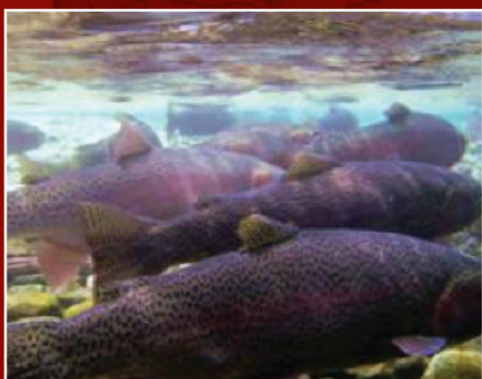
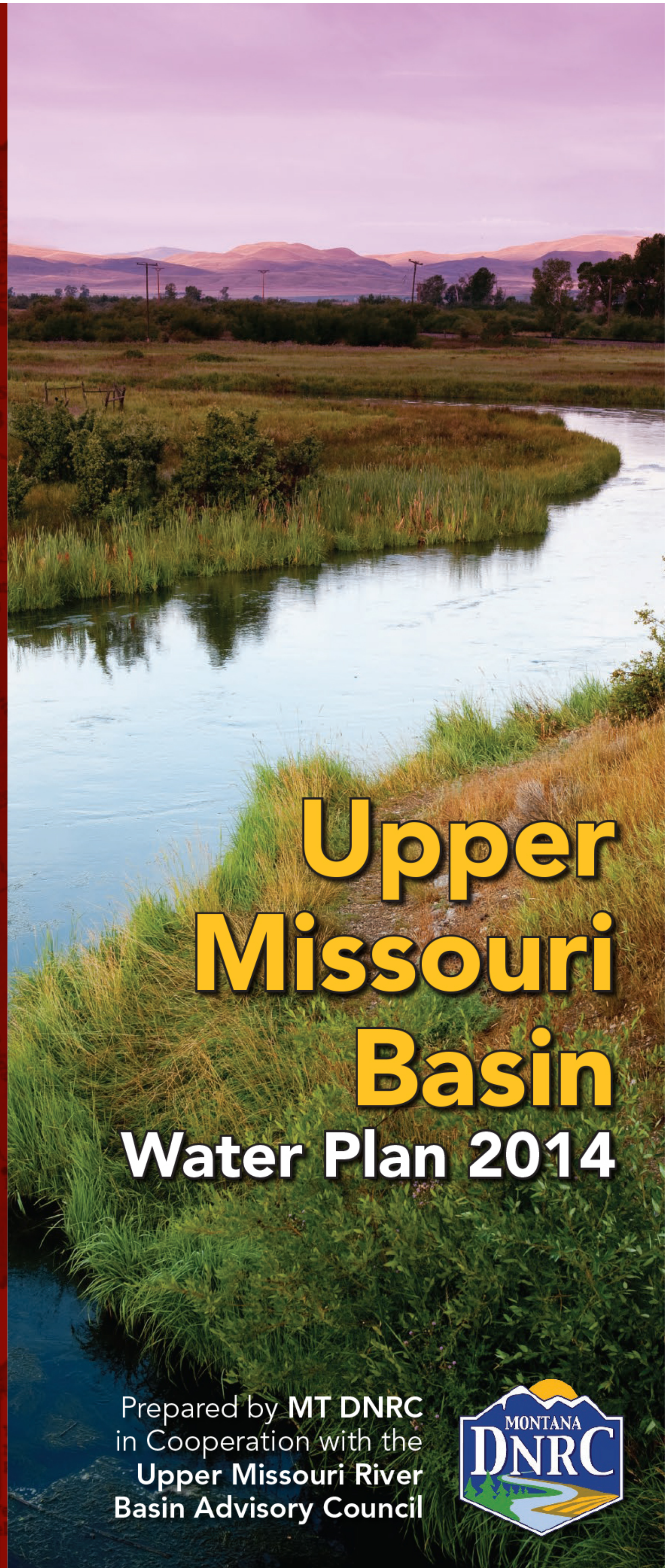




Upper Missouri Basin

Water Plan 2014

Prepared by **MT DNRC**
in Cooperation with the
Upper Missouri River Basin Advisory Council

MONTANA DNRC

I. Table of Contents

II. Executive Summary

The Upper Missouri Basin is a treasure with its own distinguishing water story that makes it a unique place to live, work and visit. It is the headwaters to the continent, spanning the Rocky Mountain front and two major national parks. It is rich in agricultural tradition and beautiful productive irrigated valleys. Unsurpassed fishing and recreational opportunities attract locals as well as people from around the world. The basin is also a place of rapidly expanding urban and business development and economic growth. But the challenge that rises above all others is the fact that most of the Upper Missouri Basin is generally closed to new surface water appropriations, and options for putting water to beneficial use will probably require changing existing rights, mitigation or contracting water from Bureau of Reclamation facilities in the basin.

The Upper Missouri Basin Advisory Council took all of these factors to heart as it developed recommendations on future water management in the Upper Missouri Basin. The Council decided to present its water plan recommendations in the context of 12 issue areas: Conjunctive Surface water/Groundwater Management; Adjudication; Storage; Instream Flow; Local Cooperative Efforts; Water Use Efficiency and Conservation; Integrated Water Quality and Quantity; Water's Role in the Economy; Water Information Systems; Available Water Supply and Climate Change; Water Transfers and Marketing; and Large Scale Factors, but was quick to recognize that all 12 issues are highly interrelated. Each of the issue areas and objectives are summarized below and the detailed specific recommendations can be found in Section X of this report.

The Upper Missouri Basin Council thoughtfully stressed three core conditions essential to representing the people, livelihoods, and resources of the Upper Missouri River Basin. The first is that all 62 of the Council's recommendations recognize and support the Prior Appropriation Doctrine and its protection of multiple uses and existing water rights. None of these recommendations should infringe on the Prior Appropriation Doctrine and valid existing water rights. The second is that, like the issues themselves, all recommendations presented are highly interrelated and difficult to consider in isolation. For example, many recommendations deal with improving water-use and management efficiencies that, if carried out, could have both positive and negative impacts. In many cases, systems are already in place, but the recommendations call for additional tools to improve systems management. Finally, it is the ardent hope of the Council that this report does not reside on a shelf, but that it is revisited often as a living document to be updated regularly, especially in a way that keeps local efforts highly engaged. In this regard, the Council hopes to continue to participate and contribute on a regular basis.

CONJUNCTIVE SURFACE WATER/GROUNDWATER MANAGEMENT

Goal: Improve Management of Surface Water and Groundwater as a Conjunctive Resource

Surface water and groundwater are invariably connected, and withdrawal from or reduced recharge to one can significantly affect availability of the other. Common examples in the Upper Missouri Basin include the degree to which well pumping reduces surface water flow, and where shifts from flood to sprinkler irrigation can, by changing the amount and timing of return flow, decrease aquifer recharge. Several state, federal and local agencies routinely collect data on groundwater quality and quantity. Although the agencies work together, at times they make management or permitting decisions internally without integration of all data, or without optimal data. Exempt wells are a topic of great importance in the Upper Missouri Basin. In particular there is broad agreement that exempt wells should not impact senior water rights, and the Council believes that resolution of the exempt well issue is imperative. The BAC supports

cooperative efforts to integrate, share, and analyze the data needed to conjunctively manage surface water and groundwater resources.

Objectives

1. Groundwater and surface water resources are conjunctively managed by DNRC and the Montana Department of Environmental Quality (DEQ)
2. Exempt wells are allowed and managed within the original intent of the legislation.

ADJUDICATION

Goal: Complete an Accurate and Enforceable Water Rights Adjudication

The Statewide Adjudication Process is critical to all water users in the Upper Missouri River Basin, and the Council recognizes that it is already occurring at an accelerated pace. When completed, it will produce enforceable Final Decrees of all historic water rights. Water users in the basin are anxious to complete decrees and resolve issues of enforcement, which are important not only to water users and managers in the basin, but also for protecting Montana’s interests against illegal uses of water and downstream claims.

Objectives

1. Decrees are accurate and enforceable in the Upper Missouri Basin.
2. Management roles of the Water Court, District Court and DNRC are well defined.
3. The public recognizes the value and outcomes of the d process, and is engaged through informative public education.
4. The Confederated Salish and Kootenai Tribal water compact is successfully endorsed and passed during the 2015 Legislative session.

STORAGE

Goal: Increase Water Availability through Storage and Retention

With much of the Upper Missouri River Basin closed to new appropriations, many stakeholder groups hope to find options for additional water storage using a variety of methods. Stakeholders point to a desire to capture high flows earlier and retain them in the basin longer for additional flexibility in the late season and to accommodate expanded demand. An increase in natural storage capacity is desirable because of its cost effectiveness and ecosystem benefits.

Objectives

1. There is public understanding of the costs and benefits of built and natural storage to increase the flow of water in the basin when it is most needed.
2. There is recognition of the public costs and benefits of both built and natural storage options in decision-making and state funding allocations.
3. Existing storage facilities (built) are retrofitted, where feasible, to increase storage capacity and uses.

INSTREAM FLOW

Goal: Maintain and Enhance Instream Flow

Instream flow pertains to streamflow in rivers and streams used non-consumptively for fish and wildlife, channel maintenance, habitat conservation, recreation, and hydropower. There is a broad recognition that streams and rivers in the Upper Missouri Basin are already heavily utilized for many purposes, yet future

water management should strive, when possible, for streamflow conditions that maintain or restore the desired ecological functions and processes, typically but not always, similar to those exhibited in their natural state.

Objectives

1. More tools are available to protect or enhance instream flows within the prior appropriation framework.
2. Instream flows preserve ecological functions and natural processes.

LOCAL COOPERATIVE EFFORTS

Goal: Expand General Support for Conservation Districts, Local Watershed Groups and Water Quality Districts

Community-based, local watershed groups, water quality and conservation districts, and other informal cooperative efforts are vital connections between water resource agencies and knowledgeable stakeholders. These groups bring diverse water users together to identify, design and implement water management solutions that address local and statewide goals.

Objective

1. There is recognition of on-the-ground water-issue expertise and awareness that local water and land management groups offer; agencies support and make use of this local expertise.

WATER USE EFFICIENCY AND CONSERVATION

Goal: Improve Water Use Efficiency and Conservation

With limited supplies, water use efficiency is playing a bigger role in the Upper Missouri Basin, especially in ranching and municipal operations. Many irrigators are converting their fields from flood to sprinkler irrigation systems to decrease labor costs and to improve crop yields. People recognize that these changes in irrigation practices can affect the hydrologic regime and return flow rates.

Objectives

1. Water use efficiency improvements are in place. There is recognition that certain irrigation methods can have return flow benefits, and that irrigation methods have trade-offs among all water users.
2. Municipal water systems promote and employ water conservation measures wherever feasible.
3. There is public awareness of the effects of water use efficiencies and mitigation measures on local basin hydrology.

INTEGRATED WATER QUALITY AND QUANTITY

Goal: Advance Integrated Water Quantity and Quality Management

The direct relationship between water quality and quantity in a basin with little unappropriated water underscores the importance of their integrated management. Low streamflows can be a major trigger of water quality concerns as problems intensify when pollutants like nutrients, metals, pathogens, and salinity concentrations are present at low flows. Warm water temperature is also a major water quality and fisheries concern associated with low flows.

Objective

1. Systems are in place to integrally manage water quality and water quantity.

WATER'S ROLE IN THE ECONOMY

Goal: Recognize the Role of Water in Montana's Growing Economy

Even though most of the Upper Missouri Basin is sparsely populated, its urban and industrial centers generate a robust economy and compliment Montana's rich agricultural and outdoor recreation traditions. The Upper Missouri Basin has 31% of Montana's population, nearly 23 % of Montana's land area, almost half of Montana's irrigated agricultural lands (more than 1,000,000 acres), and accounts for 46% of all fishing in the state. Given that population growth is inevitable in the basin; careful attention is needed to assure sustainable economic development while protecting senior users and instream resources. Accelerated changes in land and water use, and the need to better manage those changes, are drivers of this issue.

Objectives

1. The Prior Appropriation Doctrine and current water uses and conveyances are protected and recognized as supporting the economy.
2. There are incentives and protections to efficiently use and conserve water, and to allow for transfer to other uses while protecting senior users.
3. Municipal water supplies and infrastructure are managed to accommodate economic development and population growth.

WATER INFORMATION SYSTEMS

Goal: Increase Scope of and Access to Centralized Water Data

Water data collection in the Upper Missouri Basin is the responsibility of several federal, state and local agencies that monitor streamflow, snowpack, well levels, temperature trends, habitat composition and water quality. This is all good, but there are two prominent issues. First, water data collection is varied and highly dispersed among several groups, making access to data complex, time consuming and decentralized. In addition, and probably a bigger issue, is the difficulty of accurately describing local water availability where there are not enough real-time data or monitoring sites.

Objectives

1. Surface water, groundwater and snow data collected by all state, federal, local and private entities are accessible from one portal managed by the State Library Natural Resource Information System (NRIS) Water Data System.
2. New stream gages, monitoring wells and snow monitoring sites are installed and managed, and hydrologic monitoring techniques are employed, to characterize hydrologic conditions in areas of special interest and collaboration in the Upper Missouri Basin.

AVAILABLE WATER SUPPLY AND CLIMATE CHANGE

Goal: Protect Available Water Supply and Develop Strategies in Response to Climate Changes

Climate change and shifting weather patterns affect the amount and distribution of precipitation, and whether that precipitation occurs as rain or snow. As a result, streamflow is likely to change in the Upper Missouri basin in amount, timing and distribution. In response, water users are learning to adapt to changes in streamflow, growing season and irrigation demand. Ultimately, management agencies and stakeholders will need to adapt to these shifts in their land- and water-use practices and in their decisions to protect water supplies.

Objectives

1. Adaptive management strategies are in place that respond to shifts in growing seasons and streamflow.
2. Forests and rangelands are managed to protect cost-effective natural storage potential and watershed health (optimal forest density, wetlands integrity, reduced soil erosion, etc.); these measure have a direct impact on water quality.

WATER TRANSFERS AND MARKETING

Goal: Analyze the Scope of Water as a Transferable Property by Exploring Additional Opportunities for Water Marketing, Mitigations and Banking

Most western water allocation regimes evolved during periods of relative abundance and are not well suited to allowing new uses during times of water scarcity. Montana can lead the world in its innovative approaches to address scarcity as there are both unique opportunities for and concerns about water transfers and the need to plan for more water transactions. Water marketing, mitigation, aquifer recharge and water banking each offer distinct functions and opportunities, and understanding their nuances is the first step for water users in the Upper Missouri Basin. The potential for water marketing (the sale of water or the water right by the owner) is high in the Upper Missouri, especially in a closed basin where the value of water increases with new water demands.

Objective

1. Water marketing tools are effectively used as an option to assure fair and effective basin-wide water use.

LARGE SCALE FACTORS

Goal: Assess Selected Large-Scale Factors

Certain large-scale factors like quantification of the Confederated Salish and Kootenai Tribal (CSKT) reserved water rights through the proposed water rights compact with the state, perfection of state water reservations, implications of the Endangered Species Act, and downstream demands of the federal managed mainstem dams, could impact future water availability in the Upper Missouri Basin.

Objectives

1. Large federal, state and tribal water rights are quantified and interpreted such that their impacts to water users are clearly recorded and recognized.
2. Effective aquatic invasive species prevention and education in place.

III. Introduction

A. Statutory Authority for Water Planning

Article IX, Section 3 of Montana's Constitution states "*All surface, underground, flood, and atmospheric waters within the boundaries of the state are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law*". The Constitution also states that "*The use of all water that is now or may hereafter be appropriated ….shall be held to be a public use.*

The Montana Legislature recognizes that in order to achieve the public policy objectives specified in § 85-1-101 MCA "*and to protect the waters of Montana from diversion to other areas of the nation, it is essential that a comprehensive, coordinated multiple-use water resource plan be progressively formulated to be known as the 'state water plan'*" (§ 85-1-101(10) MCA).

Responsibility and statutory authority for developing the state water plan is given to DNRC in § 85-1-203 MCA with instructions to "*gather from any source reliable information relating to Montana's water resources and prepare from the information a continuing comprehensive inventory of the water resources of the state*." As directed by the Legislature in § 85-1-203(2), MCA, "*the state water plan must set out a progressive program for the conservation, development, utilization, and sustainability of the state's water resources, and propose the most effective means by which these water resources may be applied for the benefit of the people, with due consideration of alternative uses and combination of uses".*

Sections of the state water plan must be completed for the Missouri, Yellowstone, and Clark Fork River Basins, submitted to the 2015 Legislature, and updated at least every 20 years. Montana citizens are given a formal role in the planning process through water user councils established in accordance with the instructions given by the legislature in § 85-1-203(4), MCA. The role of the water user councils is to make recommendations to DNRC on the basin-wide plans.

In developing and revising the state water plan, DNRC is instructed to consult with, and solicit advice from, the Environmental Quality Council. The legislature, by joint resolution, may revise the state water plan.

BASIN PLANS AND THE STATE WATER PLAN

Although the State Water Plan represents the outgrowth of the regional basin plans, only the State Water Plan has been formally adopted by DNRC. In the event that guidance in one of the basin plans is at odds with the State Water Plan, the direction offered in the State Water Plan takes precedence. Similarly, the policy recommendations offered in the basin plans represent the collective work of the individual BACs and should not be interpreted as carrying the authority of official state policy."

B. History of Water Planning in MT

STATEWIDE PLANNING HISTORY

Water is arguably Montana's most valuable natural resource. The rivers, streams, lakes, and groundwater have shaped the stories of our rich history of settlement, agriculture, mining, industry, and recreation, and our quality of life. As the physical and economic needs of the state evolve, planning for the conservation and development of our water resources also evolves.

Initial efforts at water resources planning in Montana centered on the development of irrigated agriculture to promote settlement of the west. Water development projects were seen not just as desirable but as essential to the economic viability of the state. In 1895, the Montana Legislature created the Arid Land Grant Commission to manage the reclamation of lands granted to the State under the federal Carey Land Act of 1894. In 1903, the Commission was abolished and replaced by the Carey Land Act Board. 1903 also saw the U.S. Congress authorize construction of the Milk River Project as one of the first five reclamation projects built by the newly created Reclamation Service (now Bureau of Reclamation) under the Reclamation Act of 1902.

In the 1920s, the Montana Irrigation Commission produced county-by-county plans for irrigation development. In addition, the Commission assisted in organizing and management of irrigation districts around the state. It also had jurisdiction over the sale of water, water rights, and the contracting of water for irrigation. The Commission was abolished in 1929.

The precarious position of agriculture and the livestock industry in Montana during the early 1930s promoted extensive individual and group effort towards seeking ways to put Montana's water resources to beneficial use. Late in 1933, a special session of the state legislature passed House Bill No. 39, creating the State Water Conservation Board. The act creating the Board declared that the public interest, welfare, convenience and necessity required the construction of a system of works for the conservation, development, storage, distribution, and utilization of water. Broad powers were given to the Board, allowing it to cooperate and enter into agreements with all federal and state agencies, and to investigate, survey, construct, operate, maintain, and finance the construction of projects.

Between 1934 and 1960, the Board built 181 water conservation projects. These included 141 dams and reservoirs, 815 miles of canals, 23 miles of domestic water supply pipelines, and 24 miles of transmission lines to bring power to pumping stations. All told, the Board's actions created 438,017 acre-feet of storage and developed 405,582 acres of irrigated land (R. Kingery, personal communication 12 July 2013.). This period also saw congressional approval of all the major federal water projects in Montana. These include Fort Peck, Canyon Ferry, Hungry Horse, Tiber, Yellowtail, and Libby dams.

When Montana began to negotiate the Yellowstone Compact with Wyoming and North Dakota in 1939, the need for cataloging the state's water resources and their use became apparent. As a result, the 1939 Legislature authorized the collection of data pertaining to water use. Between 1942 and 1971, Montana undertook a comprehensive county-by-county assessment of water use. The resulting reports, known collectively as the Montana Water Resources Survey, contain an examination of water rights, water uses, and irrigation development in almost every county in Montana. This information was collected and published from 1943 thru 1965 by the State Engineer's Office and from 1966 through 1971 by the Water Conservation Board. The historical information contained in the surveys is an invaluable tool in today's efforts to adjudicate Montana's water rights.

In 1967, the Montana Legislature recognized the need for a comprehensive state water plan with passage of the Montana Water Resources Act of 1967 (89-101.2 R.C.M. 1947). The act abolished the Water Conservation Board and transferred its powers and duties to the Water Resources Board. The act stated that the *"public policy of the state is to promote the conservation, development, and beneficial use of the state's water resources to secure maximum economic and social prosperity for its citizens."* The act also designated the Water Resources Board as the state agency with responsibility to "*coordinate the development and use of the water resources of the state as to effect full utilization, conservation, and protection of its water resources."* The Board was empowered to prepare a *"continuing comprehensive inventory of the water resources of the state"*, and prepare a "*comprehensive, coordinated multiple-use water resources plan known as the 'state water plan'."*

The responsibilities given to the Board reflect a change in direction and purpose of water resource planning—from "conservation" of water through irrigation to a total concern for full use of our water resources through comprehensive multiple-use planning. In 1971, the Water Resources Board became the Water Resource Division of the Montana Department of Natural Resources and Conservation (DNRC).

Between 1972 and 1981, DNRC conducted a number of reconnaissance-level planning studies in each of Montana's major river basins in conformance with federal principals and guidelines and with federal grant assistance. While these plans produced volumes of valuable technical information, inadequate consideration was given to the institutional and political feasibility of implementing the plan recommendations. Consequently, the plans had little effect on water management decision-making. These plans were also ineffective vehicles for addressing the state's most critical water management problems such as interstate water allocation, quantification of federally reserved water rights, water use efficiency, instream flow protection, and groundwater management. Federal funding to support state water planning ended in 1981.

In 1987, DNRC embarked on a new approach to developing the state water plan. After reviewing the water planning processes of other western states, DNRC adopted an approach similar to that used in Kansas. Under this approach, the state water plan provided a forum for all affected parties, including those without jurisdictional responsibility, to collaboratively work together on resolving water management issues. This new approach included the formation of a State Water Plan Advisory Council and issued-focused Steering Committees. The resulting state water plan focused on the following nine water resource issues:

1. Agricultural Water Use Efficiency (1989)
2. Instream Flow Protection (1989)
3. Federal Hydropower and State Water Rights (1989)
4. Water Information System (1989)
5. Water Storage (1990)
6. Drought Management (1990)
7. Integrated Water Quality and Quantity Management (1992)
8. Upper Clark Fork Basin Water Management (1994)
9. Groundwater (1999)

Between 1999 and 2009, DNRC water planning resources were focused on assisting irrigation districts, conservation districts, and local watershed groups with water supply studies and drought management plans.

In 2009, the Montana Legislature amended the state water planning statute to direct DNRC to update the state water and report to the 2015 Legislature. The 2009 amendments also specify a number of items that the state water plan must address, including:

- Inventory of consumptive and non-consumptive uses associated with exiting water rights.
- An estimate of the amount of groundwater and surface water needed to satisfy new future demands;
- An analysis of the effects of frequent drought and new or increased depletions on the availability of future water supplies.
- Proposals for the best means to satisfy existing water rights and new demands.
- Possible sources of water to meet the needs of the state; and
- Legislation necessary to address water resource concerns in the Yellowstone, Missouri, and Clark Fork Basins.

UPPER MISSOURI BASIN PLANNING HISTORY

Settlement and Agriculture

Water is intrinsically linked to the settlement, growth, and development of the Upper Missouri Basin. To better appreciate the history of water planning in the basin, it is important to understand the landscapes, resources, and policies that have helped shape the communities and water use in the region.

Prior to Euro-American explorers arriving in Montana, the native Blackfeet Nation lived in the region from the North Saskatchewan River in Canada and the eastern edge of Glacier National Park, southeast to the Musselshell River, along the Rocky Mountain Front all the way to present-day Yellowstone National Park. Basically, the Blackfeet Nation home and hunting grounds covered all of the area contained in today's Upper Missouri Basin planning area. In 1851, the Fort Laramie treaty defined the Blackfeet reservation, which greatly reduced the original area claimed by the Blackfeet people. (The Blackfeet tribal water compact was agreed upon in 2009 and is discussed in more detail in the reserved water rights section of this document).

In 1805, the Lewis & Clark expedition traveled up the Missouri River and arrived at the three forks or headwaters of the Missouri in July 1805. This exploration and subsequent reporting of the landscapes and resources of Montana territory opened the door for trappers and fur traders to follow. In 1832, a trading post known as Fort McKenzie was established on the Missouri a few miles above the mouth of the Marias River. This set the stage and provided access for further development and exploration of the frontier territories. The Missouri River functioned as a transportation and commerce corridor, bringing more fur traders, troops, and supplies, and delivering the bounties of the fur traders back to the Midwest and East Coast. The first steamboats to travel deep into Montana territory arrived in Fort Benton in 1860, establishing Fort Benton as the "Birthplace of Montana," the head of navigation on the Missouri River, and gateway to Montana's riches. The discovery of gold in the 1860s generated a surge of newcomers. Between 1865 and 1869, more than 150 boats brought an estimated 10,000 miners to Fort Benton, and river traffic supported the trade of buffalo robes, gold, high grade ore, wolf hides, guns, and whiskey throughout the territory. Fort Benton was also the destination and trailhead to distribute the miners, settlers, and their wares to the mining camps of Silver City, Bannack, Virginia City, and west to The Dalles, Oregon along the 624-mile Mullan Road. It is reported by the United States Assay office that between 1863 and 1889, at least $90 million in gold was extracted from Alder Gulch (Virginia City), a figure that represents a present-day equivalent of no less than $40 billion.

Late in the 1870s and early 1880s, many herds of long-horned cattle came to Montana, with more than one million cattle living on the range in 1886. The harsh winter of 1887 put an end to open ranges, with livestock losses running from 50 to 80% by the end of the winter and Montana stockmen suffering more than $20 million in losses. The Great Northern railway was completed in 1887, ending the Missouri River traffic, but increasing the accessibility of pioneers to homestead and settle in Montana. As the gold rush began to play out and the Homestead Act encouraged settling the land, communities developed and the local economies grew and began to shift to agricultural production. In 1864, the first irrigation ditches were dug in Gallatin County to grow wheat and other grains, which then promoted the establishment of numerous flour mills, a malt plant, and a brewery. Throughout the Upper Missouri Basin, farms and ranches are still the backbone of many rural communities, supporting agricultural economies while providing open space.

Some interesting facts and features found in the Upper Missouri Basin:

- Montana Territory capital (1864) Virginia City
- Montana State Capitol (1889) Helena.

- The first hydroelectric facility (1890) in Montana was the Black Eagle Plant on the Missouri River at Great Falls.
- Giant Springs, (Missouri just below Great Falls) is one of the largest cold water springs in the United States, with an average temperature of 52°F and flows of approximately 500-600 cubic feet per second (cfs).
- St. Mary's peak in Glacier County has a triple divide that drains water to 3 different continental drainage basins: north to Hudson Bay; West to the Columbia and Pacific Ocean; and East to the Missouri River and the Gulf of Mexico.
- The Upper Missouri basin also contains Glacier and Yellowstone National Parks, and many Montana State Parks including: Bannack; Lewis and Clark Caverns; Missouri Headwaters; Madison and First People's Buffalo Jumps; Elkhorn, Spring Meadow, Smith River, Black Sandy, Tower Rock, and Big Springs Parks.

Historic Water Resource Surveys

Early water planning activities in Montana and the nation were focused on developing irrigation projects to distribute water across the landscape to support and promote agricultural production. During the 1930-1940s, the state and federal governments spent much of their time and money on designing and implementing water conservation projects. Following the construction and development of these projects was an effort to produce and publish comprehensive surveys of all of the irrigation projects in Montana. Between 1953 and 1965, the Montana Water Conservation Board and the State Engineers office developed comprehensive Water Resource Surveys for most of the counties in the Upper Missouri Basin. These surveys were developed from courthouse records, individual contacts, state and federal agency data, field surveys, and aerial photographs. They contain a historic summary of the settlement, water use, and survey maps of current water use at the time of publication. These important documents are still used for historical reference and provide the basis for understanding water use, development, water planning, and adjudication in each county. Table 1.1 summarizes the information extracted from each of the county water resource surveys. Not all areas were specifically reported in every survey, so the information is included in the manner that it was reported. A water resources survey was never quite completed for Beaverhead County, so that information is not available. Also, the surveys were conducted for the counties, which are political subdivisions rather than watersheds, so it is difficult to tease out information that is specific only to the areas within the counties that drain to the Upper Missouri Basin. For example, Silver Bow County has tributaries that drain to both sides of the continental divide, distributing water to the Missouri and Columbia basins, and Butte receives some its municipal water supplies from the Big Hole River (which drains to the Jefferson and then Missouri Rivers), but the wastewater is returned to the Clark Fork River. Also, the population and land ownership records are county wide, not generally defined by the watersheds. These water resource surveys remain a valuable tool for characterizing and understanding the communities and water distribution systems in the basin.

Table 1.0 Historic Water Resource Survey Summaries for Counties in the Upper Missouri Basin

Water Resource Surveys for Counties draining to the Upper Missouri Basin							
County	Year Publ.	Total Area (Acreage)	Irrigated Acreage at time of publ.	Land Ownership		Major Tributaries contributing above the confluence with the Marias River	County Pop.
				Federal or State or other	Private		
Beaverhead	N/A						
Broadwater	1956	795,520	42,642	33%	64%	Jefferson River, Crow, Deep, Dry & Sixteen mile Creeks	2,922
Cascade	1961	1,701,760	45,978		91.2%	Sun & Smith Rivers, Muddy & Belt Creeks	73,418
Chouteau	1964	2,508,800	13,011	160,682 fed.		Teton & Marias Rivers, Belt, Highwood, Shonkin and Birch Creeks	7,900
Gallatin	1953	1,610,800	125,926	579,244 USFS	58.3% Farm	Gallatin (East & West), Madison & Jefferson Rivers & Sixteen Mile creek	21,902
Glacier	1969	1,947,263	23,805	376,450: Glacier 30,723:USFS 874,172 Blackfeet	166,813 83.6% Farmland	Marias & Two Medicine Rivers, Cut Bank Creek	NA
Hill	1962	1,872,640	9,828	58,559 fed.	1,005,665 cropland 758,905 range & pasture	Marias River and Trail Creek	18,653
Jefferson	1956	1,056,640	26,280	455,486 USFS	394,853 farmland	Jefferson & Boulder Rivers, Fish, Pipestone and Whitetail Deer Creeks	4014
Lewis and Clark	1965	2,225,280	36,326		1,119,000 private	Sun & Dearborn Rivers, Prickly Pear & Ten Mile Creeks	24,450
Liberty	1969	933,120	4,099	22,747 Fed	551,102 cultivated 334,488 rangeland	Marias River, Cottonwood & Willow Creeks	2,624
Madison	1965	2,259,200	111,996	605,708 USFS	48.9% farms	Beaverhead, Big Hole, Gallatin, Jefferson, Madison & Ruby Rivers	5,998
Meagher	1950	1,516,160	30,304		52,706 cropland	Smith River & Tenderfoot Creek	NA
Pondera	1964	1,051,520	124,618	121,479 Fed	282,800 cropland	Marias and Two Medicine Rivers	7653
Silver Bow	1955	456,240	4577	245,219 Fed	11,725 cropland 102,231 private grazing land	Big Hole River, Camp & Fish Creeks	48,422
Teton	1962	1,468,460	141,014	312,535 Fed	1,246,526 farms	Sun, Marias & Teton Rivers, Big Muddy & Deep Cks, Pondera Coulee	2700+
Toole	1969	1,248,000	6,277	37,000 Fed	92.8% Ag	Marias River	7904

Instream Flows

With the ability to telecommute, and a retiring baby boomer population, many people are moving to Montana to be closer to the outdoor beauty, scenic amenities, and recreational opportunities that are abundant in the Upper Missouri Basin. During the 1980s, the areas around the urban centers of Bozeman, Helena, and Great Falls began to experience a surge in population with changing demographics and a piqued interest in outdoor recreation. The influx of new immigrants created a shift in the water lens, from water as a tool, to a focus on the importance of maintaining flows in the streams to benefit fisheries, wildlife, riparian health, and scenic values. This shift in ideals generated legislative changes in water administration to enable the Montana Department of Fish, Wildlife and Parks to lease water to help *protect, maintain, or enhance streamflows to benefit fishery resources (MCA 85-2-436)*. This change set up the process that allows and recognizes instream flow as a beneficial water use.

As we review past development and water planning activities and look toward the future of water in the Upper Missouri Basin we are faced with many challenges and opportunities. We are experiencing increased and sometimes conflicting demands on a finite resource. We are fortunate to have mountains to capture the snow to retain and release water in the spring, but we have a duty to be good managers and stewards of the uplands and water as it travels across the landscapes of the basin. Water is one of Montana's most valuable assets. It contributes to the beauty, security, and economic development of all in the Upper Missouri Basin.

C. The Upper Missouri Basin Advisory Council

After a broad and extensive nomination and recruiting effort that involved more than 150 organizations and individuals, in August 2013 DNRC appointed a 20-member Upper Missouri Basin Advisory Council. Council members were selected for diversity in geographic representation, scope of interests in the basin, their willingness to abide by the DNRC-developed Council guidelines, experience or interest in collaborative processes, and willingness to attend two meetings in 2013 and up to six meetings in 2014. Also appointed were resource experts (RAC) to represent their local, state, or federal agencies and contribute their professional expertise to the project. Select DNRC staff from the appropriate regional field offices also participated. The BAC and RAC members and their affiliations are listed in Table 1.2 below.

Missouri Basin Advisory Council Fort Benton Meeting Participants

Front Row, from left: Kathleen Williams, Michael Geary, Wayne Green (for Bruce Sims), Kitt Dale, Eloise Kendy, Holly Franz, Gayla Wortman; Second Row: Greg Kruzich, Ann McCauley, Sarah Converse, Lezlie Kinne, Vicki Baker, Jim Beck, Walt Sales, Lenny Duberstein, John Kilpatrick (for Wayne Berkas); Third Row: Denise Wiedenheft, Larry Dolan, Scott Irvin, Paul Siddoway, Craig Woolard, Allen Martinell, Joe Willauer, Vernon Stokes, John LaFave. Council and Resource members not pictured: Mark Aagenes, Cyndy Andrus, Bob Hardin, Earl Old Person, Dustin Stewart, Jerry Lunak, Tammy Crone, Mike McLane, Lynda Saul, Kerri Strasheim, Bryan Gartland and Ann Schwend.

Table 1.1 Members of the Upper Missouri BAC, TAC, Staff and Contracted Facilitators

UPPER MISSOURI BASIN ADVISORY COUNCIL MEMBERS			
Affiliation	**Name**	**Location**	**Professional Experience /Representation/Nomination**
Conservation	Mark Aagenes	Helena	Conservation Director of MT Trout Unlimited; MT TU
WS/ Tourism	Cyndy Andrus	Bozeman	Chair of Governor's tourism advisory council, MT FWP Region 3 Advisory Committee, Bozeman City Commissioner, MT Heritage Commission; Greater Gallatin WS Council
Ag / CD / Petroleum Assoc	Vicki Baker	Bynum	Teton Co. CD chair, Bynum Irrigation Dist, Ag in MT Schools, Teton Coop Reservoir Co, Teton County Planning board, Director of MADCS; Teton CD, MT Petroleum Assoc.
CD/ Municipal	Jim Beck	Townsend	Retired water resource specialist with MT DNRC, Broadwater CD supervisor, past chair of MRCDC; City of Townsend, Broadwater CD, Missouri River CD Council, MACD
Economic Development	Sarah Converse	Great Falls	ED of Sweetgrass Development, covering north central Montana; MT Economic Development Association

UPPER MISSOURI BASIN ADVISORY COUNCIL MEMBERS			
Affiliation	**Name**	**Location**	**Professional Experience /Representation/Nomination**
Industry Mining	Kitt Dale	Sheridan	Strategic Development Manager at Golden Sunlight Mine, MS in Mining Engineering, ranch owner/operator; MT Mining Assoc.
Industry/ Hydropower	Holly Franz	Helena	Attorney representing hydropower and water right holders for 25 years; served on many advisory councils; PPL Montana
Recreation/ Fishing Industry	Michael Geary	Clancy	Smith River Guide, Smith River Advisory Council, Past President of FOAM; Fishing Outfitters Assoc of MT
Ag/ MWRA	Bob Hardin	Fairfield	Sun River WS group, Greenfield Irrigation District Manager; Sun River WS
Conservation/ Instream flow	Eloise Kendy	Helena	Hydrologist working on international water and streamflow issues; The Nature Conservancy
Ag/ Water Commissioner	Lezlie Kinne	Harrison	Water Commissioner, Cataract Water Users/Dam; Willow Creek Water Users
Ag/ Watershed Group	Alan Martinell	Dell	Centennial Valley Assoc, Water Users, Vigilante Electric Cooperative; CVA
Tribal	Earl Old Person	Browning	Blackfeet political leader for 6 decades, past president of the National Congress of American Indians; Blackfeet tribe
Ag/CD	Walt Sales	Manhattan	Gallatin Water Resources Task force, Bozeman Integrated Water Resources Mgmt committee; Assoc of Gallatin Irrigators, Gallatin CD
WS/ Conservation	Paul Siddoway	Butte	Medical Doctor, 25-year second home resident in Big Hole; BH Watershed Committee
Industry/ Building	Dustin Stewart	Helena	ED of Montana Building Industries Association; past involvement on water issues in legislature; MT Building Industries Assoc
Ag/ MADCS/ MWRA	Vernon Stokes	Valier	President MT Assoc of Dams & Canals, member MWRA, Pondera Dam & Canal Co; MADCS & MT Water Resources Assoc
Economic/ Recreation	Joe Willauer	Twin Bridges	Natural Resource planner, fly fishing guide, Food, Ag & Economic development, Beaverhead Deer Lodge Forest working group; Headwaters RC&D
Municipal Water	Craig Woolard	Bozeman	Bozeman Municipal water, Civil Eng., past pres of Am Water Works Assoc, member of EPA national drinking water adv. Board; City of Bozeman
Ag/ CD	Gayla Wortman	Cascade	Cascade Conservation District Chair, also Big Sandy & Lewis & Clark CDs; MT Salinity Control Assoc
TECHNICAL RESOURCE ADVISORS/EX OFFICIO MEMBERS			
USGS	Wayne Berkas	Helena	US Geological Service (USGS)
Gallatin WQ District	Tammy Crone	Bozeman	Gallatin WQ Dist
USBR	Greg Kruzich	Billings	US Bureau of Reclamation
USFWS	Thomas Econopouly	Denver	US Fish and Wildlife Service
MBMG	John Lafave	Butte	MT Bureau of Mines and Geology
Blackfeet Tribe	Jerry Lunak	Browning	Blackfeet Tribe
MT DEQ	Ann McCauley	Helena	MT Dept of Environmental Quality
MT FWP	Mike McLane	Helena	MT Fish Wildlife and Parks
MT Wetlands Council	Lynda Saul	Helena	Montana Wetlands Council
USFS	Bruce Sims	Missoula	US Forest Service
NRCS	Joe Little	Bozeman	Natural Resource Conservation Service

UPPER MISSOURI BASIN ADVISORY COUNCIL MEMBERS			
Affiliation	**Name**	**Location**	**Professional Experience /Representation/Nomination**
DNRC & Contracted Facilitators			
	Larry Dolan	Helena	Hydrologist
	Bryan Gartland	Helena	Helena Regional Office
	Scott Irvin	Lewistown	Lewistown Regional Office
	Kerri Strasheim	Bozeman	Bozeman Regional Office
	Ann Schwend	Helena	Upper Missouri Basin Water Planner
	Kathleen Williams	Bozeman	Issues Scoping Facilitator
	Sue Higgins	Bozeman	Recommendations Facilitator

DEVELOPING THE PLAN AND PUBLIC PARTICIPATION

The Council held a kickoff and orientation meeting September 5-6 in Three Forks, Montana, where they met each other, heard presentations from resource experts, discussed basin issues, and confirmed the remainder of the issue scoping process. They then held five regional public scoping meetings throughout the basin (Table 1.3).

Table1.2 Public Scoping Meetings

Upper Missouri Public Scoping Meetings 2013		
Great Falls	September 30, 2013	Civic Center
Conrad	October 1, 2013	Pondera Country Club
Helena	October 2, 2013	Holiday Inn Downtown
Bozeman	October 8, 2013	Holiday Inn
Dillon	October 9, 2013	UM Western

All meetings were in the evening and widely advertised in local print media and through Council member and organizational networks. The Council and public meetings followed a similar format, with resource presentations in the first half and small group issue discussions in the second half Table 1.4). Participants in small groups listed their issues, then prioritized and reported their top three for full group discussion. More than 120 people attended and participated in the public scoping meetings. The small groups at the public meetings led their own discussions, with Council members and resource experts listening and providing support to the groups. Some public meeting participants provided follow-up comments after the meetings by mail or electronically, and a few people unable to attend the public meetings provided written input. The Council's facilitator then summarized the input and the Council met in Fort Benton on October 24-25 to review and prioritize issues and then discuss next steps. The BAC worked to prioritize and capture the issues into general categories below:

Increase Water Storage or Retention

Explore both traditional (structural) and non-traditional (natural) storage options to capture high flows and retain them in the basin longer for additional flexibility in the late season and to accommodate expanded demand.

Better Understand and Manage Surface and Groundwater Interaction
Manage surface water and groundwater conjunctively and explore the potential to use canals for aquifer recharge, protect senior users from exempt well depletions, and better understand return flow conditions.

Recognize Water's Role in the Future of State and the Economy
Recognize the need to provide and protect existing uses while providing for growth for industry, agriculture, and municipal and recreational uses.

Maintain and Enhance Instream Flow
Balance instream and agricultural needs and provide incentives for participation in streamflow enhancement projects.

Promote Local Cooperative Efforts
Support and fund local watershed/user group/stakeholder cooperative efforts related to water efficiency, conservation, and pooled management opportunities.

Increase Amount, Centralization, Diversity, and Access to Water Data
Recognize and support the importance of accurate, high-quality, consistent and accessible water resources data from varied sources; the value of good information in fostering collaborative water management and increasing accountability in water use; and the need for additional measuring devices.

Document and Project Water Use and Relationships
More information related to current water use, how those uses affect others, related trends, and projections by water use sector; the shift from agricultural land use to residential; consumptive use impacts downstream; and changing irrigation practices.

Improve Water Use Efficiency and Conservation
Promote water use efficiency and conservation through education and incentives; infrastructure upgrades and improvements; and potential impacts of efficiency improvements such as increased water consumption and effects on return flow.

Assess and Project Available Water Supply
Collective understanding of the water cycle, and available water; creating a water balance model for the basin; specific documentation of "available" water, including stored/contract water in reservoirs; and consideration of climate variability on supply, timing, and use, including a likely pattern of earlier snowmelt.

Analyze Water Transfers/Marketing/Banking and Scope of Water as Transferable Property
Need to plan for more water transactions; the potential for water banking; and concern that increasing values of water (and the ability to sever water from the land) may impact the affordability of family farms, estates, and property transfers.

Assess Select Large-Scale Factors
More information about tribal water rights, endangered species act implications, and potential for downstream entities' eminent domain actions and public trust doctrine related actions.

Accelerate Water Rights Adjudication Process and Enforce
Support for quick completion of the water rights adjudication process and moving into enforcement, while streamlining the process and ensuring interest group involvement does not slow the process or increase participant costs; assess the effects of adjudication on water supplies.

Improve Watershed/Forest Management
Improve management of upland forests in relation to water quantity and quality, including proper stocking, preserving the capability of these lands to produce clean water and mitigating effects of fires and high fuel loading.

Advance Interrelation of Water Quantity and Quality
Review summary information on statewide water quality assessment, standards and impaired water bodies, with consideration of chronically low flow or dewatered streams; consider water quality issues in wastewater reuse.

Following the work session in Fort Benton, the facilitator generated an Issues scoping report that summarized the process, information, and activities to help guide subsequent phases to assist the BAC with developing recommendations for the basin plan. The draft scoping report was posted to the DNRC website in November for public review and comments. The public comments were recorded and incorporated into the final scoping report, which was adopted by the BAC in December.

In January, the BAC convened in Helena to begin to sort through existing and additional information needed to better refine the issues and develop draft recommendations. Many of the BAC members reviewed and reported on the individual sections of the existing state water plan, including: Agricultural Water Use Efficiency, Instream Flow Protection, Water Information System, Water Storage, Drought Management, Integrated Water Quality & Quantity Management, and MT Groundwater Plan. Council members affiliated with irrigation or canal companies also provided an overview of their projects. At the end of the meeting, the Council decided to schedule a 2-day work session in February and at the February meeting determined they would also need to meet for 2 days in March and April. In keeping with the theme of moving the meetings to different locations throughout the basin, the BAC met in Twin Bridges in March and Choteau in April. Each of these 2-day meetings consisted of resource experts presenting on different topics associated with each of the targeted issues, followed by facilitated discussions to refine the issue statements, goals, and draft recommendations. Between meetings, teams of BAC and RAC members contributed significant amounts of time to further develop and refine the specific recommendations pertinent to their areas of interest or representation. At the subsequent meetings, the entire BAC reviewed and discussed the refined issue statements, goals, and objectives to reach agreement on the group recommendations. Through the refinement process the BAC made some adjustments and combinations to the originally identified issues.

