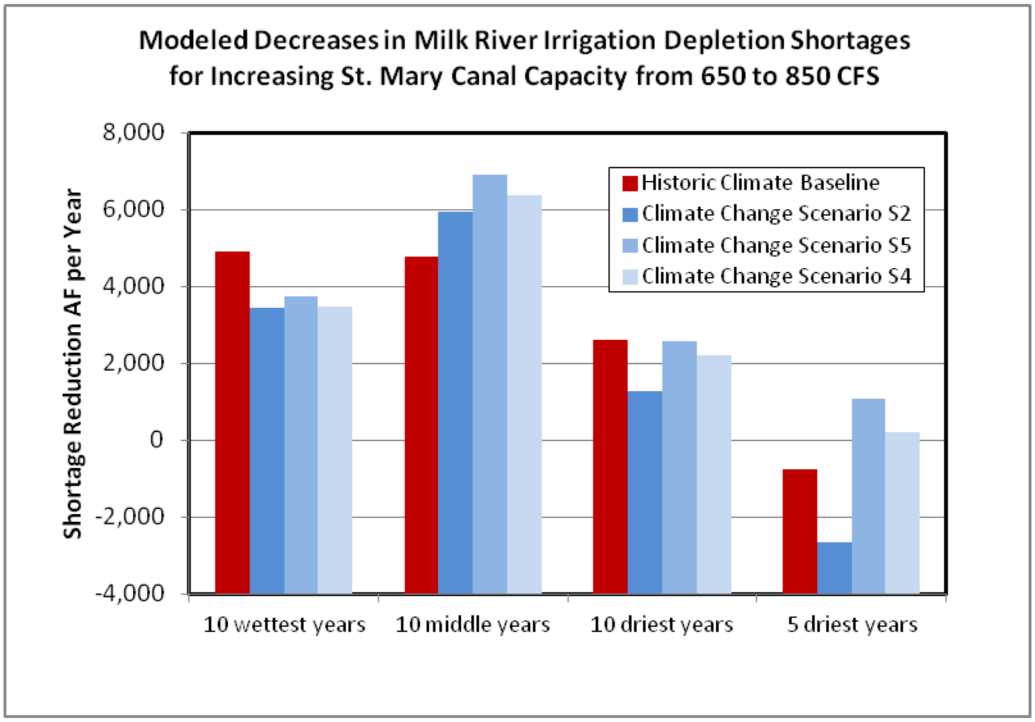


Figure 5.3: Modeled changes in irrigation depletion shortages with an increase in St. Mary Canal capacity for historic climate baseline and future climate scenarios.



This alternative would reduce St. Mary River flows, with reductions greatest during wetter and median flow years, less during dry years. The reduction in St. Mary flows during wet and median years might impact the ecological resiliency for fish and wildlife populations in the river reach below the St. Mary Diversion Dam. Species would need to adapt to changing habitat conditions, such as water temperatures and flow patterns, all of which were anticipated to occur under the climate change scenario. Adaptive management might be considered for bull trout in the St. Mary River; however, the magnitude of impacts has not been determined. In the Milk River Basin, the enlarged St. Mary Canal, along with irrigation, would increase benefits to fish and wildlife; municipal and industrial water supplies; and water quality. Assuming irrigation efficiencies remained the same, water available for the Bowdoin National Wildlife Refuge from return flows could increase, which would benefit migratory bird habitat and piping plover nesting. Increased flow in Milk River channel in Alberta could result in increased channel and bank erosion. This alternative would increase the volume of St. Mary water reaching Fresno Reservoir and generally increase reservoir levels and associated recreational opportunities. The increase in capacity might improve the feasibility of developing hydropower on the canal.

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 2580 feet. Fresno Dam construction was completed in 1939 with an original storage capacity of 130,000 AF. A 1999 reservoir survey showed that the storage capacity had shrunk to 93,000 AF: a loss of 37,000 AF of storage capacity from accumulating sediments. By 2050, Fresno's storage capacity is expected to be reduced to an estimated 62,000 AF if no action is taken (Reclamation, 2003). Raising the spillway crest to elevation 2,580 feet would increase the year 2050 storage capacity to 90,000 AF, which is near the present capacity.

Fresno Reservoir

Evaluation

By 2050, the capacity of Fresno Reservoir only is expected to be about 62,000 AF. 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.

Table 5.5 compares estimated total Milk River irrigation consumptive-use shortages for future climate *Scenario S5* 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 Crop Irrigation Depletion Shortage Comparison with and without a 5-foot Raise in Fresno Reservoir Elevation under Future Climate *Scenario S5*

	Shortages *Scenario S5*: Fresno Reservoir Storage = 62,000 AF	**Shortages *Scenario S5*: Fresno Reservoir Storage = 95,400 AF**	**Annual Reduction in Depletion Shortages AF**
Average	104,000	96,000	8,000
Wettest Ten Years	75,000	67,000	8,000
Middle Ten Years	95,000	88,000	7,000
Driest Ten Years	137,000	128,000	9,000
Driest Five Years	169,000	160,000	9,000

The benefits of increased storage would be greatest during drier years when more spring runoff could be captured and more storage could be carried over from the previous year. This holds true for all of the future climate scenarios, including historic climate conditions (Figure 5.4).

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. This is illustrated in Figure 5.4 which compares modeled Fresno Reservoir storage for historic conditions to *Scenario S5* with and without a Fresno raise. The plot is based on weather patterns for the 1983-1987 period, which included wet and dry years.

Figure 5.4: Modeled Decreases in Irrigation Depletion Shortages due to a 5-foot Raise in Fresno Reservoir Elevation under Historic Climate Baseline and Future Climate Scenarios