Table 1.3 Upper Missouri BAC Work Sessions and Topics

Upper Missouri BAC Work Sessions and Topics		
Jan 10, 2014 Helena, MT FWP MT Wild Center		
Tim Davis	DNRC WRD Administrator	Process and Recommendations Development
Gayla Wortman	Chair Cascade CD	Ag Water Use & Efficiency Review
Eloise Kendy & Mark Aagenes	Instream Flow specialist, The Nature Conservancy	Instream Flow Protection Review
Kitt Dale	MT Mining Association	Water Information System Review
Bob Hardin & Paul Siddoway	Greenfield Irrigation & Big Hole WS	Water Storage Review
Lezlie Kinne	Water Commissioner	Drought Management Review

Upper Missouri BAC Work Sessions and Topics		
Jan 10, 2014 Helena, MT FWP MT Wild Center		
Ann McCauley	DEQ	Integrated WQ & WQ Mgmt Review
Vicki Baker	Chair Teton CD	Groundwater Review
Lenny Duberstein	Federal Bureau of Reclamation	Federally owned and managed projects in the basin
Matt Norberg	MT DNRC State projects Bureau	State owned and managed projects in the basin
Bob Hardin, Vern Stokes, Vicki Baker, Allen Martinell, Lezlie Kinne	Greenfield irr. Dist, Pondera Canal, Buyan, Lima and Willow Creek	Locally managed projects in the basin
Feb 27 & 28, 2014 Helena, MT FWP MT Wild Center		
John Lafave & Ginette Abdo	MT Bureau of Mines and Geology	**Conjunct. Mgmt**: Groundwater Investigation Program and case scenarios
Tammy Crone & Jim Wilbur	Gallatin WQ District & Lewis and Clark WQ Dist	**Conjunct. Mgmt**: Roles and responsibilities of Water Quality Districts
Mark Aagenes & Mike McLane	MT Trout Unlimited, MT Fish Wildlife and Parks	**Conjunct Mgmt**: History and evolution of Conjunctive Management policies in MT
Wayne Berkas	US Geologic Survey	**Water Info:** Stream Gauging in Montana
Troy Blandford	MT Natural Resource Information System	**Water Info**: MT Water Information System
Brian Domonkos	US Natural Resource Conservation Service	**Water Info**: SNOTEL and snow pack monitoring
John Lafave	MT Bureau of Mines and Geology	**Water Info**: Groundwater Information Center
Gayla Wortman	Chair, Cascade Conservation District	**Local Coop Efforts**: Overview of CDs and Watersheds in the basin
Tim Bryggman	DNRC Economist	**Water's role in the Economy**: Growth projections for the basin
Sarah Converse & Joe Willauer	ED, Sweetgrass Development & Headwaters Economics	**Water's Role**: Value of water and the economy in the basin
Craig Woolard	Water Manager, City of Bozeman	**Water's Role**: Municipalities and economic development
Panel: Anne Yates, Holly Franz & Stan Bradshaw	DNRC Head of legal, Attorney for PPL MT, Attorney for Trout Unlimited	**Water's Role:** Policy/legal/historic perspective on the change process.
Matt Murphy	DNRC Adjudication Bureau	**Adjudication**: Overview of the Adjudication process in the state

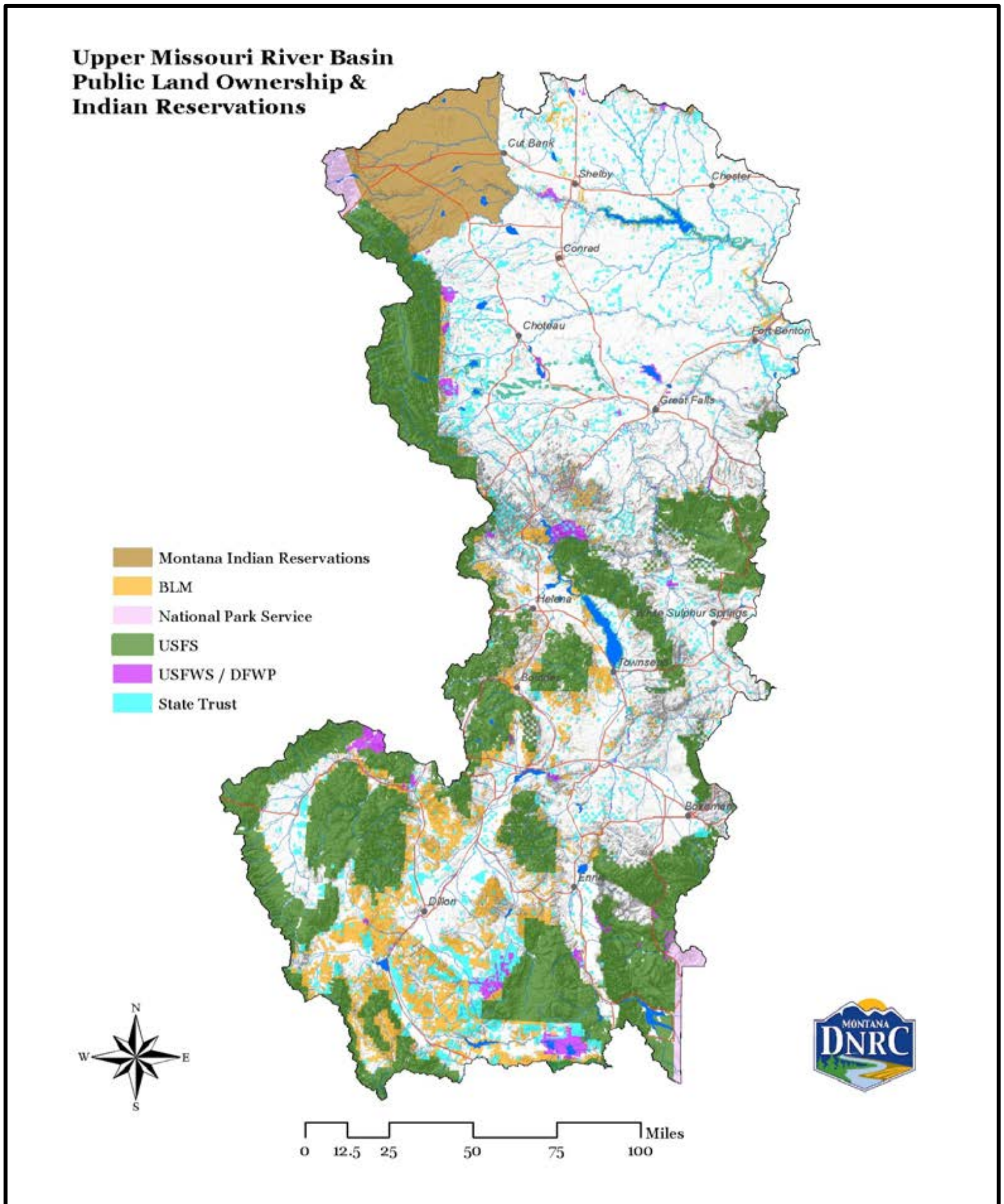
Upper Missouri BAC Work Sessions and Topics		
Jan 10, 2014 Helena, MT FWP MT Wild Center		
Judge Russ McElyea	MT Water Court	**Adjudication**: Overview of the Adjudication process in the state
March 27-28, 2014 Healing Waters Lodge, Twin Bridges, MT		
Larry Dolan	DNRC Hydrologist	**Available Water**: Supplies in the Basin Review of storage projects in the Upper Mo Basin
Todd Gartner	Senior Associate, World Resources Institute	Natural Infrastructure for Water
Lynda Saul	MT DEQ Wetlands program coordinator	**Natural Storage**: Floodplains, Wetlands, Forests and Integrating Natural Infrastructure
Bruce Sims	USFS Region 1 hydrologist	**Natural Storage**: Floodplains, Wetlands, Forests and Integrating Natural Infrastructure
Todd Gartner	Senior Associate, World Resources Institute	**Natural Storage**: Floodplains, Wetlands, Forests and Integrating Natural Infrastructure
April 24-25, 2014, Stage Stop Inn, Choteau, MT		
Melissa Hornbein	Reserved Water Rights Compact Commission	**Large Scale Factors**: Overview of Federal and Tribal water compacts in the Upper Missouri Basin
Scott Irvin	DNRC Regional Manager, Lewistown	**Large Scale Factors**: Water Reservations in the Upper Missouri
Mike McLane	MT Dept of FWP	**Instream Flows**: review of instream flows reservations, leases and Murphy rights
Bryan Gartland	DNRC Regional Manager, Helena	**Instream Flows**: Ecological considerations for instream flows
Ann McCauley	DEQ WQ Protection	**Integrating Water Quality and Quantity**: overview of TMDL and water quality concerns
Joe Little & Randy Pearce	NRCS	**Water Use Efficiency & Conservation:** NRCS irrigation efficiencies and program overview
Larry Dolan	DNRC Hydrologist	**Water Use Efficiency & Conservation:** Consumptive use and conservation
Kerri Strasheim & Bryan Gartland	DNRC regional managers, Bozeman & Helena	**Water Marketing and Transfers:** Overview

IV. Basin Profile of the Upper Missouri Basin

A. Socioeconomic Portrait

LAND USE AND OWNERSHIP

Map 4.1 Upper Missouri Basin land ownership



POPULATION

Between the 2010 census and July 1, 2013, the population of the Upper Missouri Basin increased 2.9 percent to 318,007. During the same period Montana's population increased 2.6 percent to 1,015,165. Approximately 80 percent of Upper Missouri Basin residents live within areas considered to be "Metropolitan" or "Micropolitan" by the White House Office of Management and Budget (see Figure 4.1).

Figure 4.1 Upper Missouri population 2013

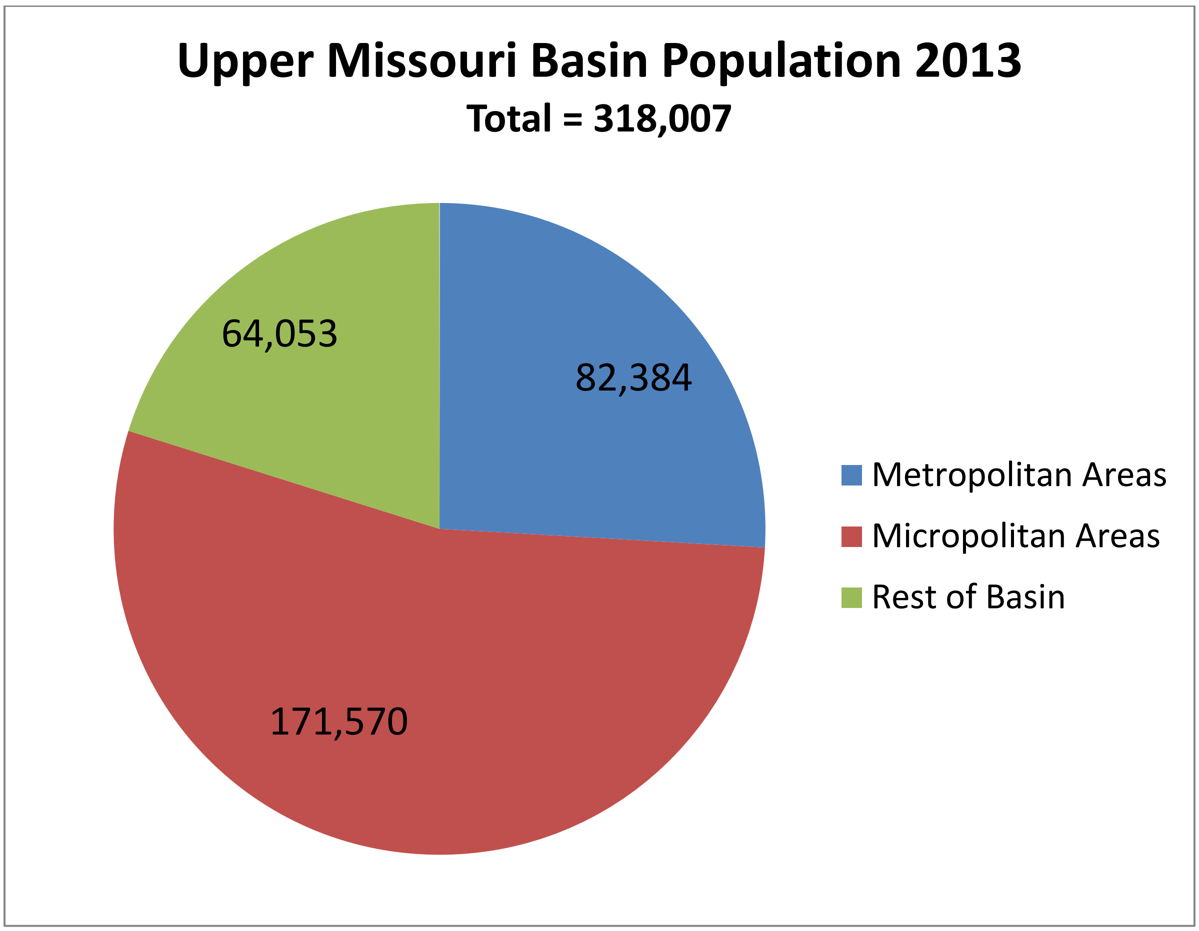


Table 4.1 Population in the Upper Missouri Metropolitan & Micropolitan Areas

Metropolitan Statistical Areas, Micropolitan Statistical Areas
Upper Missouri Basin

	2010	2013	% Change
Metropolitan Areas			
Great Falls	81,327	82,384	+1.3
Micropolitan Areas			
Bozeman	89,513	94,720	+5.8
Helena	74,801	76,850	+2.7
TOTAL	164,314	171,570	+4.4
Rest of Basin	63,542	64,053	+0.8
Montana	989,415	1,015,165	+2.6

Source: U.S. Census Bureau, Population Division

Table 4.1 displays the Metropolitan and the Micropolitan Statistical Areas in the Upper Missouri Basin. One-fifth of the Basin's population is found in "rural" areas outside of the areas characterized as Metropolitan or Micropolitan. Taken together, these areas grew at 0.8 percent between 2010 and 2013.

Populations of counties in the Upper Missouri Basin for 2013 are listed in Table 4.2. Nearly one-third of the basin's residents lived in Gallatin County. Among U.S. counties with populations exceeding 10,000, Gallatin County ranked 89th for population growth between 2012 and 2013, increasing by 2.2 percent to 94,720. More than three-quarters of the basin's population resides in the three largest counties: Gallatin, Cascade, and Lewis and Clark. The populations of Teton County and Toole County declined by 0.1 percent and 3.5 percent, respectively, between 2010 and 2013.

Table 4.2 Upper Missouri Basin Population by County - 2013

Beaverhead	9,341
Broadwater	5,692
Cascade	82,384
Chouteau	5,849
Gallatin	94,720
Glacier	13,739
Jefferson	11,512
Lewis and Clark	65,338
Liberty	2,369
Madison	7,712
Meagher	1,937
Pondera	6,211
Teton	6,065
Toole	5,138

Source: U.S. Census Bureau, Population Division

Population estimates from the 2010 Census were aggregated by 8-digit hydrologic unit code (HUC) sub-basins for the Upper Missouri Basin. Population estimates for these sub-basins are presented in Table 4.3. Nearly 75 percent of the basin population resided in three sub-basins: the Gallatin, the Upper Missouri (including Helena), and the Upper Mo-Dearborn (including Great Falls).

Table 4.3 Upper Missouri Basin Population by Sub-basin- 2010

SUB-BASIN	POPULATION
Beaverhead River	8,614
Belt Creek	1,940
Big Hole River	1,265
Cut Bank Creek	11,398
Gallatin River	84,847
Jefferson River	5,872
Madison River	6,837
Marias River	11,778
Red Rock River	674
Ruby River	2,079
Smith River	1,914
Sun River	16,949
Teton River	3,998
Two Medicine River	2,492
Upper Missouri River	72,194
Upper Mo-Dearborn	67,978
Willow Creek	576
Boulder River	2,296

Source: U.S. Census Bureau, Population Division; Montana Department of Natural Resources and Conservation

The populations of Indian reservations in the basin totaled 13,728 in 2010 with over 75 percent residing on the Blackfeet Indian Reservation. Table 4.4 displays the populations of the Blackfeet and Rocky Boy's Reservations and off-reservation trust land and the percentage change in population between 2000 and 2010. The population for the Rocky Boy's Reservation increased by nearly one-fourth.

Table 4.4 Population Change on the Indian Reservations in the Upper Missouri

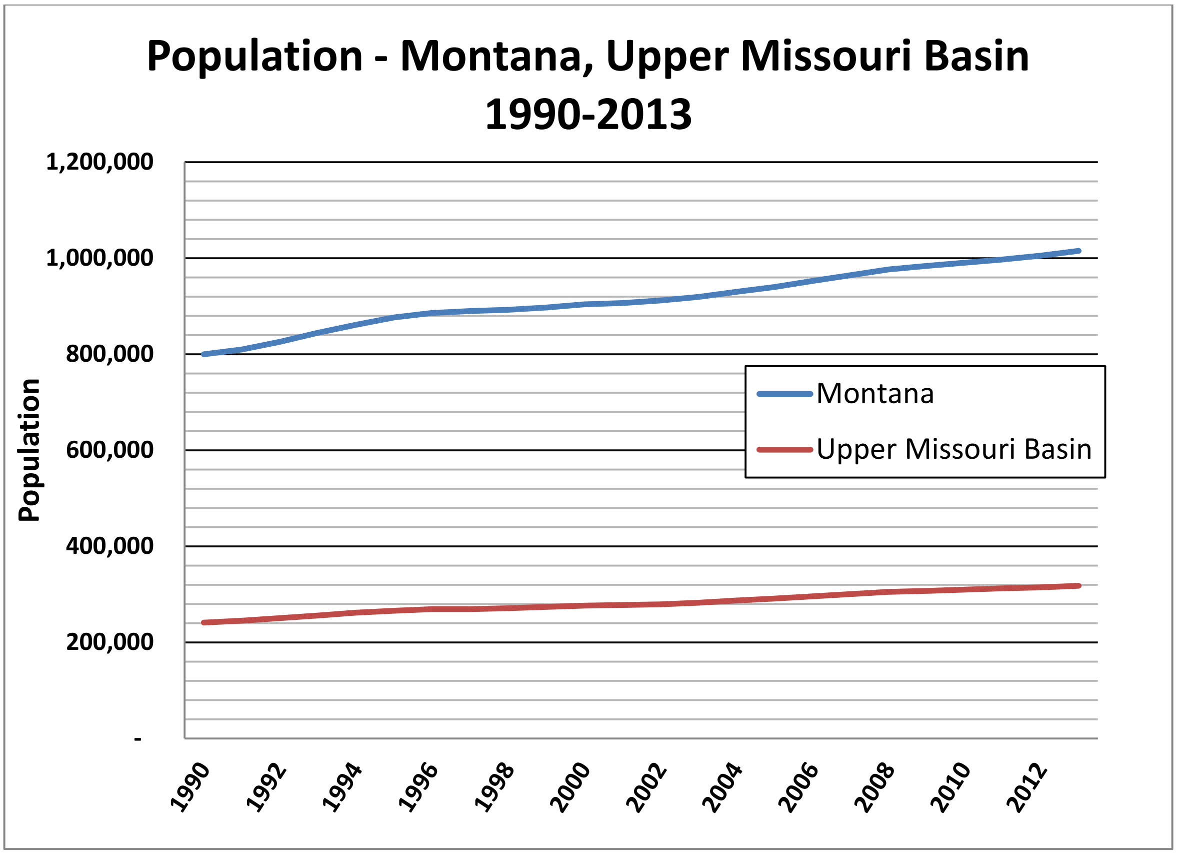
Reservations	Population 2010	% Change 2000-10
Blackfeet	10,405	3.0
Rocky Boy's	3,323	24.2
Total	13,728	7.5

Source: U.S. Census Bureau, Population Division

Trends

Between 1990 and 2013, the population of the Upper Missouri Basin increased by 32 percent while Montana's population increased by 27 percent (Figure 4.2). Gallatin, Broadwater, and Jefferson Counties were the most rapidly growing counties with populations increasing by 86 percent, 71 percent, and 44 percent, respectively. The populations of Pondera and Teton Counties declined by 3 percent over the period.

Figure 4.2 Population Montana Upper Missouri Basin 1990-2013



Projections

Accurately predicting population trends can be challenging. Complex national, regional, and local dynamics determine the geography of socioeconomic development and patterns of population change. The longer the timeframe and the smaller the region, the more difficult it is to accurately predict population changes.

For the purposes of this planning effort, population projections are provided to inform deliberations of water management issues in which population levels are but one factor among many that determine the demand for water. The intent of these projections is not to forecast precise population levels at particular points in time and locations in Montana. Rather, the purpose is to offer reasonable estimates of magnitudes of population growth that would presumably relate to the supply and demand for water in various ways over the course of the planning period.

Table 4.5 Population Projections – Upper Missouri Sub-Basins 2035
1990-2010 Trends

SUB-BASIN	2010	Estimated Population 2035	Estimated Change 2010-35
Beaverhead River	8,614	9,215	601
Belt Creek	1,940	1,996	56
Big Hole River	1,265	1,066	-199
Cut Bank Creek	11,398	11,603	205
Gallatin River	84,847	163,484	78,637
Jefferson River	5,872	8,373	2,501
Madison River	6,837	10,478	3,641
Marias River	11,778	10,857	-921
Red Rock River	674	562	-112
Ruby River	2,079	2,355	276
Smith River	1,914	1,864	-50
Sun River	16,949	18,451	1,502
Teton River	3,998	3,516	-482
Two Medicine River	2,492	2,919	427
Upper Missouri River	72,194	101,010	28,816
Upper Mo. Dearborn	67,978	64,738	-3,240
Willow Creek	576	457	-119
Boulder River	2,296	2,470	174
TOTAL	303,701	415,414	111,713

Table 4.5 presents the projected populations for the Upper Missouri sub-basins in 2035. Nearly all of the basin's population increase would occur in the Gallatin (70 percent) and the Upper Missouri, including Helena, (26 percent) sub-basins.

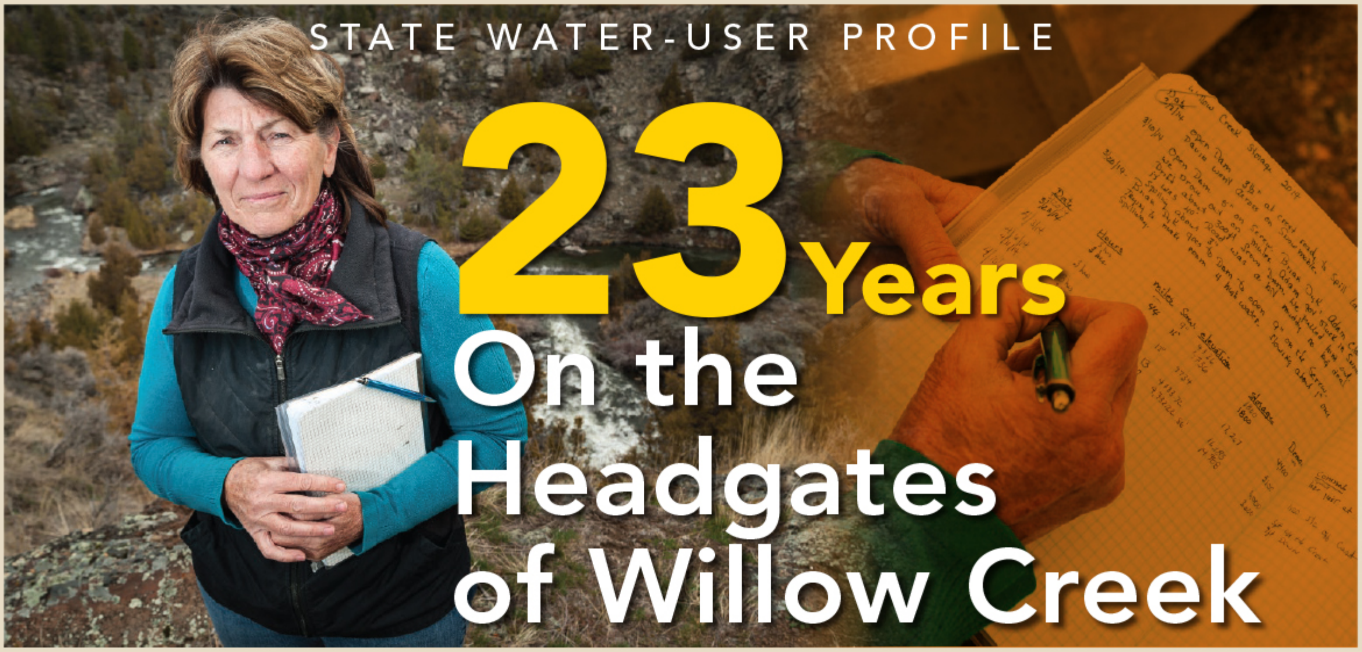
Irrigated potatoes in the Townsend area

Water Use: Agricultural

Almost 98 percent of water diverted in Montana is for agriculture, estimated to total almost 12 million acre-feet annually. About 11.5 million acre feet of that, or 98 percent, is diverted from surface water, and the small remainder from groundwater. There are an estimated 2 million acres of irrigated land in Montana, with 1.2 million in the Missouri Basin above Fort Peck Reservoir, or about half of the total farmed area in the basin. Irrigated lands in the Upper Missouri (including and above the Marias) approximate 1 million acres, or 58 percent of the total upper basin agricultural land.

Figures from 2003 indicate more than half the diverted water in the state was then used for hay production. The next highest uses were pasture, then barley, then sugar beets. Please note these are statewide figures; there is no known sugar beet irrigation in the Upper Missouri Basin. Crop types affect the timing of water demands and potential shortage. For grain, irrigation demand may be high in the early- to mid- summer period and much lower during later summer, when streamflow typically is lowest. Forage crops, such as alfalfa and grass, need irrigation water throughout the season, although irrigation to these crops is shut off periodically for haying during the growing season.

Historically, most of the irrigation rights in Montana were used for flood irrigation. Now, over half the acres continue to be flood irrigated, but others have been converted to sprinklers, notably center pivot systems. Sprinklers decrease labor requirements and allow for more even distribution of water across a field. Sprinkler irrigation can result in diverting less water, but can sometimes consume more overall, as crops are healthier and production higher. Flood irrigation typically diverts more, but much of the water returns to streams through groundwater or overland return flows. Whether the field is irrigated by flood or sprinkler, most water is still supplied to fields through open ditches.



STATE WATER-USER PROFILE

23 Years On the Headgates of Willow Creek

Legend has it that the first murder in Montana was the result of an argument over water. For farmers and ranchers, being able to water stock and irrigate crops is the difference between survival and starvation. So yes, passions tend to run a little high when it comes to getting your share.

"You have to be patient," says Lezlie Kinne, who has been the water commissioner in the Willow Creek district for twenty-three years. "It was hard in the beginning. There were some pretty tough characters out here back then, and maybe they thought they could push me around because I'm a woman."

Kinne is one of fifty-two water commissioners in the state of Montana. Most of them, like Kinne, have day jobs. They are requested by, and have their salaries paid by, the landowners they serve.

"It took three years before I stopped coming home in tears," she admits. "'Those guys are so mean!' I'd say." Kinne chuckles at the memory. "I was lucky. If I felt really intimidated, there were neighbors who would go with me."

"I've come to realize that there is always a solution," Kinne says. "It's almost never a win-win. Mostly someone has to give something up, but the law is local enough and flexible enough that you can always work something out. I get up really early and do my water work. After lunch I do ranch work."

In her first years on the job, Kinne felt tested. She slept on head gates, waiting to catch landowners sneaking extra water. Early on, she walked every ditch and checked every head gate to keep track of individual allotments, working out disputes along the way. Over time she gained respect, she treated people fairly. She learned the nuances of the law and how to base her decisions on accurate measurements.

"I make mistakes, too," she says. "There are times when I have to eat crow and take care of it." That honesty stands Kinne in good stead when it comes to earning respect.

Only once has she had to have someone arrested. "When it comes to water, I have the same powers as the sheriff," she says. Luckily it hardly ever comes to that.

The water Kinne oversees is under an 1899 water decree, which set out the early water rights along the valley from above Pony to Three Forks. In 1917, the decree went back to court to make necessary adjustments from mining allocations to agriculture, but for more than a century, the water in this southwest Montana valley has been settled law.

"We're still working off of that 1899 decree until the state works out water adjudication," she says.

While old water law might appear antiquated and quaint, perhaps even chaotic, Kinne is in no hurry to change the rules. "There is a law in place," she stresses. "More legislation is not always the answer. Let's make the law we have work."

STATE WATER-USER PROFILE

"When I started this job, the guy before me had notes scrawled on an old legal pad. 'Call me if you have any questions,' he said. That was it for training!"

Kinne carries what she calls, 'my bible', a notebook with careful lists of all the landowners and their allocations. A typical notation might read '69 – 93', which stands for an 1869 water right of 93 miner's inches. "I get real nervous when I misplace that book," she says.

Kinne took classes in mediation and special training through the Department of Natural Resources and Conservation (DNRC), but it has mostly been an on-the-ground learning curve, and the slow accumulation of trust between neighbors.

"It's quirky," Kinne admits. "A lot of negotiation takes place between pickup truck cabs on a dirt road, or out on a ditch, or at someone's kitchen table."

"Mostly, I let them make the right decision," she says. "If they can't manage that, then I have to step in. It's almost always a case of 'my neighbor's stealing my water'. We meet at the ditch and take measurements, we measure for leakage, and we measure again at the head gate. It's all pretty black and white. When they see the numbers, they generally back off."

"They trust me with their water now," she says. "That took years to establish, and it's huge. Mostly people are reasonable.

"One really dry year I went around and asked everyone to contribute ten percent of their water to maintain an instream flow for the fishery. Every single person came through."

Much of the job is a matter of education, these days. Kinne oversees a district with nine private reservoirs, seventy-two water users below the dam on Harrison Reservoir, and an evolving demographic that includes vacation homeowners, part-time residents, and old-time ranch families.

"You have people building porches over irrigation ditches," she says. "Or trying to dig a swimming pond off of a ditch, or putting pumps in creeks to water lawns. It's case by case. You go up, knock on the door, and talk to them."

"It looks like it'll be good water year," she says, taking it all in.

"What's not to like about this job," she says, getting out to adjust the flow at the top of the dam. "I'll keep doing this as long as they'll have me. As long as I can still walk." ■

"They trust me with their water now," she says. "That took years to establish, and it's huge. Mostly people are reasonable."

—Lezlie Kinne

Water Use: Industrial, Mineral, and Energy Resources

Industrial water uses in the basin include mining, energy, hydropower generation and non-agricultural food production. Water rights are required for all beneficial uses of water, including industrial uses. There are several active mines in the basin, including the Golden Sunlight gold mine and talc mines in the Dillon and Cameron areas. The malting plant near Great Falls is a relatively new industrial use in the basin. To develop, the plant leased water and used a portion of the City of Great Falls' water reservation. This basin is not seeing the scale of oil development occurring in eastern Montana.

Hydropower production is a major industry in the basin. There are twelve major hydropower projects in the basin, including nine generation facilities on the Missouri main stem. A 15 MW addition is planned at Gibson dam on the Sun River system, and a 4.7 MW addition is planned at Clark Canyon dam at the head of the Beaverhead River. Hydropower water rights are based on turbine capacity. The largest hydropower right in the basin is for Cochrane Dam. The full hydropower water rights are fulfilled for only a short period in most years, and the level may never be reached in low flow years. Holter Dam is even more constrained, where a median year does not fulfill the right. Most of the PPL facilities are run-of-the-river, meaning they aren't of the design and capacity to retain much flow. Development of new water rights above these PPL facilities was effectively eliminated until 1953 when the U.S. Bureau of Reclamation (USBR) constructed Canyon Ferry Dam. Montana Power (now PPL) and USBR entered an agreement that provided for PPL’s water rights to be met from regulated releases from Canyon Ferry storage. This allowed for additional water development in the Missouri Basin, including the construction of Clark Canyon Dam and the development of the East Bench Irrigation district. According to USBR staff, additional water remains in Canyon Ferry Reservoir that could be marketed for a multitude of purposes, provided that federal and state environmental laws are followed.

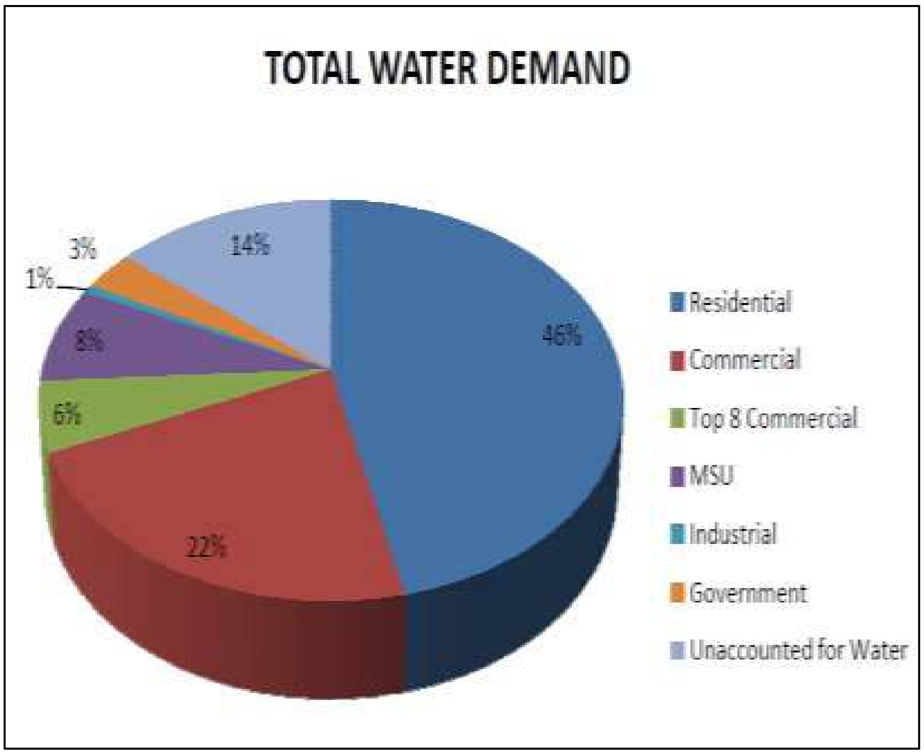
Water Use: Municipal and Domestic

This water use category includes domestic water use, whether supplied by an individual on-site well, a major municipality's water supply system, a community system in a subdivision, or a system of an intermediate scale. There are approximately 500 municipal water rights recorded in the basin, and about 33,000 individual domestic well permits (purposes include domestic, lawn and garden, and fire protection). It is important to distinguish between a "municipality" and "municipal use." A municipality is a jurisdictional status: an incorporated city or town organized and incorporated under Title 7, Chapter 2, of state law. Municipal water use is considered a type of water use that is not limited to municipalities; it also includes subdivisions and water and sewer districts, including water appropriated by and provided for those in and around a municipality or an unincorporated town.

Municipal suppliers have diverse demands they must fulfill, which makes planning challenging. Water quality comes into play as well. Many municipalities rely on higher-elevation storage, which can bring unique challenges (ice damage, forest fire effects, etc.). Municipal water demand figures vary widely, and may include demand from residential, commercial, industrial, university, and government agency users. In general, in-home water use is not highly consumptive, but lawn and garden uses are. Fourteen municipalities in the Upper Missouri Basin have water reservations for future use. Municipalities are being creative in other ways in planning for future water needs, including buying shares from state-owned reservoirs, leasing USBR contract water, requiring existing water rights be transferred to the city when a city annexes land (both surface water and groundwater rights), and purchasing nearby rights to change to municipal use. DNRC continues to develop policies for rainwater harvesting and wastewater reuse. Generally, if the capture is within the place of use of an existing right, there is not a concern. DNRC is asking that anyone proposing rainwater harvest of more than 0.1 acre-feet contact DNRC before moving forward. Regarding wastewater reuse, if the reuse is a new beneficial use of water, a water right permit or change may be needed.

The City of Bozeman recently completed an integrated water resource management plan that could provide a model for water supply planning elsewhere. The city used 30- and 50-year planning horizons; projected demand with both moderate and high growth rates; considered firm water supply yields, water rights, and seasonality; reviewed available water supply in context with the future water balance gap; modeled conditions with and without climate change; and scored and ranked supply options. The process resulted in identified water supply alternatives to further investigate to meet future water supply needs. Bozeman's characterization of water demand by use class is shown in Figure 4. 3. "Unaccounted for" water is likely largely system leakage.

Figure 4.3 Total Municipal Water Demand for the City of Bozeman



Water Use: Recreation and Tourism

Recreation and tourism are also major uses of water in the Upper Missouri Basin. Of the 54 state parks in Montana, 14 are located in the basin and six are water-based parks. Other major water-related recreational attractions include the Missouri main-stem reservoirs, the area's many trout streams, tailwater fisheries below hydropower facilities, reservoirs in the headwaters systems (Hebgen, Ennis, Ruby, and Clark Canyon), and national forest land. In 2011, the Missouri/Madison corridor supported close to 550,000 summer recreation group visits. The visits were fairly evenly divided across three regions, with somewhat more activity occurring on rivers in comparison to reservoirs. Fishing and boating remain popular recreational activities in the country, with more than 46 million Americans fishing in 2011. Montana residents make frequent use of rivers, streams, natural lakes and reservoirs, and 46 percent of all fishing in Montana occurs in the Upper Missouri Basin. Ten million visitors a year come to Montana to hike, fish, ski, bike, hunt, kayak, boat, and explore. When travelling in Montana, visitors indicated that clean waterways and clean air are among the most important attributes to their experience.

Water Use: Fisheries and Environmental Concerns

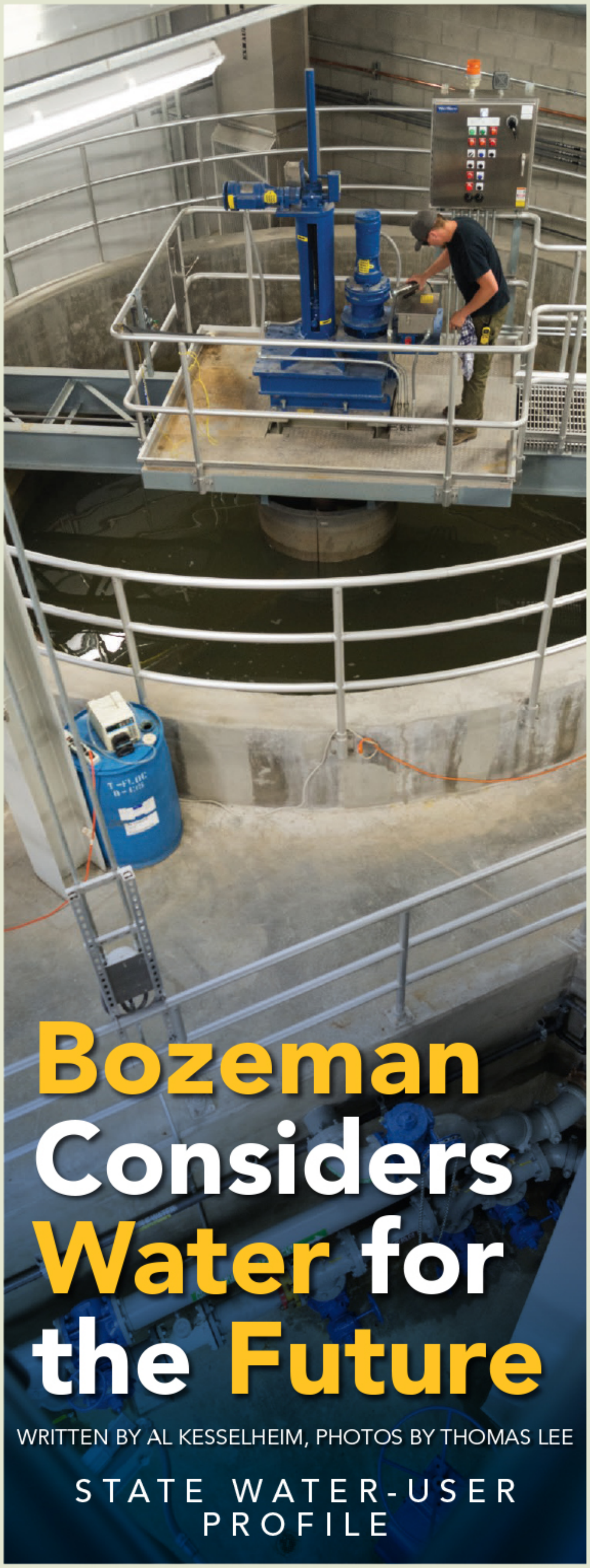
Streams, lakes, and reservoirs in the Upper Missouri River basin support popular fisheries. The headwaters streams typically support cold water, trout fisheries. Further downstream, and especially below Great Falls, the system transitions to a warm-water fishery with a more diverse assemblage of fish species. Protection for fisheries resources is provided through the presence of downstream senior water rights, water rights targeted to specifically protect instream flow, and reservoir operational considerations. Still, water development and habitat alteration have contributed to fisheries and other environmental concerns in the Upper Missouri River Basin.

Streamflow patterns have been modified by reservoirs, diversions and return flows. Stream channels have been changed through the construction of levees, dikes, and berms. Riparian habitat and floodplain landscapes have been altered. Non-native species have displaced native fish in some instances. The effects of all these factors have been detrimental to some native fish species. Table 4.1 lists fish species of concern in the Upper Missouri River basin. Of the species listed in Table 4.6*,* only the Pallid Sturgeon is a federally listed endangered species; the others are identified as species of concern.

Table 4.6 Native fish species of concern in the Upper Missouri River Basin as indicated by the MT Natural Heritage Program

Common Name	Scientific Name	Status
Pallid Sturgeon	Scaphirhynchus albus	G1, S1, E
Blue Sucker	Cycleptus elongatus	G4, S2, S3
Paddle Fish	Polyodon spathula	G4, S1, S2
Sturgeon Chub	Macrohybopsis gelida	G2, S2
West Slope Cutthroat Trout	Oncorhynchus clarki lewisi	G4, T2, S2
Sauger	Sander canadensis	G5, S2
Spoonhead Sculpin	Cottus rhotheus	G5, S3
Lake Trout	Salvelinus namaycush	G5, S2
Arctic Grayling	Tymallus arcticus	G5, S1, C
Northern Red Belly Dace	Chrosomus eos	G5, S3
Northern Red Belly Dace X Finscale Dace	Chrosomus eos x chrosomus neogaeus	GNA, S3

G1 S1 - At high risk because of **extremely limited** and/or **rapidly declining** population numbers, range and/or habitat, making it highly vulnerable to global extinction or extirpation in the state.
G2 S2 - At risk because of **very limited** and/or **potentially declining** population numbers, range and/or habitat, making it vulnerable to global extinction or extirpation in the state.
G2 S3 - Either very rare and local throughout its range, or found locally in a restricted range, or vulnerable to extinction throughout its range.
G4 S4 - Apparently secure, though it may be quite rare in parts of its range, and/or suspected to be declining.
G5 S5 - Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range
GNA - A conservation status rank is not applicable because the taxa is of Hybrid Origin
C - Sufficient information on biological status and threats exists to propose to list them as threatened or endangered. Consideration in environmental planning and partnerships is encouraged; however, none of the substantive or procedural provisions of the Act apply to candidate species.
E - Listed federally endangered.



Bozeman Considers Water for the Future

WRITTEN BY AL KESSELHEIM, PHOTOS BY THOMAS LEE

STATE WATER-USER PROFILE

"50 years ago, 100 years ago, people sat down and thought about Bozeman's water," says Craig Woolard, Bozeman's Director of Public Works. "We're dealing with those decisions today—their foresight, and also their mistakes. A big part of our work day is spent fixing problems started 50 years ago, and trying not to make those kinds of mistakes today."

"Part of the reason I took this job is that Bozeman is really trying to look ahead and take comprehensive stock of the future," Woolard continues. "It speaks to a quality of stewardship that doesn't happen everywhere."

"As recently as 5 or 6 years ago, Bozeman was on the 'dam train'," says Carson Taylor, Bozeman City Commissioner. "That was the go-to option everyone assumed would be the next thing on the horizon when water shortages became an issue."

Building a dam is one of those satisfying fixes, a tangible, targeted plan that everyone can understand and that sounds plausible. Also, something that can be put off to some murky future date when whoever is in charge then can deal with the particulars.

"Around 2010 we decided to take a hard look at those assumptions," says Taylor. "We started asking the difficult questions about the status of realistic water rights, about the cost/return ratio of building a dam. Did it really pencil out? Turns out that there were some problems with the assumptions everyone was making.

"When you depend on engineers for your plans, you get schemes that reflect a love affair with technology," stresses Taylor. "There were even plans for piping water from reservoirs on the Missouri. Of course engineering has to be part of the process, but these plans often don't factor in bigger picture costs, things like the impacts on the environment."

While some sort of dam or system of reservoirs in the foothills south of Bozeman may still be in Bozeman's future, the issues raised in the early assessment provoked the City Commission to take on a full-scale study of options.

"We're a headwaters community," stresses Woolard. "We don't have the main stem of the Missouri River flowing past to count on. What that means is that we have to look at an all-of-the-above approach to water supply."

Starting in 2010, Bozeman's City Commission took steps to get a handle on the big picture. They hired a consulting firm and established a Technical Advisory

Committee with a diversity of stakeholders, from Trout Unlimited to agriculture. It wasn't rocket science, but it cost money and took genuine effort. Mostly, it took a willingness to look at realistic components of a potential solution to future water issues, and to do it sooner than later.

By definition, these studies are part crapshoot. Population estimates are at best informed guesswork. Planners used a projected population of 120,000 for 2060 and came up with a municipal water demand of 17,000 acre-feet per year. Currently, the city can adequately manage 10-12,000 acre-feet. The million-dollar question was, how does Bozeman cover that shortfall?

What emerged from several years of study, a clear-eyed look at options, and hundreds of hours of volunteer effort is the Integrated Water Resources Plan, which essentially codifies the all-of-the-above approach to Bozeman's water for the next half century.

The first step in the plan is to emphasize conservation. Bozeman hired a conservation coordinator, Lain Leoniak, who is one of the first paid conservation specialists in Montana city government.

"This is something we can start right now," says Woolard. "It begins with education, everything from more efficient toilets to community outreach and billing. It's the common sense approach."

It's also tricky, because it requires challenging long-held attitudes and practices. "It's a level of consciousness," emphasizes Taylor. "It means that you think about water use with every decision, every project."

Part of conservation for Bozeman, as with many municipalities, is keeping up with maintenance. "We want to drop leakage in our pipes and infrastructure from 20 percent to 10 percent," says Taylor. "That's thousands of acre feet right there."

"We've been investing in leak detection and a program of repairs. We want to be 'Best In Class' when it comes to infrastructure efficiency," agrees Woolard.

Bozeman also built a state-of-the-art water treatment plant in Sourdough Creek that Woolard calls "the nicest treatment facility in the state."

At the same time, Bozeman is looking long-term at upgrading the supply from Lyman Creek, which is Bozeman's oldest source of city water, while also exploring potential sources of groundwater supply and the potential for a set of small reservoirs in the Sourdough drainage which could be instrumental in maintaining a steady and predictable supply.

"It never stops," stresses Woolard. "You have to keep on top of it constantly. It isn't something that ever gets done."

"Just because we have this document doesn't mean we can sit back," agrees Taylor. "We'll revisit the plan every five years or so."

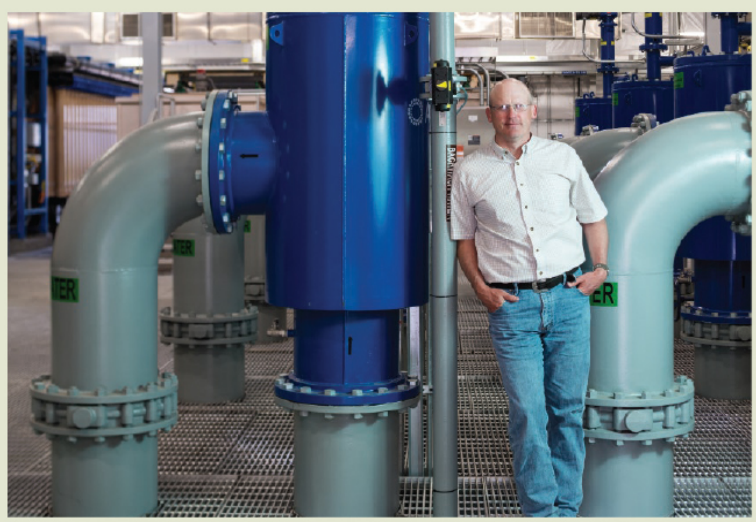
In every scenario, there are the weaknesses that give planners nightmares.

"What keeps me up at night," admits Woolard, "is our lack of redundancy in treated water storage. At this point we have about a 10-million-gallon capacity. That's one day of peak summer demand. It's the riskiest aspect of Bozeman's system."

The good news, despite an occasional sleepless night, is that there is a plan and a commitment to work within its principles. ■

"We've been investing in leak detection and a program of repairs. We want to be 'Best In Class' when it comes to infrastructure efficiency."

—Craig Woolard



V. Water Resources in the Upper Missouri Basin

A. Basin Overview

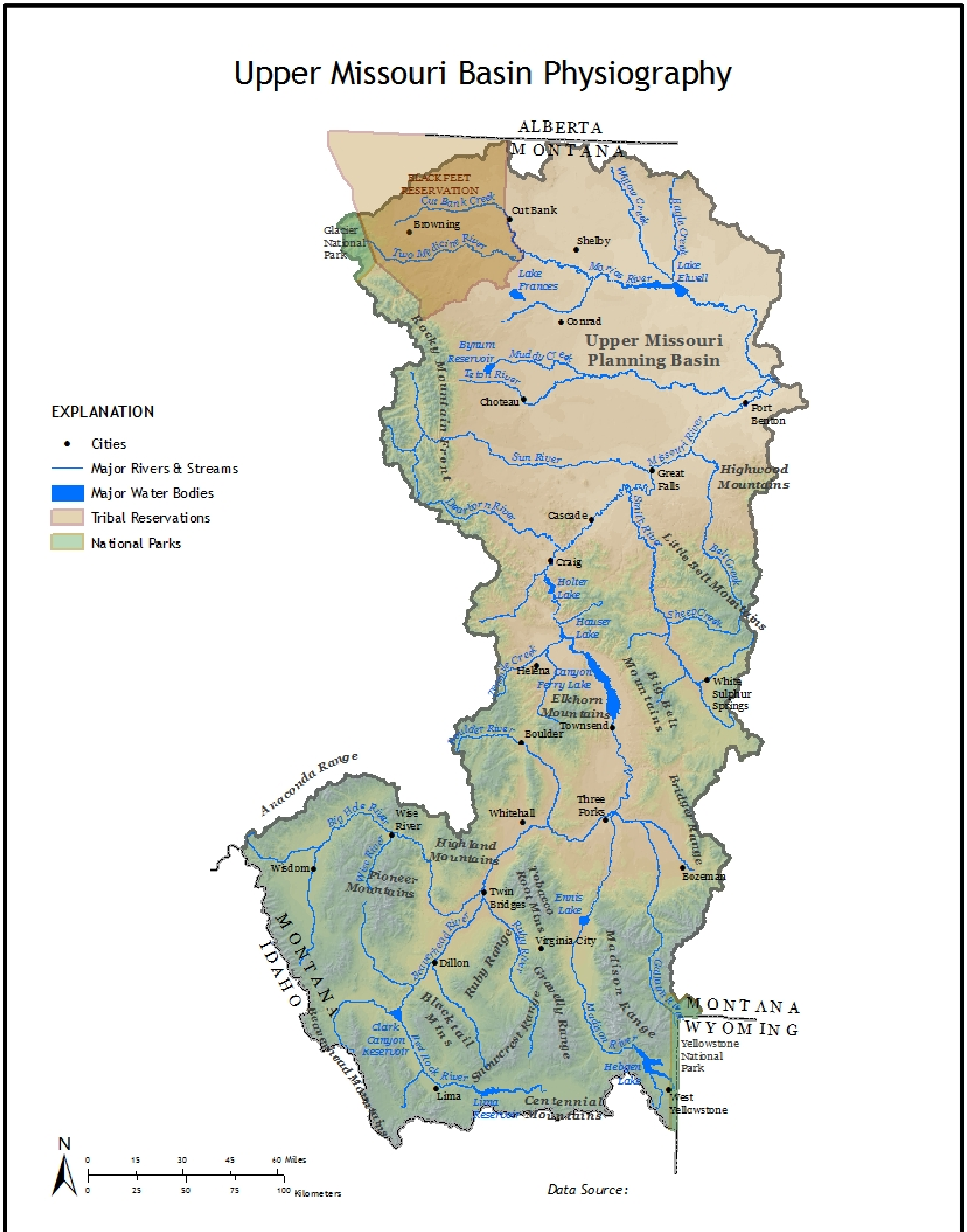
PHYSIOGRAPHY

The Upper Missouri River Basin is the headwaters to a continent. The first trickles of flow that originate from snowfields high above the Centennial Valley in southwestern Montana eventually find their way to the distant Gulf of Mexico. The mighty Missouri proper is formed by the confluence of the Gallatin, Madison, and Jefferson Rivers near Three Forks, Montana. Other important tributaries include the Beaverhead, Big Hole, Ruby, Smith, Sun, Teton, and Marias Rivers (Map 5.1).

Upper Big Hole Basin

The Upper Missouri River Basin drains an area of about 33,300 square miles (21,300,000 acres). Topographically, the headwaters area is partitioned into a series of mountain ranges and valleys. The highest snow-capped peaks here exceed 11,000 feet and typical mountain valley elevations are about 4,500 to 6,000 feet. After leaving the headwaters, the Missouri River descends through a series of somewhat lower mountains, valleys, and plateaus before cascading over the Great Falls and entering the Great Plains physiographic region near Great Falls, Montana. In the lower portions of the basin, the Sun, Teton, and Marias Rivers and their tributaries arise in the Rocky Mountains, but they flow substantial distances through drier prairie regions. By the time the Missouri River reaches Loma at the outlet of this basin, it has dropped to an elevation of about 2,600 feet.

Map 5.1 Upper Missouri River Basin and streams



GEOLOGY

Headwaters and Middle Regions

The mountainous region of the upper Missouri River Basin includes the Missouri River to Great Falls and the Madison, Gallatin, Jefferson, Big Hole, Beaverhead, Ruby, and Smith Rivers. Mountain uplift, basin subsidence, and erosion have resulted in the deposition of complex sequences of sedimentary materials in valleys surrounded by bedrock mountains. The relatively broad valleys were formed when blocks of bedrock dropped along mountain-front faults as the Earth’s crust was stretched. The resulting roughly parallel valleys contain thousands of feet of unconsolidated sediments and semi-consolidated sedimentary rocks eroded from the mountains. The variable character of the basin fill sediments reflects variations of climate, erosion rates, sediment deposition processes, and volcanic activity.

Geologic units in the headwaters and middle regions of the upper Missouri River basin can be grouped generally as Quaternary-age unconsolidated surficial sediments, Tertiary semi-consolidated sedimentary rock, and bedrock. Unconsolidated surficial sediments generally consist of relatively narrow strips along major stream and colluvial and alluvial fan deposits around basin perimeters. These sediments generally are less than 100 feet thick but are thicker in some locations. Semi-consolidated sedimentary rocks overlying fine-grained units underlay unconsolidated surficial sediments and outcrop along the margins of many of the basins. Shallower coarser-grained Tertiary deposits were deposited as mud and debris flows and channel fills on alluvial fans (Fields and others, 1985). Deeper fined-grained Tertiary deposits consist of volcanic origin, lakebed silt, fine sandstone, wetland deposits, and local conglomerate (Fields and others, 1985).

Dense metamorphic and igneous rocks form the cores of the many of the mountain ranges in the mountainous portion of the upper Missouri River Basin. Archean-age metamorphic rocks are found in the Gallatin, Madison, Ruby, Gravelly, Tobacco Root, and Highlands mountain ranges. Igneous intrusions are found in the Boulder Batholith between Butte and Helena and in the Tobacco Root Mountains as well as isolated intrusions throughout the region. Metasedimentary rocks of the Belt Supergroup outcrop in the Belt and Little Belt mountains and intermittently in other mountain ranges. Volcanic rocks are found in the Elkhorn and Adel Mountains and in scattered isolated outcrops throughout the southwest mountains. Folded and faulted Mesozoic-age and Paleozoic-age sandstone, shale, and limestone outcrop along the margins of mountain ranges and form the cores of the Bridger, Big Belt, and Little Belt Ranges.

Plains Region

The plains region of the upper Missouri River Basin, including drainages of the Sun, Teton, and Marias Rivers and Belt Creek, is underlain by relatively flat-lying Cretaceous-age mudstones and sandstones that are deformed by the Sweetgrass Arch. Surficial sediments along the Rocky Mountain front consist of sand and gravel alluvium deposited along the floodplains of the Sun, Teton, and Marias Rivers and dissected alluvial terrace remnants of older floodplains that cap benches such as the Greenfield and Burton Benches between the modern drainages. Glacial till and outwash from continental and alpine glaciers were deposited in the northern extent of the basin near the mountain front on the Blackfeet Reservation. Alluvium of the Missouri River and a buried and abandoned gravel-filled channel south of Great Falls also influence movement and availability of groundwater.

The Sweetgrass Arch and the Rocky Mountain disturbed belt are the dominant geologic structures in the region. The Sweetgrass Arch is a broad arch in bedrock formations extending from the Little Belt Mountains into southern Alberta and includes South Arch and the Kevin-Sunburst Dome. South Arch extends from the Little Belt Mountains to Conrad. The Kevin-Sunburst Dome is on the west side of the Sweetgrass Hills (Wilke, 1983). Paleozoic-age limestone of the Madison Group appears as outcrops in ridges in the Little Belt Mountains and the complexly faulted and folded disturbed belt that forms the western edge of the basin within the mountains of the Rocky Mountain Front.

HYDROGRAPHY

The headwater tributaries to the Missouri River Basin generally flow north in response to the dominant south-north trend of the relatively parallel mountain ranges in the headwaters. The Missouri River itself flows north, as does the tributary Smith River, before trending more northeasterly in the vicinity of Great Falls. In contrast, the Sun, Teton, and Marias Rivers, which drain the Rocky Mountain Front, flow in a mostly easterly direction. Map 5.2 shows the major streams in the basin and their relative flow contributions.

WATERSHEDS

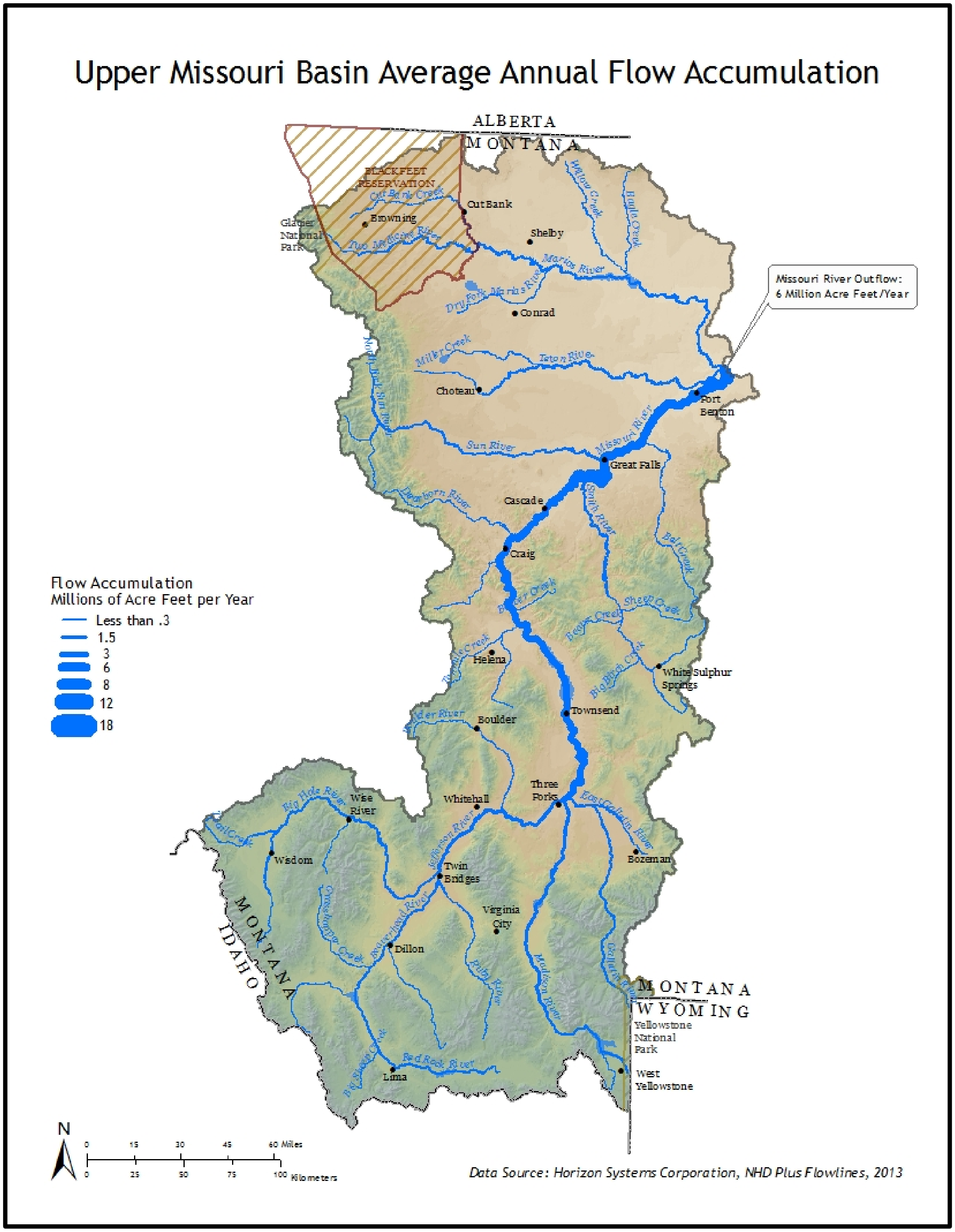
Because the Upper Missouri River Basin is so large and diverse, some of the discussions and data summaries in this report will be categorized by the watersheds described in Table 5.1. These watersheds correspond to what might be considered the major drainages in the basin, based on volumes of water produced, level of water resources use, and geographic extent. Also included is the Missouri River and its smaller tributaries that are not within the any of the watersheds listed below. Cumulative summation points, listed in bold, have been included for the headwaters area and the entire upper Missouri River Basin.

Table 5.1 Upper Missouri River watersheds (Source of data for median annual volume computations, U.S. Geological Survey streamflow gaging data records for 1955-2012 period)

Watershed	Drainage Area (square miles)	Approximate Median Annual Volume of Water Produced (acre-feet)
Gallatin River	1,800	946,000
Madison River	2,510	1,310,000
Ruby River	965	216,000
Beaverhead-Red Rock Rivers	3,620	592,000
Big Hole River	2,500	817,000
Jefferson River*	2,445*	120,000*
Missouri River Headwater Total (to Toston)	**14,700**	**4,000,000**
Smith River	2,000	244,000
Sun River	1,850	560,000
Missouri River main stem and smaller tributaries	5,600	1,400,000
Teton River	2,010	166,000
Marias River	7,140	705,000
Missouri River to Marias River Total	**33,300**	**7,070,000**

- For the Jefferson River, the drainage areas and flow volumes listed are only for that portion contributed from the confluence of the Beaverhead and Jefferson Rivers near Twin Bridges to where the Missouri River is formed near Three Forks.

Map 5.2 Major Upper Missouri River streams and relative flow contributions



B. Surface Water Resources of the Upper Missouri Basin

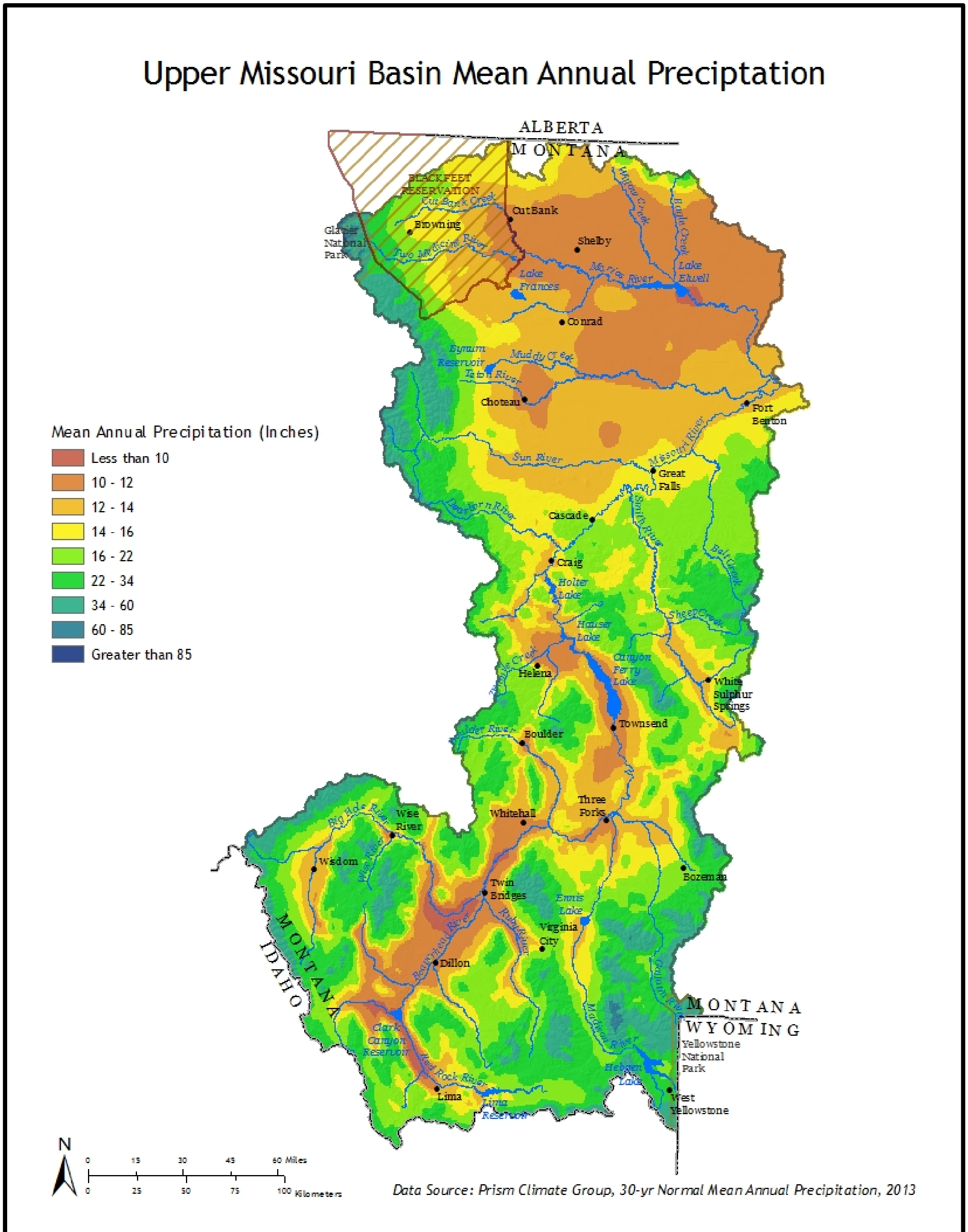
CLIMATE

Precipitation

Water resources in the Upper Missouri Basin are supplied by precipitation, a portion of which ultimately will be realized as surface water flow. Most of the rest will evaporate or be transpired by vegetation, or percolate, at least temporarily, to groundwater aquifers. Map 5.3 depicts average annual precipitation in the Upper Missouri Basin. Average annual precipitation ranges from about 10 inches in the drier valleys and prairies to about 80 inches at the highest elevations, with the overall average being about 19 inches. This average is disproportionately weighted by relatively smaller higher elevation areas, which receive much higher precipitation than the more extensive lower elevation zones. In fact, about 70 percent of the basin land surface receives less than 20 inches of precipitation on an average annual basis.

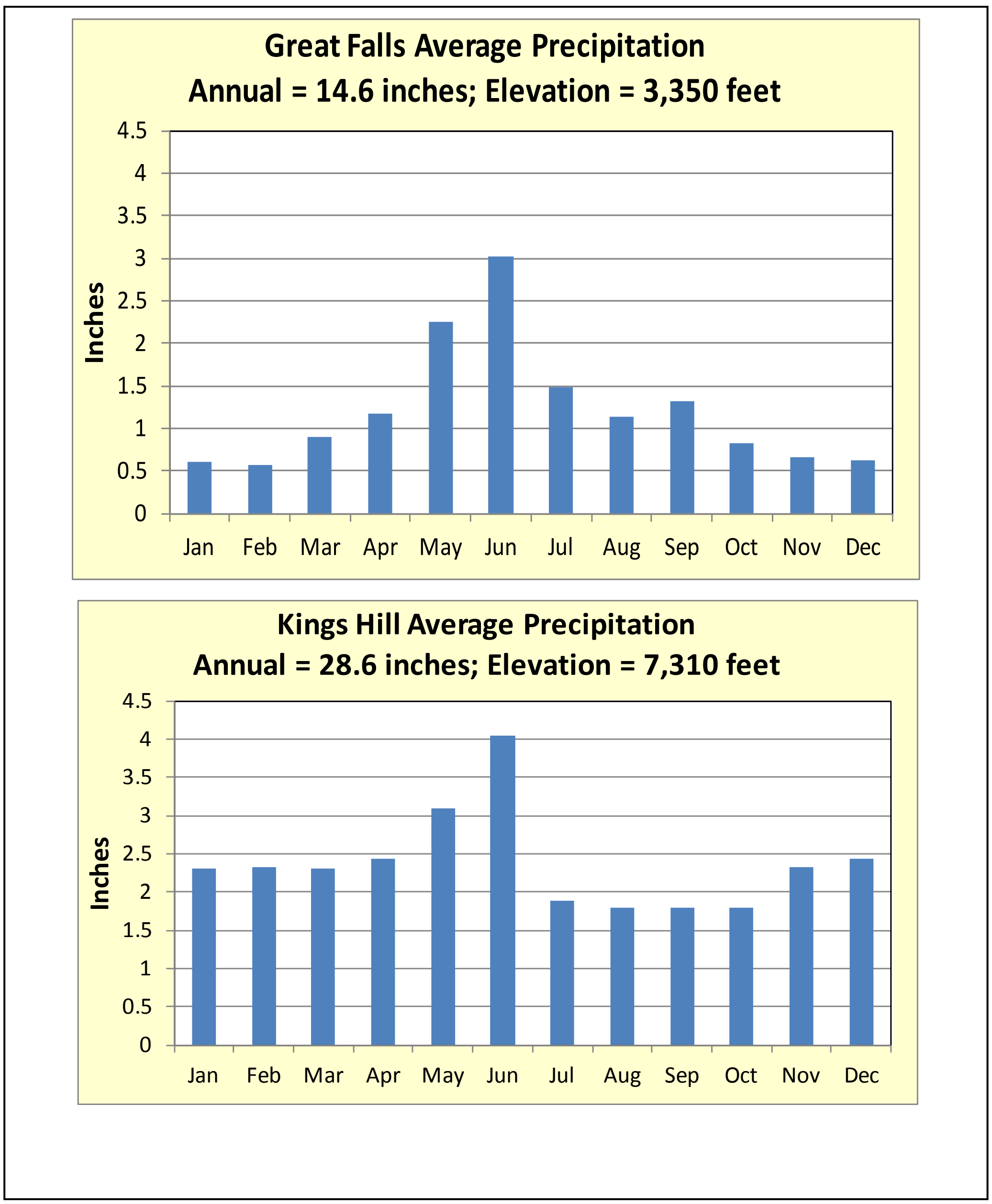
Precipitation in the Upper Missouri River Basin generally increases with elevation. Higher elevations and mountains are water producing areas, where precipitation is often higher than the amount of water the plants need to grow. Lower elevation valleys are water deficit areas, where the precipitation is usually less than evaporation and evapotranspiration. Another area of generally low precipitation is the Great Plains in the north-eastern portion of the basin, where average precipitation is generally in the range of 10 to 15 inches.

Map 5.3 Upper Missouri River Basin precipitation map

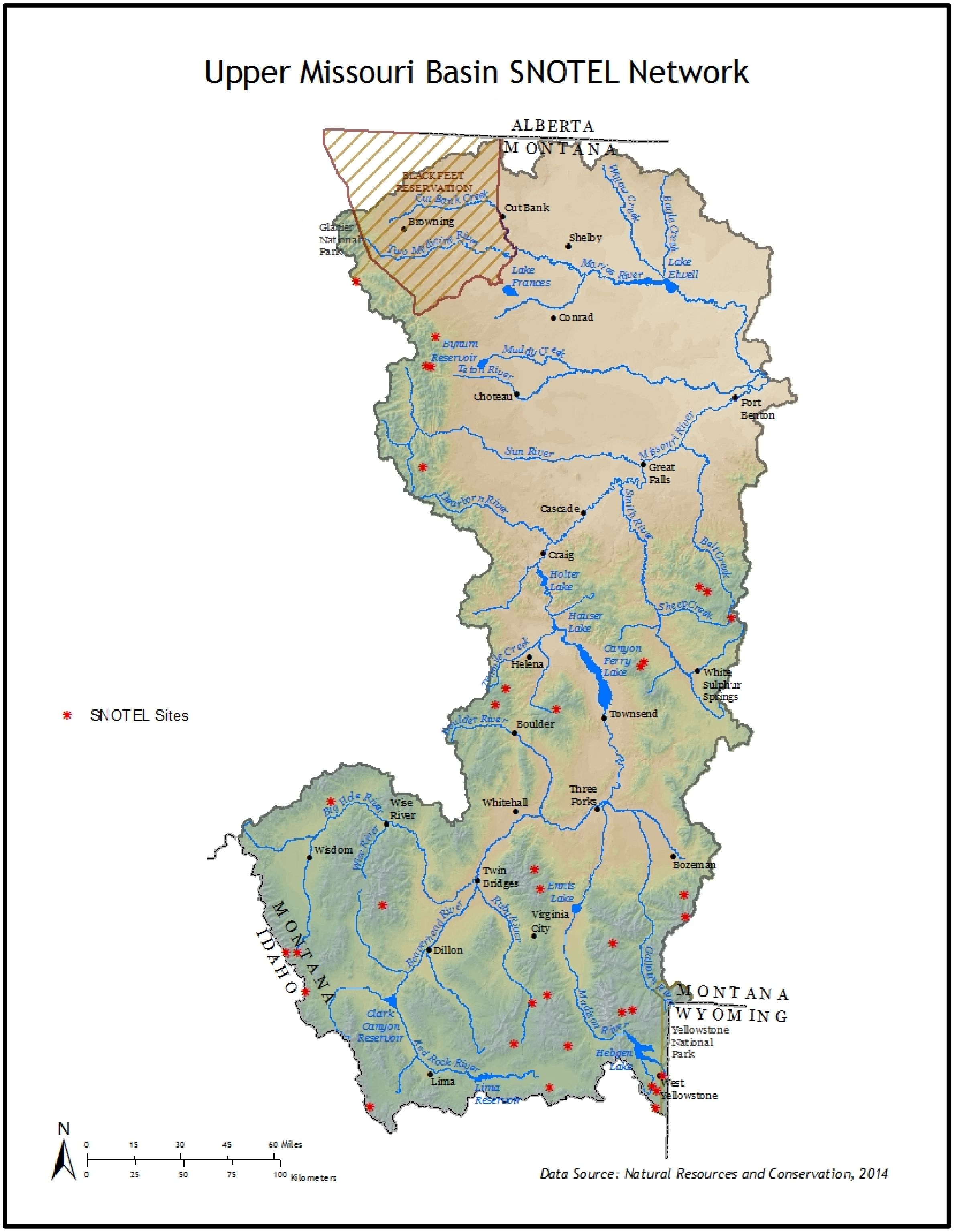


To demonstrate the influence of elevation on precipitation, Figure 5.1 compares average annual precipitation for the Great Falls and Kings Hill weather stations, both which are in the north-central portion of the basin. The elevation—and also precipitation—at Kings Hill in the Little Belt Mountains is almost twice that at Great Falls on the edge of the Great Plains. As is typical in the basin, precipitation at these stations usually is greatest during the month of June, followed by May, although month-to-month precipitation is more consistent at the higher elevation Kings Hill station.

Figure 5.1 Precipitation at Great Falls and Kings Hill compared (data source: Western Regional Climate Center; http://www.wrcc.dri.edu/)

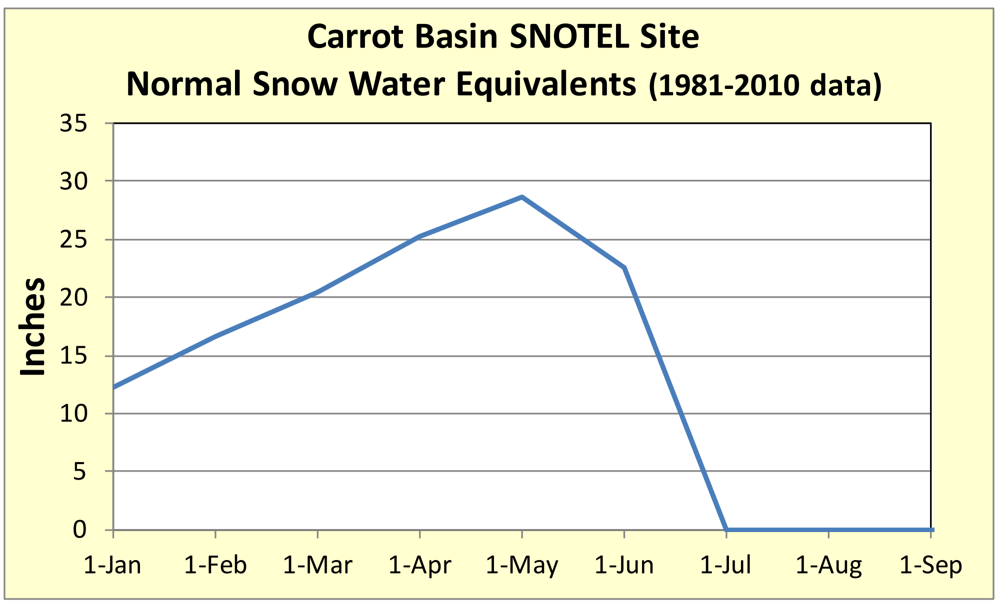


Map 5.4 NRCS SNOTEL monitoring sites in the Upper Missouri River Basin



An important component of the annual precipitation in the Upper Missouri River Basin is snow. Mountain snowpack in the Upper Missouri River Basin generally begins to accumulate in the late fall, with the snowpack peak typically occurring near the end of April or beginning of May. Snow accumulation and snow water equivalents are tracked in near real time through the Natural Resources Conservation Service's SNOTEL monitoring network (Map 5.4). Figure 5.2 depicts winter snowpack accumulation (inches of snow water equivalent) and spring melt for the Carrot Basin SNOTEL Site, a higher elevation site in the Madison Range in southwestern Montana. Note how snow water equivalents peak at about 28 inches, on average, at about the first of May. Some of this accumulated snow melts in May, but the majority of the snow melts during June. Prairie and valley snow can be important too, but it is more variable, with some years having considerable snow buildup and other years having drier, open winters. When there is prairie snow build up, the main melt might typically occur from later February through mid-April, but can occur as late as May.

Figure 5.2 Average snow water equivalents for the Carrot Basin SNOTEL Site



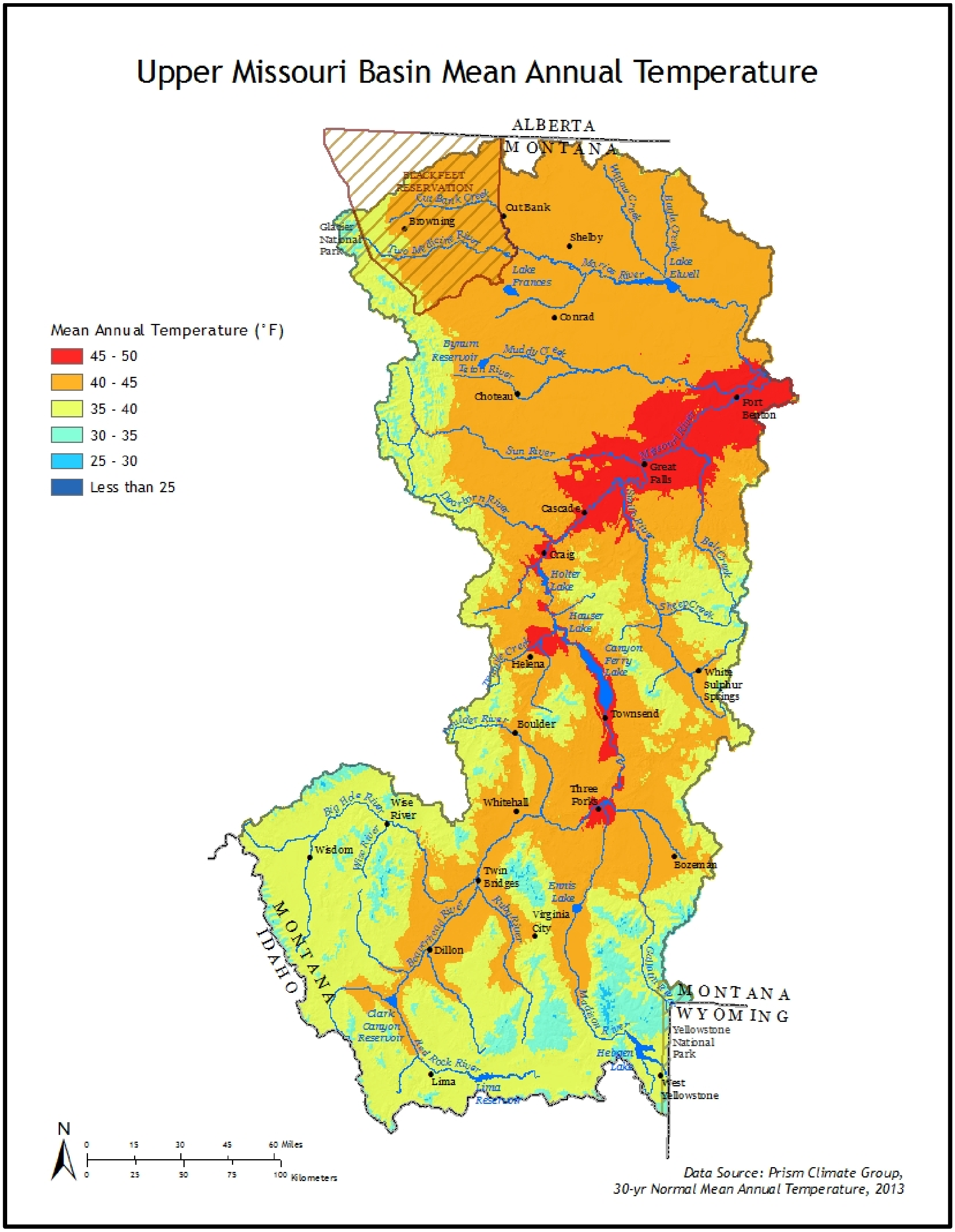
(Data source: USDA Natural Resources Conservation Service, Montana Snow Survey and Water Supply Forecasting Program; http://www.nrcs.usda.gov/wps/portal/nrcs/main/mt/snow/)

Temperature

Map 5.5 depicts the average daily temperatures for the Upper Missouri River Basin. The overall annual average annual temperature for the basin is about 41° Fahrenheit. For the most part, the coolest temperatures are associated with the highest elevations. This is not always the case, though, especially during the winter, when cold air pockets settle in the valleys and on the plains, bringing below-zero temperatures.

Temperature also affects the length of the growing season and evapotranspiration water requirements for plants. Typically, evapotranspiration is highest in the valleys and on the plains where summer temperatures are warmer and the growing season is longer.

Map 5.5 Average Annual Temperatures for the Upper Missouri River Basin



STREAMFLOW

Higher elevation mountainous areas are the source for most of the streams in the Upper Missouri Basin headwaters. Streams that flow through the plains, such as the Marias, Teton, and Sun Rivers, typically receive most of their flow from the Rocky Mountain Front, although during some years the large prairie areas can generate substantial amounts of runoff too.

The following sections briefly describe the major streams in the watershed and characterize flow rates and patterns. Table 5.2 summarizes representative U.S. Geological Survey gaging stations and average annual flow rates and volumes for some of the major streams in the watershed. For most stations, average flow rates and volumes were computed using 1955-2012 records, the period following the construction of Canyon Ferry Dam, although for some of the streams, flow data were not available for that entire period. Based on the average flow volume of 6,160,000 acre-feet near Virgelle and an average precipitation of 19 inches (see precipitation section) over the 21,300,000 acre-basin, only about 18 percent (about 3.5 inches) of the precipitation that falls on the Upper Missouri Basin leaves as surface flow.

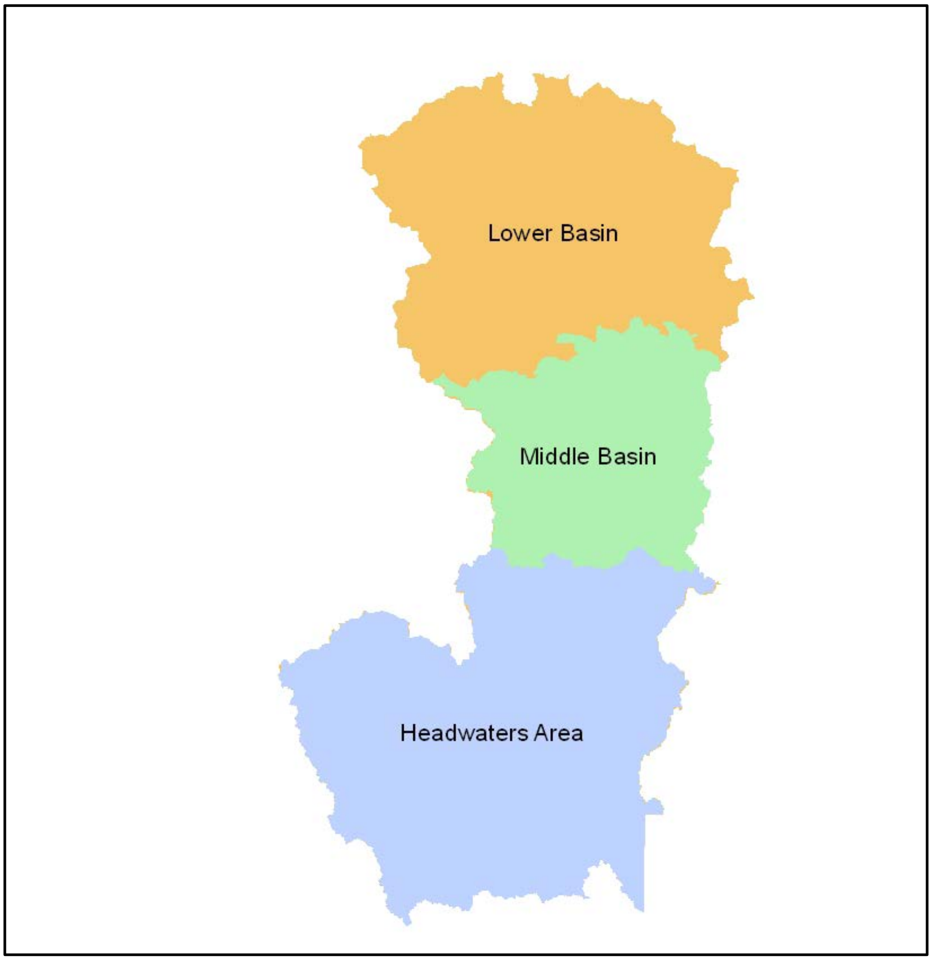
Table 5.2 Flow summary for stream gaging stations in the Upper Missouri River Basin

Stream and Gage Location	USGS Gage Number	Average Annual Flow (cfs)	Average Annual Volume (acre-feet)	Drainage Area* (square miles)
Gallatin River at Logan	06052500	1,130	821,000	1,795
Madison River below Ennis	06041000	1,790	1,300,000	2,186
Ruby River near Twin Bridges	06023000	195	141,000	596
Beaverhead River at Barretts	06016000	488	354,000	2,737
Big Hole River near Melrose	06025500	1,110	804,000	2,476
Jefferson River near Twin Bridges	06026500	1,800	1,310,000	7,632
Boulder River near Boulder	06033000	124	90,100	381
Missouri River at Toston	06054500	5,020	3,630,000	14,669
Missouri River below Holter Dam	06066500	5,380	3,900,000	17,149
Dearborn River near Craig	06073500	182	132,000	325
Smith River near Eden	06077500	354	256,000	1,594
Sun River near Vaughn	06089000	660	478,000	1,849
Teton River near Dutton	06108000	122	88,200	1,307
Two Medicine River near Browning	06091700	330	239,000	250
Birch Creek near Valier	06098100	94.2	68,200	471
Cut Bank Creek at Cut Bank	06099000	175	127,000	1,041
Marias River near Shelby	06099500	829	600,000	3,242
Missouri River at Virgelle	06109500	8,510	6,160,000	34,379

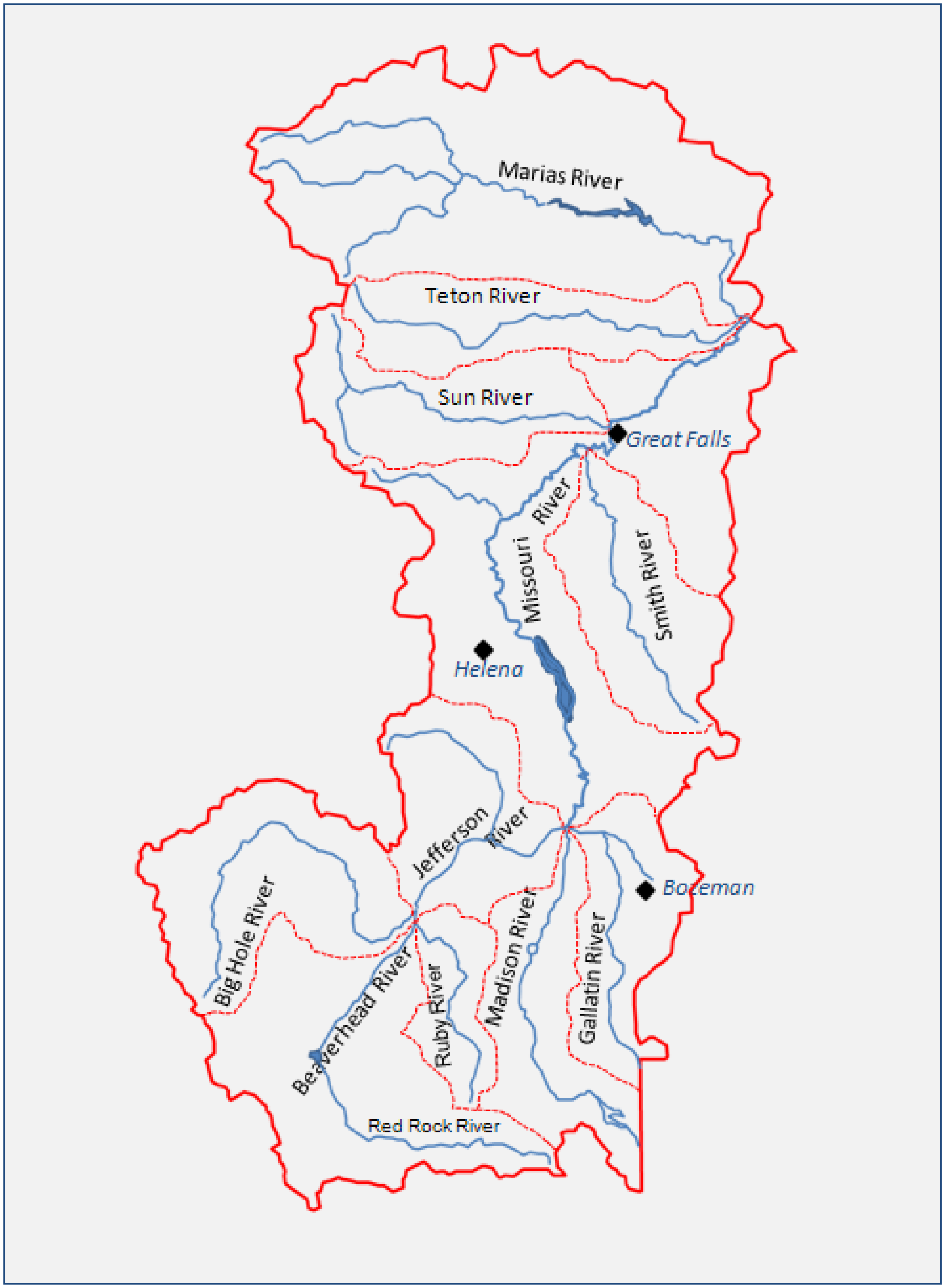
* Representative of area above gage. Because gages are not always included at the mouth, some drainage area for sub-basins may not be included. Data source: U.S. Geological Survey streamflow data at http://mt.water.usgs.gov/.

Streamflow characteristics will be described for the headwaters area, middle portions of the basin, and lower portions of the basin (Map 5.6), and the major watersheds within these subbasins as described in Table 5.1 and depicted in Map 5.7.

Map 5.6 Upper Missouri River major sub-basins



Map 5.7 Upper Missouri Basin streams with major watersheds outlined



Headwaters area

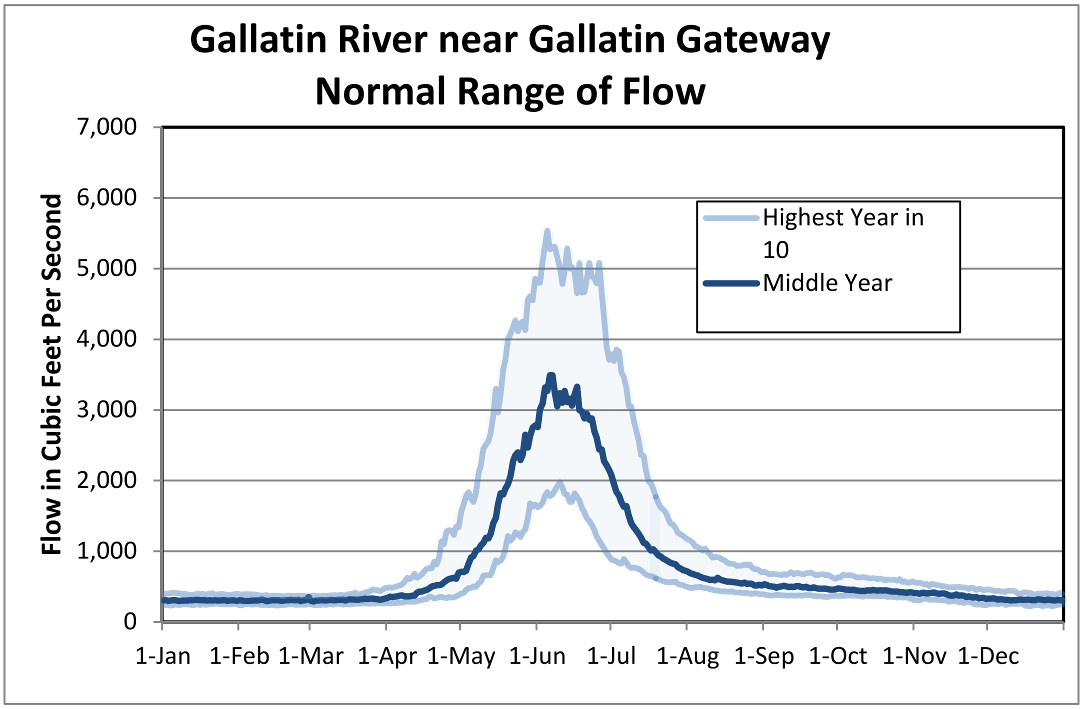
The headwater area includes the three forks of the Missouri River—the Jefferson, Madison, and Gallatin rivers—and tributaries to these streams. Most flow in the headwaters originates in the mountain ranges that rise to as high as 11,000 feet and which receive substantial amounts of rain and snow. Valley bottoms, on the other hand, are typically much drier and range in elevation from 4,000 to 6,000 feet. Streamflow patterns in the headwaters area are snowmelt dominated, typically peaking during late May or early to mid-June, which coincides with peak mountain snowmelt and spring rains.

Ruby River near Sheridan

Gallatin River

The Gallatin River originates in the Yellowstone National Park, and is further supplemented by streams from the Madison, Gallatin, and Bridger mountain ranges. The main stem is unregulated, although Middle Creek Dam on Hyalite Creeks captures and stores about 10,200 acre-feet of water. Figure 5.3 graphs the normal range of flow for the Gallatin River at Gallatin Gateway, which is upstream of the Gallatin Valley and above most irrigation diversions. The "normal range of flow", as displayed in this graph and others that follow, depicts daily flow statistics for the highest year in 10 (the top line), the lowest year in 10 (the bottom line) as well as the middle or median year flow (the middle line). The magnitude of the hydrograph peak can vary significantly from year to year, depending on snowpack conditions and the amount of spring precipitation. Base flows, most easily recognized on the graph for the September-through-March period, are much lower but more consistent from year to year.