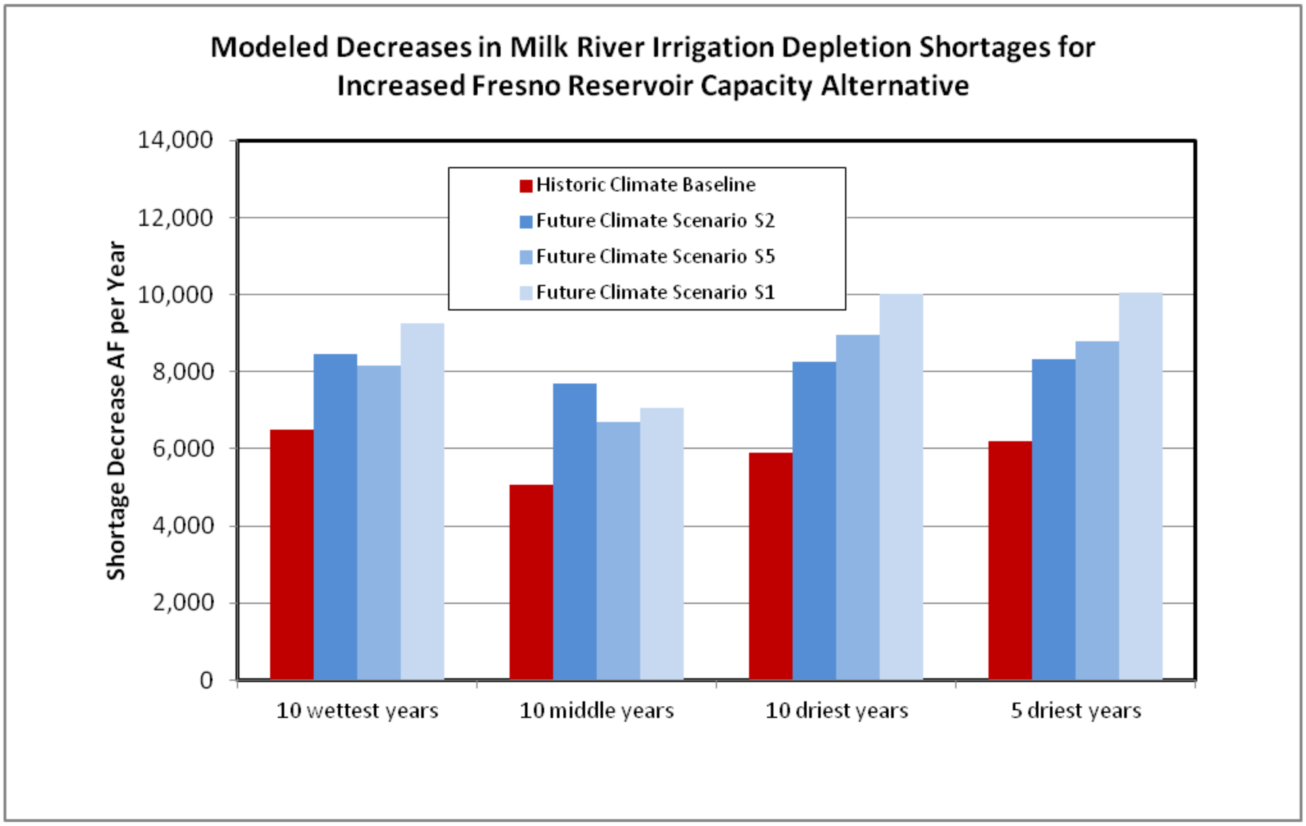
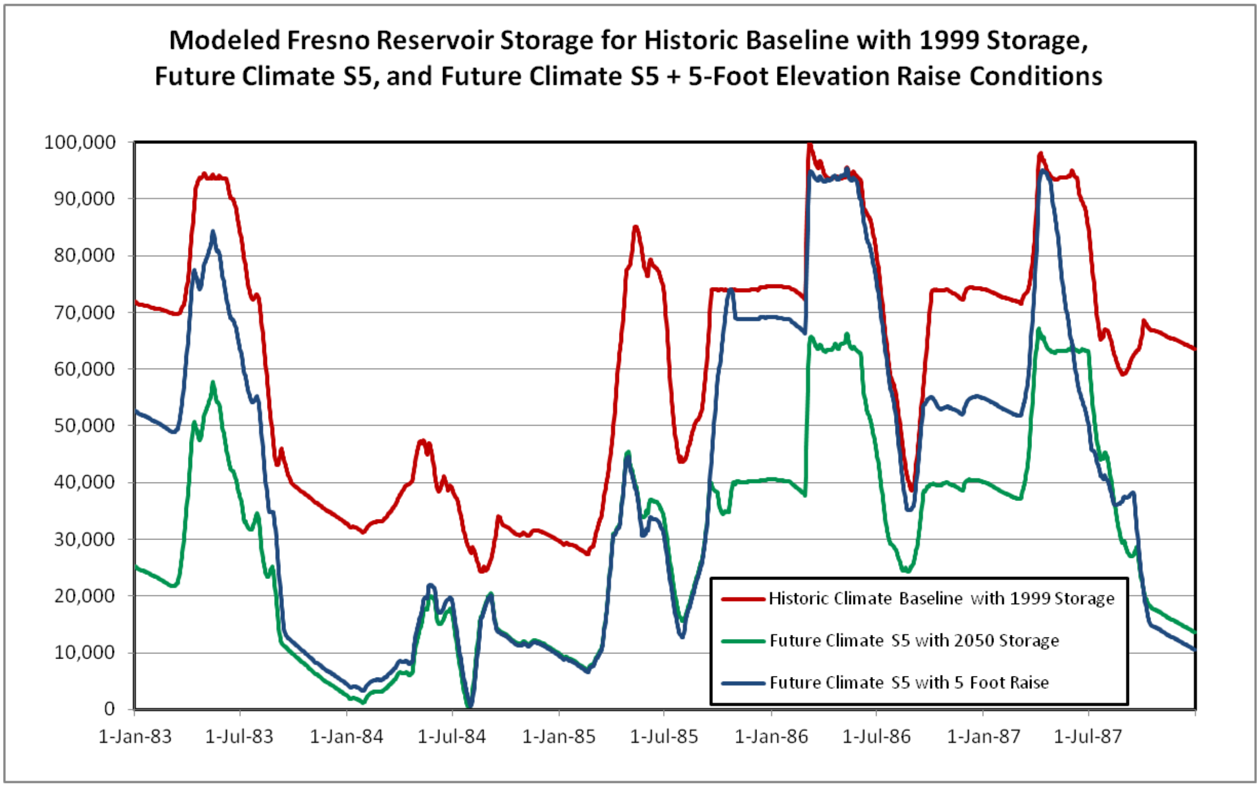


Figure 5.5: Modeled Fresno Reservoir Storage for Historic Climate Baseline with 1999 Storage Volume, and Future Climate (*Scenario S5*) with and without a 5-foot Raise in Reservoir Elevation



Continued storage loss to sedimentation is a long-term problem that threatens to diminish all of the benefits of Fresno Reservoir. This alternative offers an effective, medium-term solution to the problem. Benefits include meeting Montana Fish, Wildlife, and Parks' minimum pool recommendations to benefit the fishery and recreation. Water supplies for municipal and industrial users would be safeguarded, and water quality along the Milk River would likely remain the same. The increase in storage would also preserve benefits associated with flood control. Water available for the Bowdoin National Wildlife Refuge might increase, which would benefit migratory and nesting bird habitat.

An adverse effect of this alternative would result from more frequent inundation of land at an elevation from the current reservoir crest to five feet above it. These lands are only infrequently covered with water now, when the reservoir is high and spilling. Some recreational facilities, such as cabins, docks, and picnic area, might need to be relocated.

Expanded Frenchman Reservoir Alternative

Description

Frenchman Dam is a state-owned project on the Frenchman River; a tributary to the Milk River. The dam has experienced severe deterioration since it was built in 1952-1953. Furthermore, the reservoir has lost 60 percent of its design capacity of 7,010 AF (4,200 AF) to sedimentation. Frenchman Dam's spillway also cannot safely pass a 500-year flood as required by State of Montana regulation. Given this small volume of storage and the variability of Frenchman River flows, Frenchman River irrigators experience substantial irrigation water shortages in most years. In order to provide a reliable water supply to Frenchman River water users, and to provide benefits to downstream Milk River irrigators, the existing reservoir would need to be raised or a new reservoir constructed.

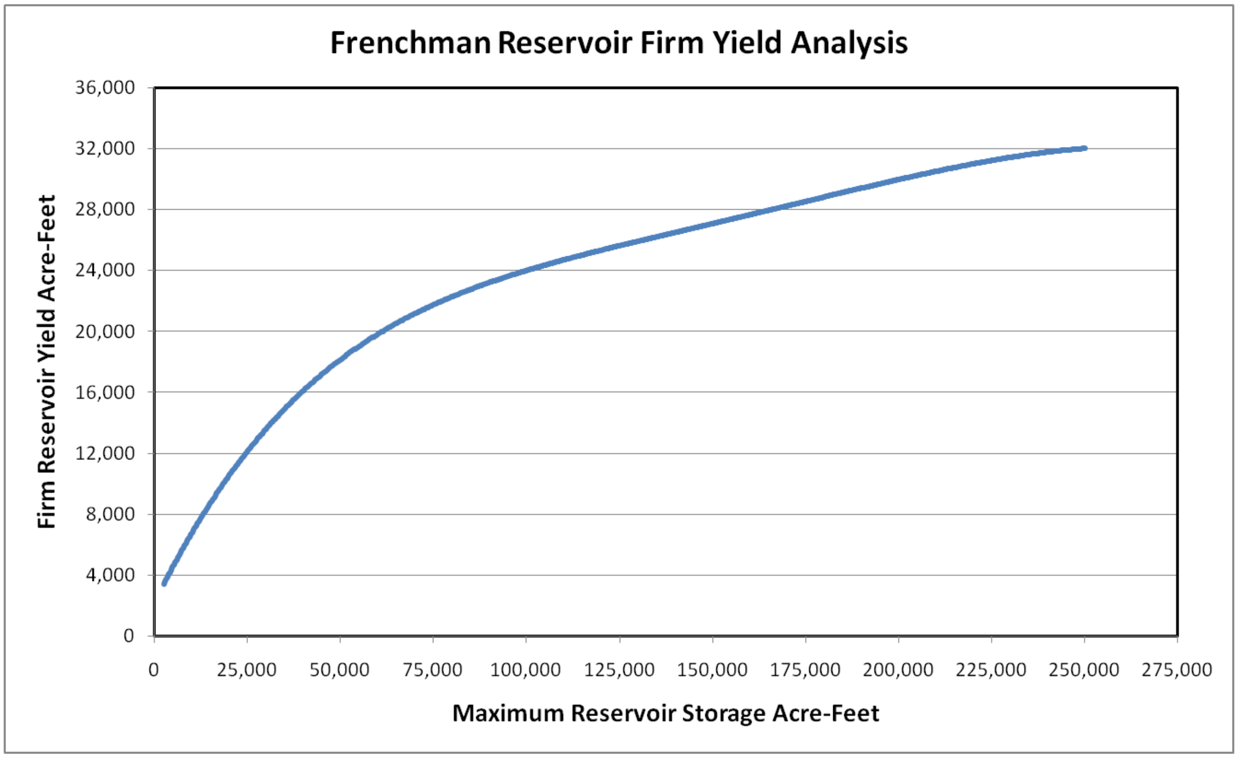
DNRC is currently conducting a feasibility study to evaluate enlargement of Frenchman Dam or building a new dam at a site upstream, with the goal of improving use of the U.S. share of the Frenchman River and its potential for mitigating impacts from Fort Belknap Compact implementation. The Frenchman project area consists of 3,485 irrigated acres. If the capacity of Frenchman Reservoir was 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 in/ac, with the gains typically occurring during the mid-summer months when flows of the Frenchman Creek decline.