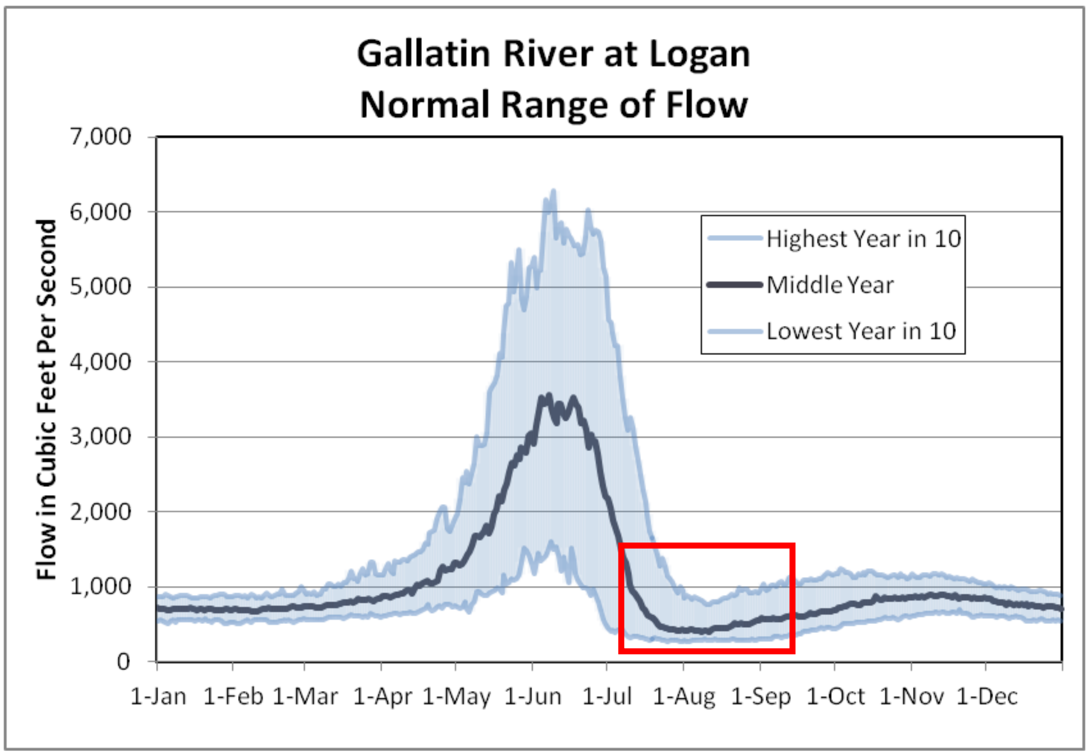
Figure 5.3: Normal range of flow for the Gallatin River near Gallatin Gateway



Data source http://mt.water.usgs.gov/

For comparison, Figure 5.4 displays the normal range of flow for the Gallatin River near Logan, just upstream of the confluence with the Missouri River. During the peak flow months, the tributaries, such as the East Gallatin River, add water to the stream, which increases the flow at Gateway. During mid- to late summer, diversions and depletions for about 110,000 acres of irrigation reduce streamflow, as shown in the portion of the graph outline by the red box. Following the irrigation season, flows at Logan increase and these base flows persist through the fall, winter, and early spring. Much of the increase in base flow at Logan, as compared to the flow at Gateway, results from tributary inflow. Fall and winter flow in the lower Gallatin River likely is further enhanced by irrigation return flow that is coming back to the stream through the aquifer systems.

Figure 5.4 Normal range of flow for Gallatin River near Logan



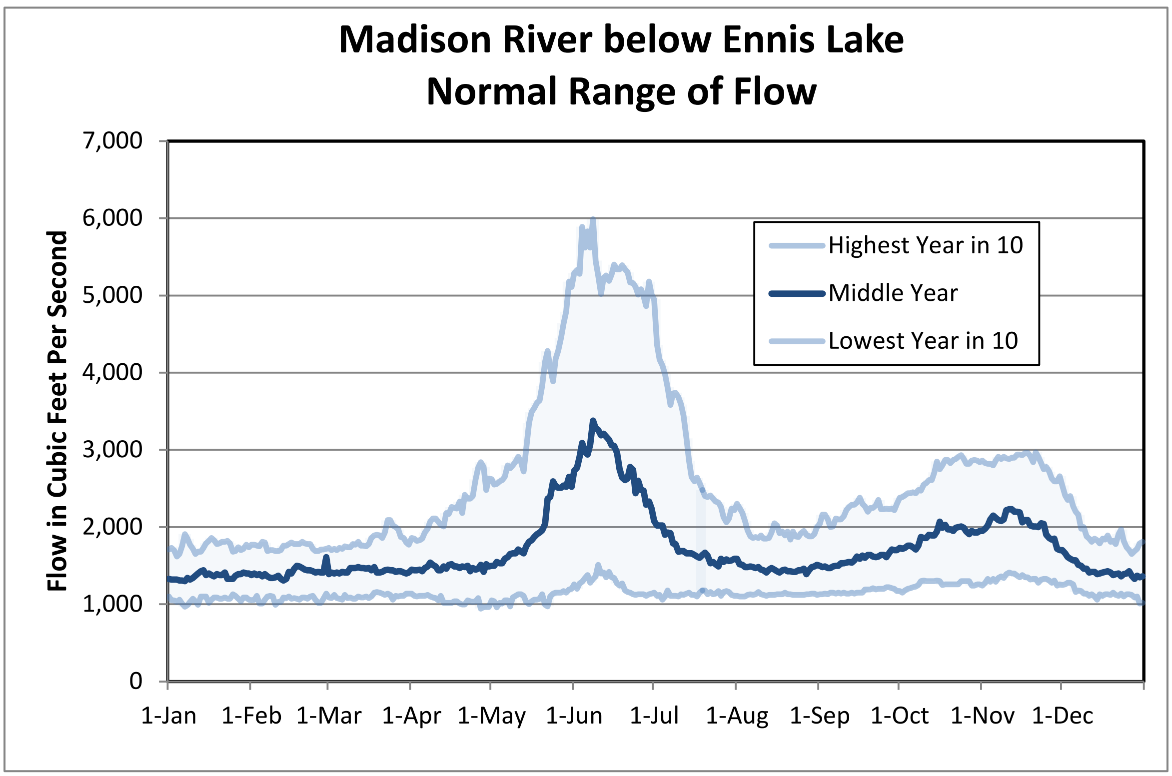
Data source http://mt.water.usgs.gov/

Madison River

The Madison River also originates in Yellowstone National Park, with important flow contributions from tributary streams in the Madison, Gravelly, and Tobacco Root mountain ranges. The Madison is regulated by Hebgen Reservoir just downstream of Yellowstone Park, with a capacity of about 386,000 acre-feet, and Ennis Lake with 27,200 acre-feet of storage. The Madison Valley is characterized by alluvial terraces about 100 to 200 feet above the river, with a limited amount of river-bottom land that was historically easier to irrigate. For this reason, there is not as much irrigation development (about 37,000 acres) relative to other headwater tributaries, and irrigation depletions relative to the total flow are less.

Figure 5.5 depicts the normal range of flow for the Madison River below Ennis Lake (Madison Dam). The effects of flow regulation at Hebgen Reservoir, which stores water during spring runoff and releases water to increase hydropower production when reservoir inflow is lower, especially during the fall, are evident.

Figure 5.5 Normal Range of Flow for the Madison River below Ennis Lake



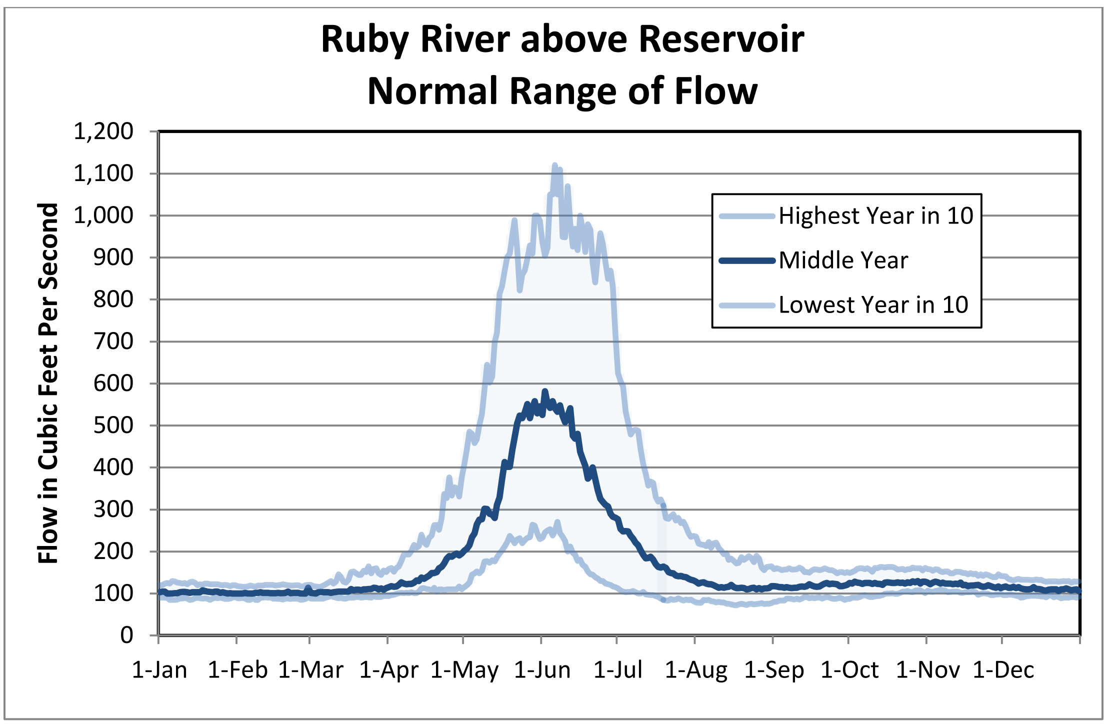
Data source http://mt.water.usgs.gov/

Ruby River

The Ruby River originates in the Snowcrest, Gravelly, and Greenhorn mountain ranges, with flow contributed to the lower Ruby River from tributaries in the Ruby and Tobacco Root mountains. About 36,000 acres of land are irrigated in the Ruby River watershed. Ruby Reservoir, which stores 36,600 acre-feet, has a major effect on the distribution of flow downstream, and is representative of the operations of other mid-sized reservoirs in the basin.

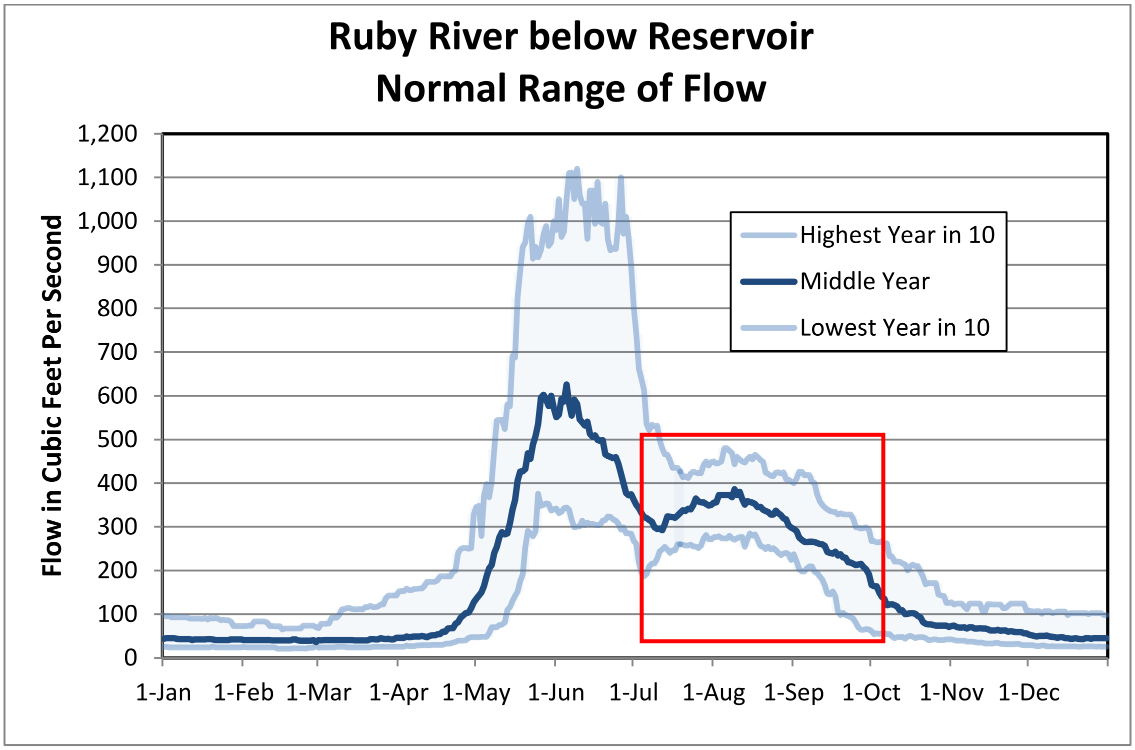
Figures 5.6 and 5.7 depict the normal range of flow for the Ruby River above and below Ruby Reservoir. Inflow to the reservoir follows the typical snowmelt dominated pattern, with peak inflow from late May to early June and a rapid drop to base flow by the early fall. The hydrograph for below the dam reflects the releases of stored water (mostly stored during the winter), which supplements the flow of the river during the peak irrigation season in July, August, and early September (see red box on graph).

Figure 5.6 Normal range of flow for Ruby River above the Ruby Reservoir



Data source http://mt.water.usgs.gov/

Figure 5.7 Normal range of flow for Ruby River below the Ruby Reservoir



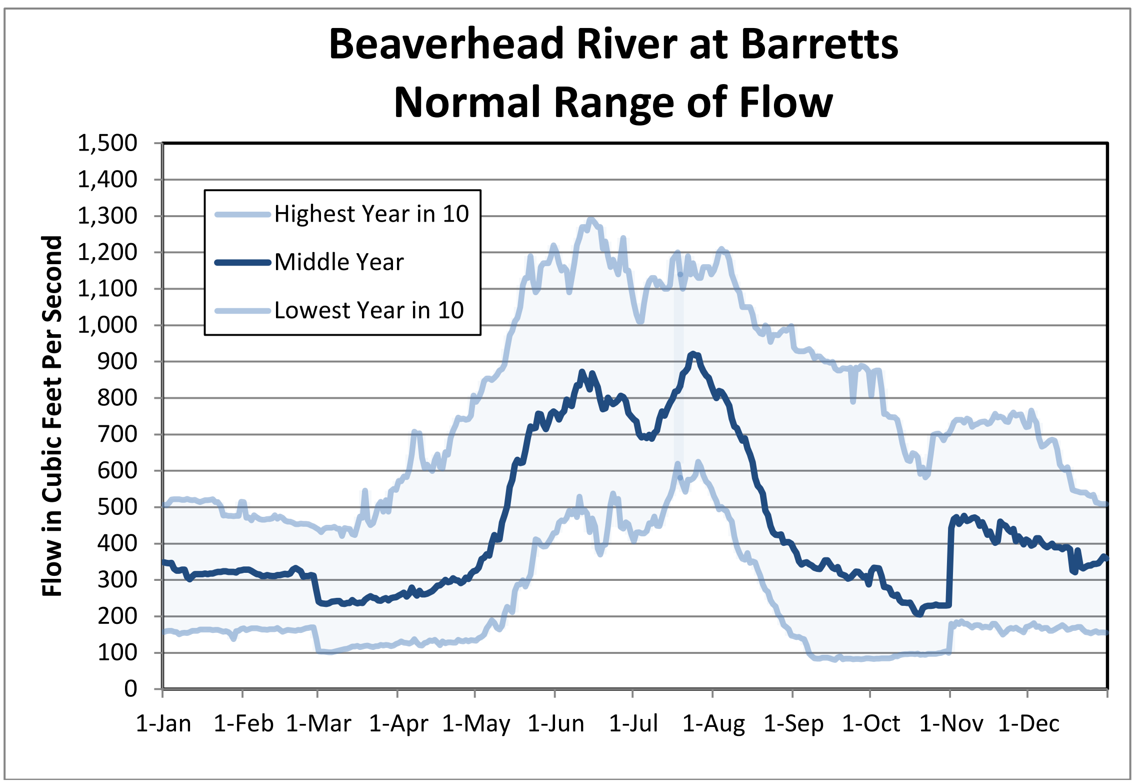
Data source http://mt.water.usgs.gov/

Beaverhead-Red Rock Rivers

The Red Rock River originates in the Centennial Valley in the southwestern corner of Montana. Lima Dam and Reservoir regulate the flow of the stream, where it leaves the Centennial Valley. The Red Rock River then merges with several tributary streams in the vicinity of Clark Canyon Reservoir. Below Clark Canyon Dam, the stream is referred to as the Beaverhead River. There is substantial irrigation and storage development in the Beaverhead-Red Rocks drainage, which has had a considerable effect on streamflow. Approximately 135,000 acres are irrigated overall, and the two major reservoirs can store a combined volume of 338,400 acre-feet: Lima Reservoir on the Red Rock River stores 85,000 acre-feet, and Clark Canyon Reservoir on the Beaverhead River stores 253,400 acre-feet.

Figure 5.8 is a graph of the normal range of flow for the Beaverhead River, just downstream of Clark Canyon Dam and upstream of the major irrigation diversions in the vicinity of Dillon. As the graph depicts, the flow pattern of the stream has been substantially reshaped by operations of Clark Canyon Dam and Reservoir. The graph also shows how much lower flows in the stream can be during dry years as compared to wet years, throughout the season.

Figure 5.8 Normal range of flow for Beaverhead River at Barretts



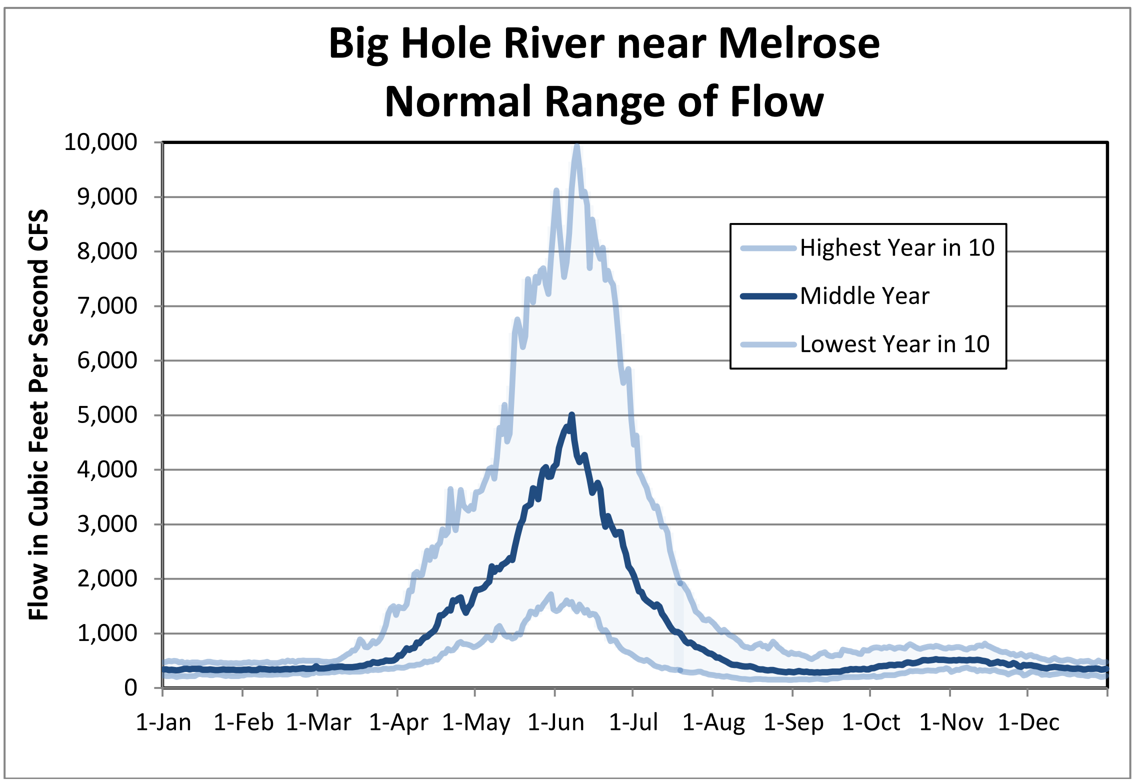
Data source http://mt.water.usgs.gov/

Big Hole River

The Big Hole River originates in the Beaverhead, Pioneer, and Pintler mountain ranges. The river passes through an upper and lower valley. The upper valley, which includes the communities of Jackson and Wisdom, is relatively high with typical elevations from 6,000 to 6,500 feet. The river then passes through a more confined canyon before flowing into a lower valley centered near the town of Melrose. About 170,000 acres are irrigated from the Big Hole River, and most of this is flood irrigated hay or pasture.

Figure 5.9 depicts the normal range of flow for the lower Big Hole River near Melrose. Because there are no significant dams in the watershed, streamflow is typical of a snowmelt dominated system, with the peak most often occurring during early June. Also note that the flow peak during wet years can be about five times higher than during dry years. The flow of the Big Hole River decreases relatively quickly during midsummer, with irrigation diversions and consumption further reducing the flow. Base flows during the fall, winter, and early spring are relatively stable.

Figure 5.9 Normal Range of flow for the Big Hole River near Melrose



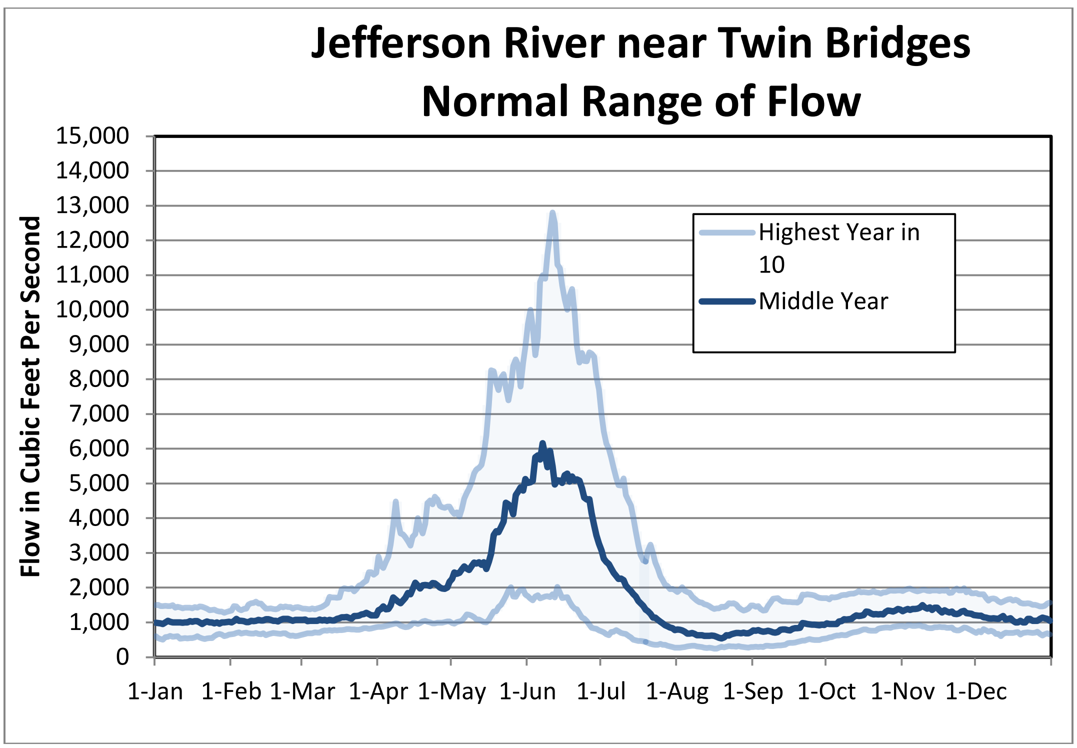
Data source http://mt.water.usgs.gov/

Jefferson River

The Jefferson River is formed by the confluences of the Ruby, Beaverhead, and Big Hole Rivers near the town of Twin Bridges, Montana. The Boulder River and Willow Creek are major tributaries to the Jefferson River. Other tributaries that originate in the Tobacco Root and Highwood Mountains also add flow to the Jefferson. About 52,000 acres are irrigated from the Jefferson River and smaller tributaries, with another 12,000 acres irrigated from the Boulder River. Flows are also regulated on the Willow Creek tributary by Willow Creek Reservoir, with a capacity of 17,700 acre-feet.

Figure 5.10 depicts the normal range of flow for the upper Jefferson River near Twin Bridges, at the upper end of the stream. Although the snowmelt flow pattern is apparent in this graph, peak flows have been reduced by the operations of reservoirs in the Beaverhead and Ruby River watersheds. The effects of upstream irrigation can also be seen, which reduce flows during the late summer, and increase flow through irrigation returns during the fall.

Figure 5.10 Normal Range of Flow for the Jefferson River near Twin Bridges



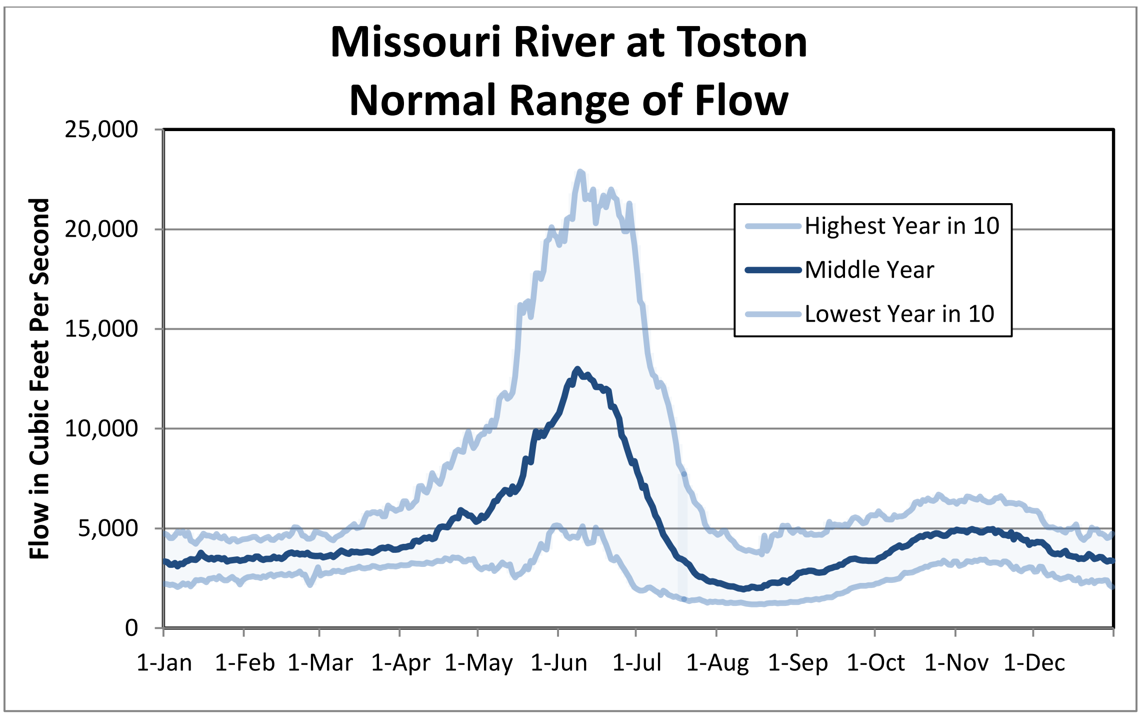
Data source http://mt.water.usgs.gov/

Total Flow Contributed by the Missouri Headwaters

The flow of the Missouri River below the Three Forks represents the combined flow of the Gallatin, Madison, and Jefferson Rivers, along with the flow from some smaller tributaries, such as Sixteenmile Creek. Figure 5.11 depicts the range of flow for the Missouri River at Toston, just below Toston Dam and upstream of Canyon Ferry Reservoir. By this point, the flow pattern in the river has been altered by reservoirs in the headwaters tributaries and diversions and depletions for about 400,000 acres of upstream irrigation.

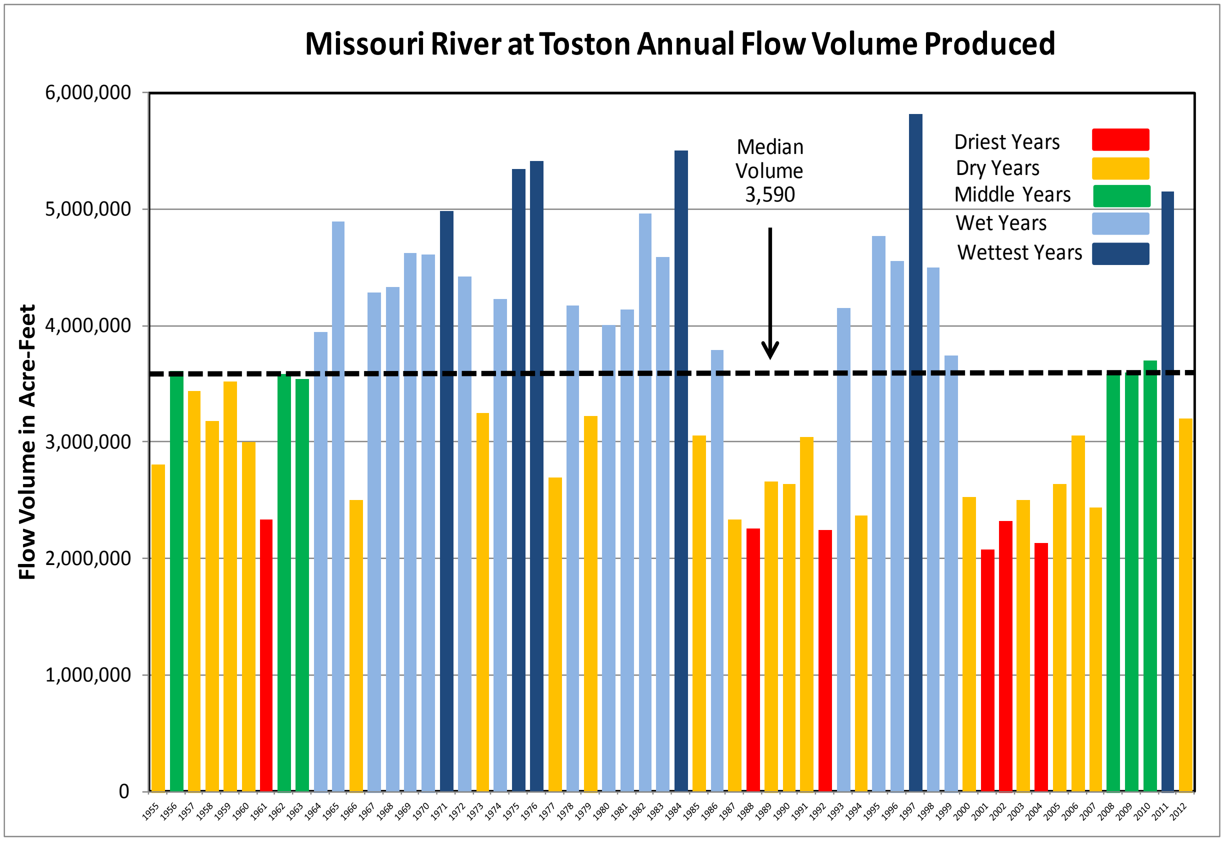
The total annual volume of water contributed by the Missouri River headwaters to Canyon Ferry Reservoir varies considerably from year to year as depicted in Figure 5.12. Annual volumes of water produced range from about 2,100,000 to about 5,800,000 acre-feet, with a median volume of about 3,600,000 acre-feet.

Figure 5.11 Normal range of flow for Missouri River at Toston



Data source http://mt.water.usgs.gov/

Figure 5.12 Comparison of annual flow volumes produced for the Missouri River at Toston, 1955-2012



Data source http://mt.water.usgs.gov/

Middle and Lower Portions of the Upper Missouri Basin

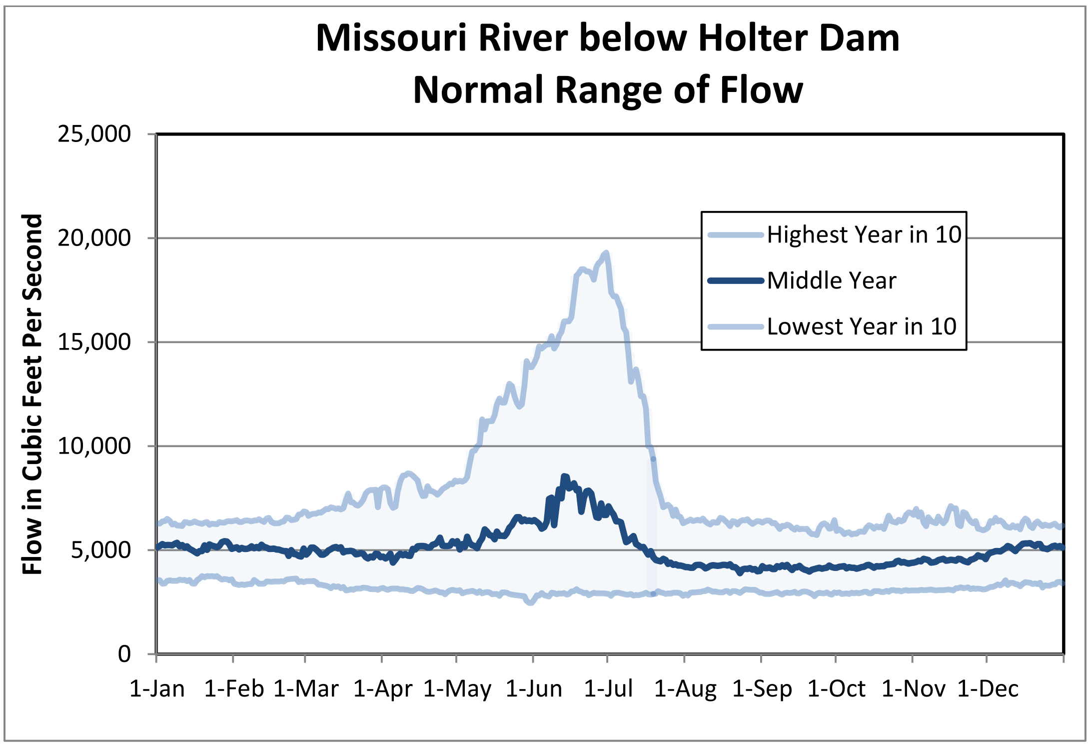
The flow of tributary streams to the middle and lower portions of the Upper Missouri Basin are still primarily supplied by mountain runoff, although the mountain elevations are generally not as high here as in the headwaters area. Flows are a little more variable as well, with base flows fluctuating considerably from wet to dry years. For the lower basin streams, such as the Sun, Teton, and Marias Rivers, prairie runoff can add substantial flow, especially during wetter years. The flow in these streams generally peaks in late May and early June, although they can peak during the March-April period when there is significant prairie snowmelt. The following sections describe flow characteristics of the Missouri River and the larger streams in the middle and lower portions of the basin.

The Sun River

Missouri River Canyon Ferry to Holter Dam

The middle and lower portions of the Missouri River are markedly influenced by the operations of Canyon Ferry Reservoir, which stores flow during the runoff season and releases water during late summer, fall, winter, and early spring. The operations of Canyon Ferry Reservoir are discussed in more detail in the water storage section. Figure 5.13 depicts the normal range of flow for the Missouri River below Holter Dam. Note that, when compared to the flow at Toston above the reservoir, flow peaks are about 5,000 cubic feet per second (cfs) less and, for the very lowest years data, there is no discernible peak. Note also how base flows below the dam are consistently maintained at about the 3,000-to-6,000-cfs range.

Figure 5.13 Normal Range of flow for Missouri River below Holter Dam

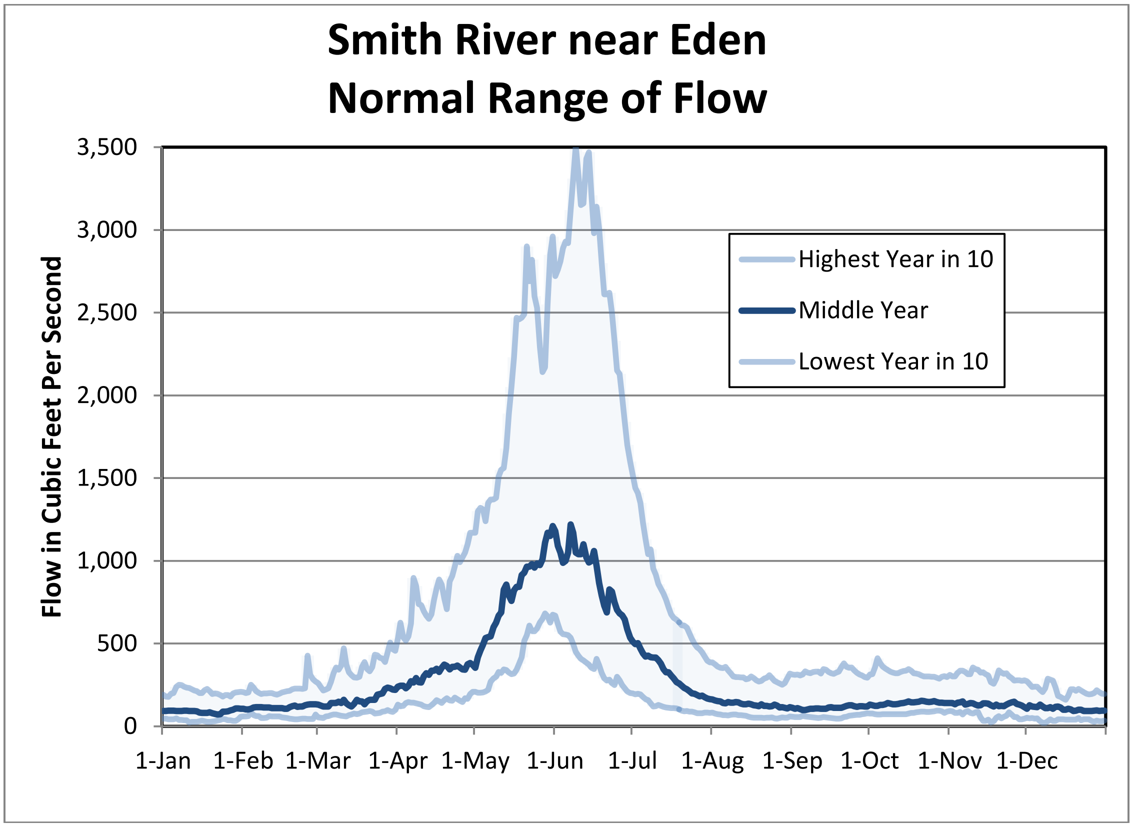


Data source http://mt.water.usgs.gov/

Missouri River Holter Dam to Great Falls

Several tributaries enter the Missouri River in this reach, the two largest being the Dearborn and Smith Rivers. The Dearborn River originates on the east slope of the Rocky Mountains. A substantial amount of water is diverted from the Dearborn River to irrigate lands along Flat Creek, a lower-elevaiton tributary to the Dearborn with a much less reliable water supply. Return flow from this irrigation re-enters the Dearborn River where Flat Creek joins it further downstream. The Smith River originates in the Big Belt, Little Belt, and Castle mountain ranges. It flows through an upper valley near White Sulphur Springs, where elevations are 4,500 to 5,500 feet; most of the 36,000 acres irrigated in the Smith River watershed are in this upper valley. Below that point, the Smith River winds through the Little Belt Mountains, a popular floating stretch, before passing through a shorter plains area and joining the Missouri River near Ulm.

Figure 5.14 Normal range of flow for the lower Smith River near Eden



Data source http://mt.water.usgs.gov/

Smith River

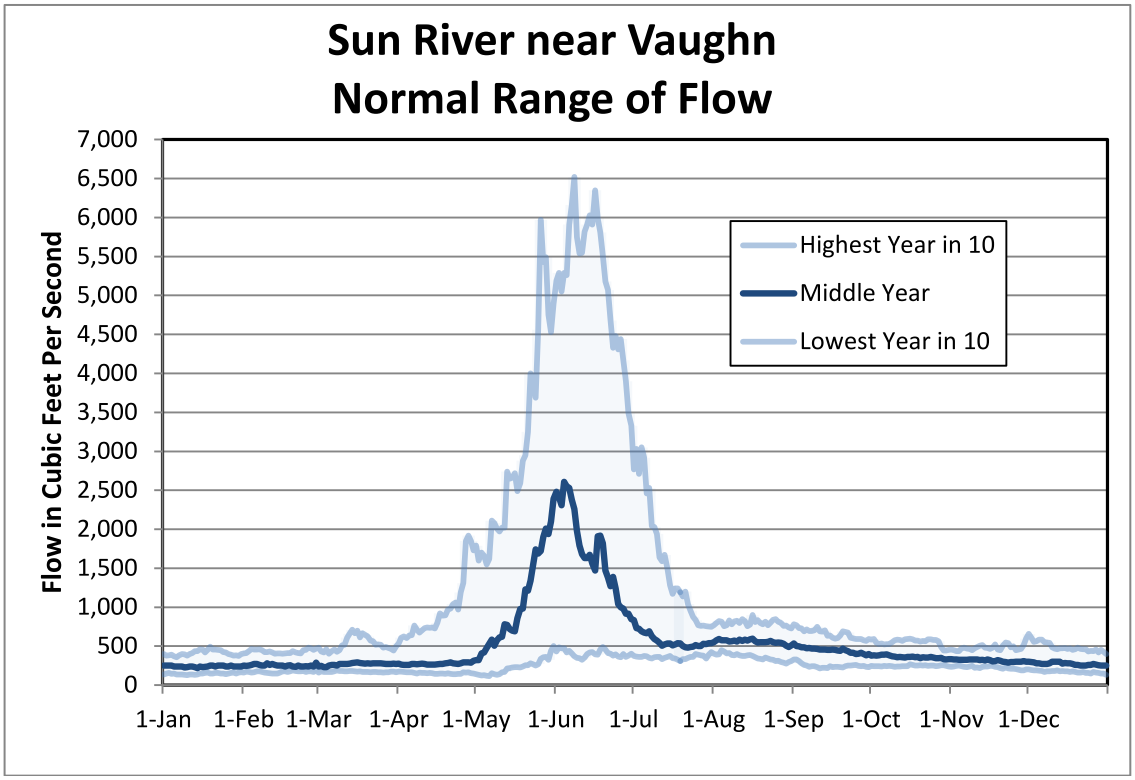
Figure 5.14 graphs the normal range of flow for the Smith River near Eden, on the lower portion of the stream. Overall, the flow pattern does not look too differnet from that of the headwaters streams. The flow of the upper North Fork of the Smith River is regulated by the North Fork Reservoir, with a storage capacity of 11,400 acre-feet. Newlan Creek Reservoir, on a tributary of the Smith River, stores about 15,600 acre-feet, with a portion of the water supply to that reservoir imported by canal from Sheep Creek, the largest tributary to the Smith River. The flow patterns for the Dearborn River, although not included, are similar to those for the Smith River.

Sun River

The Sun River originates on the east slope of the Rocky Mountains and flows across the prairie before joining the Missouri River at Great Falls, Montana. Flow in the Sun River is regulated by Gibson Reservoir, just below the junction of the North and South Forks of the Sun River, with a capacity of 98,700 acre-feet. Much of the flow produced by the Sun River is diverted below Gibson Reservoir to Pishkun Reservoir (an offstream reservoir with 46,700 acre-feet of storage) and from there on to the Green Fields Irrigation District, which irrigates about 88,000 acres of benchland in the vicinity of Fairfield, Simms, and Fort Shaw. Sun River water is also diverted to Willow Creek Reservoir (storage of 32,400 acre-feet), which stores and releases exchange water for the Greenfields Irrigation District and supplemental flows for the Fort Shaw Irrigation District. Overall, about 120,000 acres are irrigated in the Sun River watershed.

Figure 5.15 depicts the normal range of flow for the Sun River near Vaughn, at the lower end of the stream. Muddy Creek, a large tributary, enters the Sun River just above the Vaughn gage and adds substantial amounts of irrigation return flow to the Sun River year-round. Further upstream, the flow can be much lower, both during the irrigation season and during the winter when water is being stored in Gibson Reservoir.

Figure 5.15 Normal range of flow for the Sun River near Vaughn



Data source http://mt.water.usgs.gov/

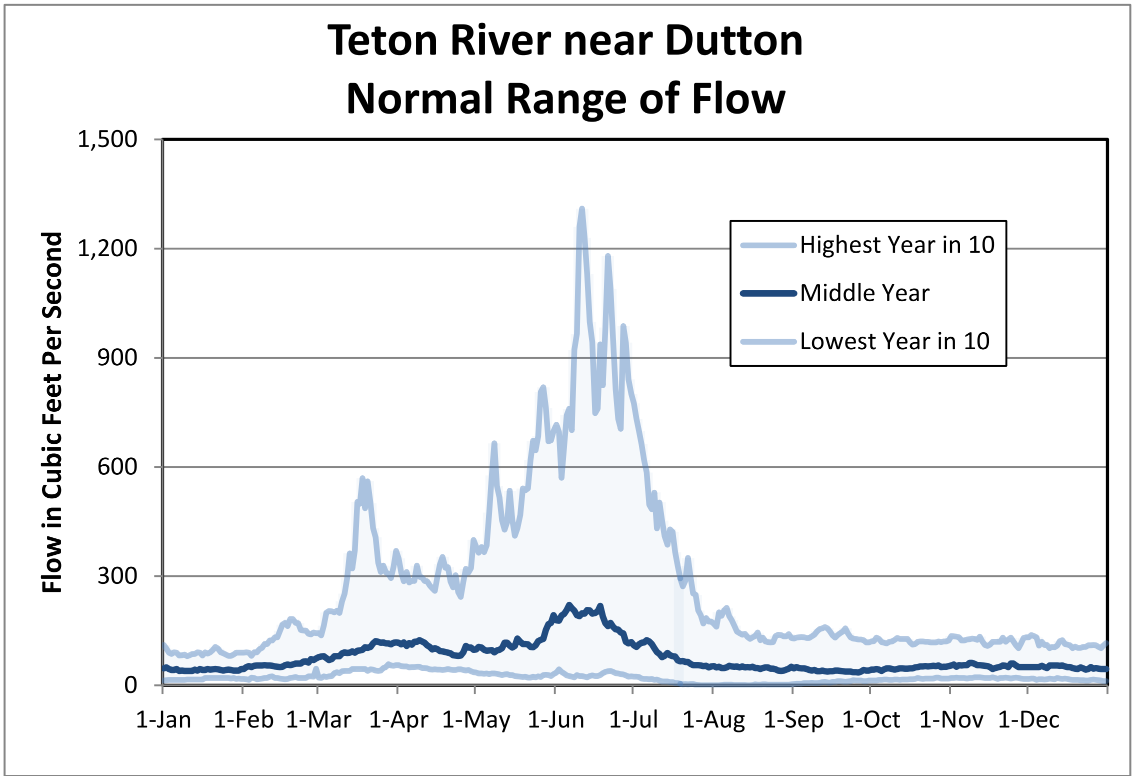
Teton River

The headwaters of the Teton River are in the Rocky Mountains west of Choteau. Although most of the flow of the stream originates from the mountains, the largest part of the drainage area of the river is on the Great Plains. The Teton River flows into the Marias River, just above that streams confluence with the Missouri River near Loma.

Although there are no on-stream storage reservoirs on the Teton River, there are serveral significant off-stream storage reservoirs in the Choteau area. The largest of these are Bynum Reservoir (85,000 acre-feet) and Eureka Reservoir (2,700 acre-feet), both of which supply water to lands associated with the Teton Cooperative Reservoir Company.

Water demands on the Teton River are heavy during the irrigation season, with approximately 74,000 acres irrigated from this mid-sized stream. Reservoir operations and irrigation diversions and depletions have modified the flow characteristics of the Teton River, as depicted in Figure 5.16, which is for the flow of the river at Dutton, about midway on the stream. Note how low the flow can be during the driest years. Further downstream from Dutton, after more water is diverted and depleted, the stream ceases to flow during dry years. The graph also shows how the lower-elevation prairies can produce substantial flow during the early spring, especially in wetter years.

Figure 5.16 Normal range of flow for the Teton River near Dutton



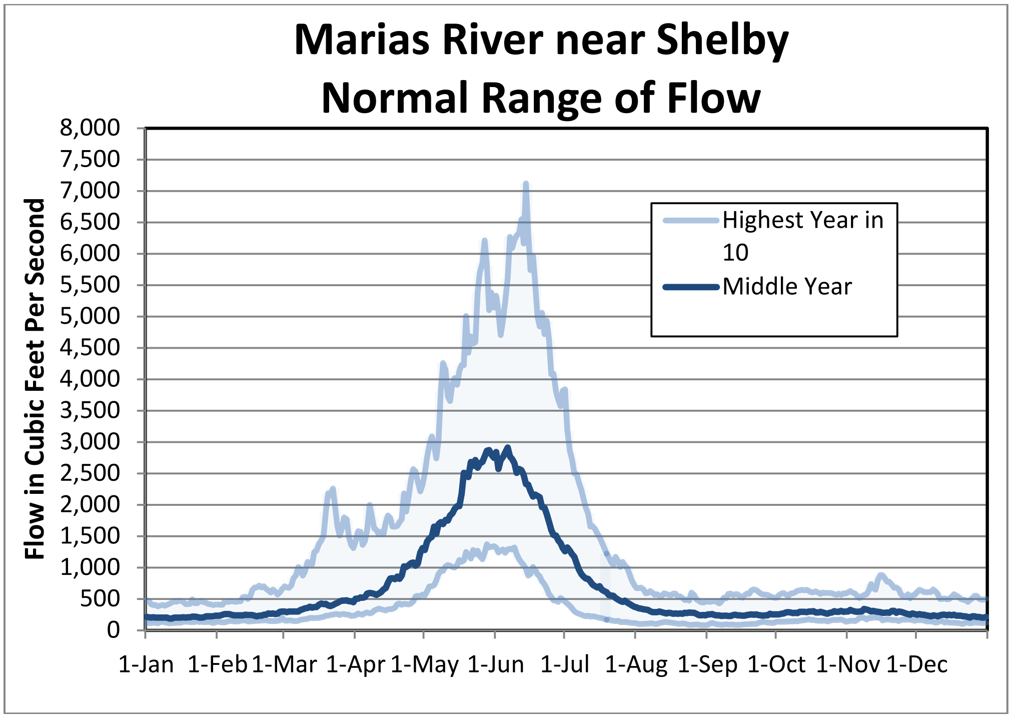
Data source http://mt.water.usgs.gov/

Marias River

The Marias River is fed by three major tributaries: Birch Creek, the Two Medicine River, and Cut Bank Creek. All of these tributaries originate on the east slope of the Rocky Mountains, with the Two Medicine and Cut Bank Creek drainages flowing primarily through the Blackfeet Indian Reservation. There is a substantial capacity to store water in the Marias River watershed. Swift Lake stores up to 34,000 acre-feet in the headwaters of Birch Creek. Lake Francis, an off-stream storage reservoir, has a capacity of 130,000 acre-feet for storing Birch Creek and Dupuyer Creek flow. Four Horns Reservoir, on the Blackfeet Reservation, can store up to 19,300 acre-feet off-stream of Badger Creek flow, and Lower Two Medicine Lake can store up to 13,500 acre-feet of Two Medicine River water. But by far the largest storage reservoir is Tiber Reservoir on the Marias River near Chester, which has a maximum volume of about 1,556,000 acre-feet.

Figure 5.17 depicts the flow of the Marias River neary Shelby, above Tiber Reservoir. Flow characteristics are similar to those of Missouri River tributaries upstream, but with the difference that prairie runoff can be an important contributor, especially during wetter years. The relative importance of lower-elevation runoff is also reflected by the timing of the peak flow, which most often occurs during late May. In some years, however, prairie snowmelt and rain may result a much earlier peak flow.

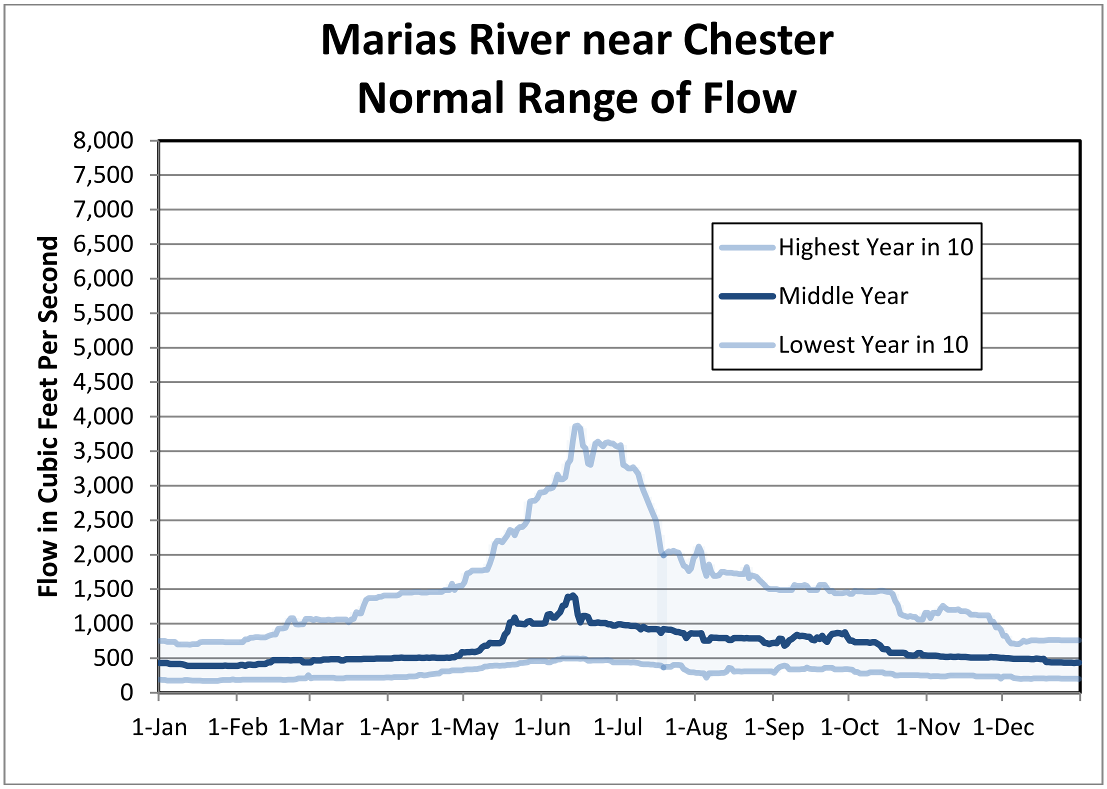
Figure 5.17 Flow graph for Marias River near Shelby (upstream of Tiber Reservoir)



Data source http://mt.water.usgs.gov/

Because Tiber Reservoir is so large relative to the flow of the Marias River, it can almost completely regulate the stream during all but the wettest years. Figure 18s depicts the typical range of flow for the Marias River below Tiber Dam, near Chester. Note that the scale on the vertical axis is the same as that for Figure 5.18, above Tiber Dam. Peak flows have typically been reduced by about one-half while the flow during the rest of the year has generally been enhanced, especially during dry years.

Figure 5.18 Normal range of flow for the Marias River near Chester below Tiber Reservoir

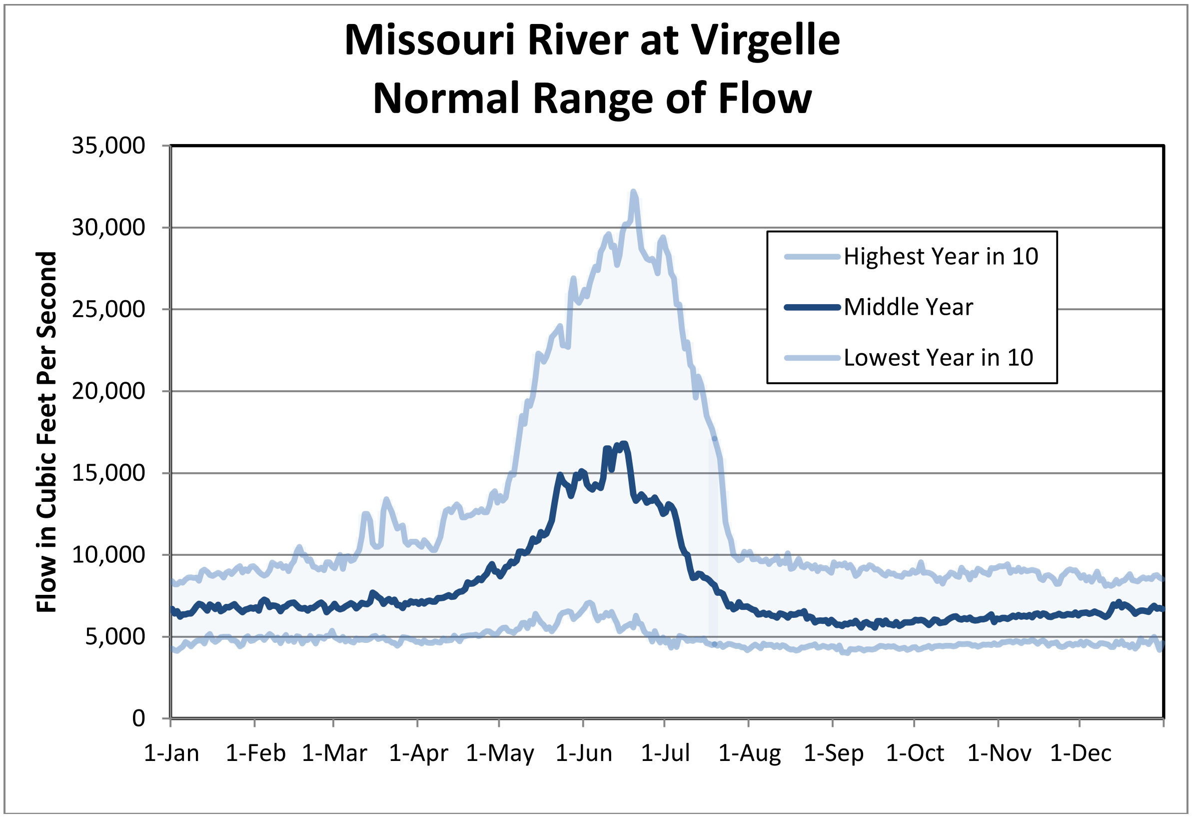


Data source http://mt.water.usgs.gov/

Missouri River Great Falls to Mouth of Marias River

The middle and lower tributaries described above add significantly to the total flow of the Missouri River. Other tributaries, such as Belt Creek, also add flow to the river in this section. Figure 5.19 depicts normal flow ranges for the Missouri River at Virgelle, just downstream of where the Marias River joins the Missouri River and what we have defined as the Upper Missouri River Basin.

Figure 5.19 Normal range of flow for Missouri River at Virgelle

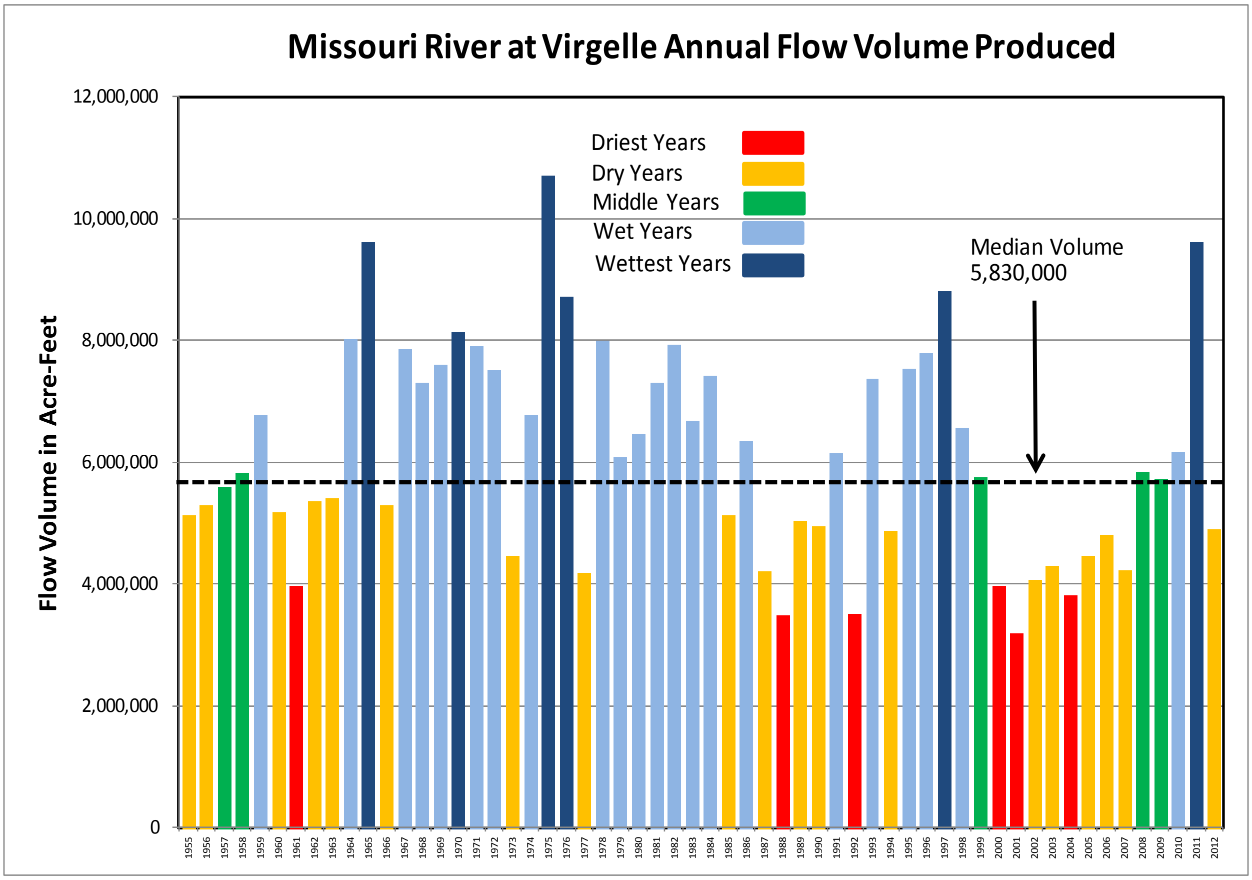


Data source http://mt.water.usgs.gov/

Flow produced by the Upper Missouri Basin

The total amount of flow from the Upper Missouri watershed varies considerably from year to year as depicted in Figure 5.20. Annual flow volumes at Virgelle range from about 3.2 million to about 11 million acre-feet, with a median volume of about 5.8 million acre-feet. About 60 percent of this flow originated in the headwater area, with about 15 percent originating in the middle basin (Three Forks to the mouth of the Sun River). The remaining 25 percent originates in the lower portions of the basin, primarily from the contributions of the Sun, Teton, and Marias Rivers. About 204,000 acres are irrigated in the Marias River watershed.

Figure 5.20 Comparison of annual flow volumes produced for the Missouri River at Virgelle, 1955-2012

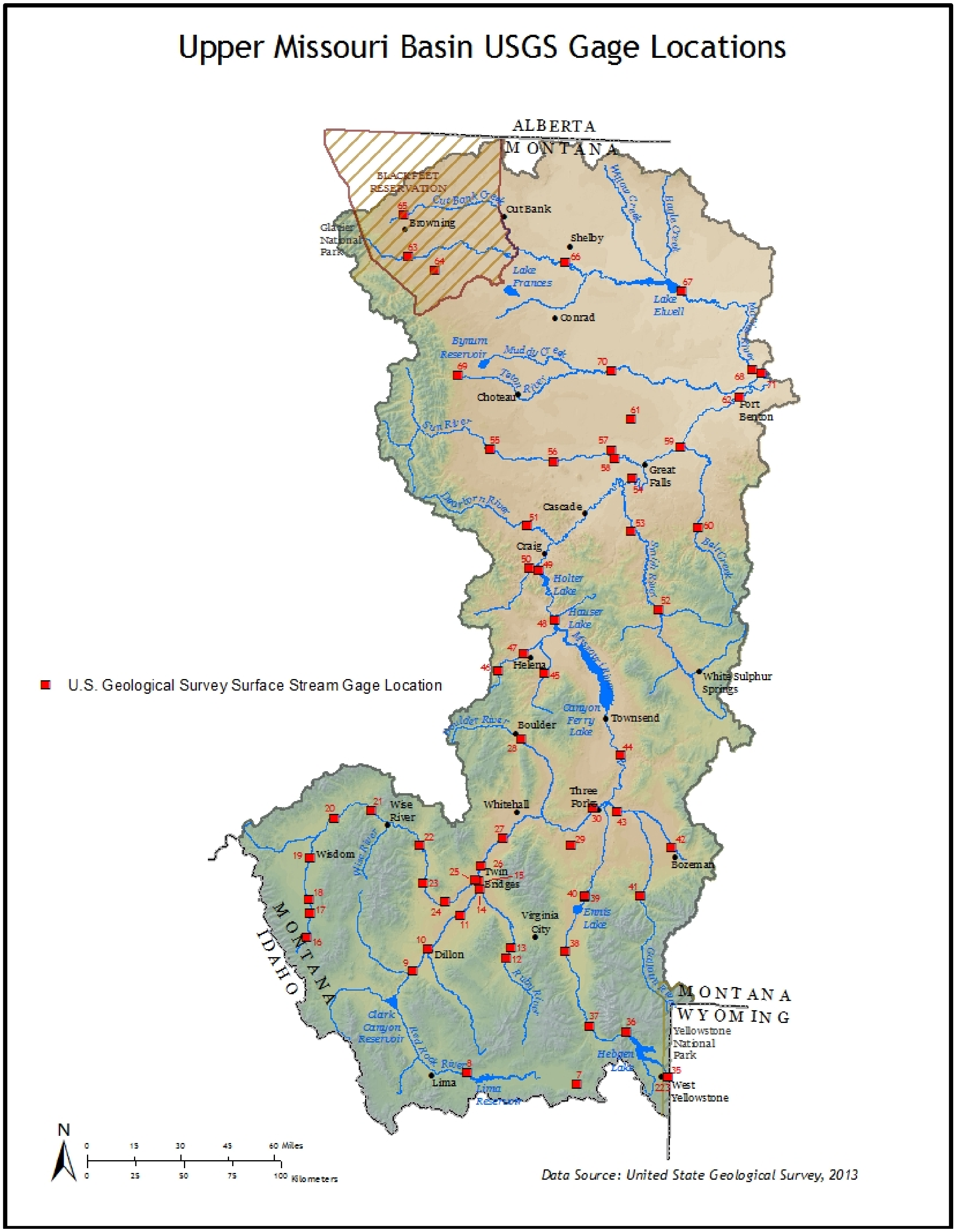


Data source http://mt.water.usgs.gov/

OPPORTUNITIES FOR RESEARCH AND INVESTMENT

For the larger streams in the Upper Missouri River Basin, the USGS operates a comprehensive real-time streamflow gaging network (Map 5.8), the data from which characterizes the amount, patterns, and ranges of flow for these streams. Most mid-sized and smaller streams in the basin are not gaged, and existing gages on these streams typically are seasonal, with no flow data collected during the winter. Funding the USGS long-term gaging program is important to continuing to characterize the flow on larger streams, to monitor flow trends, and for managing reservoir operations and diversions. A more comprehensive network of real-time gages on smaller streams would allow for better characterization and management of the flow of these streams too.

Map 5.8 U.S. Geological Survey gaging stations in the Upper Missouri River Basin



C. Groundwater Resources of the Upper Missouri Basin

The groundwater inventory for the Upper Missouri Basin includes discussions of source aquifers and estimates of groundwater contribution to surface water and groundwater storage. Information and description of aquifers is based on review of reports published by the Montana Bureau of Mines and Geology (MBMG) and the USGS, master's theses, and reports prepared by consultants for water right applications. Wells and springs yield water from aquifers in shallow alluvium, deeper semi-consolidated to consolidated basin-fill sediments, and bedrock.

AQUIFERS

Shallow Alluvium

Alluvial aquifers are by far the most common sources of water for irrigation, municipal, industrial, household, and livestock purposes. These aquifers are comprised of Quaternary river alluvium, terrace deposits, and glacial outwash deposits and occur along floodplains of all the major streams (Map 5.9). Shallow alluvial aquifers are generally aerially extensive, have large storage capacities, and have hydraulic properties favorable to groundwater production. In addition, these aquifers are typically less than 100 feet thick and therefore, are accessible by shallow wells at relatively low expense. Alluvial fans and terrace deposits around the perimeter of the mountain valleys also may be important aquifers for small uses; however, they generally do not contain continuous coarse-grained layers necessary for larger production wells. Alluvium and terrace deposits are generally unconfined and are recharged by direct infiltration of precipitation, leakage from irrigation ditches, irrigation return flows, and seepage from streams, and they constitute a single water-bearing unit. Figure 5.21 shows the typical water level response of an alluvial aquifer well to seasonal recharge and trends in precipitation and runoff. Aquifer discharge includes diversion to wells, base flow discharge to surface water, seepage to springs, evapotranspiration, and subsurface underflow to other aquifers or basins.

Alluvial aquifers in the plains portion of the Upper Missouri Basin are found in relatively narrow strips along the Sun, Teton, Marias, and main stem Missouri Rivers. In the broad valleys of the headwaters of the basin, these aquifers are likewise found along the larger streams but are far more substantial in size.

Map 5.9 Alluvial and terrace aquifers in the Upper Missouri River Basin

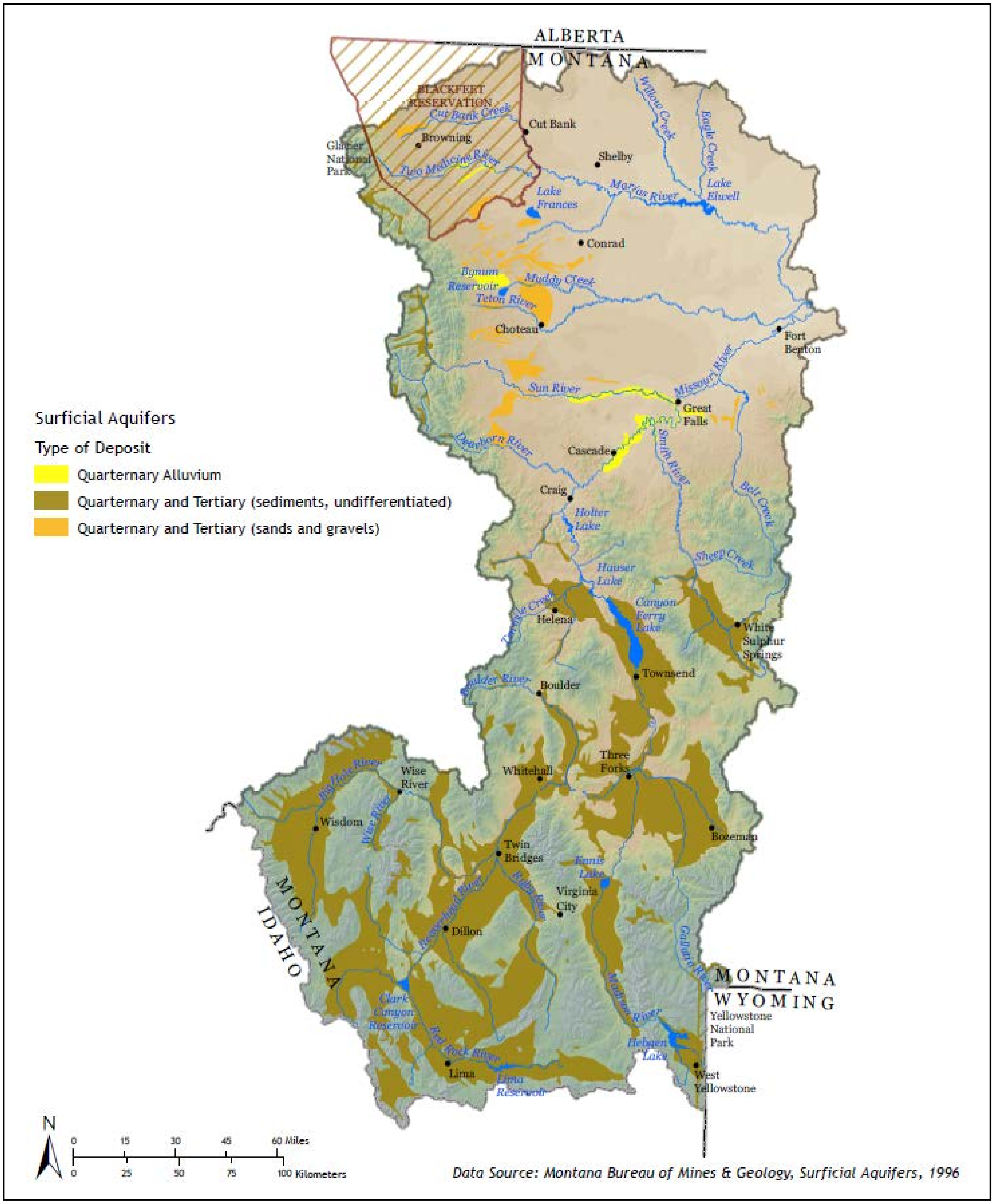
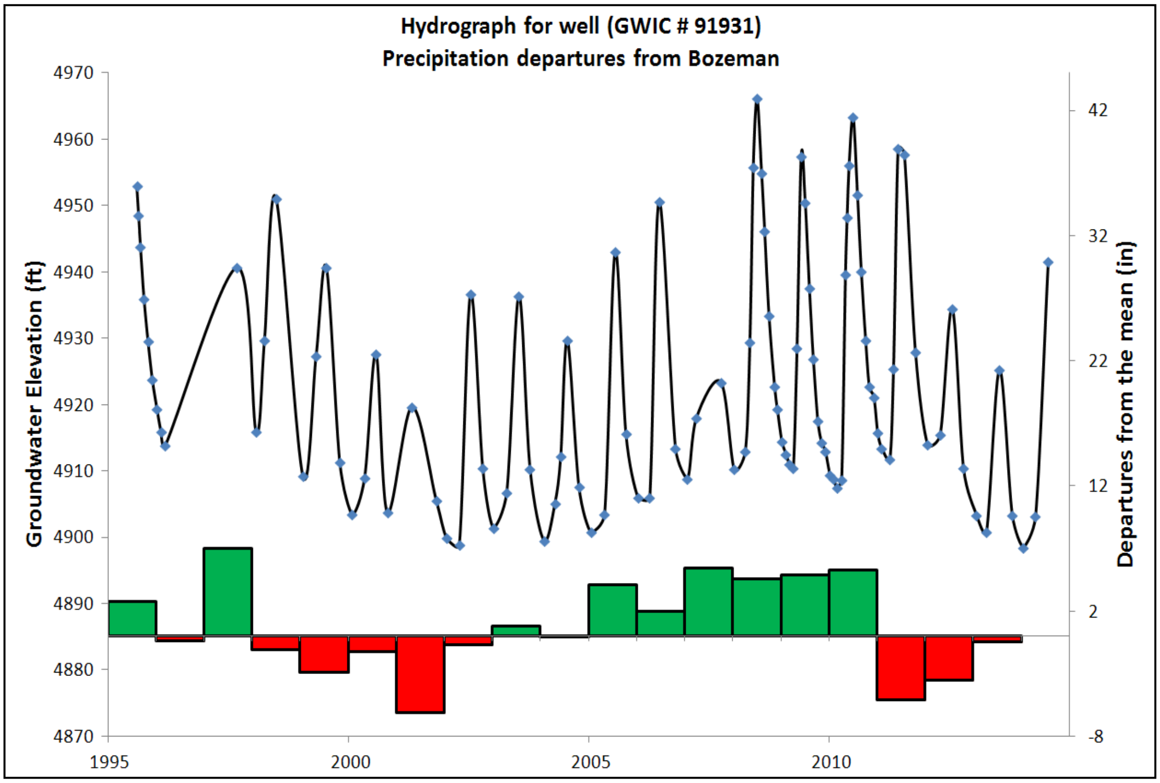


Figure 5.21 Water level in a well near the base of the Bridger Range that responds to seasonal recharge from a nearby stream as well as multi-year trends in precipitation and runoff (*GWIC # 91931*)

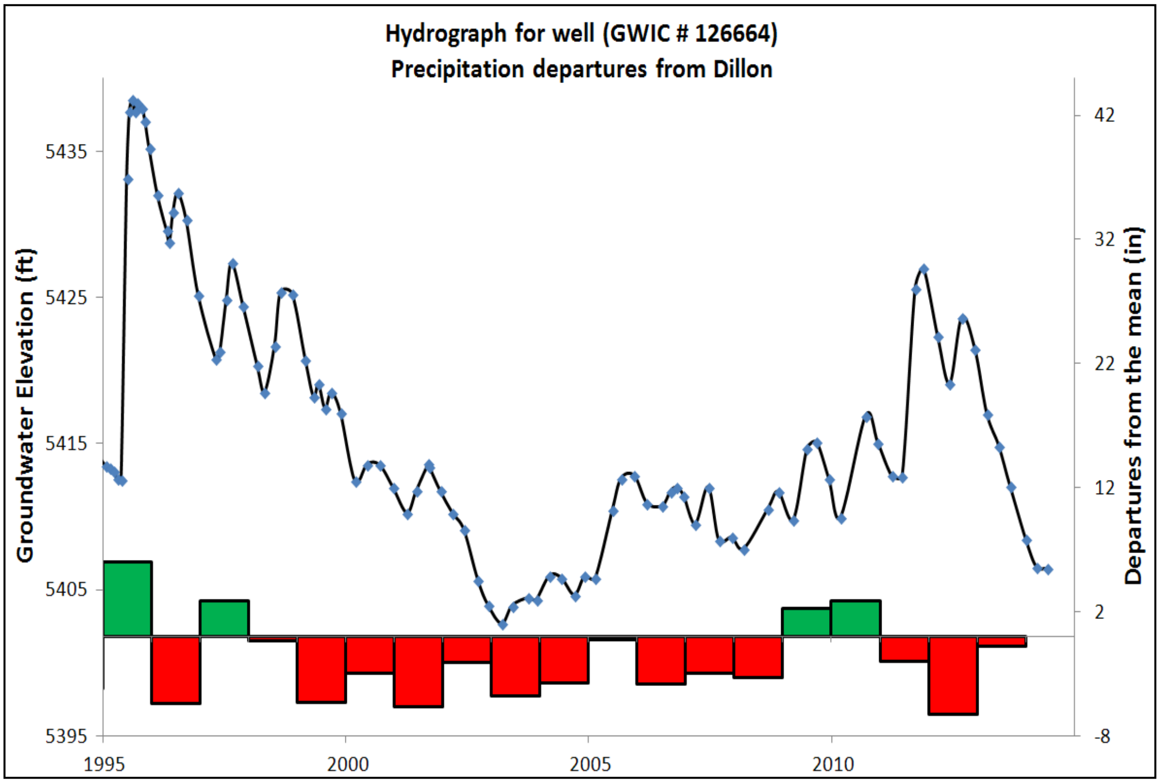


Tertiary-Age Basin Fill

Discontinuous sand and gravel layers in upper sequence of coarse-grained Tertiary basin-fill sediments in the headwaters and middle parts of the basin are productive aquifers, although production generally is less predictable and at greater depth and expense than in unconsolidated alluvial aquifers. The thickness of the overlying Quaternary alluvial aquifer is variable, and often there is no clear, distinct boundary between the Quaternary alluvium and the underlying Tertiary sediments. For example, over 400 feet of gravel fills a trough in the Belgrade area identified by Hackett and others (1960); this may be Quaternary alluvium or a combination of alluvium and Tertiary basin fill. Discontinuous water-bearing zones in Tertiary sediments are capable of producing only small yields to domestic and stock wells, and they produce sufficient amounts of water for irrigation where thicker gravel and sand sequences occur.

Recharge to Tertiary basin fill is through leakage from overlying alluvium and infiltration of precipitation, ditch or canal leakage, and irrigation returns where they are at the surface around valley margins (see Figure 5.22).

Figure 5.22 Water level in this well in the Blacktail Deer Creek Valley southeast of Dillon reflects the seasonal drawdown resulting from pumping groundwater for irrigation and larger long-period fluctuations related to climate (GWIC # 126664)

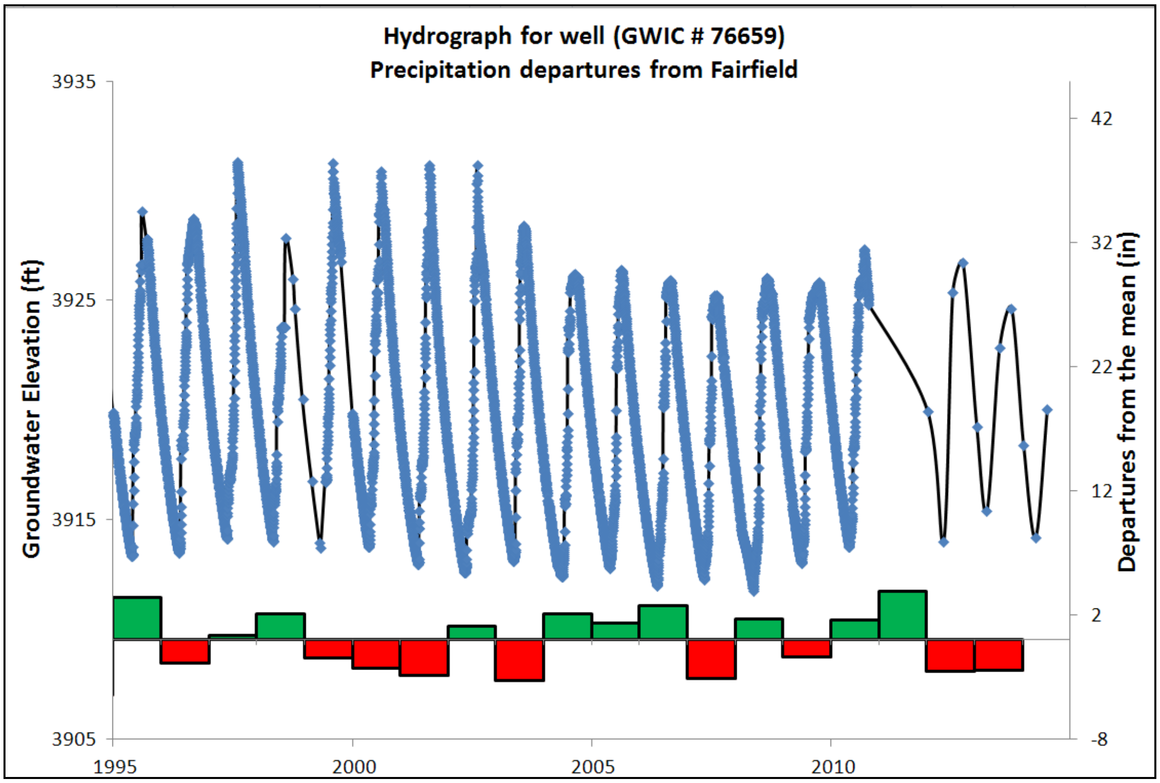


Terrace Deposits

Aquifers in the plains portion of the Upper Missouri Basin include surficial sediments consisting of unconsolidated Tertiary and Quaternary terrace deposits. These thin sand and gravel terrace deposits overlie bedrock and top benches including the Greenfields Bench and Burton Bench. The Greenfields Bench is actually three separate gravel terraces from 3 to 50 feet thick deposited on bedrock eroded by ancestral Sun River at different stages of glaciation (Miller et al., 2002). These terraces supply water to three public water supplies and over 400 wells serving individual residences. Sand and gravel on the Burton Bench is up to 70 feet thick, a remnant of older alluvial valley cut into bedrock by the Teton River and Muddy Creek (Madison, 2004). The Greenfields Bench and Burton Bench aquifers have relatively high permeability and are the primary sources of water for domestic and public water supply use in the area, in particular in comparison to the underlying bedrock formations.

The Greenfields Bench aquifer owes its existence to delivery of irrigation water by the Greenfields irrigation system from the Sun River via Gibson Dam and Pishkun Reservoir starting in 1920. Osborne and others (1983) estimate that 52 percent of groundwater recharge is from delivery and on-farm losses of irrigation water. Similarly, irrigation water accounts for 60 percent of recharge to Burton Bench (Madison, 2004). Figure 5.23 shows over 10 feet of water level fluctuations in a well located on Greenfields Bench in response to seasonal recharge of irrigation water.

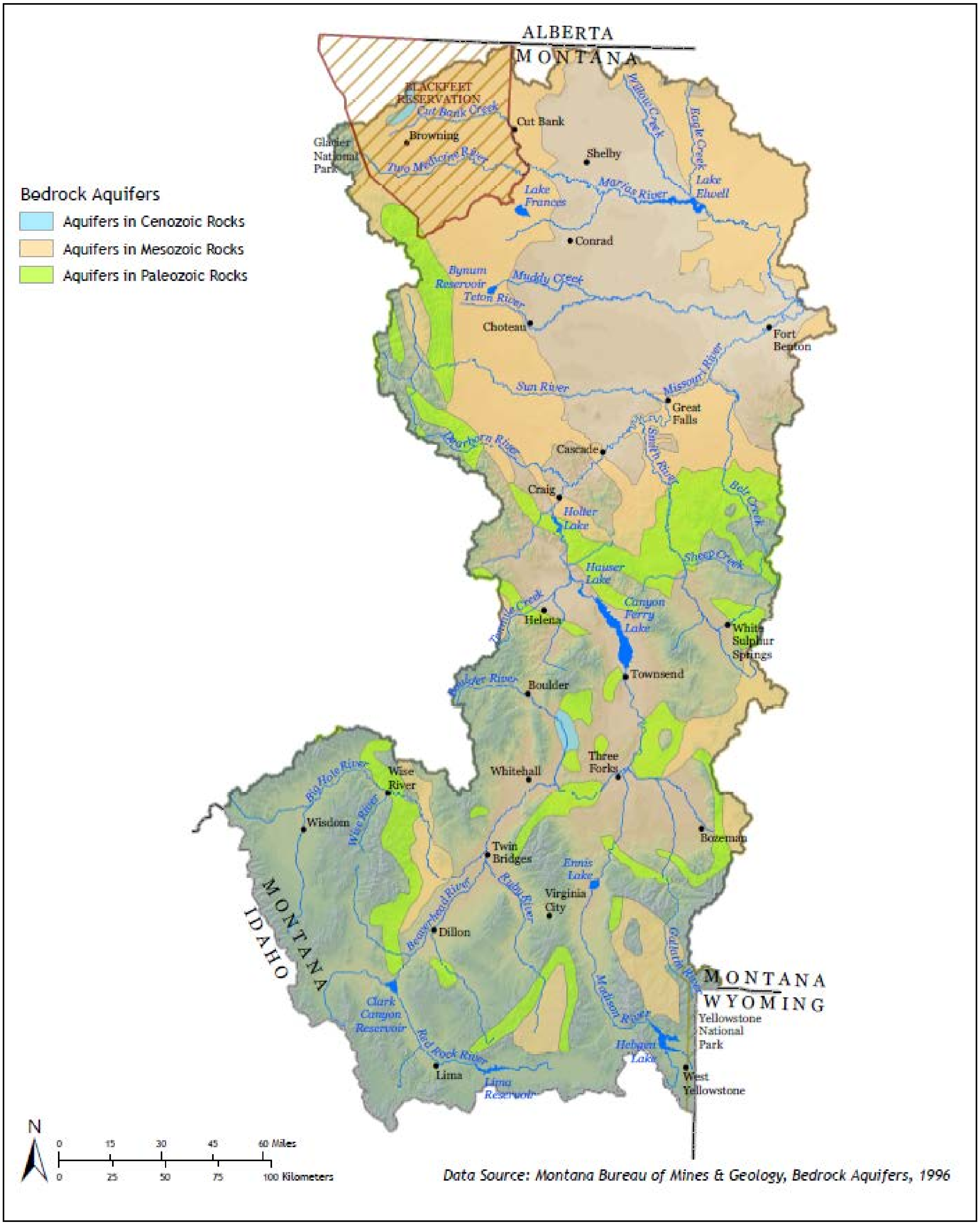
Figure 5.23 Hydrograph of a well on Greenfields Bench that shows recharge from irrigation (GWIC # 76659)



Bedrock

Groundwater occurrence within bedrock aquifers is primary found in discontinuous fractures and faults resulting in large variations in well yield, often over short distances. The bedrock aquifers host rock type includes sandstone, siltstone, shale, and carbonate rock types of the Cenozoic, Mesozoic, and Paleozoic Eras (Map 5.10). Fracture generally is not sufficiently continuous to create regional-scale aquifers; however, fracturing often is sufficient to provide yield-adequate water supplies for individual residential or small public water supplies with multiple wells. Bedrock aquifers often are connected to aquifers in Tertiary sedimentary rock and shallow alluvium and, as with Tertiary aquifers, ultimately to surface water.

Map 5.10 Upper Missouri Basin Bedrock Aquifers



The most productive bedrock aquifer in the basin is the Madison Group aquifer where solution openings and/or fracturing are encountered. The Madison is especially important in the vicinity of Great Falls area and is the source of Lyman Springs, which is an important source for the city of Bozeman. Though the Madison is known for highly productive springs and wells, low-production wells are more the rule than the exception in areas where the Madison Group limestone is not extensively fractured (Huntoon, 1993). Streams provide significant recharge where they cross caves or sinkholes in the Madison on the north side of the Little Belt Mountains. The majority of this water discharges to Giant Springs and the bed of the Missouri River.

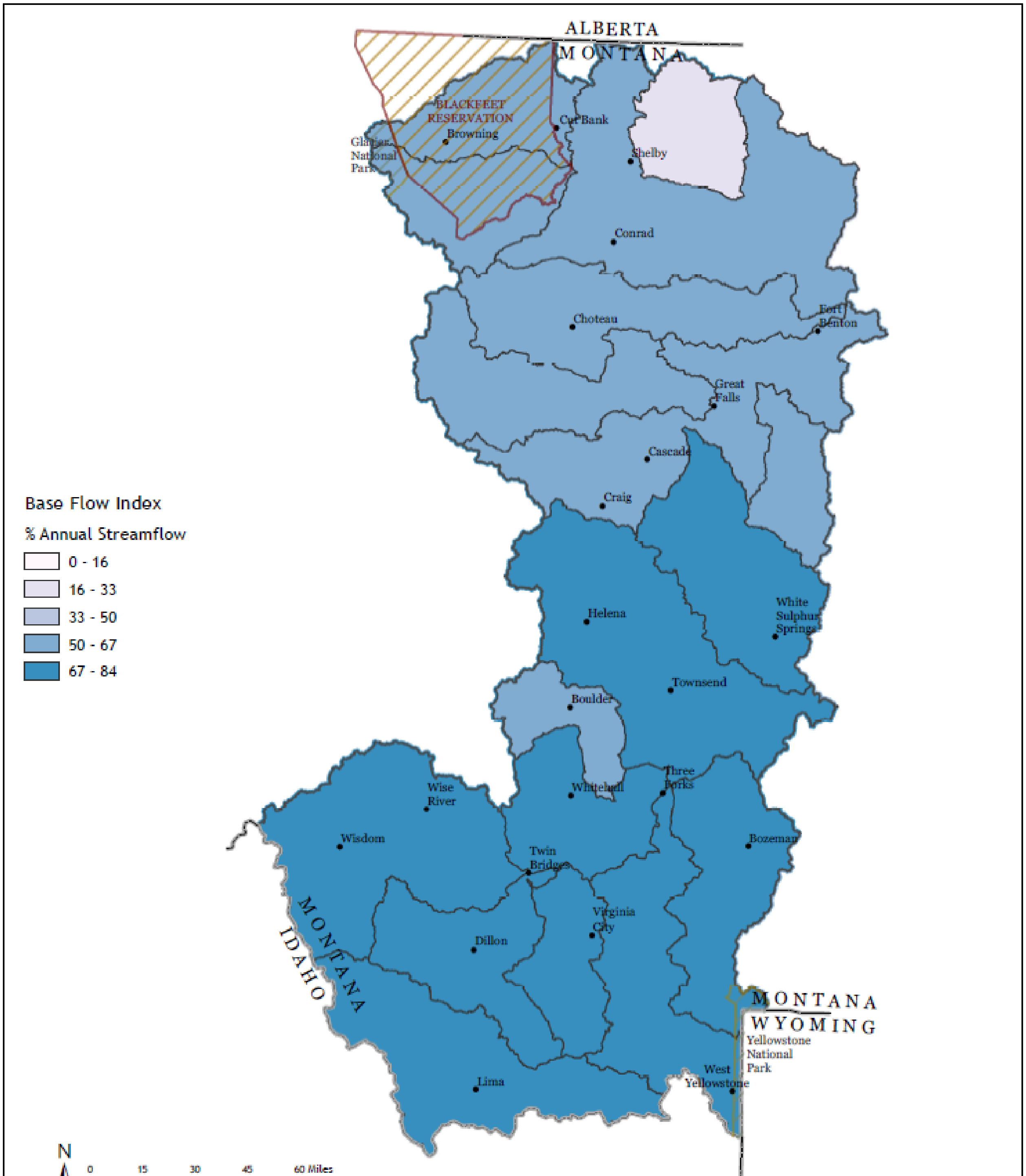
Cretaceous sandstone aquifers are extensive throughout plains part of the basin, but are generally deeply buried and exposed only in mountainous areas. The Kootenai Formation and Swift Formation are sandstone aquifers that overlie the Madison Group aquifer and are sources for wells south of Great Falls. Two zones, known as the second and third Cat Creek Sands, are in the lower portion of the Kootenai Formation and tend to be the primary water producing zones (Perry, 1933). The Virgelle Sandstone Member of the Eagle Formation is capable of well yields of 250 gpm (Zimmerman, 1967) and is the water source for Valier.

Recharge to bedrock aquifers is primarily derived from seepage from the streams, infiltration of precipitation, snowmelt in topographically high outcrop areas, and leakage through confining units. On a regional scale, groundwater in the bedrock often is in hydraulic communication with alluvial aquifers and discharge in topographically lower areas by upward leakage to shallower aquifers and streams.

Base Flow Contribution

The contribution of groundwater to surface water base flow (Map 5.11) is derived from Base Flow Index (BFI) information from USGS (2003). BFI values, representing the ratio of base flow to total annual flow, are estimated by the USGS by automated hydrograph separation and are available for many historic gage sites across the United States (Wolock, 2003-146). Where no gage exists, or for sites that are influenced by reservoir effects, BFIs can be estimated from another USGS product, an interpolated grid of BFI values (Wolock, 2003-263). To estimate the contribution of base flow in Montana, one gaged site was used to determine a representative BFI for each 8 Digit/4th Code HUC sub-basin. If a BFI specific to that site was estimated by the USGS and that location was determined to be free of reservoir effects, then the BFI specific to that gage site was selected. Otherwise, the interpolated grid product was used to estimate a representative BFI. BFI values in USGS (2003) are based on surface water base flow estimates and, therefore, rely on assumptions that groundwater does not leave a basin through regional groundwater flow.