Frenchman Reservoir

Evaluation

Similar to most prairie streams, the flow of the Frenchman River 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. The river system model was operated for various sizes of reservoir to determine the yield. Figure 5.6 shows that if Frenchman Reservoir were increased to 50,000 AF of storage capacity, it would only be able to yield about 18,000 AF reliably every year.

Figure 5.6: Firm Yield of 50,000 AF Frenchman Reservoir



Raising Frenchman Reservoir to its original capacity of 7,010 AF would greatly improve the water supply for the approximately 3,500 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 the Frenchman River and also could release some additional water during most years for downstream Milk River irrigators. A reservoir of this size would yield about 18,000 AF per year. If water users were willing to accept shortages one year out of ten, then the reservoir would yield about 24,000 AF in the other nine years. This water could be used to meet the needs of irrigators on the Frenchman River and to provide some additional water for downstream users.

Tables 5.6 and 5.7 compare modeled decreases in shortages for Frenchman River irrigators for baseline and future-climate *Scenario S5* using a 50,000 AF reservoir with 90 percent reliability. Most of the modeled shortages that remain under the expanded reservoir alternative would be during dry years that are at the end of a sequence of drought years. With a reservoir of this size, shortages would be small under both historic and future climate conditions, with substantially more water provided under the warmer conditions for future climate *Scenario S5*.

Table 5.6: Modeled Frenchman Watershed Irrigation Depletion Shortages under Historic Climate Baseline with and without a 50,000 AF Storage Reservoir

	Historic Climate Baseline S0 Modeled Shortage Existing Reservoir AF	**Historic Climate Baseline S0 Modeled Shortages 50,000 Reservoir AF**	**Shortage Decrease AF**
Average	3,100	300	2,800
Wettest Ten Years	2,200	200	2,000
Middle Ten Years	2,400	200	2,200
Driest Ten Years	3,900	500	3,400
Driest 5 Years	5,000	800	4,200

Table 5.7: Modeled Frenchman Watershed Irrigation Depletion Shortages under Future Climate Conditions *S5* with and without a 50,000 AF Storage Reservoir

	Future Climate S5 Modeled Shortage Existing Reservoir AF	**Future Climate S5 Modeled Shortages 50,000 Reservoir AF**	**Shortage Decrease AF**
Average	4,200	600	3,600
Wettest Ten Years	2,900	200	2,700
Middle Ten Years	3,400	300	3,100
Driest Ten Years	5,300	900	4,400
Driest 5 Years	6,400	1,500	4,900

After the needs of the Frenchman River water users were met, there would be an additional 6,000 -9,000 AF per year that could be released for downstream irrigation demands on the Milk River in all but the very driest years when only very small releases could be made. Table 5.6 shows modeled decreases in shortages for Milk River irrigation crop water consumption needs with the 50,000 AF reservoir for *Scenario S5*. The modeled reductions in shortages are due both to releases made from the reservoir during times of low flow and high crop demand and an increase in return flow from lands irrigated on the Frenchman River downstream of the reservoir. The irrigation for the land served by Frenchman Reservoir was modeled with 30 percent efficiency.

Table 5.8: Modeled Decreases in Milk River Irrigation Depletion Shortages due to an Expanded Frenchman River Storage Reservoir

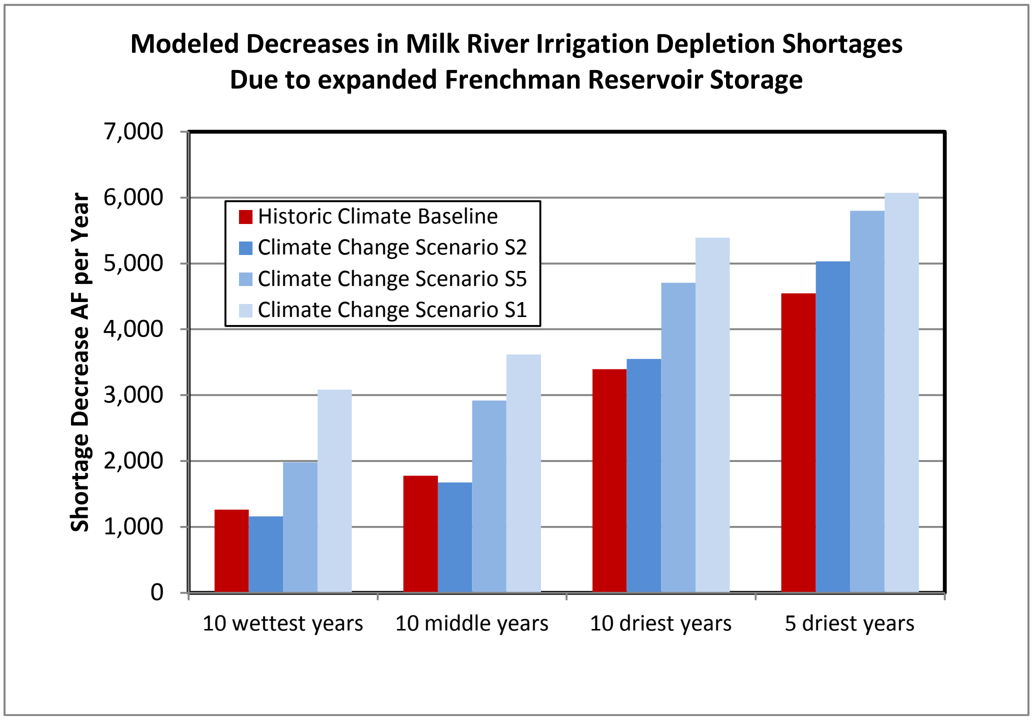
	***Scenario S5*: Shortages AF**	***Scenario S5*: With 50,000 AF Frenchman Reservoir Shortages AF**	**Annual Reduction in Shortages AF**
Average	104,000	101,000	3,000
Wettest Ten Years	75,000	73,000	2,000
Middle Ten Years	95,000	92,000	3,000
Driest Ten Years	137,000	132,000	5,000
Driest Five Years	169,000	163,000	6,000

Under both historic and future climate conditions, the benefits of the reservoir are modeled to be greatest during drier years. Modeled benefits also would be greater under the future climate scenarios because overall Milk River shortages would be higher with a warmer climate, the need for the stored water would be greater, and the Frenchman River Basin yields more water under most of the future climate scenarios due to projected higher average precipitation. Figure 5.8 graphically depicts the modeled decreases for Milk River irrigation depletion shortages and includes additional future climate scenarios. Because of its downstream position in the basin, the Frenchman Reservoir only has the potential to 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 might be relatively high except during times of drought. 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 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 birds. Because a larger Frenchman Reservoir could capture peak flows from a large drainage area, flooding on the lower portion of the Frenchman River and the Milk River might be reduced, especially if reservoir operations included flood-control criteria. This alternative would have no impact on Bowdoin National Wildlife Refuge.

Negative impacts associated with a larger reservoir would be inundated riparian and upland habitat used by existing wildlife populations. Homes near the reservoir might be affected if the existing dam were enlarged. Evaporation losses from the larger reservoir surface would be significant. Downstream of 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 the Frenchman River tributary also would result in lower peak flows downstream, which could have an adverse effect on native fish that spawn in the lower Milk River.

Figure 5.8: Modeled Decreases in Milk River Irrigation Crop Consumption Shortages due to expanded Frenchman River Reservoir Storage



New Storage on Milk River in Alberta Alternative

Description

This alternative evaluates a 237,000 AF new reservoir in Alberta, Canada just below the confluence of the North Fork on the Milk River main stem. Alberta has no reservoir to store and regulate Milk River flow, which results in an average of 36,000 AF per year of Canada's share of the river flowing into the U.S. 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 the Province of Alberta. Because the natural flow of the Milk River usually is below 666 cfs during the summer irrigation season (and often near zero), 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 26,000 acres in total.

Milk River in Canada

Evaluation

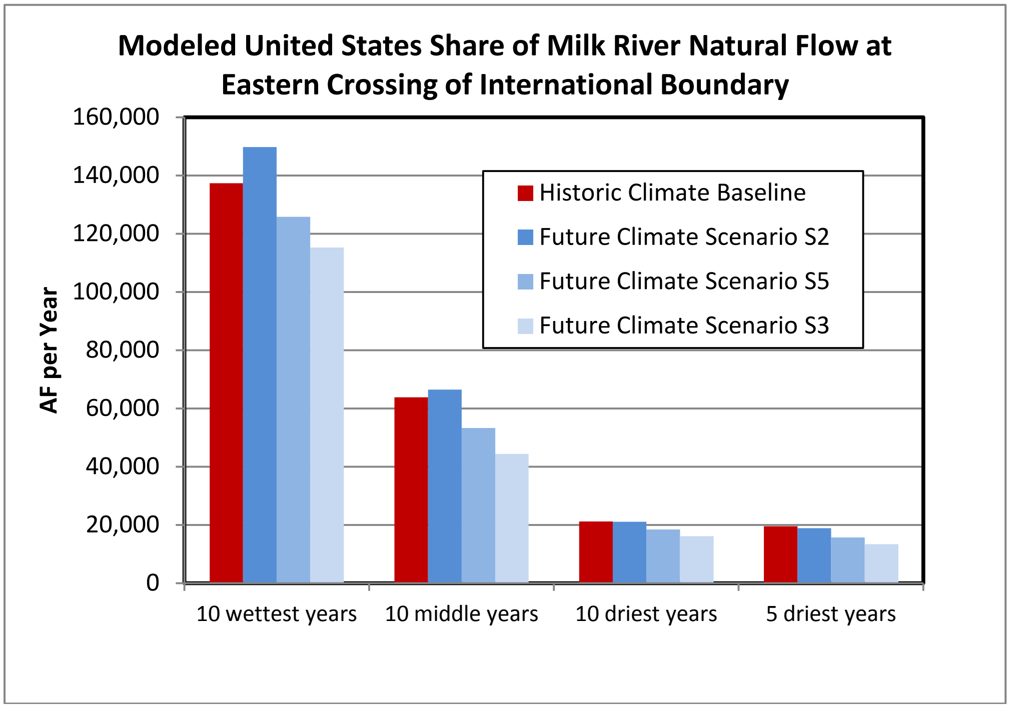
The 237,000 AF reservoir on the Milk River was modeled to provide water to 26,000 acres in Alberta. Reservoir operations were simulated to store only the Canadian share of Milk River natural flow to meet Alberta irrigation demands using the baseline and future climate scenarios.

Table 5.9 compares modeled Milk River flow decreases at the Eastern Crossing, with the Alberta storage reservoir, under baseline and *S5* 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 15-20 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 5.10).

Table 5.9: Modeled Flow Decreases for the Milk River at the Eastern Crossing with Alberta Milk River Storage Reservoir and Associated Irrigated Acres Expansion under the Historic Climate Baseline and Future Climate S5 Scenarios

	Annual Flow Volume Decrease Historic Climate Baseline AF	**Annual Flow Volume Decrease Future Climate S5 AF**
Average	28,000	24,000
Wettest Ten Years	52,000	47,000
Middle Ten Years	15,000	13,000
Driest Ten Years	7,000	7,000
Driest 5 Years	7,000	9,000

Figure 5.10: Modeled U.S. Share of Milk River at the Eastern Crossing under Historic Climate Baseline and Future Climate Scenarios



Canada would no longer benefit from the Letter of Intent if a reservoir was constructed, and it is unlikely that the LOI would be kept in place solely for the benefit of the United States. Therefore, the LOI was removed from the Alberta reservoir model simulation. The resulting decline in St. Mary Canal diversions adds some to the decrease in total flow at the Eastern Crossing.

With an Alberta storage reservoir, the U.S. would receive less Milk River natural flow from Canada (Tables 5.10 and 5.11) because the Alberta storage reservoir would allow Canada to use most, but not all, of its share. The primary reason why Alberta could not capture the entire Canadian share is that the reservoir would be located 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.

Table 5.10: U.S. Share and Natural Flow Delivered to the U.S. at the Milk River at Eastern Crossing before and after Alberta Milk River Storage Reservoir and Associated Irrigated Acres Expansion under the Historic Climate Baseline

	S0: US Share of Milk River Natural Flow, AF	**S0: Natural Flow Delivered to U.S. Without Reservoir, AF**	**S0: Natural Flow Delivered to U. S. With Reservoir, AF**
Average	71,000	103,000	76,000
Wettest Ten Years	121,000	183,000	126,000
Middle Ten Years	54,000	74,000	57,000
Driest Ten Years	24,000	30,000	28,000

Table 5.11: U.S. Share and Natural Flow Delivered to the U.S. at the Milk River at Eastern Crossing before and after Alberta Milk River Storage Reservoir and Associated Irrigated Acres Expansion under Future Climate *Scenario S5*

	S5: US Share of Milk River Natural Flow, AF	**S5: Natural Flow Delivered to U.S. Without Reservoir, AF**	**S5: Natural Flow Delivered to U. S. With Reservoir, AF**
Average	62,000	89,000	66,000
Wettest Ten Years	110,000	165,000	117,000
Middle Ten Years	47,000	63,000	49,000
Driest Ten Years	21,000	24,000	21,000

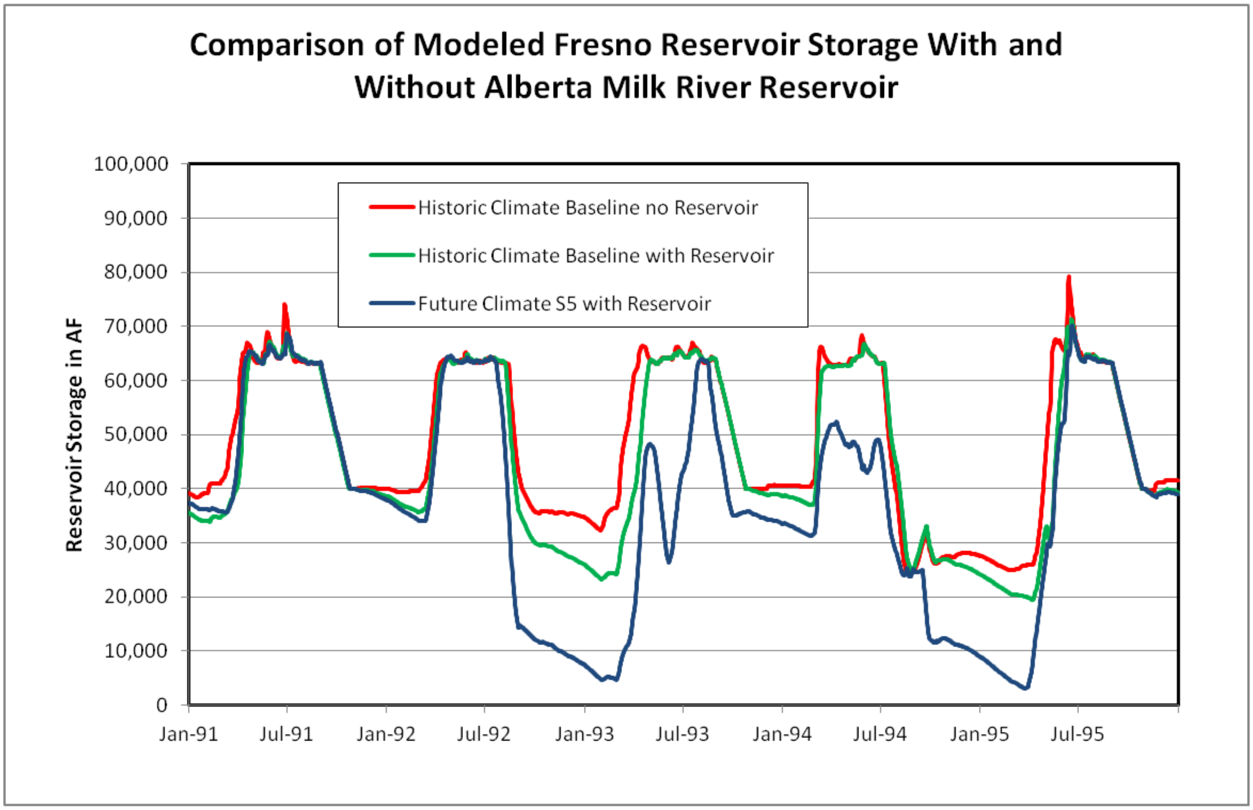
Because less Milk River natural flow would be available to the U.S., irrigation shortages for U.S. Milk River irrigators would increase some (Table 5.12). The decreases are smaller than might be expected because much of the flow that the Alberta storage reservoir would capture is higher spring flows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