Map 5.11 Generalized map of Base Flow Index for the Upper Missouri River Basin



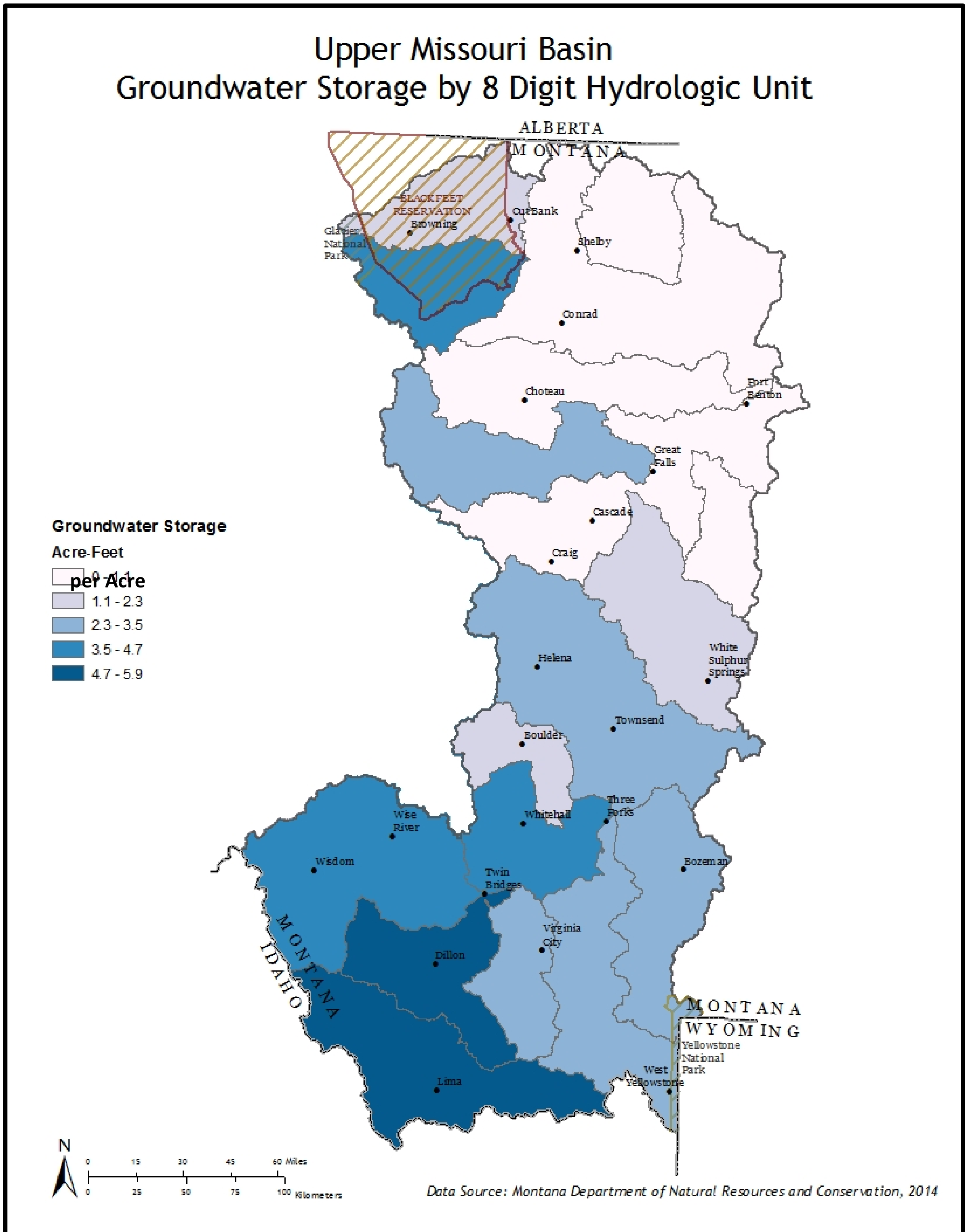
Data Source: Montana Department of Natural Resources and Conservation, 2014

Groundwater Storage

The groundwater storage capacity (Map 5.12) of the upper 50 feet saturated thickness of alluvial and Tertiary basin-fill aquifers is estimated from the areal extent of aquifers and their storage capacities. The areal extent of alluvium, alluvial terraces, and Tertiary basin-fill sediments with the primary rock type identified as coarse grained is obtained from a digital geologic map available from USGS (2005). Aquifer storage is assigned a uniform specific yield value of 0.20.

The value of 50 feet for saturated thickness used in calculations is representative of the typical thickness of coarse-grained unconfined portions of aquifers and the thickness that accounts for the majority of groundwater circulation. Although an alluvial aquifer may store a considerable quantity of water, pumping cannot remove groundwater in aquifer storage without reducing discharge or inducing recharge, often to the detriment of surface water flows and the rights of surface water users. Removal of even small amounts of groundwater resulting in much less than 50 feet of drawdown will deplete flows and impact existing users, thereby limiting new appropriations of groundwater.

Map 5.12 Generalized map of groundwater storage (acre-feet per acre of watershed) in the upper 50 feet saturated thickness of alluvium and basin-fill sediments.



Opportunities for Research and Investment
Information on the distribution and properties of aquifers is based on review of reports published by MBMG and USGS, master's theses, reports prepared by consultants for water right applications, and other documents included in a separate annotated bibliography. The MBMG Montana Groundwater Assessment Program (GWAP) maps the distribution and documents the water quality and physical properties of Montana's aquifers. Within GWAP are the Groundwater Monitoring Program—a long-term well monitoring program—the Ground Water Characterization Program (GWCP), which provides basic information about aquifers within prioritized specific areas, and the Ground Water Information Center (GWIC), where groundwater level and water quality data are housed. On the national level, groundwater information is available through the National Water Information System (NWIS) housed with USGS.

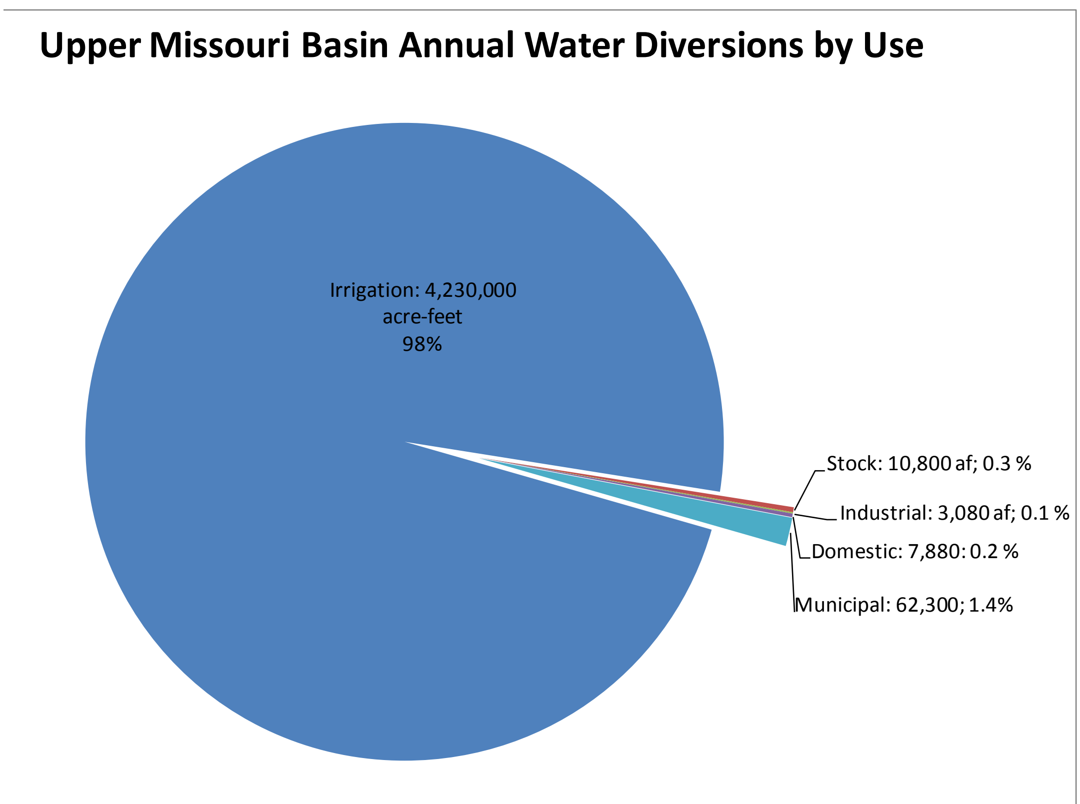
The Groundwater Investigations Program (GWIP), also administered by MBMG, is a potential source of hydrogeologic information at the scale of a few square miles to address specific issues such as surface water depletion by groundwater development and water quality. GWIP projects have been completed in the Lower Beaverhead study area near Dillon, and the Scratchgravel Hills and North Hills study areas near Helena. Current projects are ongoing in the Four Corners, Belgrade-Manhattan, Boulder River Valley, Big Sky, and Upper Jefferson River study areas within the Upper Missouri Basin. Additional prospective GWIP projects can be proposed and are ranked for consideration by the Groundwater Assessment Steering Committee.

VI. Water Use in the Upper Missouri Basin

OVERVIEW

Annually, about 4.3 million acre-feet is diverted from the Missouri River and tributaries for irrigation, stock, industrial, and municipal and domestic use (Figure 6.1). By far the largest of these uses is irrigation, which accounts for about 98 percent of all diversions.

Figure 6.1 Upper Missouri River Basin average annual water diversions by sector



Only a portion of the water diverted for these uses is consumed. Of the 4.3 million acre-feet diverted in the Upper Missouri River Basin, about 1 million (about 24 percent) is consumed, with over 95 percent of the consumption attributed to irrigation (Figure 6.2). Diversions are typically highest in the watersheds with the most irrigation, such as the Beaverhead, Gallatin, and Sun, as depicted in Map 6.1.

Data Source: USGS 2004

Map 6.1 Upper Missouri Basin Surface Water Withdrawal

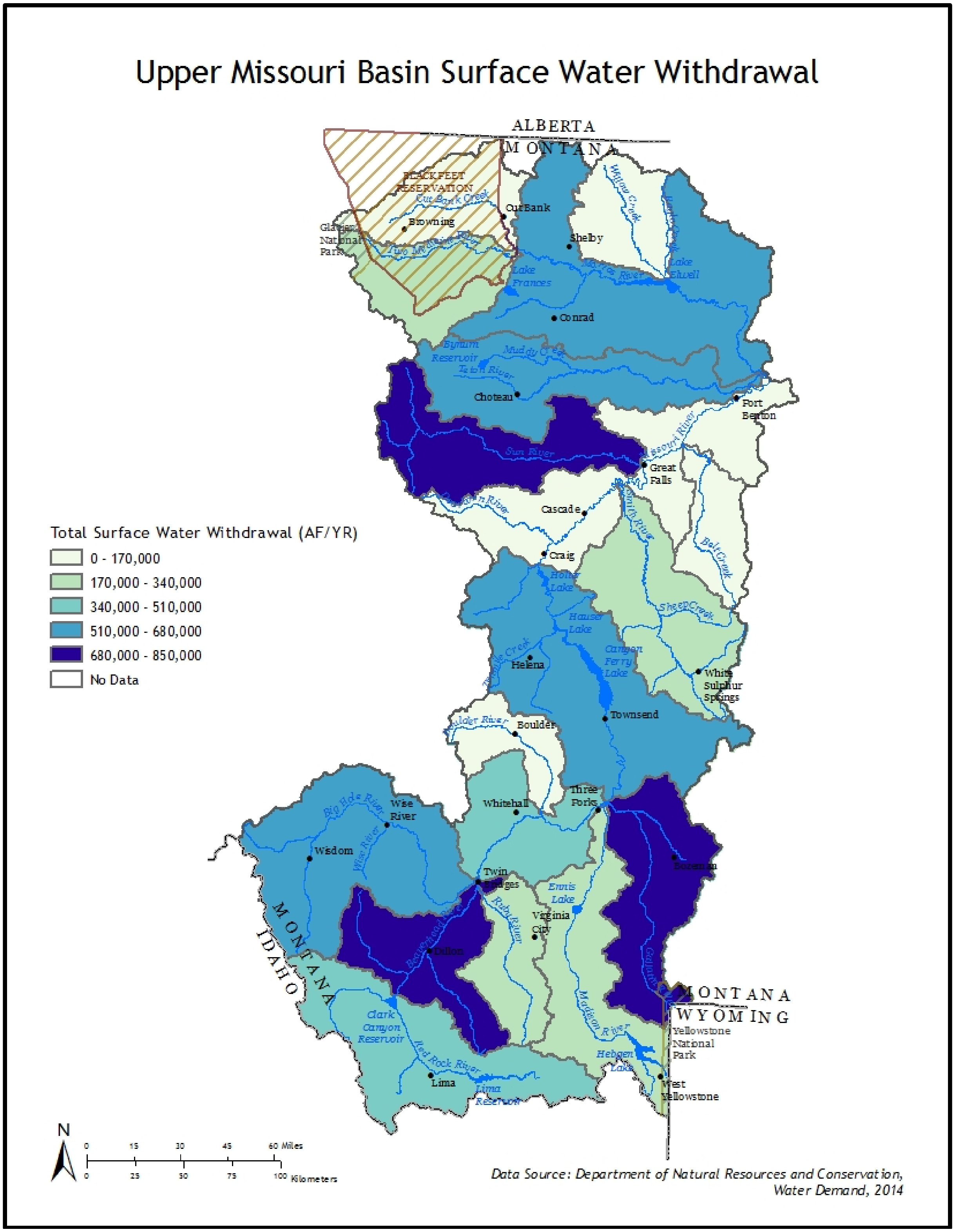
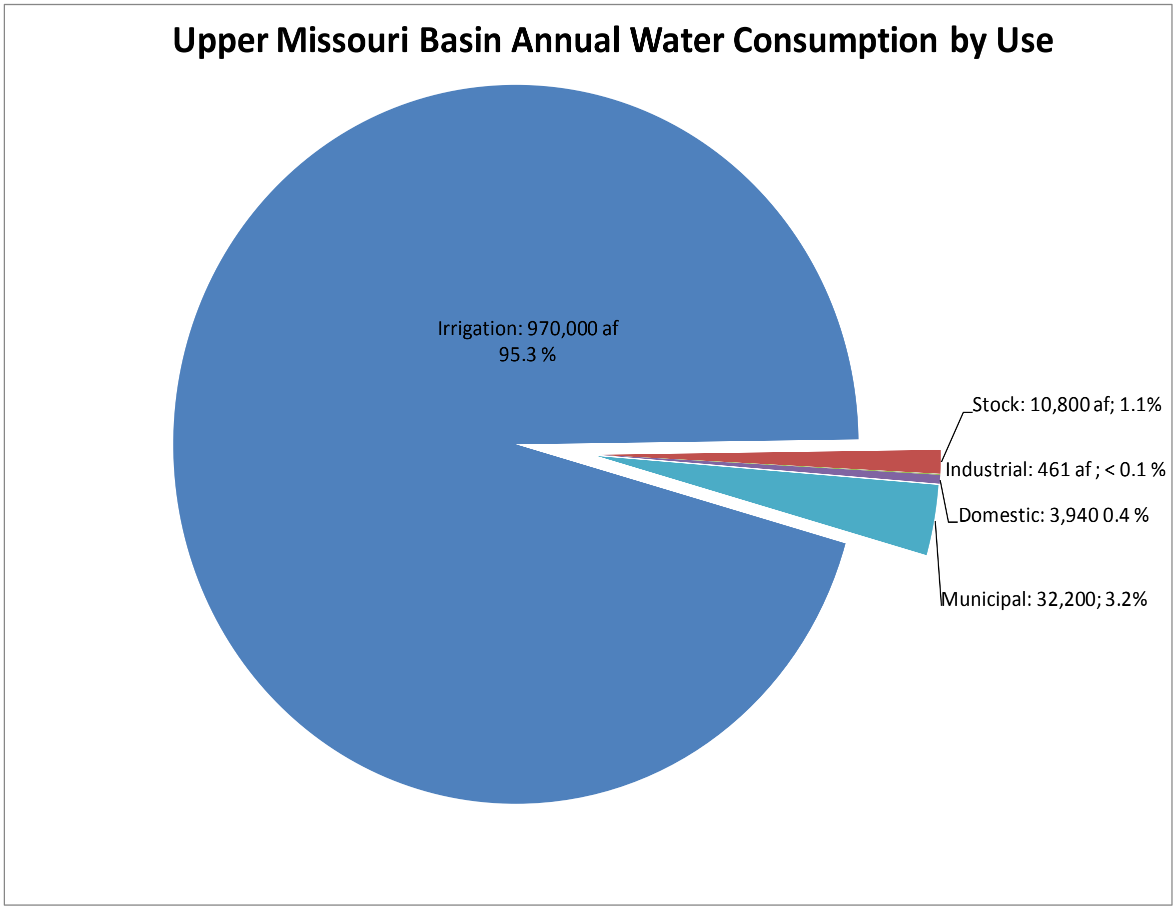


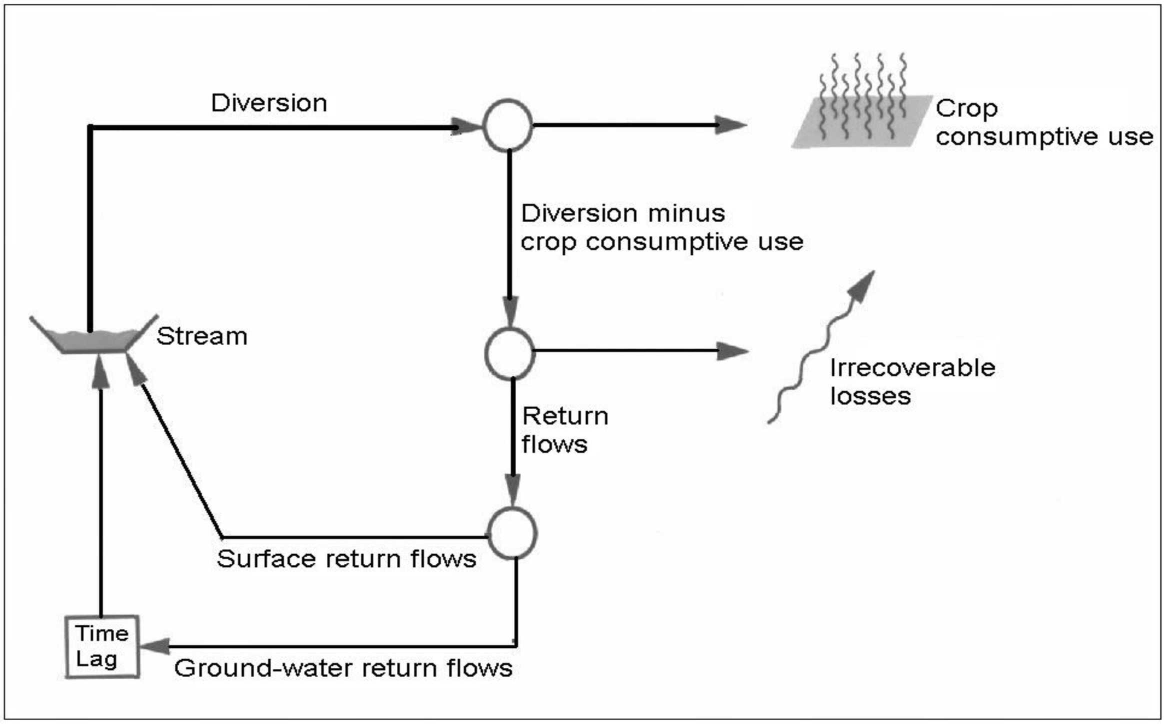
Figure 6.2 Upper Missouri Basin average annual water consumption by sector



Data Source: USGS 2004

Much of the water that is diverted for consumptive use will eventually return to the water source—a river, stream, or groundwater aquifer. In the case of municipal systems, most household water that is used will flow back through the waste-water system and may return to the original source, or another stream or aquifer, downstream, after treatment. In the case of irrigation, a portion of the diverted water is consumed by the crop through the process of evapotranspiration and some water is depleted, irrecoverably, during application, such as water that is evaporated before it hits the ground during application by sprinklers. Most of the rest of the water will eventually return to the source, although there can be a substantial time lag for irrigation water that returns through an aquifer system. Figure 6.3 is a diagram of irrigation water use that depicts these concepts of consumptive water use and return flow.

Figure 6.3 Irrigation water use diagram



Basin Water Budgets

The diagrams that follow (Figures 6.4 through 6.9) depict generalized annual water budgets for the major streams in the Upper Missouri River Basin, and for overall water use in the headwaters area, above Canyon Ferry Reservoir (Figure 6.10), and for the Upper Missouri River Basin as a whole (Figure 6.15). The water budgets are based on the flow for a median year and do not include non-consumptive instream and hydropower uses, which are discussed later in the Chapter. For basins where irrigation is heavily developed and there are sizable water storage projects, such as the Beaverhead River watershed in the headwaters area (Figure 6.4) and the Teton River basin near Great Falls (Figure 6.13), almost all of the water that is produced by the basin is captured or diverted at least once. This would especially be the case during dry years. For streams such as the Madison River (Figure 6.8), where there is relatively less irrigation and storage reservoirs are operated primarily for non-consumptive hydropower generation, most flow is never diverted during a typical year.

For streams such as the Beaverhead and Teton Rivers (Figures 6.4 and 6.13), the actual “diverted and not consumed” amounts are greater than depicted, because a substantial amount of the flow is diverted more than once (diverted, returned to the stream, and then diverted again further downstream).

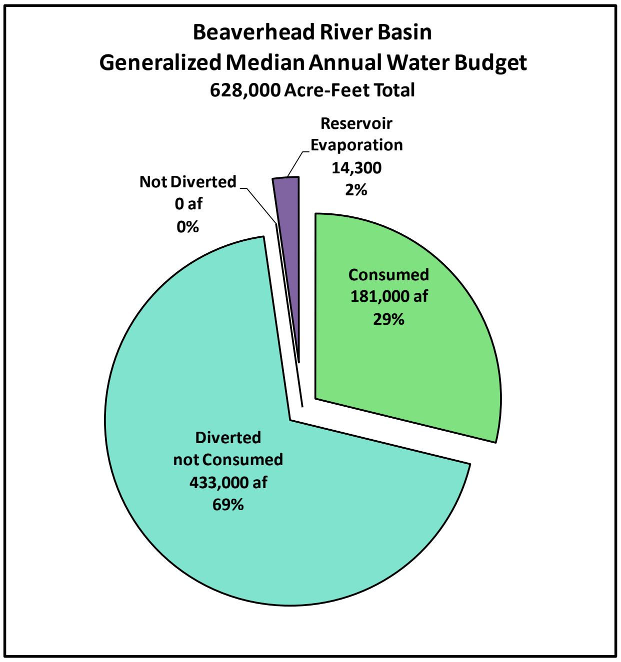


Figure 6.4 Generalized water budget for the Beaverhead River

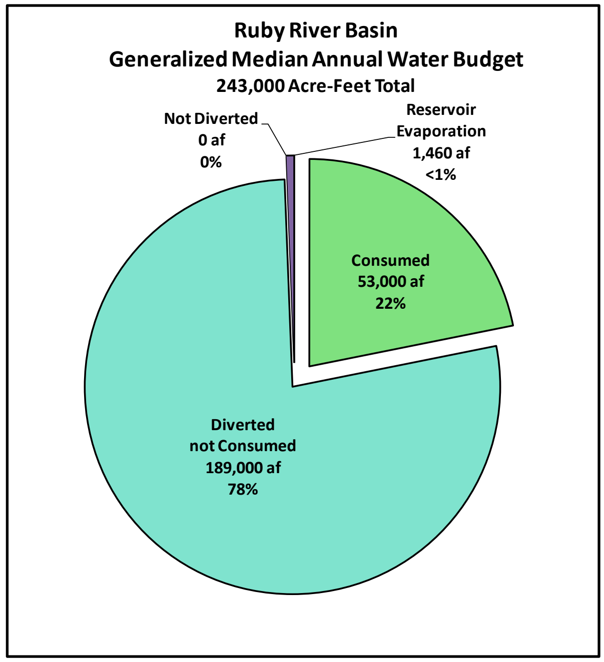


Figure 6.5 Generalized water budget for Ruby River

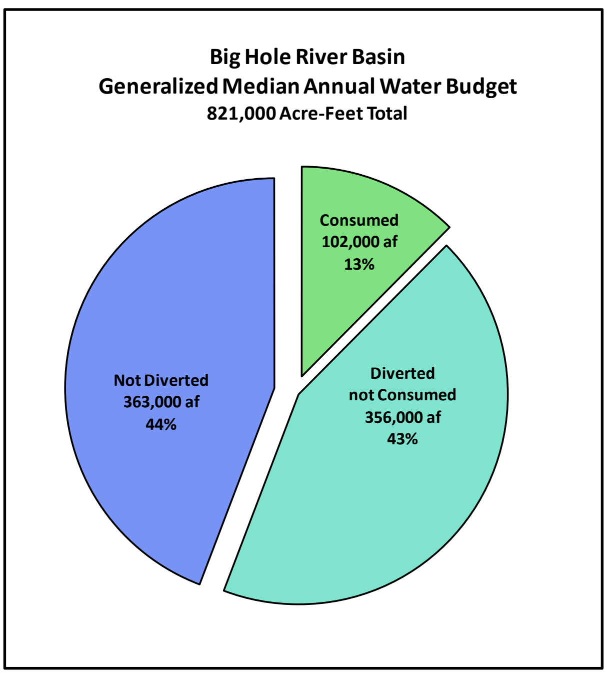


Figure 6.6 Generalized water budget for the Big Hole River

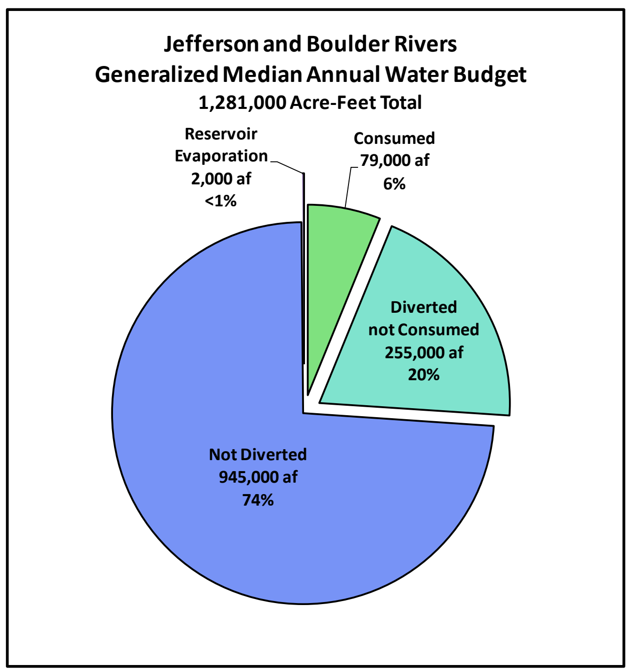


Figure 6.7 Generalized water budget for the Jefferson and Boulder Rivers

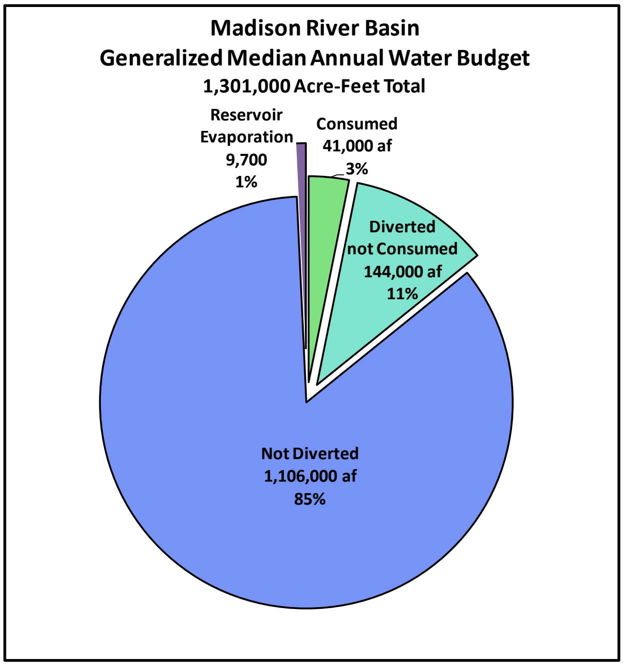


Figure 6.8 Generalized water budget for the Madison River

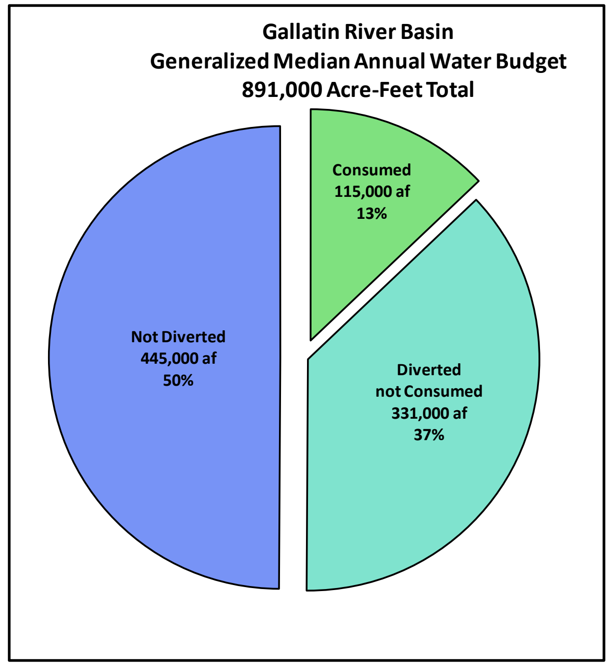


Figure 6.9 Generalized water budget for the Gallatin River

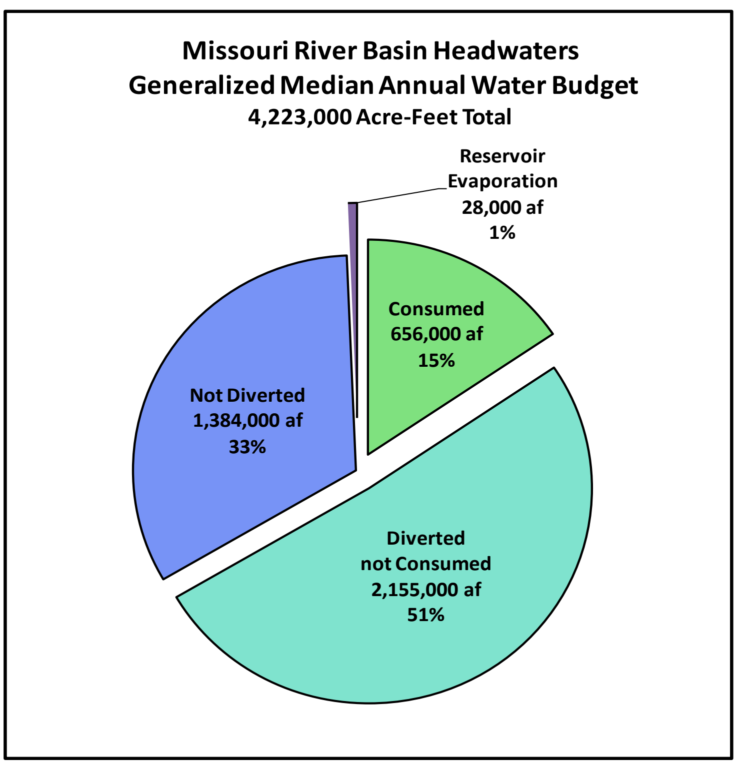


Figure 6.10 Total generalized water budget for Missouri River headwaters (based on Missouri River flow at Canyon Ferry)

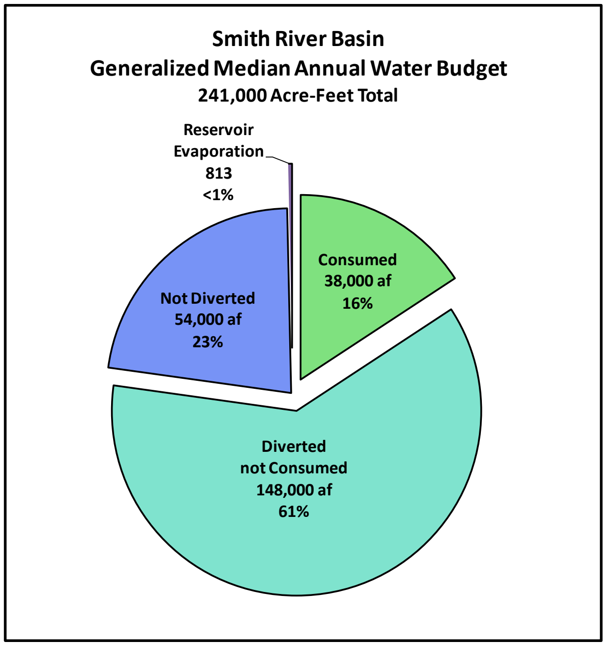


Figure 6.11: Generalized water budget for the Smith River

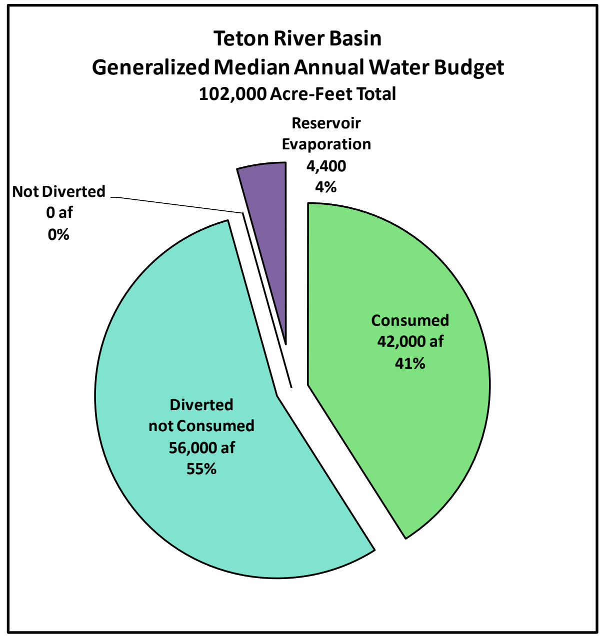


Figure 6.12: Generalized water budget for the Teton River

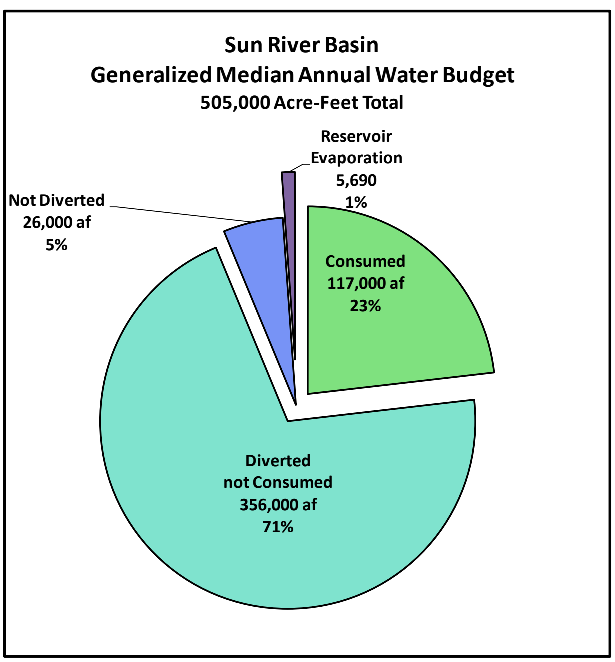


Figure 6.13: Generalized water budget for the Sun River

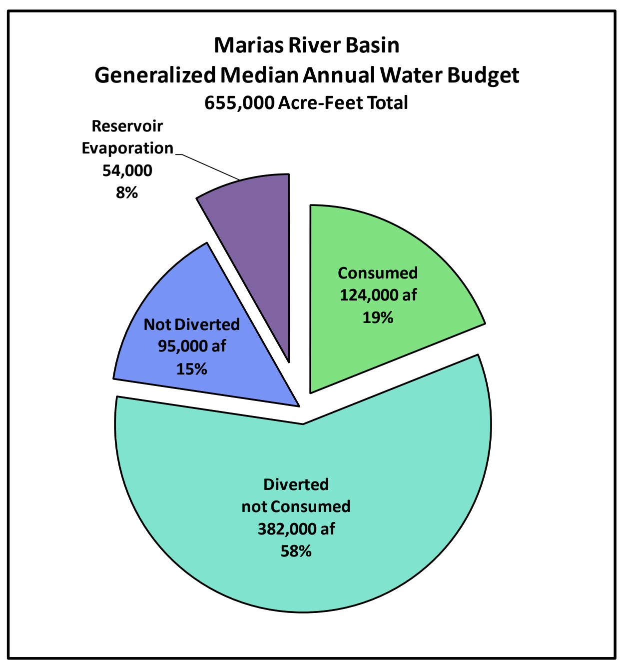


Figure 6.14: Generalized water budget for the Marias River

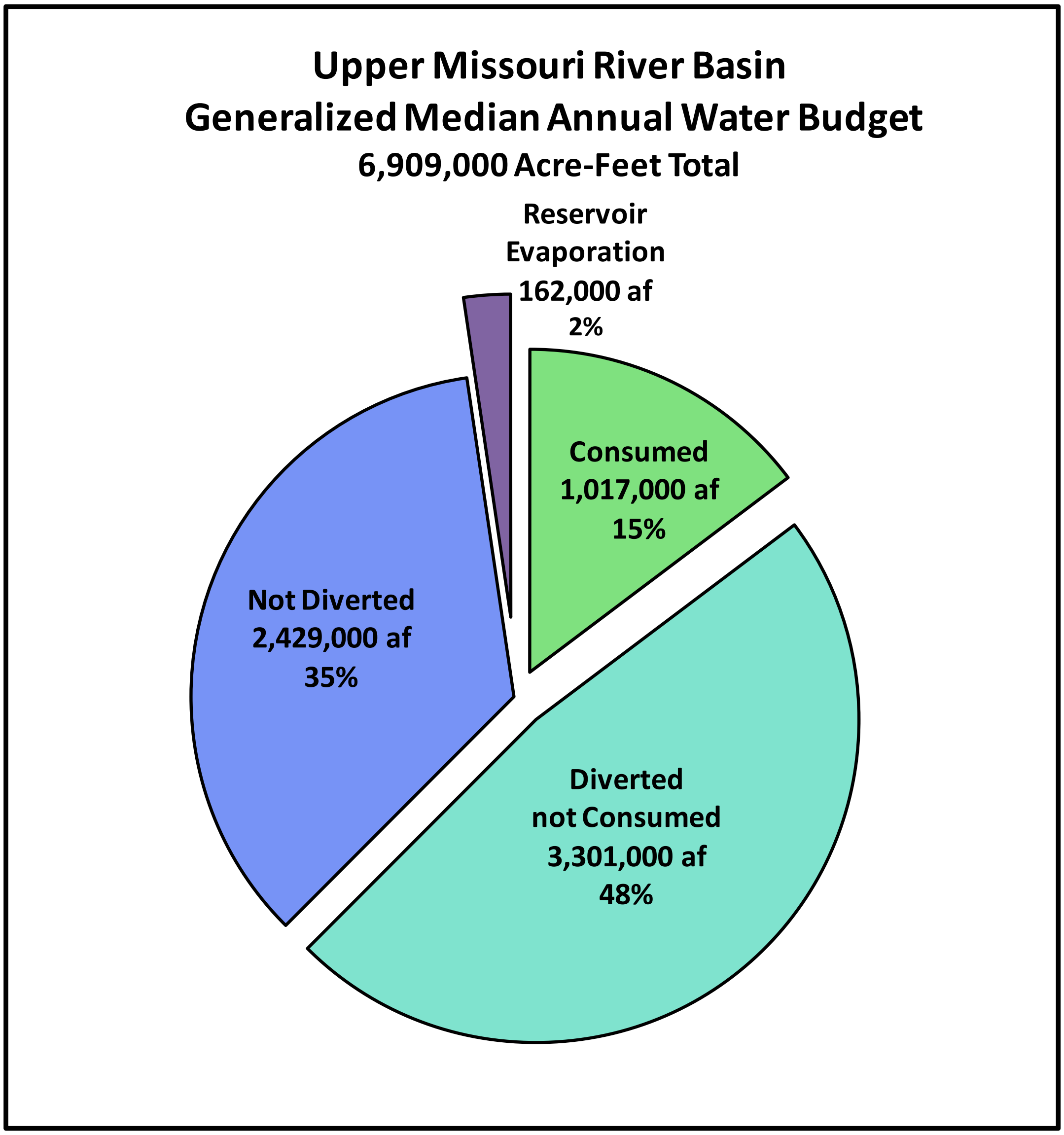


Figure 6.15: Total Upper Missouri River basin water budget diagram (based on flow of Missouri River at Virgelle

Data sources Figures 6.4 through 6.1: water volumes are based on USGS streamflow data, 1955-2012 period; irrigation water use data sources include Water Conservation and Salvage Report for Montana (SCS, 1978), DNRC Water Resources Surveys, Montana Department of Revenue 2010 Revenue Final Land Unit (FLU), DNRC Historic Use Methodology (2010); data sources for other uses include Montana Public Water System Sources Database, USGS Estimated Water Use in Montana 2000 report (2004), DNRC Montana Water Use in 1980 report (DNRC 1986).

A. Water Use By Sector

IRRIGATED AGRICULTURAL WATER USE

Wheel lines and irrigated grain, Teton River watershed

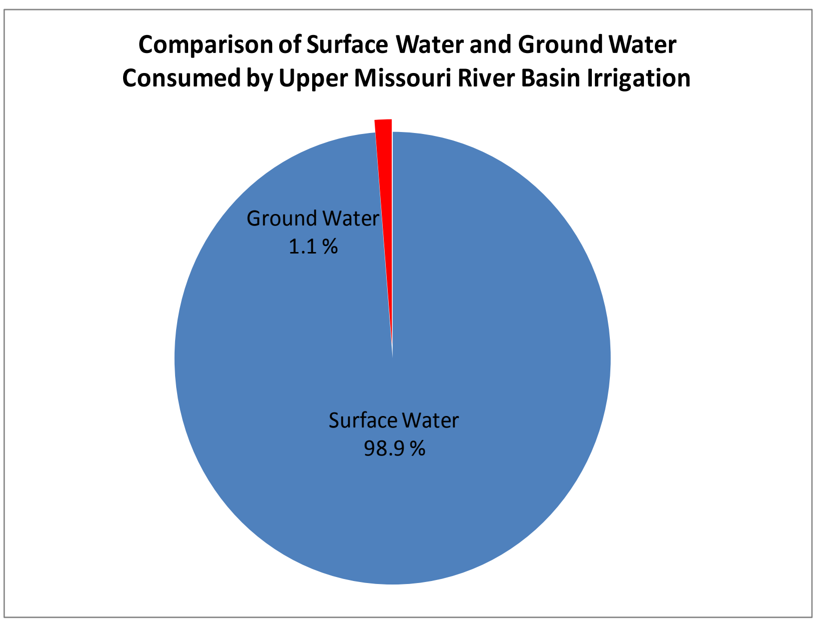


Figure 6.16 Relative comparison of irrigation source water in the Upper Missouri River Basin

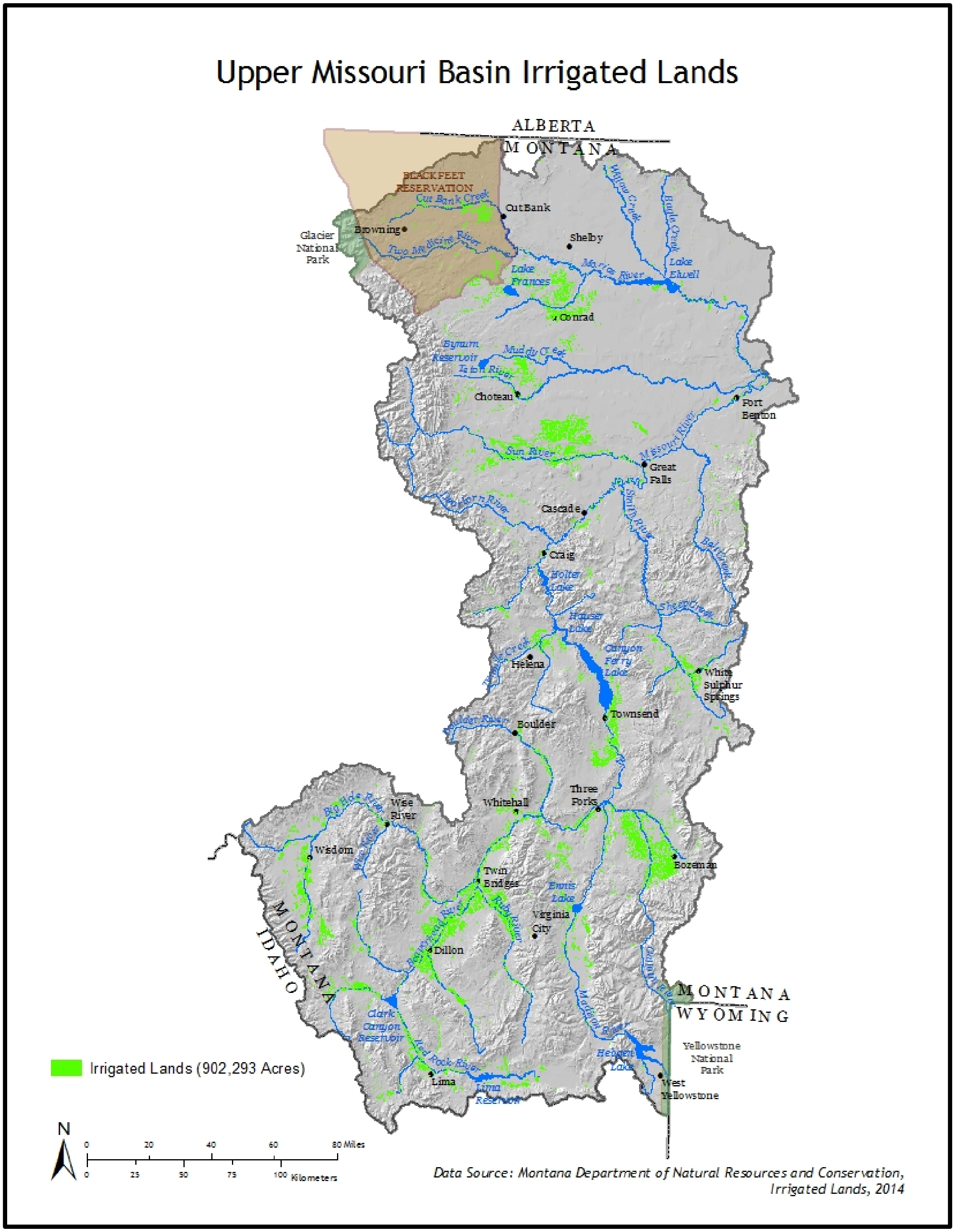
Most of the irrigation in the Upper Missouri River Basin is serviced by surface water (Figure 6.16), although groundwater can be an important source locally. Table 6.1 describes the number of acres irrigated, and volumes of water diverted and consumed by irrigation by sub-basin. These irrigated acres are depicted in Map 6.2.

Table 6.1 Upper Missouri River Basin irrigation water use by sub-basin

Sub-basin	Acres Irrigated	Volume Diverted (acre-feet)	Volume Consumed (acre-feet)
Gallatin River	104,000	431,000	109,000
Madison River	34,000	183,000	40,000
Ruby River	35,000	280,000	53,000
Beaverhead-Red Rock Rivers	164,000	801,000	179,000
Big Hole River	77,000	443,000	87,000
Jefferson River	62,000	331,000	78,000
Upper Missouri River and other Tributaries	71,000	287,000	77,000
Missouri River Headwater Total (to Canyon Ferry Dam)	**547,000**	**2,756,000**	**623,000**
Smith River	35,000	185,000	37,000
Sun River	113,000	471,000	116,000
Middle Missouri River main stem and smaller tributaries	35,000	136,000	33,000
Teton River	43,000	187,000	41,000
Marias River	129,000	499,000	120,000
Missouri River to Marias River Total	**902,118**	**4,234,000**	**970,000**

(Data sources include Water Conservation and Salvage Report for Montana (SCS, 1978), DNRC Water Resources Surveys, Montana Department of Revenue 2010 Revenue Final Land Unit (FLU).

Map 6.2 Upper Missouri River basin irrigated lands



Opportunities for Research and Investment

There has not been a comprehensive inventory of irrigated lands in Montana since the Water Resources Surveys were completed in the 1950s, 1960s, and early 1970s. Irrigated lands have changed substantially since then, in acreages, distributions, and especially irrigation system types. A statewide irrigation survey, of similar scope as the old water resources surveys, would provide valuable information on irrigation patterns in the basins. It also could be used to characterize irrigation system types and water delivery systems. Much of the work could be done with remote sensing data, such as aerial photography and satellite imagery. There would need to be field checking in some cases to separate active irrigation from sub-irrigation and riparian areas, and to better define irrigation system characteristics and water sources.

Water consumption patterns by irrigation have not been well quantified in Montana. Most investigations to date have relied on theoretical equations to predict evapotranspiration rates and associated water use. Because these equations were developed to predict evapotranspiration in controlled conditions with unrestricted water supplies, the equations generally overestimate water use compared to what typically is occurring in the field. Remote sensing approaches that use satellite imagery better estimate actual irrigation water use. Through incorporation with GIS, remote sensing methods can characterize irrigation water use spatially, and also by irrigation system type and crop type. DNRC is investigating the use of remote sensing for estimating evapotranspiration spatially, similar to approaches used in some other western states.

The amount of water diverted from streams in the Upper Missouri Basin for irrigation is not well known, although there are measuring devices on many diversions. Expanded measurement of water diversions, from surface and ground sources, and an associated water measurement database would enhance our understanding of irrigation water use, assist in local water management, and help to document changes in water use through time. Measurement of water diverted also could be used in conjunction with estimates of water consumed (as described in the paragraph above) to estimate irrigation system efficiencies and return flows.

LIVESTOCK WATER USE

The number of livestock (cattle, sheep, and hogs and pigs) was derived from NASS data for 2010. Water withdrawn for stock was estimated using the assumptions applied in the USGS 2000 Water Use report (USGS, 2004), and all water withdrawn for livestock was assumed to be consumed.

Beef Cattle: 15 gallons per day (gpd)/head

Dairy Cattle: 23 gpd/head

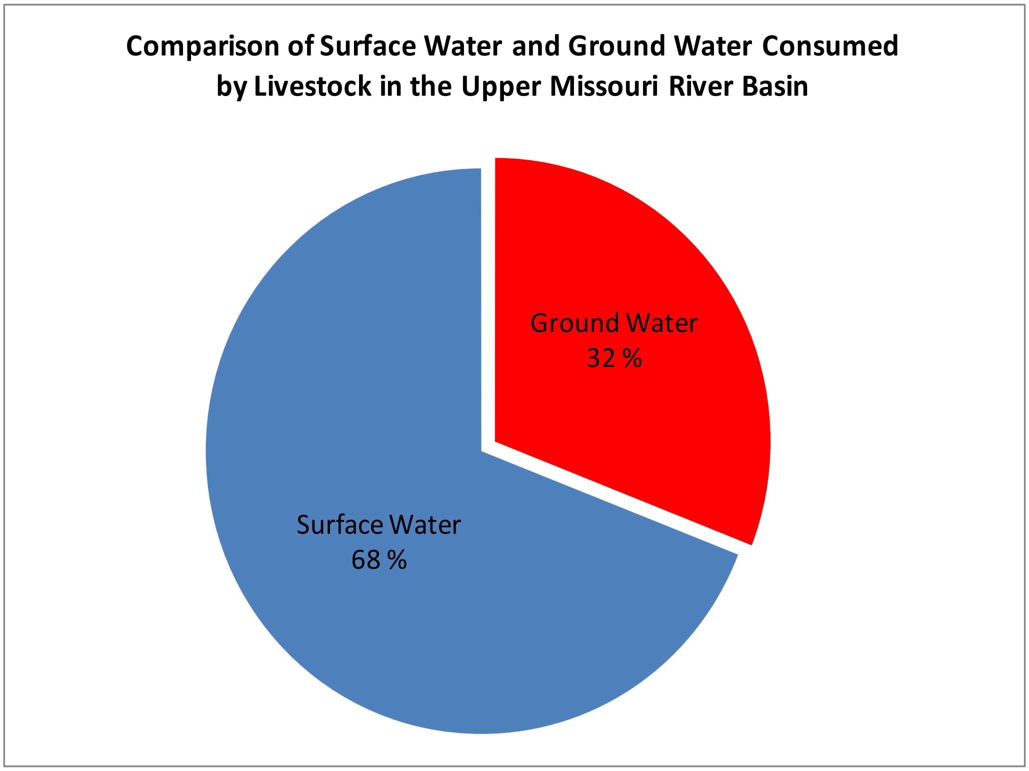
Hogs and Pigs: 5 gpd/head

Sheep: 2 gpd/head

Assignment of source was based on county percentages of groundwater and surface water originally assigned in the 1986 DNRC water use document. These percentages originated from water rights permits issued at the time of that report.

In the Upper Missouri River Basin, about 10,800 acre-feet of water is consumed in a typical year by livestock. About two-thirds of the water needed by livestock is supplied by surface water, with the remainder by groundwater (Figure 6.17). Table 6.2 summarizes livestock use by sub-basin.

Figure 6.17 Water sources for livestock in the Upper Missouri River Basin



Data sources: USGS 2004, NASS 2010 data

Table 6.2 Upper Missouri River Basin stockwater consumed by sub-basin

Sub-basin	Volume Consumed (acre-feet)
Gallatin River	618
Madison River	663
Ruby River	341
Beaverhead-Red Rock Rivers	1,292
Big Hole River	823
Jefferson River	530
Missouri River Headwater Total (to Canyon Ferry Dam)	**4,268**
Smith River	788
Sun River	662
Missouri River main stem and smaller tributaries	2,302
Teton River	785
Marias River	2,025
Missouri River to Marias River Total	**10,830**

Data sources: USGS 2004, NASS 2010 data.

Opportunities for Research and Investment

Although estimates are available on per-animal consumption by livestock, these amounts do not include all water that is diverted from streams or pumped from aquifers for livestock use. On-the-ground surveys would be needed to determine these diverted amounts.

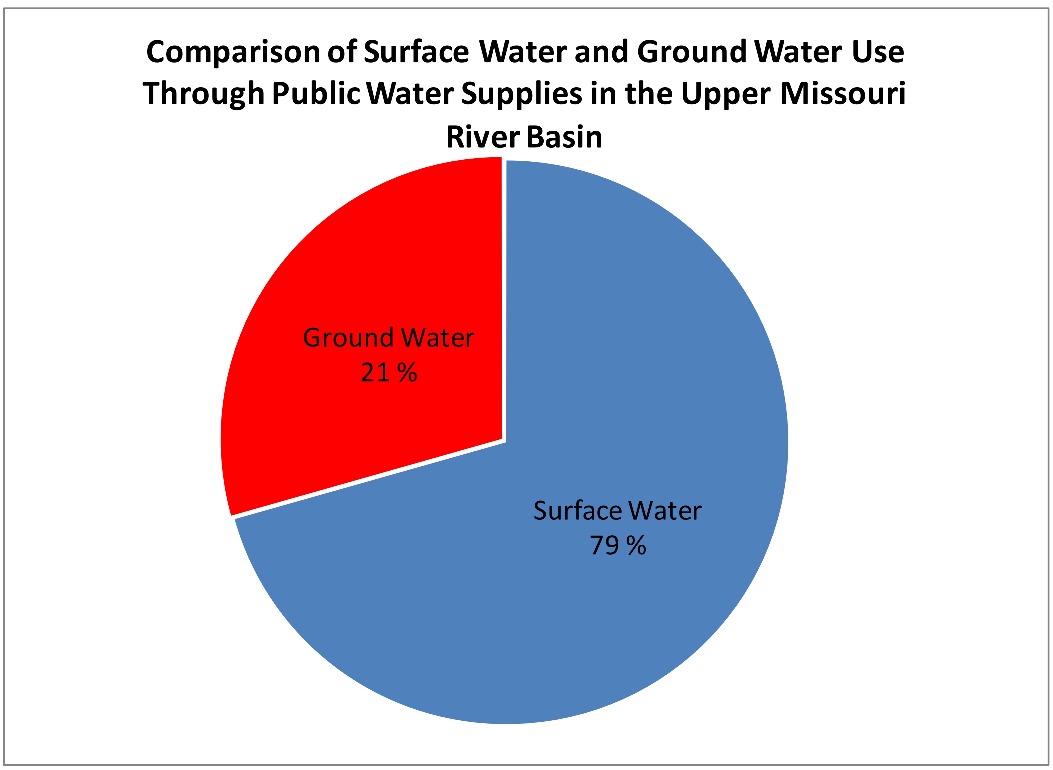
PUBLIC AND SELF SUPPLIED WATER USE

Public Water Supply

Public water systems (PWS) were identified by combining data from two sources: 1) the Montana Public Water System Sources database (MT DEQ, accessed through the Montana GIS portal; data published 9/19/2012); and 2) the EPA Safe Drinking Water Information System (SDWIS). The resulting dataset identifies the number of users, source, county, and HUC for each PWS. Water withdrawn by each PWS was estimated using values of per capita day use reported by county in the USGS (2004) document applied to the number of resident users. An additional 10 gallons per day was applied to cover non-resident users of the PWS. Consumptive use by PWS was assumed to be 37 percent of withdrawals (DNRC, 1975; USGS, 1986).

Upper Missouri Basin water is delivered to about 274,000 people through public water supplies. Most of the water supplied is surface water, although a large proportion is supplied by groundwater as well (Figure 6.17). Table 6.3 describes public water supply use by sub-basin.

Figure 6.18 Relative contributions of surface water and ground water for public water supplies in the Upper Missouri River Basin



Data sources: Montana Public Water System Sources database, EPA Safe Drinking Water Information System (SDWIS), USGS (2004)

Table 6.3 Upper Missouri River Basin water diverted and consumed through public water supplies by sub-basin

Sub-basin	Population Served	Volume Diverted (acre-feet)	Volume Consumed (acre-feet)
Gallatin River	71,202	11,876	4,394
Madison River	11,853	943	349
Ruby River	834	113	42
Beaverhead-Red Rock Rivers	5,560	2,025	749
Big Hole River	33,555*	14,471	14,464
Jefferson River	2,713	1,023	378
Missouri River Headwater Total (to Canyon Ferry Dam)	**125,717**	**30,451**	**20,376**
Smith River	1,774	397	147
Sun River	4,022	911	337
Missouri River main stem and smaller tributaries	113,661	24,554	9,085
Teton River	2,327	760	281
Marias River	26,894	5,239	1,938
Missouri River to Marias River Total	**274,395**	**62,312**	**32,164**

*Big Hole River water is used by the City of Butte; waste-water returns are to the Clark Fork River basin.
Data sources: Montana Public Water System Sources database, EPA Safe Drinking Water Information System (SDWIS), USGS (2004)

Self Supplied Domestic

The number of self-supplied domestic users was calculated by subtracting PWS resident users from 2010 population estimates (U.S. Census Bureau). The amount of water withdrawn by domestic users was assumed to be 78 gpd per person (DNRC, 1986; DNRC, 1975). Per the 1986 document, this estimate of water use was originally derived from statistics of municipal systems serving fewer than 55 users. All self supplied domestic water use was assumed to be from groundwater, and 50 percent of the water withdrawn is assumed to be consumed. Assignment of domestic users to HUCs was performed by assuming uniform distribution of residential users, consistent with the 2010 USGS documentation. Domestic systems serve the needs of about 90,000 households in the Upper Missouri River Basin, as summarized by sub-basin in Table 6.4.

Table 6.4 Upper Missouri River Basin water diverted and consumed through domestic water systems by sub-basin

Sub-basin	Users Served	Volume Diverted (acre-feet)	Volume Consumed (acre-feet)
Gallatin River	27,037	2,369	1,184
Madison River	2,169	190	95
Ruby River	1,247	109	55
Beaverhead-Red Rock Rivers	3,729	327	163
Big Hole River	1,235	108	54
Jefferson River	5,455	478	239
Missouri River Headwater Total (to Toston)	**40,872**	**3,581**	**1,790**
Smith River	140	12	6
Sun River	5,621	492	246
Missouri River main stem and smaller tributaries	40,634	3,560	1,780
Teton River	1,701	149	75
Marias River	953	83	42
Missouri River to Marias River Total	**89,921**	**7,877**	**3,939**

Data sources: 2010 county population estimates (U.S. Census Bureau, DNRC, 1986; DNRC, 1975, USGS (2004)

Opportunities for Research and Investment

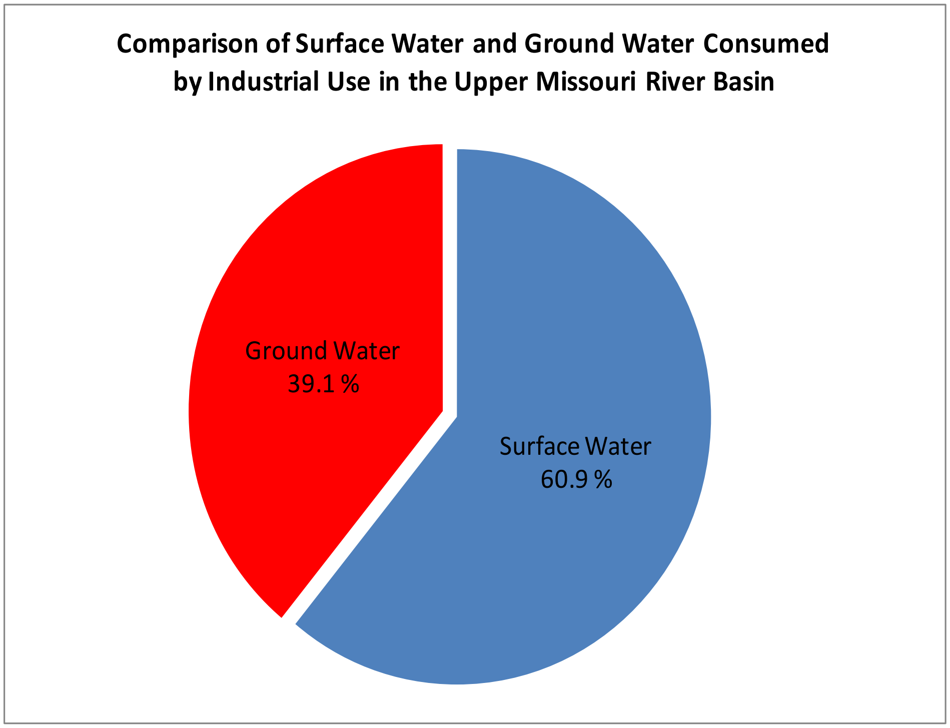
Larger municipalities generally record water diversions and returns of treated water to the source. For smaller municipalities and domestic users, water use estimates are based on what might be considered “typical” per capita water use, which may not accurately reflect the actual use at a particular location. More site-specific surveys would be needed to better characterize water use for smaller municipal system and for domestic users.

INDUSTRIAL WATER USE

Direct estimates of industrial use in 2010 were not possible. Instead, past USGS estimates (1985 through 2000, where both HUC and county estimates were provided, and 2005, which provided only usage by county) were analyzed to determine HUC assignment of those counties where the majority of industrial water use occurred. Then for those counties with the largest share (representing 90 percent of statewide industrial use), the 2005 USGS estimates were used as the best estimate for 2010 water use. All other industrial use estimates remain as reported in the 2000 water use document.

Industrial water use in the Upper Missouri Basin primarily is for mining, mineral processing, processing of agricultural products, and manufacturing. Figure 6.18 shows that surface water and groundwater are both important sources of water for industrial users. Table 6.5 summarizes industrial water use in the Upper Missouri River Basin by sub-basin.

Figure 6.19 Industrial water use comparison for the Upper Missouri River Basin by source.



Data source: USGS (2004)

Table 6.5 Industrial water use summary for the upper Missouri River Basin

Sub-basin	Volume Diverted (acre-feet)	Volume Consumed (acre-feet)
Gallatin River	101	15
Madison River	0	0
Ruby River	0	0
Beaverhead-Red Rock Rivers	303	46
Big Hole River	0	0
Jefferson River	326	49
Missouri River Headwater Total (to Toston)	**730**	**110**
Smith River	135	20
Sun River	0	0
Missouri River main stem and smaller tributaries	1,629	244
Teton River	0	0
Marias River	584	88
Missouri River to Marias River Total	**3,078**	**462**

Data source: USGS (2004)

Thermoelectric

Thermoelectric generators were identified from Energy Information Administration reporting (EIA923 – Power Plant Operations Report, Schedule 8D: Cooling System information). Six projects were identified in the report, three of which reported withdrawals and consumptive use for cooling in 2010. No water was reported withdrawn in the Upper Missouri Basin for thermoelectric cooling in 2010. This does not necessarily imply, however, that there is no thermoelectric generation in these basins.

Opportunities for Research and Investment

At present, there are few large industrial water users in the Upper Missouri Basin other than the larger hydropower generating facilities. It is difficult to predict what new industrial use is likely to occur in the basin in the future, and more difficult to estimate what future water demands might be for these uses.

B. Non-Consumptive Water Use in the Upper Missouri Basin

RECREATIONAL AND ENVIRONMENTAL WATER USES

Water for recreational use generally includes what nature provides, incidental use associated with reservoir storage and operations, and what is left instream after consumptive uses are satisfied. As such, it is difficult to assign a water volume or flow rate to recreational water use. Because some reservoirs (Canyon Ferry Reservoir being an example) are operated with recreational interests in mind, it might be possible to better quantify recreational water-use characteristics associated with these facilities.

Montana Department of Fish, Wildlife and Parks

Murphy Rights

In 1969, the Montana Legislature authorized the Montana Department of Fish, Wildlife and Parks (FWP) to file for instream or “Murphy” rights (named after James Murphy, a legislator who sponsored the bill) to protect flows on blue ribbon trout streams for fish and wildlife habitat. FWP filed on six streams in the Upper Missouri River Basin these rights have December, 1970 priority dates. Like other pre-1973 rights, the extent of these Murphy rights is being defined through the adjudication process.

Figures 6.19, 6.20, 6.21, and 6.22 compare FWP Murphy Right claims for selected locations on the Madison, Gallatin, Missouri, and Smith Rivers to the normal range of flow for those streams. A complete listing of FWP’s Murphy Rights can be found in Appendix A, Table A-1.

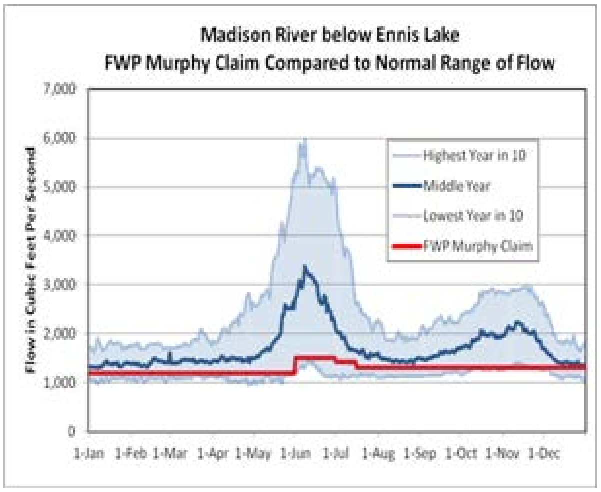


Figure 6.20 Madison River normal range of flow compared to FWP Murphy Right Claim

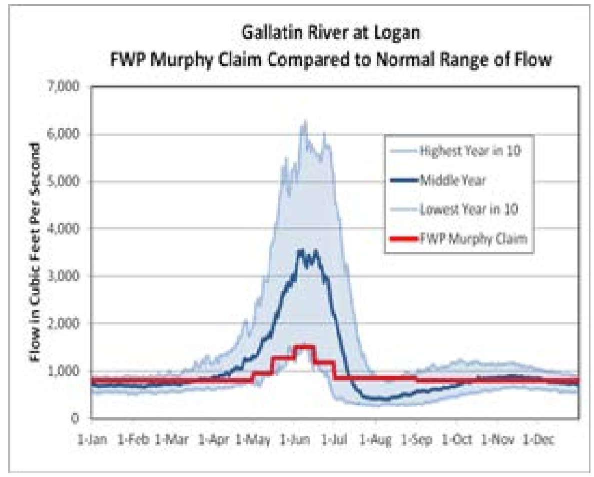


Figure 6.21 Gallatin River normal range of flow compared to FWP Murphy Right Claim

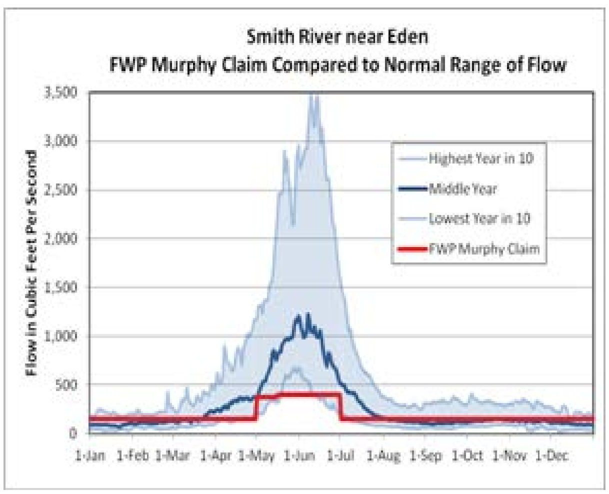


Figure 6.22 Smith River normal range of flow compared to FWP Murphy Right Claim

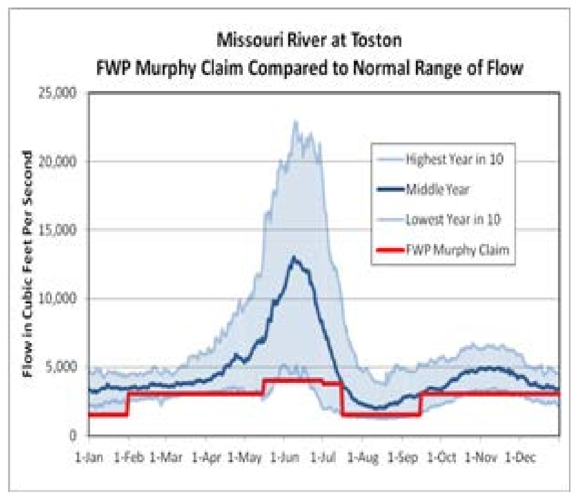


Figure 6.23 Upper Missouri River normal range of flow compared to FWP Murphy Right Claim

Water Reservations

In 1992, FWP was granted water reservations for minimum instream flows for 245 streams or stream reaches in the Upper Missouri River Basin to protect fisheries, aquatic habitat, and associated recreational values. In the Upper Missouri River basin, reservations generally were based on the amount of instream flow required to protect riffle habitat in the streams. The method typically used to define these flow rates was the Wetted Perimeter Inflection Point (WETP) method (FWP 1989). The WETP method recognizes that aquatic organisms, which make up the majority of food for gamefish, are produced in riffle areas and that riffles are used by many gamefish for spawning and rearing. The wetted perimeter is the linear distance along the bottom and sides of a stream that is in contact with water. Wetted perimeter declines with streamflow but the rate of decline is not linear. Instream reservations typically are based on an “inflection point” where riffle wetted perimeter declines rapidly with additional reductions in streamflow.

Because most of the FWP reservations are based on flow rates needed to just cover the riffle areas, they are generally in the range of what might be considered a stream's "base flow. Figures 6.23 through 6.32 compare FWP water reservations to the normal rates of flow at select locations for some of the major streams in the Upper Missouri River Basin. Graphs with reservations have not been depicted for the Madison, Gallatin, and Smith Rivers because the reservations are generally for lower rates of flow than the Murphy rights of early priority date. Appendix A presents a complete summary of all FWP reservations in the Upper Missouri River Basin. The reservations have a priority date of July 1, 1985.

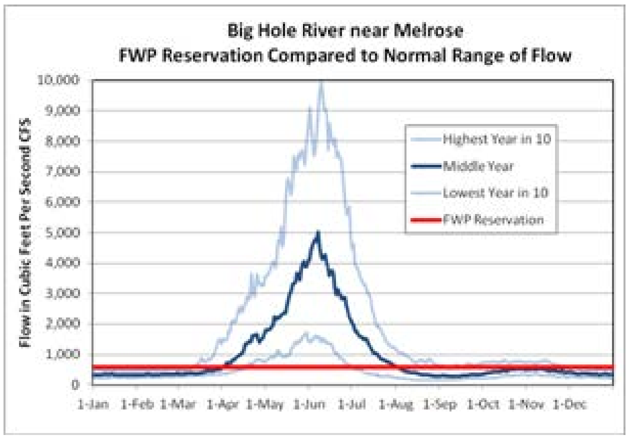


Figure 6.24 FWP instream flow reservations compared to normal range of flow for Big Hole River

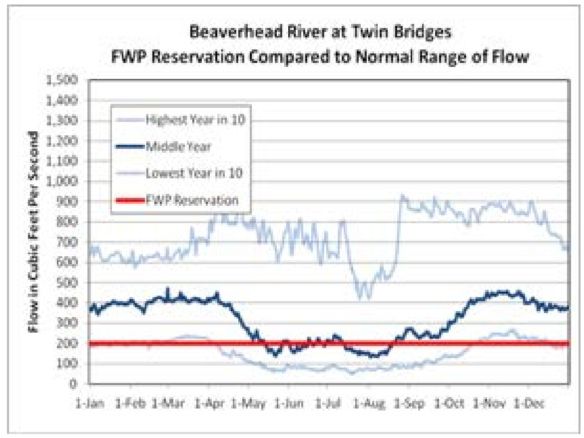


Figure 6.25 FWP instream flow reservations compared to normal range of flow for Beaverhead River

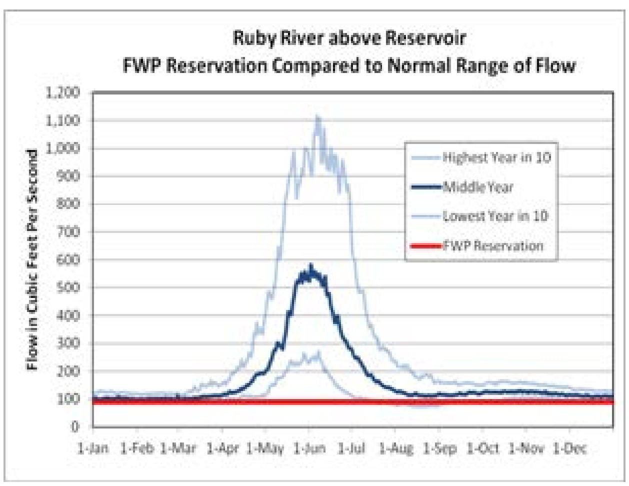


Figure 6.26 FWP instream flow reservations compared to normal range of flow for Ruby River

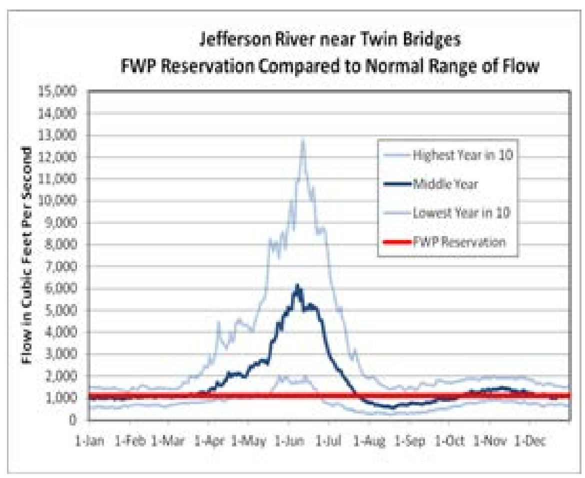


Figure 6.27 FWP instream flow reservations compared to normal range of flow for Jefferson River

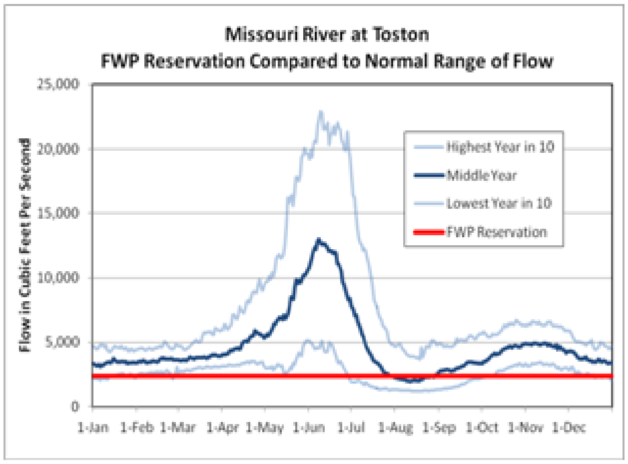


Figure 6.28 FWP instream flow reservations compared to normal range of flow for Upper Missouri River

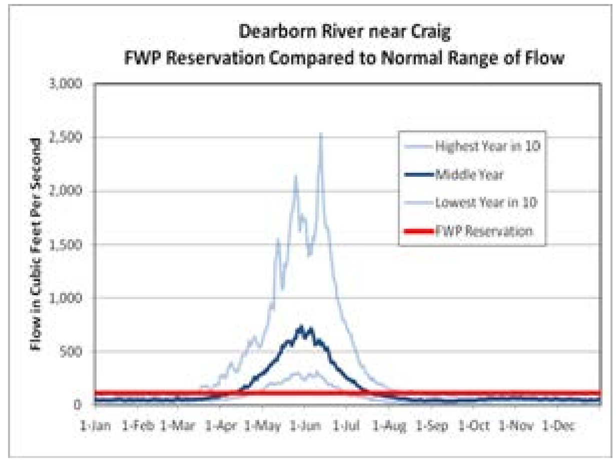


Figure 6.29 FWP instream flow reservations compared to normal range of flow for Dearborn River

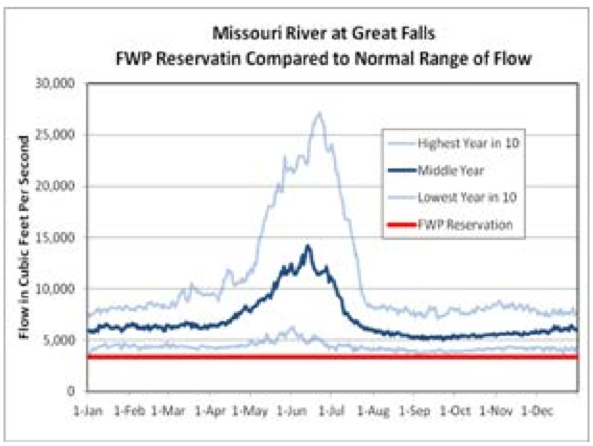


Figure 6.30 FWP instream flow reservations compared to normal range of flow for Middle Missouri River

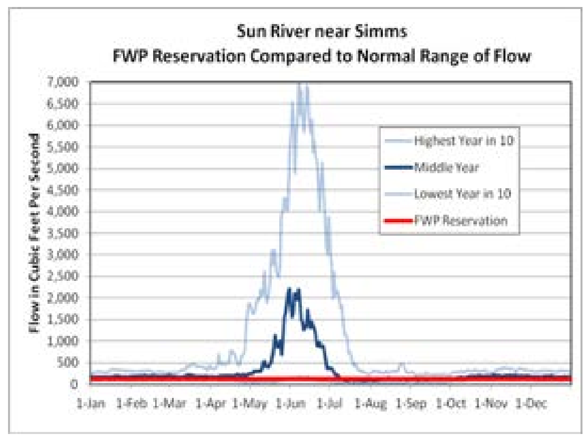


Figure 6.31 FWP instream flow reservations compared to normal range of flow for Sun River

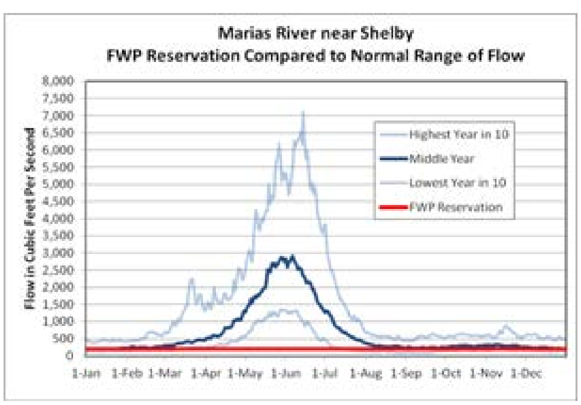


Figure 6.32 FWP instream flow reservations compared to normal range of flow for Marias River

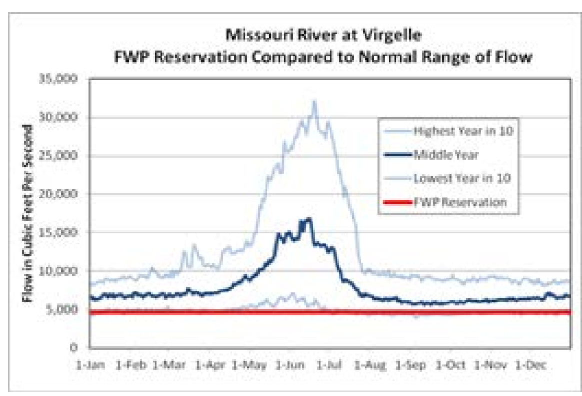


Figure 6.33 FWP instream flow reservations compared to normal range of flow for Lower Missouri River

Public Recreation Claims
FWP also has a public recreation claim for 200 cfs in the Beaverhead River from Grasshopper Creek to Clark Canyon Dam, as well as a fish and wildlife claim for 25 cfs from Clark Canyon downstream to the confluence with the Big Hole River. These claims are relatively junior to other users, with priority dates of August 29, 1964, and February 31, 1961, respectively.

UNITED STATES BUREAU OF LAND MANAGEMENT

Water Reservations
The Bureau of Land Management (BLM) has instream flow water reservations for 31 smaller streams in the Missouri River headwaters, where those streams pass through lands administered by the BLM. Appendix B presents a summary of these water reservations. These reservations, which include year-round minimum flows and instantaneous peak discharges for channel maintenance purposes, have a July 1, 1985, priority date.

Water Compacts
A water compact between the State of Montana and U.S. Bureau of Land Management quantifies the instream flow rights for the Upper Missouri National Wild and Scenic River and the Bear Trap Canyon public recreation site, which are administered by the BLM. The Bear Trap Canyon public recreation site (below Madison Dam on the Madison River) water right has a priority date of June 9, 1971, and is for a flow of 1,100 cfs year-round. The water right for the Upper Missouri National Wild and Scenic River downstream of Fort Benton is for the amount of remaining flow in the river after all water appropriations before December 31, 1987, are accounted for, and then allows for additional depletions of water by month as specified in Table 5.6. In addition, uses such small domestic and stock wells, lawn and garden, and instream stock uses are allowable and not subtracted from the volumes in Table 5.6. See section 7, Reserved Water Rights Compacts, for more details.

Table 6.6 Available water supply (depletion) amounts by month under the Compact for the Upper Missouri National Wild and Scenic River

Month	Acre-feet
January	104,000
February	121,000
March	124,000
April	185,000
May	219,000
June	62,000
July	82,000
August	66,000
September	40,000
October	35,000
November	57,000
December	98,000

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

Water Reservations

The Montana Department of Environmental Quality (DEQ) has instream flow reservations to maintain water quality on the main stem Missouri River. The purpose of these reservations is to dilute naturally occurring arsenic in the river, which primarily originates from geothermal springs in the Madison drainage in Yellowstone National Park. The reservations are for what was computed to be one-half the average annual flow of the Missouri River at four locations as summarized in Appendix C, Table C-1. These reservations are similar to the amounts reserved by FWP for these same stream reaches and also have a July 1, 1985, priority date. The DEQ reservations run concurrently with the other instream flow reservations, such as those granted to FWP—that is, they are not additive to the other instream reservations.

Opportunities for Research and Investments

The water needs for environmental uses are generally associated with those needed for fish and wildlife and for water quality purposes. In the Upper Missouri River Basin, this would include FWP Murphy rights and water reservations, BLM instream flow reservations and federal reserved rights for the Upper Missouri National Wild and Scenic River, and DEQ instream water reservations for water quality protection. These instream rights typically are for what is considered to be near the minimum flow needed to protect these resources. Higher flows that might also have environmental and ecological values typically are not protected. More detailed analysis is needed to determine what high flows are needed to protect these resources. This could include flushing and channel maintenance flows.

Gibson Dam and Reservoir near the end of the irrigation season

SURFACE WATER STORAGE

Physical Characteristics

There are numerous dams that store and regulate the flow of water in the Upper Missouri River Basin (Map 6.3). There also are dams that divert flow into irrigation canals, generate hydropower, or provide some combination of these functions. Rather than describe all of these dams, this section will focus on larger storage projects that can significantly store or regulate the flow of larger perennial streams in the basin. Table 6.7 lists these dams. Although the purposes of these dams might be listed for just a single use, such as irrigation, most offer other benefits beyond the stated purpose, such as providing still-water fisheries or recreation.

Table 6.7 Summary of larger dams in the Upper Missouri River Basin

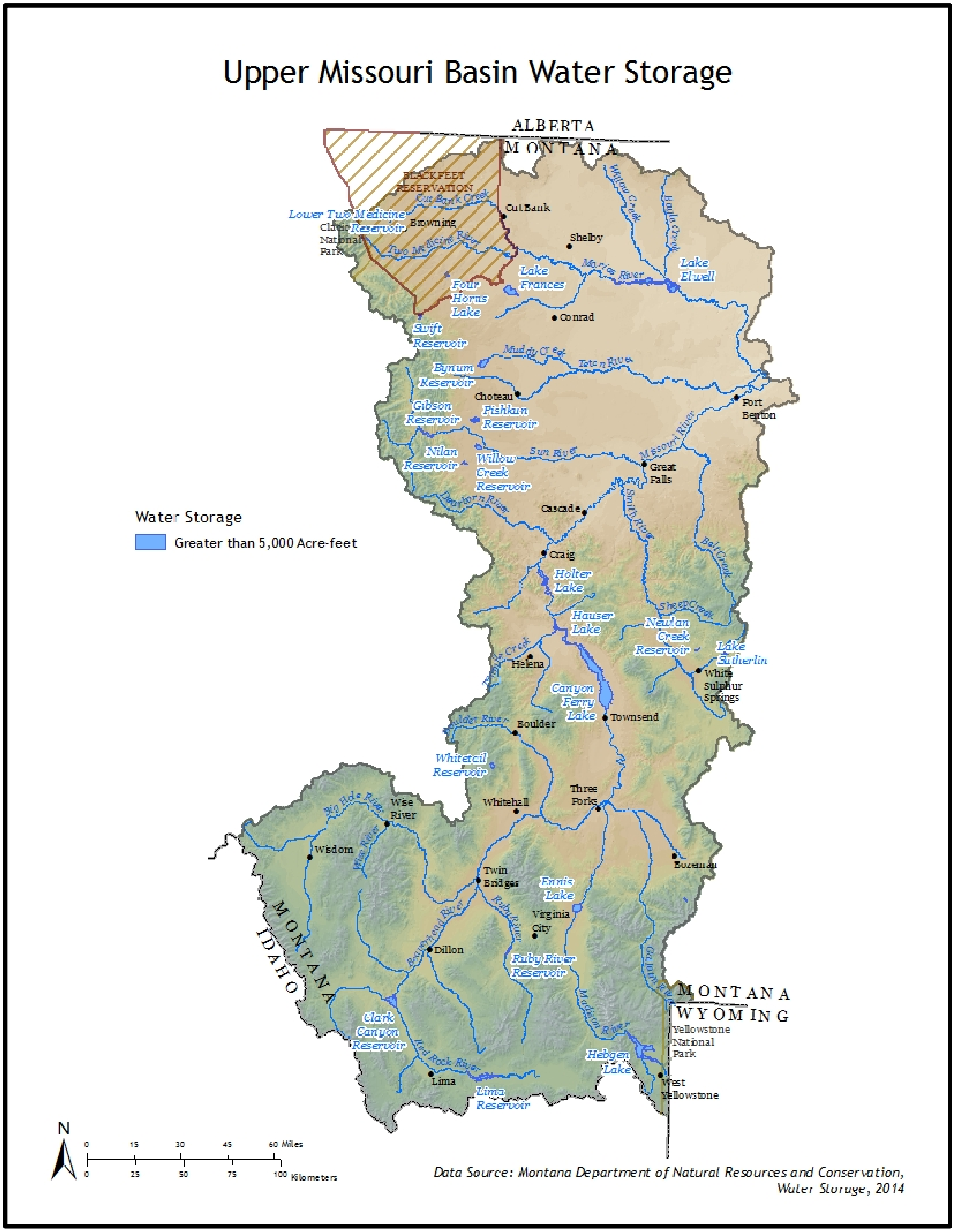
Dam	Stream	Approx Total Capacity (acre feet)	Owner	Purposes
Hebgen	Madison River	386,000	PPL Montana	Hydropower
Madison Dam	Madison River	27,200	PPL Montana	Hydropower
Middle Creek (Hyalite)	Hyalite Creek	10,200	Montana DNRC	Irrigation, municipal
Lima	Red Rock River	85,000	Red Rock Water Users Association	Irrigation
Clark Canyon	Beaverhead River	253,400	Bureau of Reclamation	Irrigation, fish, wildlife, and recreation
Ruby	Ruby River	36,600	Montana DNRC	Irrigation
Willow Creek	Willow Creek	17,700	Montana DNRC	Irrigation
Whitetail	Little Whitetail Creek	8,000	Whitetail Water Users Association	Irrigation
Canyon Ferry	Missouri River	1,993,000	Bureau of Reclamation	Hydropower, flood control, irrigation, fish, wildlife, and recreation
Helena Valley	Missouri River/Canyon Ferry Reservoir	10,500	Bureau of Reclamation	Irrigation, municipal, fish, wildlife, and recreation
Chessman	Buffalo Creek (off-stream)	1,870	City of Helena	Municipal
Hauser	Missouri River	98,000	PPL Montana	Hydropower
Holter	Missouri River	243,000	PPL Montana	Hydropower
North Fork (Lake Sutherlin)	North Fork Smith River	11,400	Montana DNRC	Irrigation
Newlan Creek	Newlan Creek and Sheep Creek	15,600	Meagher County, Newlan Creek Water District	Irrigation
Nilan	Smith and Ford Creeks (off-stream)	10,100	Montana DNRC	Irrigation
Gibson	Sun River	98,700	Bureau of Reclamation	Irrigation
Willow Creek	Sun River and Willow Creek (off-stream)	32,400	Bureau of Reclamation	Irrigation

Dam	Stream	Approx Total Capacity (acre feet)	Owner	Purposes
Pishkun	Sun River (off-stream)	46,700	Bureau of Reclamation	Irrigation
Bynum	Teton River (off-stream)	85,000	Teton Cooperative Reservoir Company	Irrigation
Eureka	Teton River (off-stream)	2,700	Teton Cooperative Reservoir Company	Irrigation
Lake Francis	Birch and Dupuyer Creeks (off-stream)	130,000	Pondera County Canal and Reservoir Company	Irrigation
Swift	Birch Creek	34,000	Pondera County Canal and Reservoir Company	Irrigation
Four Horns	Badger Creek (off-stream)	19,300	Bureau of Indian Affairs	Irrigation
Lower Two Medicine	Two Medicine River	13,500	Bureau of Indian Affairs	Irrigation
Tiber (Lake Elwell)	Marias River	1,556,000	Bureau of Reclamation	Irrigation, fish, wildlife, and recreation, flood control, hydropower

Sources: DNRC dams database, USGS 2004.

Combined, the capacity of the reservoirs associated with these dams totals to about 5,000,000 acre-feet. This is similar to the annual volume of runoff produced by the Missouri River at Virgelle, about 6,000,000 acre-feet. However, the storage behind many of these dams is not always fully used on a seasonal basis. For instance, Holter and Hauser Dams on the Missouri River are held at relatively consistent levels to maintain head to produce hydropower, even though the reservoirs store substantial amounts of water. Canyon Ferry Reservoir, the largest in the basin, has a capacity of almost 2,000,000 acre-feet, but is seldom if ever drawn below 1,000,000 acre-feet.

Map 6.3 Reservoirs in the Upper Missouri River Basin



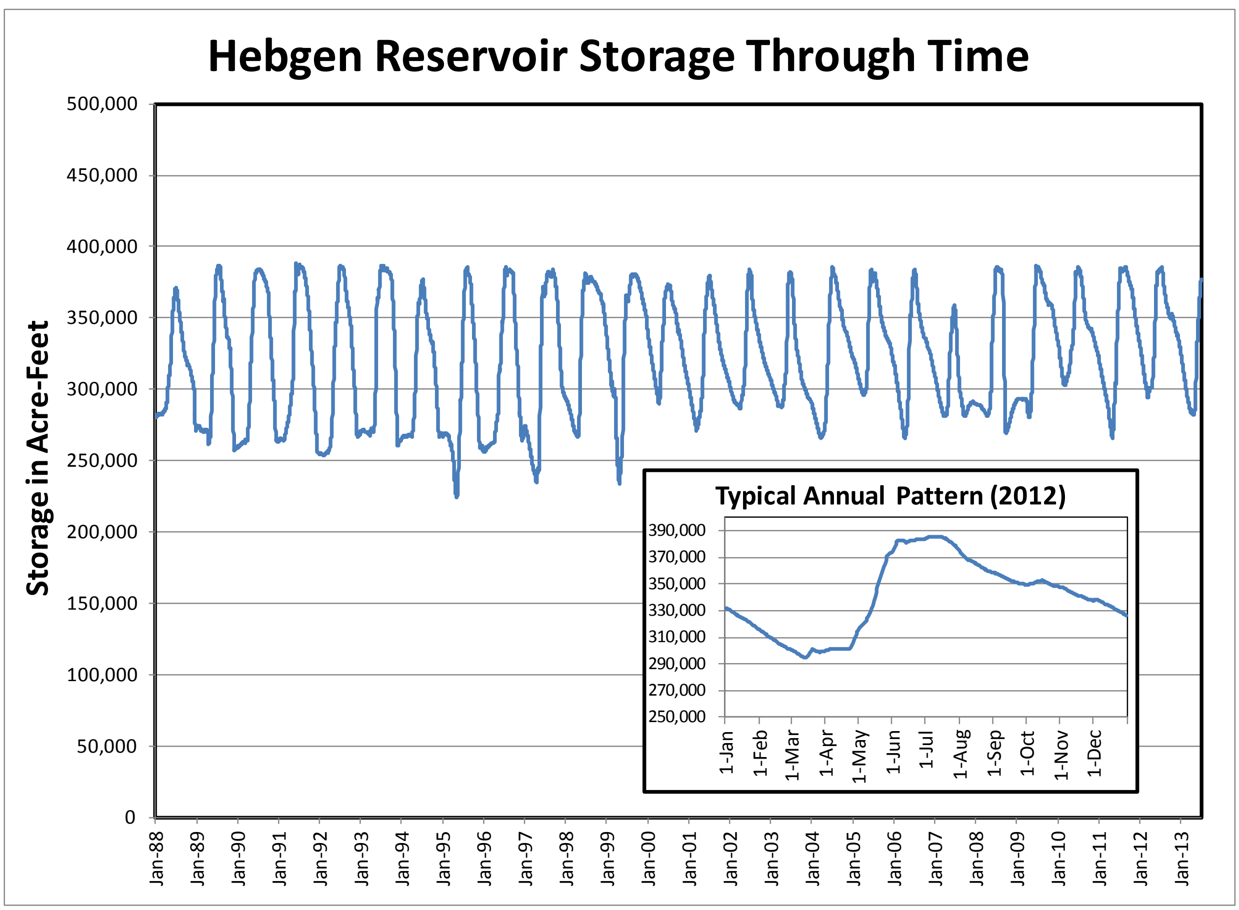
RESERVOIR MANAGEMENT AND OPERATIONS

Although it is beyond the scope of this report to describe in detail the operation of all of the dams and reservoir in the basin, the operations of a few will be described as examples, including the largest dams that substantially affect the flows of the major rivers.