Table 5.12: Modeled Milk River Crop Depletion Shortage Increases due to Alberta Milk River Reservoir Alternative under Baseline and Future Climate *Scenario S5*

	Scenario S0 Shortage Increase AF	***Scenario S5* Shortage Increase AF**
Average	2,000	3,000
Wettest Ten Years	3,000	3,000
Middle Ten Years	2,000	2,500
Driest Ten Years	1,000	4,000
Driest Five Years	2,000	4,000

Figure 5.11 depicts simulated Fresno Reservoir storage for a selected baseline period, with and without the Alberta storage reservoir, and under *S5* conditions. The amount of water stored in Fresno Reservoir would be less if the Alberta storage reservoir were built. The decreases in storage for *Scenario S5* are due to a combination of decreased natural flow at the Eastern Crossing and new Alberta storage.

Figure 5.11: Comparison of Modeled Fresno Reservoir Storage
with and without the Alberta Milk River Storage Reservoir



If the reservoir and associated increases in irrigation were developed in Alberta, Montana water users would no longer receive the surplus Milk River flows they have become 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 about 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. Lower lake levels would be detrimental to the reservoir fishery and reduce recreational opportunities. On the Milk River downstream of Fresno Reservoir, peak flows would be reduced. This could adversely affect riparian vegetation that relies on overbank and scouring flows for rejuvenation.

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 as well. Some local U.S. recreationists might take advantage of those nearby recreational opportunities across the border. 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 of the proposed dam location. 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. The Canadian dam also might have negative impacts on migratory and nesting bird habitat at Bowdoin National Wildlife Refuge.

Other Potential 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. 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 modifications to the model may be needed to adequately evaluate then.

- 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

- New Storage at Lower St. Mary Lake
- Sherburne Winter Low-Flow Releases
- Winter 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, and
- Hydropower
- Fort Belknap Indian Reservation Off-stream storage reservoir

Table 5.13: Alternatives for Meeting Water Demands Under Historic and Climate Change Conditions

Modeled Water Supply Impact	**Average AF**		**Wettest 10 Years AF**		**Middle Ten Years AF**		**Driest 10 Years AF**		**Driest 5 Years AF**				
Modeled Alternative	***Scenario S5 Without Alternative***	***Scenario S5 With Alternative***	***Scenario S5 Without Alternative***	***Scenario S5 With Alternative***	***Scenario S5 Without Alternative***	***Scenario S5 With Alternative***	***Scenario S5 Without Alternative***	***Scenario S5 With Alternative***	***Scenario S5 Without Alternative***	***Scenario S5 With Alternative***	**Description**	**Benefits**	**Potential Impacts**
Canal and On-Farm Efficiency Improvements (Total Milk River irrigation depletion shortages)	104,000	85,000	75,000	55,000	95,000	75,000	137,000	121,000	169,000	156,000	10% conveyance and 7% on-farm efficiency increases over baseline	Greatest irrigation benefit during normal to wet years when conveyance capacity is limiting factor, not water supply; improved crop projection	Less return flow for downstream use; less water leaving the basin; Increased crop consumption; Water quality
Rehabilitate St. Mary Canal for Increased Capacity (Annual diversions for 650 cfs and 850 cfs canal capacity)	196,000	214,000	188,000	227,000	209,000	225,000	169,000	173,000	148,000	150,000	Increase the St. Mary Canal capacity from 650 cfs to 850 cfs	Greatest irrigation benefit during normal to wet years; Divert more of U.S. share of St. Mary R. and improve Milk R water supply	Fishery impact in St. Mary R; Bank erosion upstream of Fresno Reservoir
Increase Fresno Reservoir Storage (Total Milk River irrigation depletion shortages)	104,000	96,000	75,000	67,000	95,000	88,000	137,000	128,000	169,000	160,000	Raise Fresno Dam Spillway Crest from elevation 2,575' to 2,580' increasing Year 2050 projected storage from 62,000 AF to 95,400 AF	Greatest irrigation benefit during drier years; preserves incidental benefits	Greater reservoir storage fluctuation; Continued storage loss
Expanded Frenchman River Reservoir (Total Milk River irrigation depletion shortages)	104,000	101,000	75,000	73,000	95,000	92,000	137,000	132,000	169,000	163,000	Evaluate Frenchman Res. storage capacity increase from current 3,000 AF to 50,000 AF	Greatest irrigation benefit during drier years; Provide water for Frenchman Water Users and additional 6-9,000 AF water for downstream users in Milk R.; Increased recreational opportunity	Homes near Frenchman Res might be affected if reservoir is enlarged; Potential effects to downstream riparian areas
New Storage on Milk River in Alberta (Annual Milk River natural flow available to U.S. at Eastern Crossing)	89,000	66,000	165,000	117,000	63,000	49,000	24,000	22,000	23,000	22,000	Evaluate a 237 KAF reservoir below the confluence of the North Fork, Milk R. With another 26,000 irrigated acres in Alberta.	Possibly slow sedimentation rates in Fresno Res.; Might provide additional storage opportunity for U.S. share of St. Mary and Milk Rivers.	Canada utilizes most of its share of the Milk R.; LOI no longer benefits useful. Reduced recreational benefits in U.S.

Chapter 6: Findings and Recommendations

The purpose of this Basin Study is to create and test a river system model or “tool” that would be acceptable to all stakeholders to assist in analyzing a range of potential alternatives that could address present and future water needs in the St. Mary River and Milk River basins. The Basin Study also provides a first look into what future water supplies and demands might be, and how the existing infrastructure performs when trying to meet these future demands. This Chapter will summarize findings and make recommendations for advancing the model beyond this study, and therefore provide the best model for stakeholders to use for future planning activities. It also will discuss some of the findings for the alternatives that were examined in this study, and will discuss other alternatives, or combinations of alternatives, that might be examined with the model in the future.

Findings

Water shortages occur for the Milk River irrigators every year for the existing climate and baseline conditions. For purposes of this report, shortage is the volume of unmet crop water demand. Modeled shortages average 68,000 AF annually, which is 35 percent of the crop irrigation demand. During the driest years, shortages are modeled to be 42 percent of demand.

Overall, streamflow for the region is projected to increase for the central tendency and most climate change scenarios for 2050. These increases in flow though would be modest; the median streamflow of the St. Mary River is expected to increase 3,700 AF, and the median streamflow of the Milk River at the mouth is expected to increase 15,000 AF, for a total increase of 18,700 AF. Although 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 Milk and St. Mary basins, with wetter years producing more runoff than in the past and drier years producing disproportionally less runoff. An earlier shift in runoff timing also is projected for most in the subbasins of the St. Mary 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 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 scenarios. 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 and 29 percent as compared to the existing climate, or between 51,000 and 56,000 AF. By year 2050, increases in runoff, if it could all be captured and used, is expected to only make up for between 33 and 37 percent of the expected increase in crop irrigation depletions. During dry years, when runoff might decrease, shortages increases are modeled to be relatively higher.

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 in the future. Because the natural flow of the Milk River might be somewhat less in the future, the overall volume of flow in the Milk River at the Eastern Crossing might be similar to, or perhaps a little bit higher, in the future than today. On the other hand, losses in storage due to sedimentation in Fresno Reservoir would contribute to a decrease the ability of the Milk River Project 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 for the central tendency climate projection indicates that total Milk River irrigation shortage would increase by an average of about 32,000 AF, to a total average shortage of 104,000 AF for projected 2050 climate conditions.

Recommendations

Several alternatives for meeting future demands were analyzed in this Basin Study. Although it was not the intent of this study to make recommendations for future feasibility level studies, the findings do provide some insights on the potential that these alternatives might have. General findings for each alternative are discussed below.

Canal and On-Farm Water Use Efficiency Improvements

The efficiency of canals and ditches that deliver Milk River water and the efficiency of systems that apply the water to irrigated fields could be improved, and this would decrease shortages for Milk River irrigators. Ditch efficiencies could be improved by reducing seepage losses, and in some cases increasing capacities, so that peak demands could be met. On-farm efficiency could be improved through more efficient flood irrigation water distribution, and by converting some flood irrigation to sprinkler irrigation. In this report, and overall efficiency increase of 17 percent was examined.

Improving efficiencies was found to be alternative with 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.

Increasing the capacity of the St. Mary Canal

Increasing the capacity of the St. Mary Canal would allow the U.S. to use more of its share of St. Mary River water and reduce shortages for Milk River irrigators. Water availability and the flow apportionment with Canada though would limit the use of that extra capacity during much of the time. For example, during very dry years the U.S. already is able to take most if not all of its share of St. Mary River flow with a 650 cfs capacity canal. During years when the canal capacity isn't the limiting factor, a higher capacity canal might only allow the U.S. to more quickly move Sherburne Reservoir stored water across from the St. Mary to Milk River. Still, a larger canal would allow the U.S. to bring substantially more St. Mary River water to the Milk River during most years. On average, the U.S. might be able to bring across 15,000-20,000 AF more water in the future with an 850 cfs St. Mary Canal. Some but not all of this water would be effective at decreasing irrigation shortages. On average, crop consumption shortages might be decreased by about 5,000 AF per year with an 850 CFS canal.

Increasing Fresno Reservoir Storage

The continued loss of storage capacity in Fresno Reservoir is increasing irrigation shortages. Fresno Reservoir is losing storage to sedimentation and this storage loss is expected to continue into the future. At current rates of sedimentation, by 2050, the active storage of the reservoir is expected to be about 62,000 AF . This is less than half of the storage of about 130,000 AF when the reservoir was completed in 1939.

For the shorter term, losses in storage might be offset by putting a control structure on the reservoir spillway that could increase the maximum usable water surface elevation by 5 feet. This would regain about 27,000 AF of lost storage. During most years, this extra storage might decrease crop consumptive use shortages by about 8,000 AF. Shortage reductions might even be a little higher during dry years, when the water is most needed. The increase in water surface elevation also would help to maintain the existing reservoir fisheries and recreational values.

Expanded DNRC Frenchman Reservoir

The DNRC reservoir on the Frenchman River has lost about 60 percent of its original capacity to sedimentation, which has substantially decreased the volume of contract water it can deliver to water users on that stream. An expanded reservoir would decrease water shortages to Frenchman water users and might provide some additional water for irrigators on the Milk River downstream. Because of the enormous year-to-year variability of the flow of the Frenchman River, a quite large reservoir would need to be constructed to provide a reliable year-to-year water supply to both of these groups of users. A 50,000 AF reservoir was modeled, and shortages for Frenchman River water users were eliminated in all but the driest years. This size reservoir might also reduce crop depletion shortages by about 4,000 AF per year for downstream water users on the Milk River, with slightly higher benefits possible during dry years.

New Storage on the Milk River in Alberta

A new storage reservoir on the Milk River in Alberta, with associated irrigation expansion, has the potential to decrease water supplies for U.S. Milk River irrigators. The flow of the Milk River at the Eastern Crossing might be reduced by about 25,000-30,000 AF on average; during middle to dry years reductions would be 7,000-15,000 AF. Because such a reservoir primarily would capture and store higher peak flows, shortages to U.S. irrigation crop depletions needs might only be about 2,000-5,000 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 benefit of shared Milk River storage to U.S. Milk River water users.

Combinations of Alternatives

If some of the alternatives above were combined, benefits to water users could be increased. Because the benefits of each alternative likely overlap to some degree, it is unlikely that benefits would be additive. The river system model could be used to analyze combinations alternatives and to determine which combinations optimized benefits.

Federal Reserved Water Rights

The Blackfeet Tribe and the Fort Belknap Indian Community have water compacts with the State of Montana. Currently, there is legislation before Congress for the Blackfeet Tribe and the Ft. Belknap Tribes are preparing legislation. Settlement acts approved by Congress typically address funding of potential tribal projects to develop reserved water, and may detail the level of federal agency involvement. Although the compacts quantify the volume of water that the tribes could eventually develop, the types of projects actually developed could significantly affect the "choice" of what alternative or plan is suitable for study at the feasibility level. The river system model could be used in the future to evaluate possible Tribal water development projects, and the potential impact of these projects on other water users.

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 recommends the following:

- DNRC and Reclamation intend to utilize this model in the coming years to address regional water needs. There will be a need to regularly update the models This would include annual updates to most recent streamflow and water use information, any new information about the basin as it becomes available, and keeping the model current with RiverWare ™ software updates

- A comprehensive study of groundwater/surface water interaction in the Milk River valley related to irrigation and the fate of irrigation return flows, and update the model to allow it to better simulate return flow
- Continue joint efforts with Federal, Tribal, State, and water users, on collecting data and monitoring canal diversions; with additional data the models calibration and predictive capabilities can be improved
- Expand the river system model to more comprehensively model water supply and water uses on the larger Milk River tributaries
- Expand the models capability to analyze irrigation system improvements by accounting for canal efficiencies and irrigation field efficiencies separately in the model
- Add accounting capabilities that allow the model to track the current semi-monthly balancing of the U.S. and Canadian shares of Milk and St. Mary River natural flow
- Annually update the DNRC management and the Federal Negotiating Teams on the river system model status so they are informed of the ability of the model to simulate proposed projects by the Tribes to move water settlements forward
- Explore the capability and utility in modeling water quality data
- Update the model to include any refined climate change projections.

Chapter 7: Coordination and Consultation

Public Involvement

Public involvement is an important part of this study processes. It serves as the public's opportunity to provide input of different interest, assist in defining issues, brainstorm model scenarios, help identify constraints, and to review results. In 2010, Reclamation and DNRC began a public involvement process to provide the public, organizations, stakeholders, government agencies a way to provide comments and to learn about the St. Mary-Milk River Basin Study. Reclamation and DNRC developed a public involvement strategy to include:

- Meetings for information sharing and evaluating level of interest
- Meetings with stakeholders to define issues, modeling scenarios, and constraints
- Regular status meetings with stakeholders to report progress and review interim results
- A draft St. Mary River and Milk River Basin Study Report for review and comment by stakeholders
- Distribution of the final report and model

Stakeholders

- *Milk River Joint Board of Control:* The JBOC consists of representatives from the eight irrigation districts that comprise the Milk River Project. Works with Reclamation in developing annual operations plans and in setting annual water allotments.
- *St. Mary Rehabilitation Working Group:* The SMRWG is a group of stakeholders that seeks rehabilitation of the St. Mary Canal. It includes representatives from irrigation district, Indian Tribes, municipalities, counties, recreational groups, and local economic development groups.
- *Blackfeet Tribe:* Administers Blackfeet Indian Reservation in the headwaters of the St. Mary and Milk River watersheds. Has substantial Federal Reserved Water Rights in both watersheds.
- *Fort Belknap Indian Reservation:* The Gros Ventre and Assiniboine Tribes of the Fort Belknap Indian Reservation have substantial Federal Reserved Water Rights to the natural flow of the Milk River and some tributaries.
- *Montana Department of Fish, Wildlife, & Parks (MFW&P)*: Responsible for management of Fish and Wildlife Resources in the State of Montana, including interests in the lower Milk River watershed.
- *International Joint Commission*: The IJC, established by Boundary Waters Treaty of 1909, has six members appointed by the governments of Canada and the U.S.

- *U. S. Fish and Wildlife Service*: Responsible for compliance with the Endangered Species Act and manages Bowdoin National Wildlife Refuges in the Milk River Basin.

Other Stakeholders:

- U. S. Geological Survey
- U. S. Bureau of Indian Affairs
- U. S. National Park Service
- Province of Alberta, Canada
- University of Lethbridge, Alberta, Canada

Consultation and Review

Reclamation and DNRC informed stakeholders of the study goals and timelines by attending regular scheduled meetings of stakeholder groups. As the study progressed and model results became available, specific meetings were scheduled with stakeholders to solicit input for developing alternatives to model. Input from these meetings on modeling other alternatives are described in Chapter 5.

Milk River Project Joint Board of Control

In March, 2010, Study Team members met with the Joint Board of Control at a regular meeting of the Board. The plan of study was presented and discussed. Board Members were invited to contribute options and ideas for the model. DNRC and Reclamation staff gave the Board an update at their meeting in October 2011 with an overview of the river system model, climate change analysis, and presentation of preliminary model results.

St. Mary Rehabilitation Working Group

Members of the study team met with the St. Mary Rehabilitation Working Group in May, 2010 to introduce this Basin Study and invite its members to participate. Updates were provided at meetings on August, 2010. The SMRWG was updated in October 2011 with an overview of the river system model, climate change analysis, and presentation of preliminary model results.

Indian Tribes

Blackfeet Nation

Members of the Study Team met with the Blackfeet Tribe in March, 2010 to introduce the Basin Study and to invite Tribal participation. Updates were provided during subsequent meetings in April, 2011, and August, 2011.

Fort Belknap Indian Community

No formal meetings with the Fort Belknap Indian Community have been held; however, members of the Study Team have had informal meetings with Tribal staff. Members of the Tribal Council have been unavailable to meet.

Federal and State Agencies

DNRC and Reclamation met with other state and federal agencies in May, 2010. Those in attendance included the Montana Departments of Environmental Quality (DEQ); Fish, Wildlife and Parks (FW&P); U.S. Geological Survey (USGS); National Park Service; U.S. Fish and Wildlife Service; U.S. Bureau of Land Management; and the U.S. National Resources and Conservation Service. Reclamation held a meeting with state and federal agencies in September, 2011. Those in attendance included the USGS, DEQ, and U.S. Fish and Wildlife Service. The agencies were given a presentation on the river system model, climate change analysis, and preliminary model results were discussed.

Professional Organizations

DNRC presented an overview of the River Basin Study and discussed some preliminary findings to the Montana Chapter of the American Water Resources Association at their annual meeting in Great Falls, MT on October 7, 2011.

IJT and Canadian counterparts

As part of the Montana/Alberta Joint Initiative Team (JIT), DNRC has informed their Canadian counterparts of the Basin Study and invited their participation. Representatives from the University of Lethbridge have shown some interest in the climate change work included in the study. Copies of all climate change studies and investigations have been shared with interested Canadian parties.

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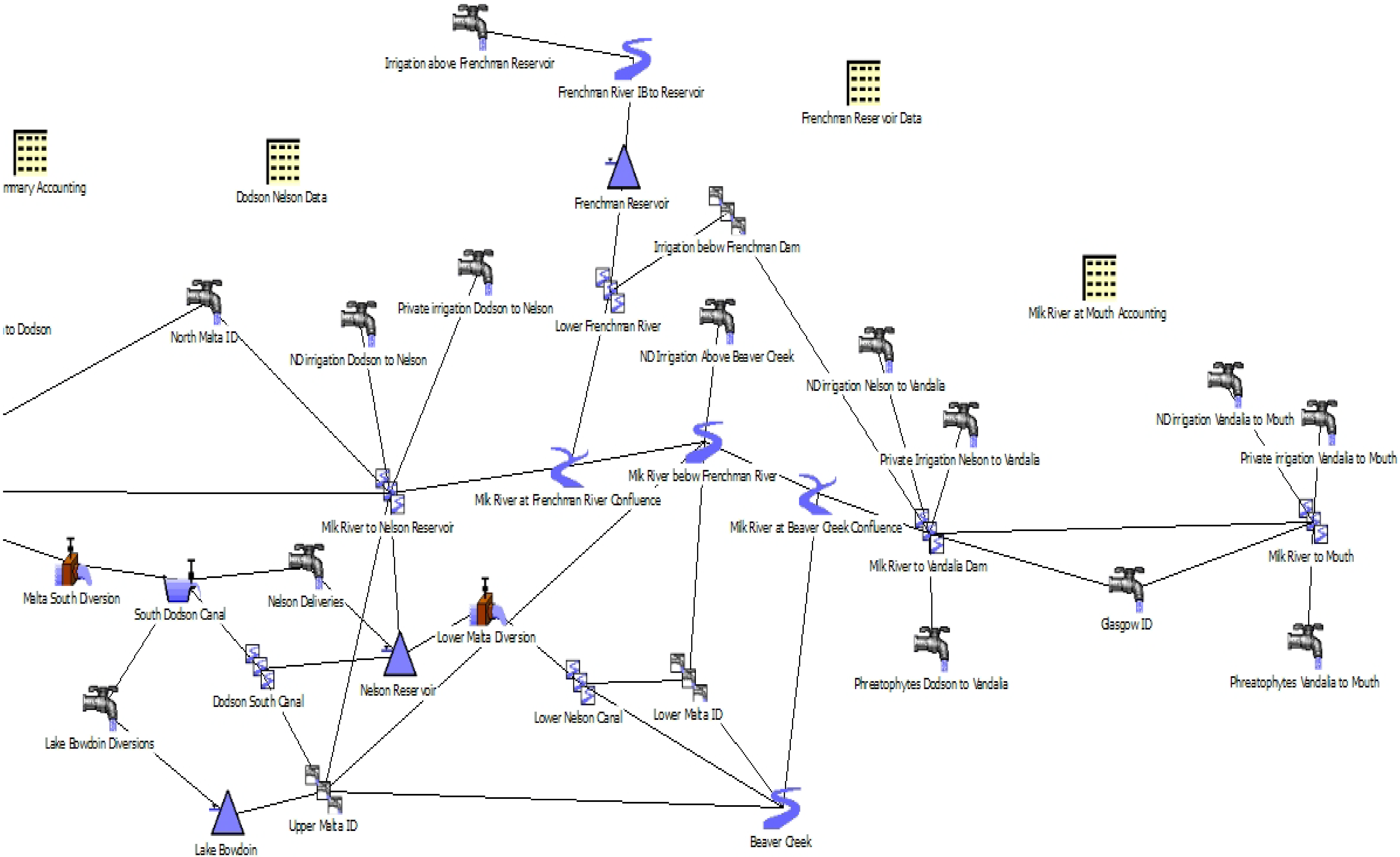
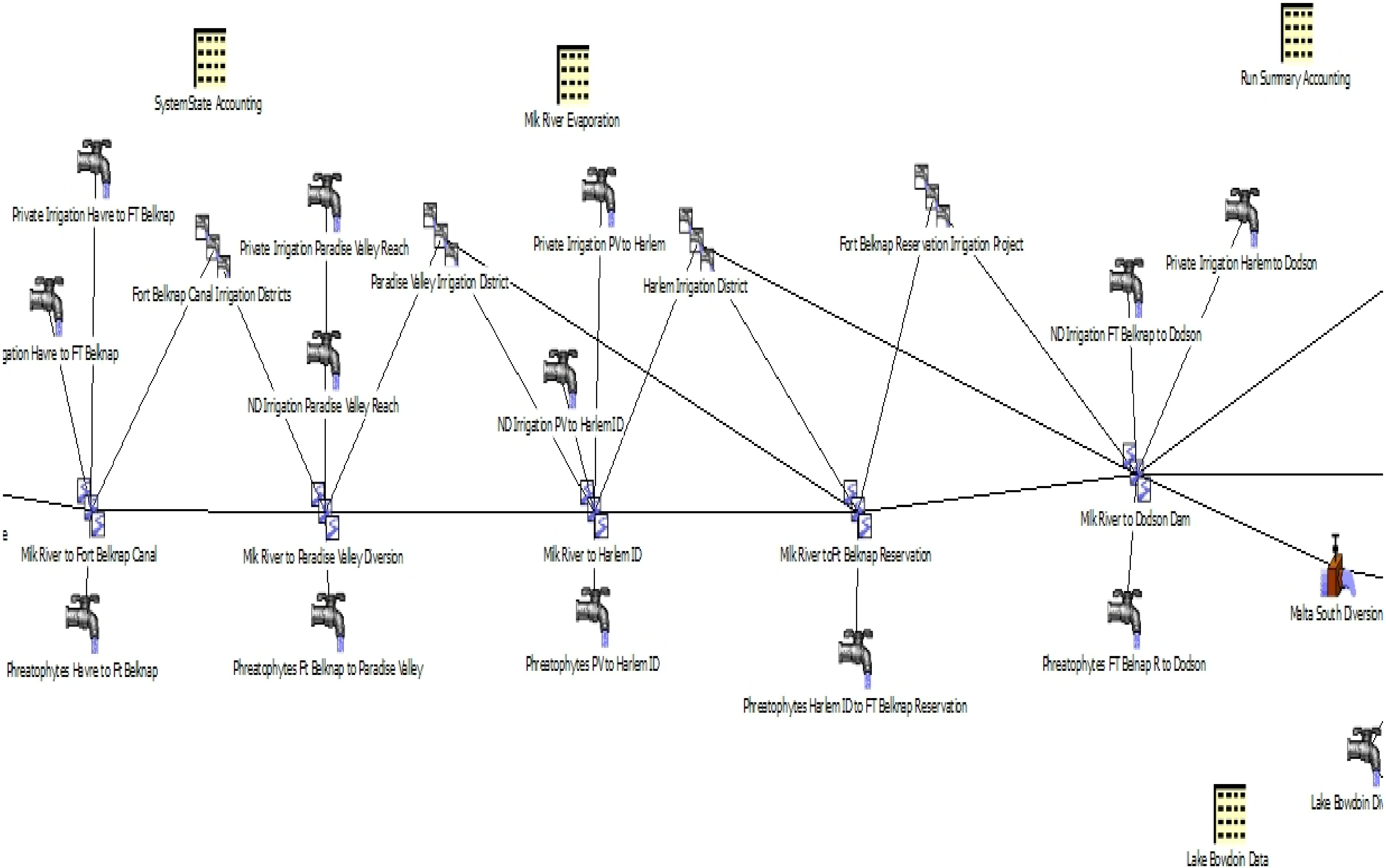
Supporting Information

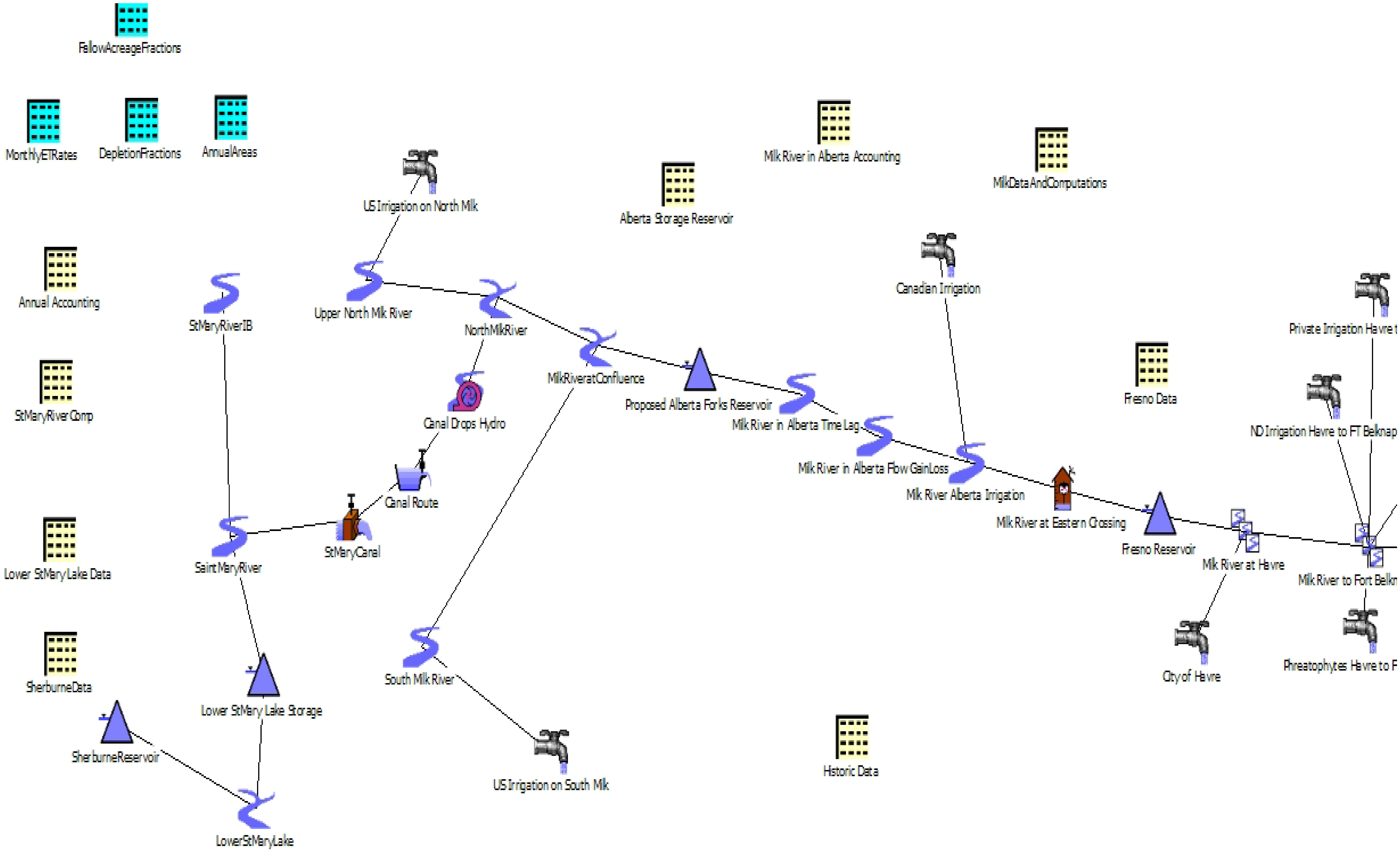
Appendix: Schematic of the River System Model



Irrigation above Frenchman Reservoir
Frenchman River IB to Reservoir
Frenchman Reservoir Data
mmary Accounting
Dodson Nelson Data
Frenchman Reservoir
Irrigation below Frenchman Dam
Milk River at Mouth Accounting
Private irrigation Dodson to Nelson
Lower Frenchman River
to Dodson
North Malta ID
ND irrigation Dodson to Nelson
ND Irrigation Above Beaver Creek
ND irrigation Nelson to Vandalia
ND irrigation Vandalia to Mouth
Private Irrigation Nelson to Vandalia
Private irrigation Vandalia to Mouth
Milk River below Frenchman River
Milk River at Frenchman River Confluence
Milk River to Nelson Reservoir
Milk River at Beaver Creek Confluence
Milk River to Vandalia Dam
Milk River to Mouth
Malta South Diversion
South Dodson Canal
Nelson Deliveries
Lower Malta Diversion
Glasgow ID
Nelson Reservoir
Dodson South Canal
Lower Nelson Canal
Lower Malta ID
Phreatophytes Dodson to Vandalia
Phreatophytes Vandalia to Mouth
Lake Bowdoin Diversions
Upper Malta ID
Lake Bowdoin
Beaver Creek



SystemState Accounting
Mlk River Evaporation
Run Summary Accounting
Private Irrigation Havre to FT Belknap
Private Irrigation Paradise Valley Reach
Paradise Valley Irrigation District
Private Irrigation PV to Harlem
Harlem Irrigation District
Fort Belknap Reservation Irrigation Project
Private Irrigation Harlem to Dodson
Fort Belknap Canal Irrigation Districts
ND Irrigation FT Belknap to Dodson
ND Irrigation Paradise Valley Reach
ND Irrigation PV to Harlem ID
Mlk River to Fort Belknap Canal
Mlk River to Paradise Valley Diversion
Mlk River to Harlem ID
Mlk River to Ft Belknap Reservation
Mlk River to Dodson Dam
Malta South Diversion
Phreatophytes Havre to Ft Belknap
Phreatophytes Ft Belknap to Paradise Valley
Phreatophytes PV to Harlem ID
Phreatophytes Harlem ID to FT Belknap Reservation
Phreatophytes FT Belknap R to Dodson
Lake Bowdoin Data



FallowAcreageFractions
MonthlyETRates
DepletionFractions
AnnualAreas
US Irrigation on North Milk
Alberta Storage Reservoir
Milk River in Alberta Accounting
MilkDataAndComputations
Annual Accounting
StMaryRiverIB
Upper North Milk River
NorthMilkRiver
Canadian Irrigation
Private Irrigation Havre t
StMaryRiverComp
MilkRiveratConfluence
Proposed Alberta Forks Reservoir
Fresno Data
Canal Drops Hydro
Milk River in Alberta Time Lag
ND Irrigation Havre to FT Belknap
Milk River in Alberta Flow GainLoss
Canal Route
Milk River Alberta Irrigation
Milk River at Eastern Crossing
Lower StMary Lake Data
Saint MaryRiver
StMaryCanal
Fresno Reservoir
Milk River at Havre
Milk River to Fort Belkn
City of Havre
Phreatophytes Havre to F
SherburneData
South Milk River
Lower StMary Lake Storage
SherburneReservoir
US Irrigation on South Milk
Historic Data
LowerStMaryLake