Hebgen Dam

Hebgen Dam is located on the Madison River just downstream of where it leaves Yellowstone National Park. It is owned and operated by PPL Montana. The reservoir has a storage capacity of 386,000 acre-feet, which equivalent to about 60 percent of the average annual flow into the reservoir. The purpose of Hebgen Dam is to store water for hydropower production. No hydropower is actually produced at Hebgen Dam itself. Instead, water is stored and released from Hebgen Reservoir to maximize hydropower production and revenues at downstream dams, such as Madison Dam near Ennis. Figure 6.33 shows storage in the reservoir for the 1988-2013 period. The reservoir fills most years and is seldom drawn below 250,000 acre-feet of storage. The inset graph shows the typical annual operational pattern of storing water during the May-June peak runoff period, and releasing water to enhance Madison River flows, and downstream hydropower productions, from late summer through winter.

Figure 6.34 Hebgen Reservoir storage 1988-2013

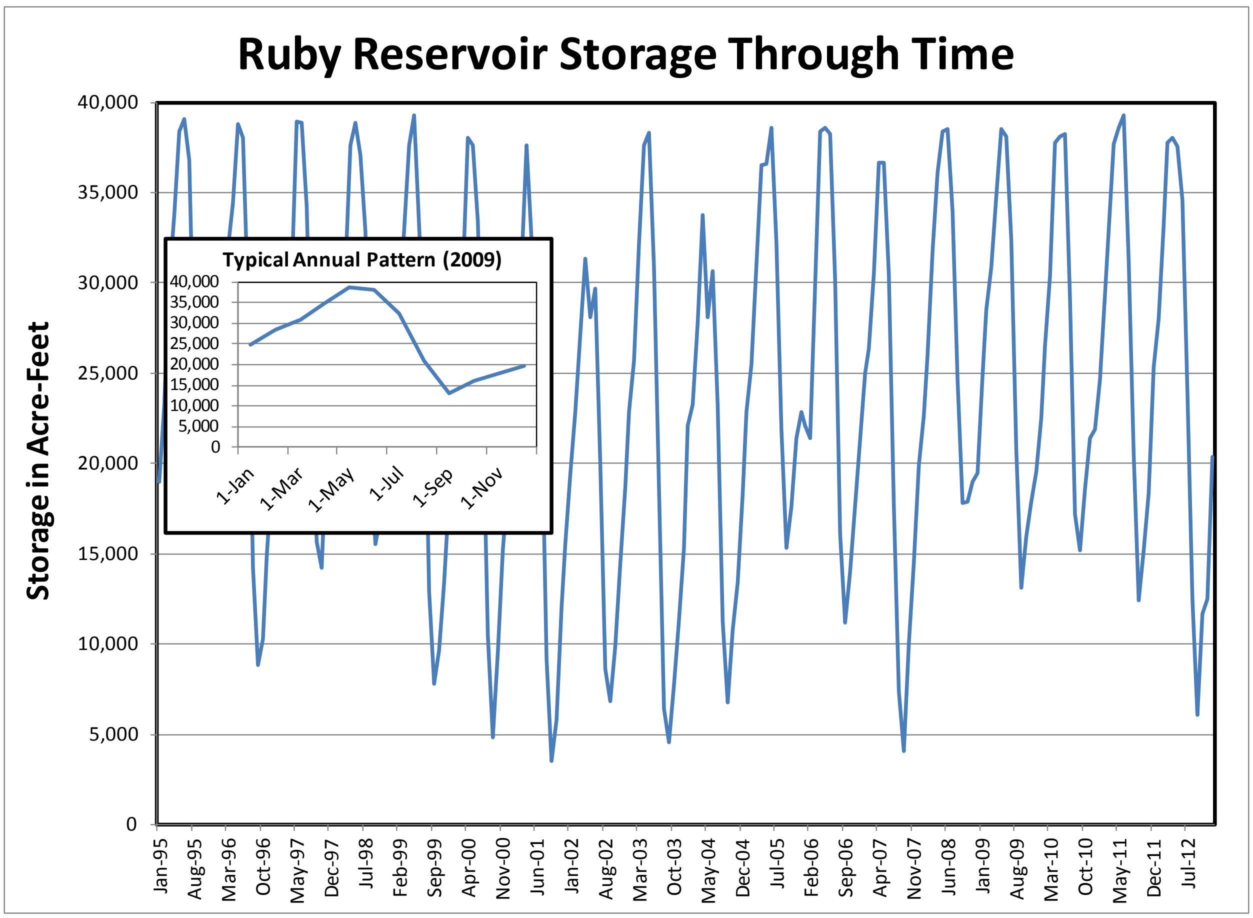


Data Source: U.S. Bureau of Reclamation Hydromet system; http://www.usbr.gov/gp/hydromet/

Ruby River Dam

Ruby River Dam is representative of a mid-sized project that is operated seasonally to store and release water for irrigation. The dam and reservoir are owned by DNRC and operated by the local Ruby River Water Users Association. The dam can store 36,600 acre-feet, although the lower-most 2,600 acre-feet of storage is reserved as a minimum pool to maintain the reservoir fishery and to keep sediment concentrations from becoming too high in the river below the dam. The reservoir typically is filled during fall, winter, and early spring, and water is released from storage during the summer peak irrigation season (Figure 6.34). A minimum release of 20-to-30 cfs from November through March typically is maintained.

Figure 6.35: Ruby Reservoir storage, 1995-2012

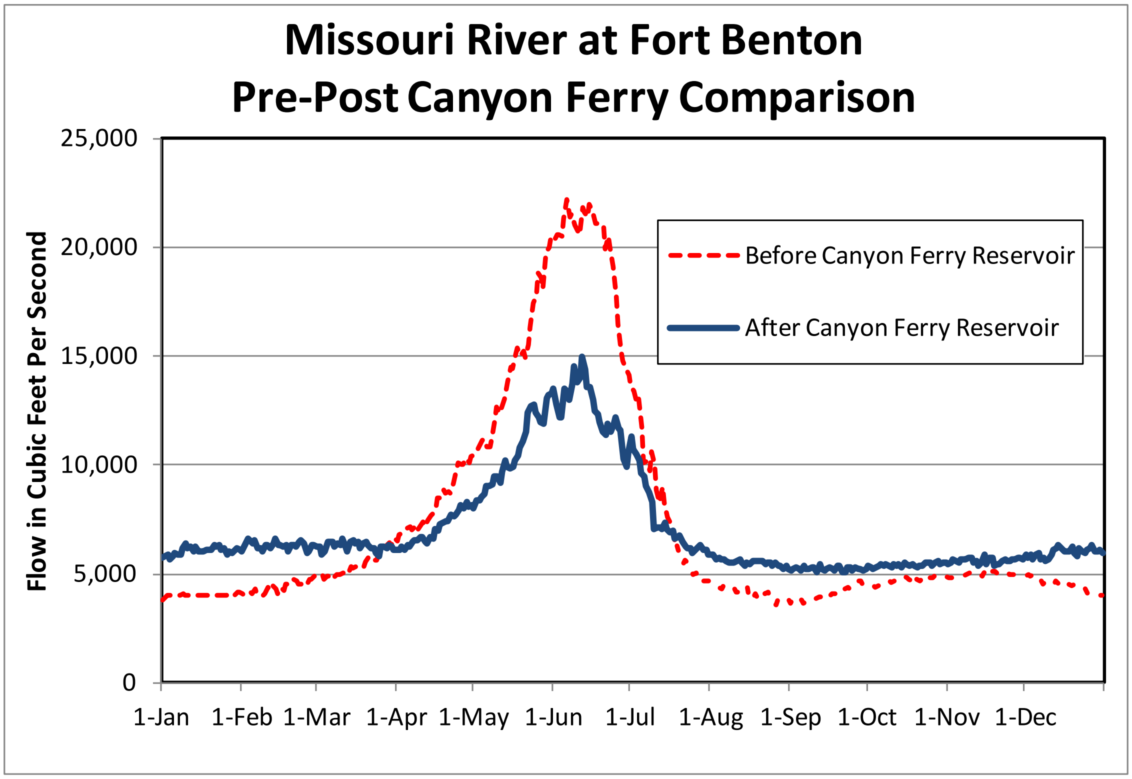


Data Source: DNRC State Water Projects Bureau

Canyon Ferry Dam

Canyon Ferry Dam and Reservoir on the Missouri River is the largest storage project in the Upper Missouri River Basin at 2,000,000 acre-feet. The dam is owned by the U.S. Bureau of Reclamation (USBR) and operated for the purposes of flood control, hydropower production, irrigation, recreation, and fish and wildlife. Because of its large storage capacity and the amount of storage available for flood control (up to about 900,000 acre-feet) Canyon Ferry Reservoir operations have considerable controlling effects on the flow of the Missouri River all the way downstream to Fort Peck Reservoir. To depict these effects, Figure 6.35 compares average annual flows for the Missouri River at Fort Benton prior to and after the construction of Canyon Ferry Dam. Prior to construction of the dam, spring peak flows were typically higher. Now the dam captures much of the high spring flow and redistributes, resulting in enhanced flows during late summer, fall, and winter.

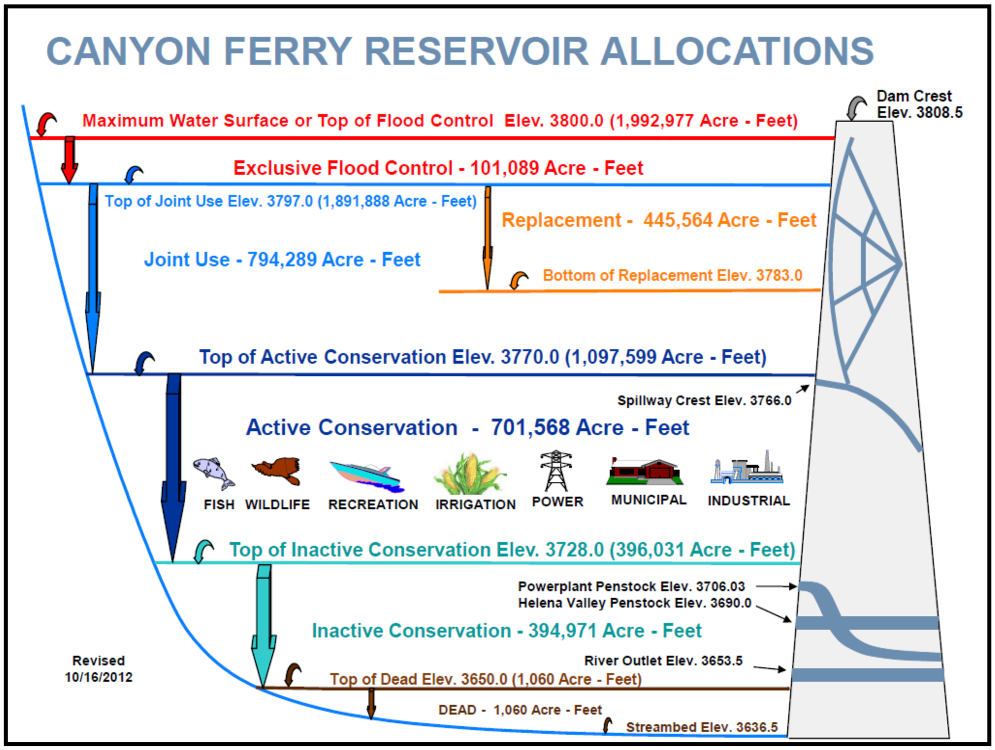
Figure 6.36 Effects of Canyon Ferry Dam on Missouri River flows at Fort Benton



Data source: USGS streamflow data: http://mt.water.usgs.gov/.

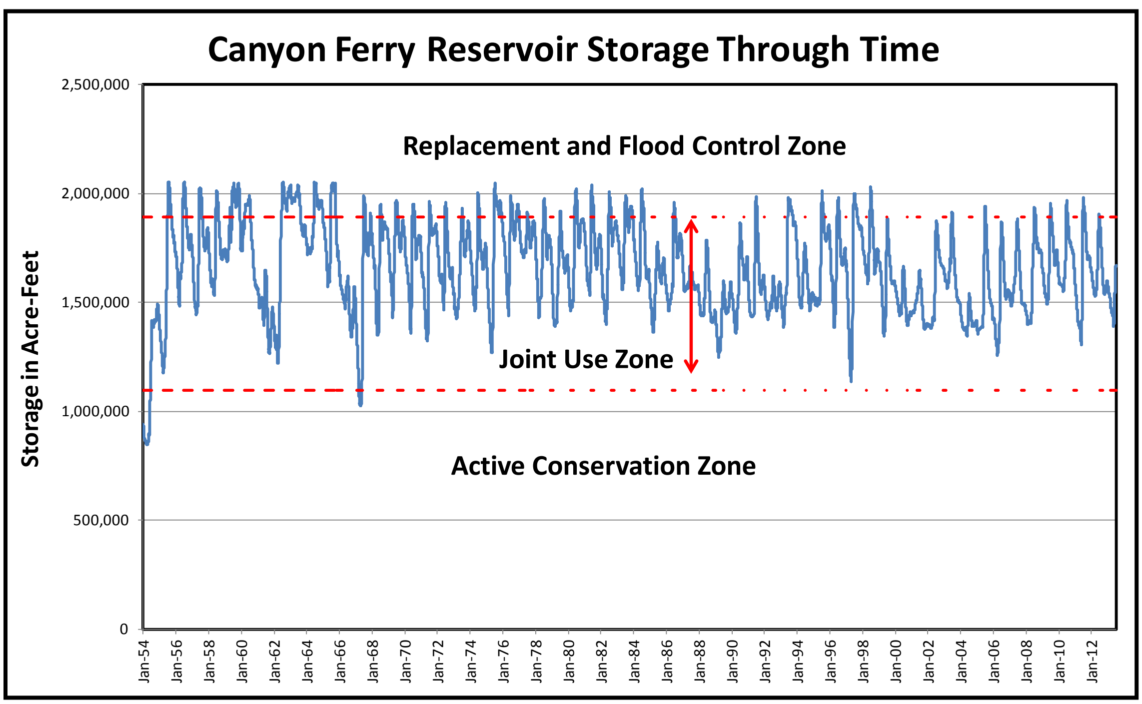
Figure 6.36 is a diagram from USBR showing storage allocations in Canyon Ferry Reservoir. Figure 6.37 shows Canyon Ferry storage since 1954, when the dam was completed, until present. During most years, the storage reaches or exceeds the top of the joint use zone (1,891,888 acre-feet of storage). When there is an extended drought, such as during 2000 through 2006, there can be multiple years when the reservoir does not fill and storage is drawn down to near the bottom of the joint use zone.

Figure 6.37 Bureau of Reclamation Canyon Ferry Water Allocation Diagram



Source: U.S. Bureau of Reclamation; http://www.usbr.gov/gp/aop/resaloc/canyon_ferry.pdf

Figure 6.38 Canyon Ferry Reservoir storage from date of dam construction to near present



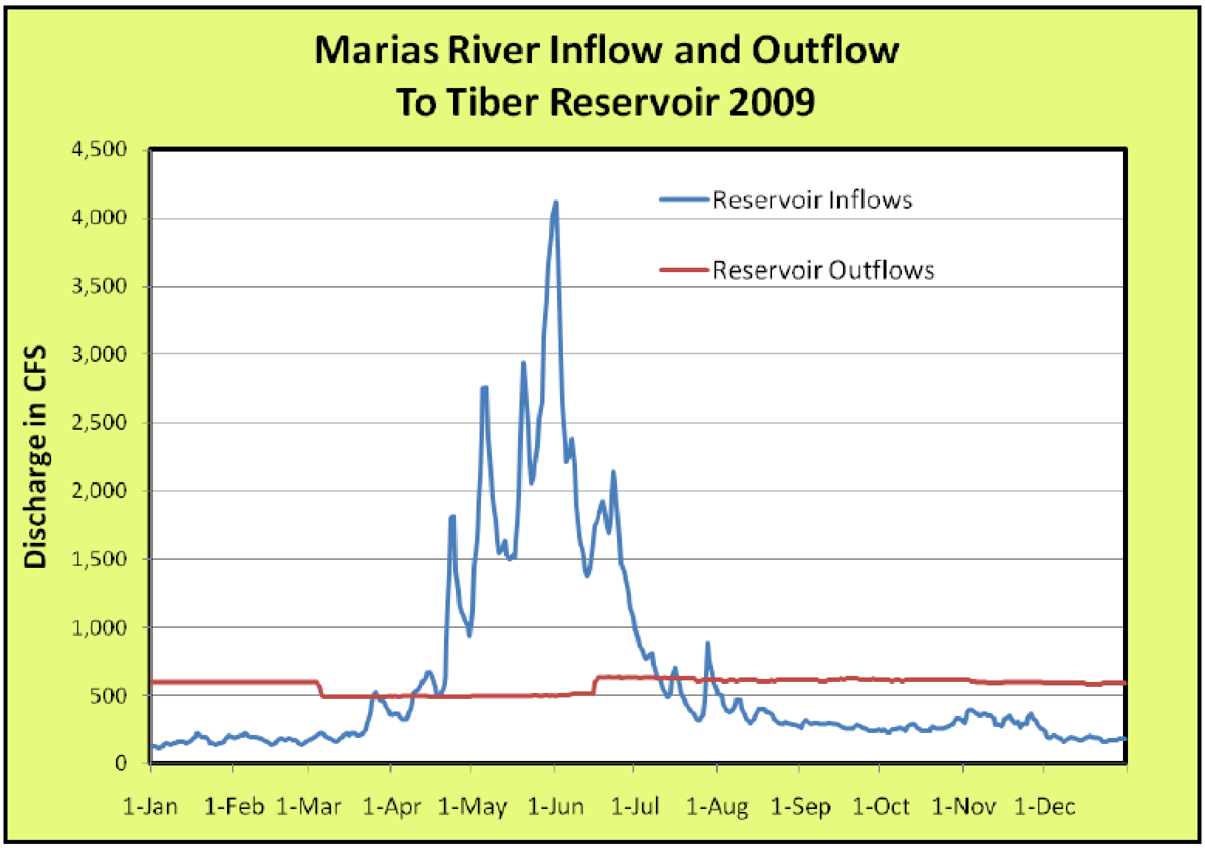
Data Source: U.S. Bureau of Reclamation Hydromet system; http://www.usbr.gov/gp/hydromet/.

Tiber Dam

Tiber Dam on the Marias River near Chester creates the second largest reservoir in the Upper Missouri Basin, storing up to 1,556,000 acre feet in Lake Elwell. The dam was originally constructed to supply a proposed irrigation project of over 100,000 acres, but the irrigation features associated with the original project were never constructed. Today, about 4,000 acres are irrigated with water from Lake Elwell, and the dam provides flood control, recreation, and fisheries and wildlife benefits. A hydropower facility was recently added to the reservoir by a private company.

Because the storage capacity of Lake Elwell is about 2.4 times greater than the average flow of the Marias River upstream of the reservoir, the operations of Tiber Dam have the ability to entirely reshape the hydrograph of the stream, as is depicted in Figure 6.38, which compares flows for the Marias River upstream and downstream of Lake Elwell for the year 2009.

Figure 6.39 Flows upstream and downstream of Tiber Reservoir during 2009

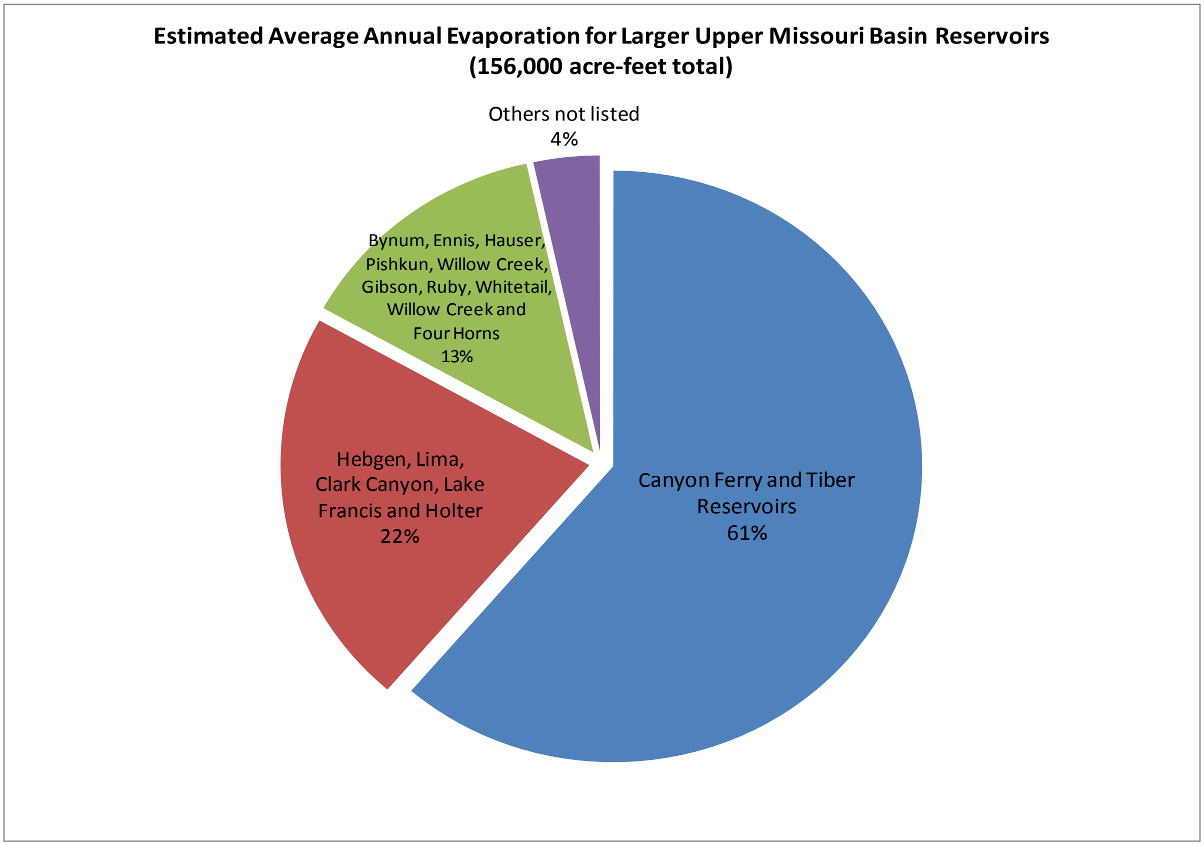


Data source http://mt.water.usgs.gov/

Reservoir Evaporation

A considerable amount of water evaporates from the surface of reservoirs in the Upper Missouri River Basin. Figure 6.39 presents a general quantification of average annual net evaporation (evaporation minus precipitation that the reservoir surface captures) from the reservoirs in the Upper Missouri River Basin that were identified in Table 6.7. The pie chart has been partitioned to depict the evaporation attributable to reservoirs in the following size categories: (1) the two largest reservoirs, (2) the next five largest, (3) the next 10 largest, and (4) the remaining 9 reservoirs.

Figure 6.40 Estimated average annual evaporation for reservoirs in the upper Missouri River Basin



Data Sources: USGS 2004.

Black Eagle Dam at Great Falls

HYDROPOWER

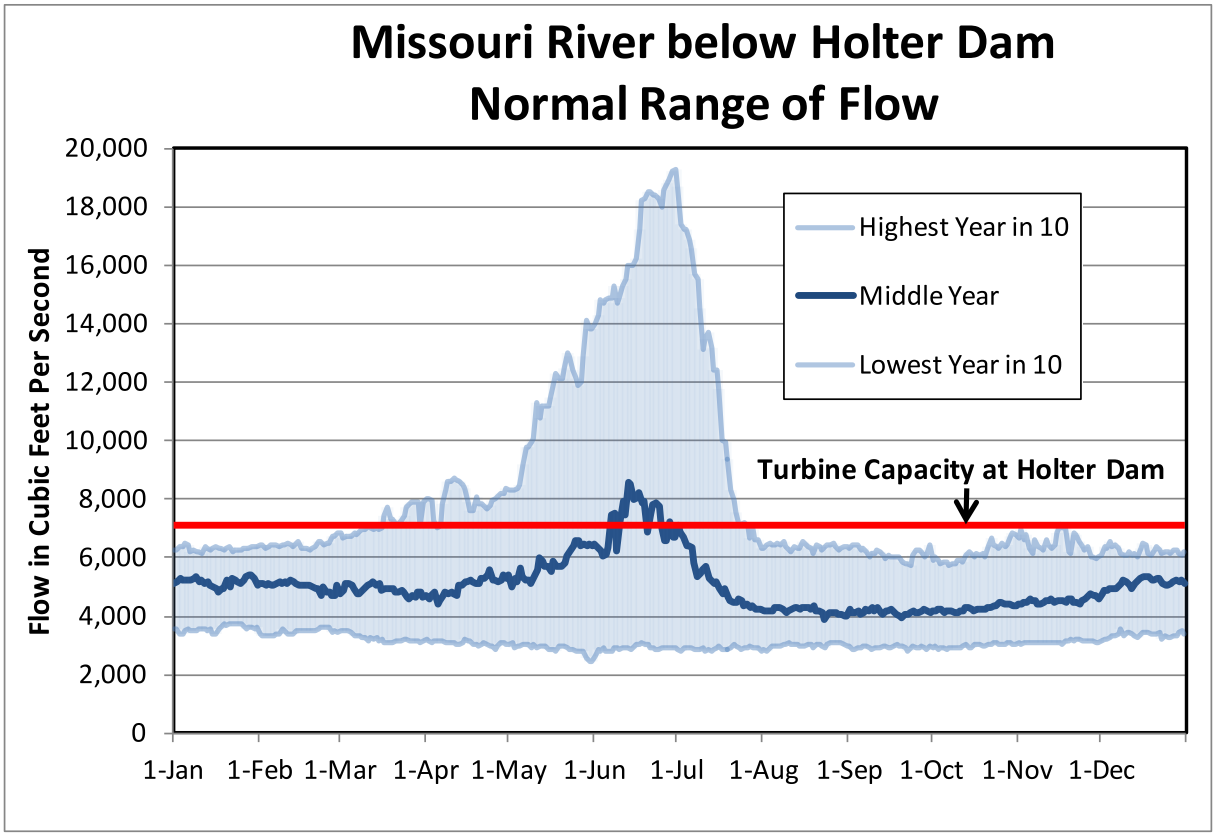
Table 6.8 lists the major hydropower producing dams in the Upper Missouri River Basin. The table does not include Hebgen Lake Dam, which does not directly produce power but rather stores and releases water to optimize power production at downstream dams. Except for a periods of high flow, hydropower facilities on the Missouri and Madison Rivers can use all of the available flow of these rivers, as is depicted in Figure 6.40 for the Missouri River at Holter Dam. The locations of the major hydropower producing facilities in the Upper Missouri River basin are shown on Map 6.4.

Table 6.8 Major hydropower projects in the Upper Missouri River Basin

Dam	Stream	Capacity Megawatts	Owner or Operator
Madison	Madison River	9	NorthWestern Energy
Toston	Missouri River	10	Montana DNRC
Canyon Ferry	Missouri River	50	U.S. Bureau of Reclamation
Hauser	Missouri River	19	NorthWestern Energy
Holter	Missouri River	48	NorthWestern Energy
Black Eagle	Missouri River	21	NorthWestern Energy
Rainbow	Missouri River	60	NorthWestern Energy
Cochrane	Missouri River	64	NorthWestern Energy
Ryan	Missouri River	60	NorthWestern Energy
Morony	Missouri River	48	NorthWestern Energy
Tiber	Marias River	7.5	Tiber-Montana LLC
Totals		**396.5**	

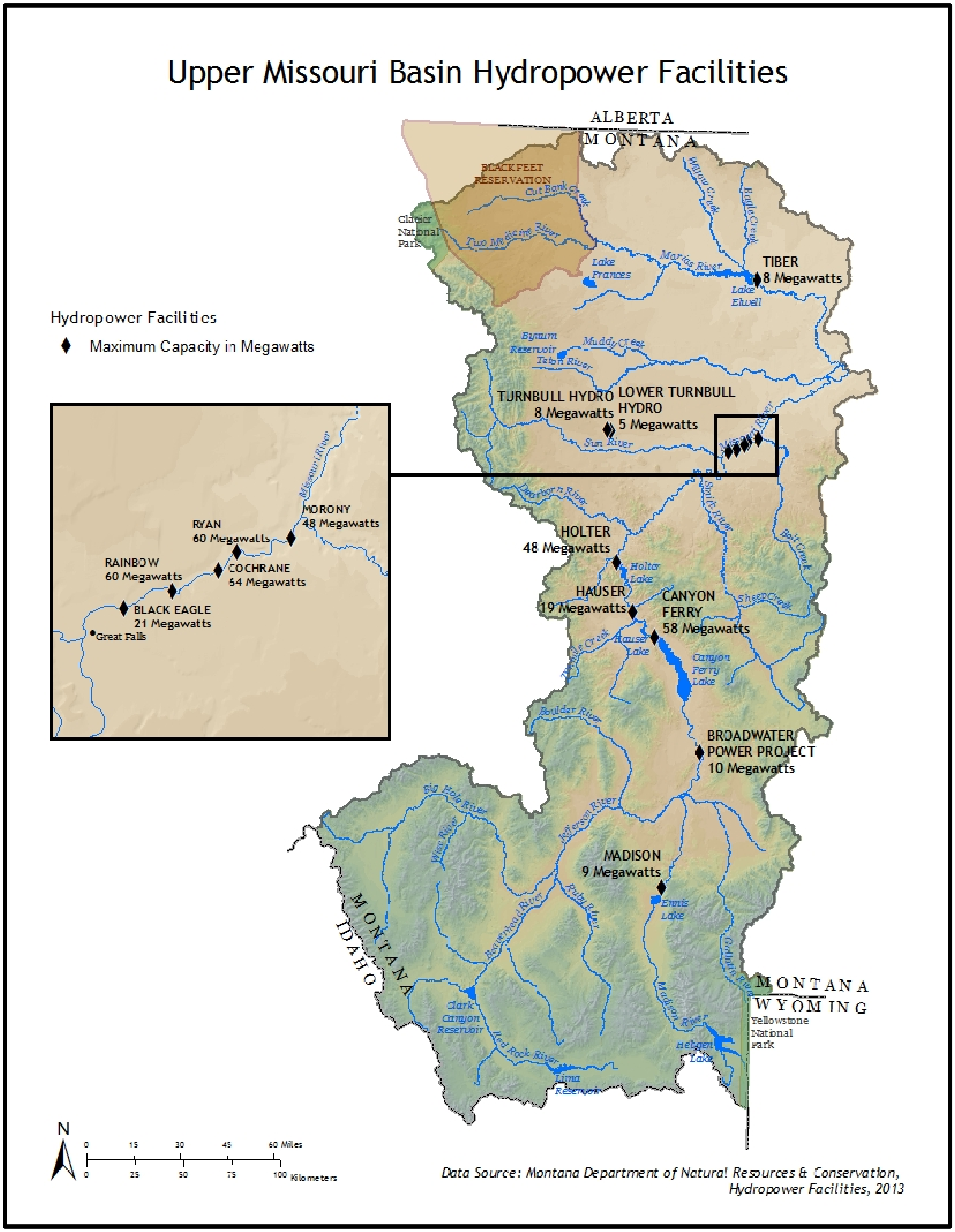
Information sources: NorthWestern Energy at http://www.northwesternenergy.com/our-company/hydroelectric-facilities; Bureau of Reclamation: http://www.usbr.gov/projects/Facility.jsp?fac_Name=Canyon+Ferry+Dam; Montana DNRC: http://www.dnrc.mt.gov/wrd/water_proj/hydro/hydropower.asp; Great Fall Tribune, 2004.

Figure 6.41 Normal range of flow for Missouri River at Great Falls compared to turbine capacity at Holter Dam.



Streamflow data source http://mt.water.usgs.gov/

Map 6.4 Major Upper Missouri River Basin Hydropower Facilities



C. Existing Water Quality Impairments in the Upper Missouri Basin

MONTANA WATER QUALITY LAWS

Numerous laws and regulatory programs in Montana control activities to protect water quality. There are laws that regulate discharges to surface water, discharges to groundwater, streambed disturbance, mining operations, hazardous waste, underground storage tanks, septic systems, and almost every other activity that poses a threat to water quality. Most of these laws are administered by DEQ, with a handful administered by other state and local entities.

The Montana Water Quality Act (75-5-101, MCA) is the primary water pollution control authority in Montana. The act states that it is public policy to: conserve water by protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry, recreation, and other beneficial uses; [and] provide a comprehensive program for the prevention, abatement, and control of water pollution; and balance the inalienable rights to pursue life's basic necessities and possess and use property in lawful ways with the policy of preventing, abating, and controlling water pollution.

Water quality standards, adopted by the Montana Board of Environmental Review, establish the level of water quality necessary to support existing and future beneficial uses of rivers, lakes, and groundwater resources. The standards establish a basis for limiting discharges of pollutants.

The 1972 federal Clean Water Act (CWA) established a national framework for protecting and improving water quality. Sections of CWA passed in 1987 (303(d) and 305(b)), require states to monitor and assess statewide water quality conditions, identify and list water bodies that fail to meet water quality standards, and prepare Water Quality Improvement Plans (WQIPs) for restoring water quality. These WQIPs must include quantitative limits, known as Total Maximum Daily Loads (TMDLs), for each of the pollutants of concern. Most of Montana's water quality impairments reflected on the 303(d) list are a result of nonpoint source (NPS) pollution.

In areas of Montana, the ability to put water to a beneficial use is limited as much by water quality as physical availability. Water quantity and water quality are closely intertwined and the Montana Water Use Act recognizes this relationship (§85-2-311 MCA). However, this document offers limited guidance regarding water quality issues because DNRC has no authority to regulate water quality and the state water planning statute does not explicitly address water quality. The Department of Environmental Quality has primary authority over the regulation of water quality in Montana. For more information on water quality regulation in Montana, please reference DEQ's *Montana Nonpoint Source Management Plan* at: http://deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram.mcpx).

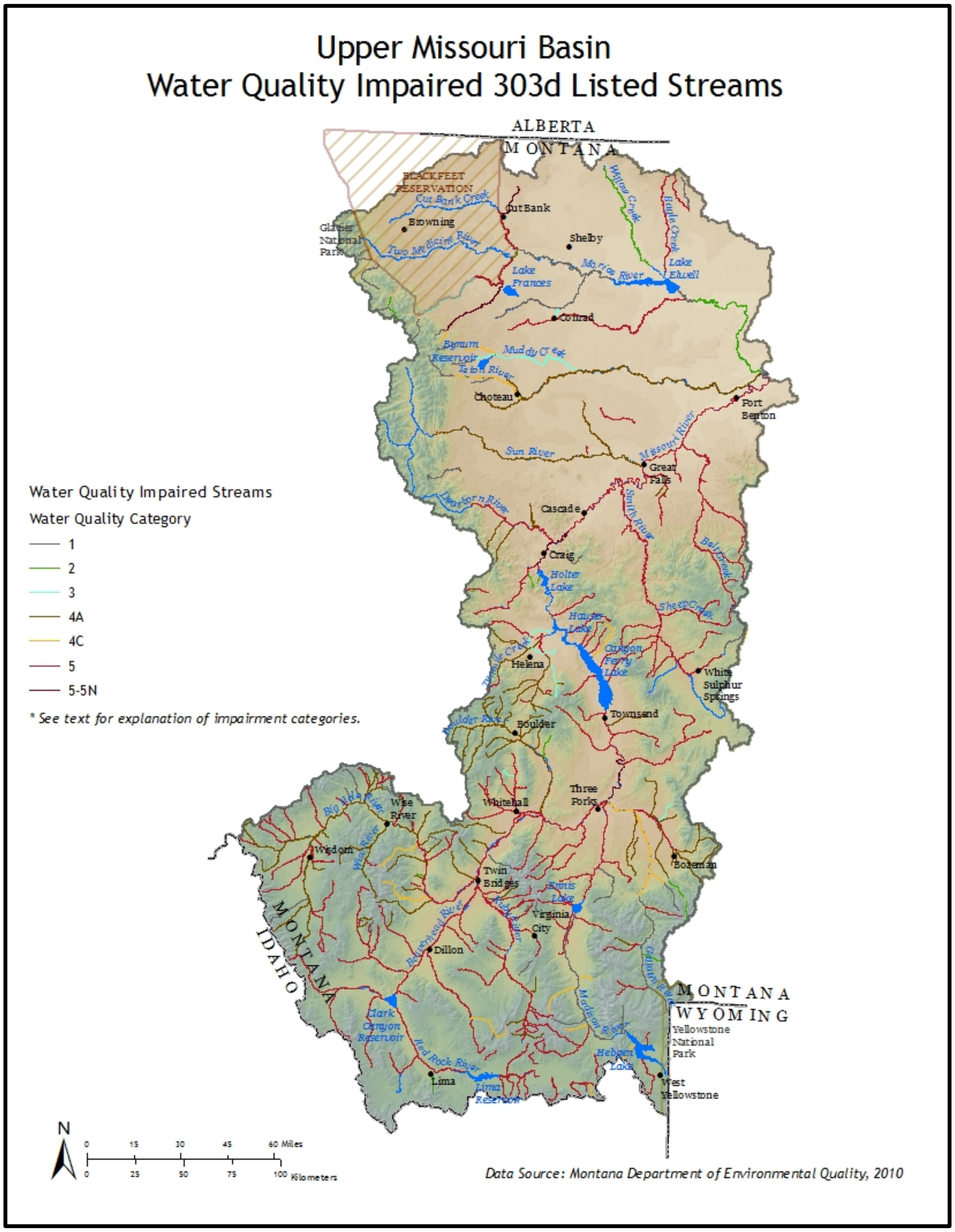
Another good source of information is the *Clean Water Act Information Center:* http://deq.mt.gov/wqinfo/CWAIC/default.mcpx . These sites provide information, strategies, goals and reports that address water quality issues generally as well as water quality as it is affected by water quantity."

Surface Water Quality Protection

Nonpoint water pollution comes from contaminants (originating from a variety of land-use activities over generally large areas) that are transported to streams, lakes, wetlands, and groundwater by precipitation, snowmelt, and stormwater runoff. Nonpoint pollution also comes from substances that erode directly into surface waters or from aerially transported substances deposited on land and water. Common nonpoint pollutants include sediment, nutrients (nitrogen and phosphorus), temperature changes, metals, pesticides, pathogens, and salt.

Nonpoint pollution is a significant problem in Montana, constituting the single largest cause of water quality impairment on a statewide basis. More than 75 percent of Montana's assessed rivers and streams and 45 percent of its lakes, reservoirs, and wetlands fail to meet state water quality standards largely as a result of the effects of non-point source (NPS pollution) (from Table 4-1, DEQ, 2012). Map 6.5 illustrates water quality impaired streams in the Upper Missouri River Basin.

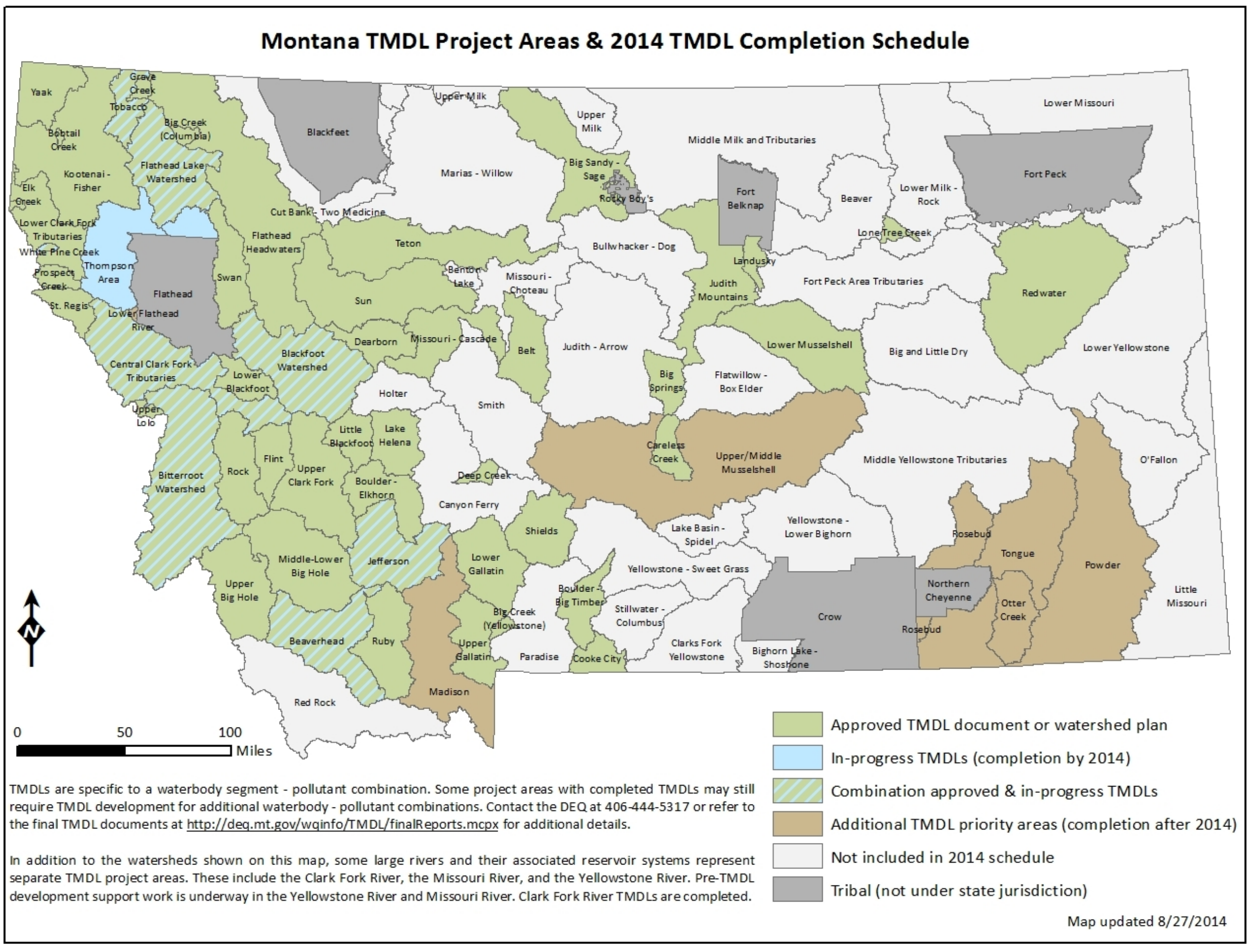
Map 6.5 Water quality impaired streams in the Upper Missouri River Basin



Water Quality Category Descriptions for Map 6.5
1 - All applicable beneficial uses have been assessed and all uses are determined to be fully supported.
2,2A - Available data and/or information indicate that some, but not all of the beneficial uses are supported.
3 - Insufficient or no data available to determine whether or not any designated use is attained.

4A - All TMDLs required to rectify all identified threats or impairments have been completed and approved.
4B - Other pollution control requirements [see 40 CFR 130.7(b) (1)(iii)] are in place, are expected to address all waterbody-pollutant combinations, and attain all water quality standards in a reasonable period of time. These control requirements act in lieu of a TMDL, thus no actual TMDLs are required.
4C - Identified threats or impairments result from pollution categories such as dewatering or habitat modification thus a TMDL is not required.
5 - One or more applicable beneficial uses are impaired or threatened and a TMDL is required.
5,2B or 5,5N - Available data and/or information indicate that a water quality standard is not met due to an apparent natural source in the absence of any identified man-made sources

Map 6.6 Montana TMDL project areas and completion schedule



The Montana Department of Environmental Quality (DEQ) has been working on developing TMDLs (Total Maximum Daily Loads) for watershed basins in Montana since 1996. A TMDL document provides information on water quality problems in the watershed and provides a framework for reducing pollutants. Once a TMDL is completed for a watershed, DEQ works with local watershed groups, conservation districts and other entities to improve water quality by implementing voluntary best management practices. Watershed assessments and plans provide a basis for water quality improvement through water and land use conservation practices. The TMDL program establishes the maximum amount of a pollutant that a water body may receive and still be expected to achieve applicable water quality standards. TMDLs are designed to achieve and protect designated beneficial uses. Many of the watersheds in the Upper Missouri Basin have an approved TMDL document or watershed plan, with several more in progress (Map6.6).

Besides nonpoint pollution, there is point source pollution. Point source pollution comes from a single point, commonly thought of as an end-of-pipe discharge. DEQ maintains a point source pollution control program, known as the Montana Pollutant Discharge Elimination System (MPDES), which is aimed at protecting water quality in water bodies receiving point source discharges from sewage, industrial, or other wastes.

Other water quality protection laws include Section 310 of the Montana Stream Protection Act, which requires conservation districts to regulate private activities that disturb the bed or banks of rivers and streams. Similarly, government activities that disturb the bed or banks of streams are regulated by FWP. Such activities include temporary disturbances, such as construction or maintenance activities for irrigation diversions. In addition, the legislature provided for creation of local water quality protection districts. Such districts have limited regulatory authority, and are primarily intended to provide funding to locally monitor and plan for the protection of water quality resources of particular concern to the people within the district.

Further detailed information about surface water quality issues in Montana can be obtained through the DEQ website and the Clean Water Act Information Center website.

Groundwater Quality Protection

The Montana Ground Water Pollutant Control System (MGWPCS) (Chapter 17.30, subchapter 10, ARM) is a regulatory program to control all otherwise unregulated sources of groundwater pollution. Important aspects of the MGWPCS rules are groundwater quality standards, a non-degradation requirement, and a discharge permit system. A wide variety of activities are exempt from having to obtain MGWPCS permits (see 75-5-401 MCA and 17.30.1022, ARM). Discharges from the exempted activities are typically covered under other permitting programs or regulations.

Groundwater quality is also addressed in the Agricultural Chemical Ground Water Protection Act. Under this act, DEQ is responsible for developing and enforcing groundwater quality standards for agricultural chemicals. DEQ is also charged under this act with monitoring, promoting research, and providing public education in cooperation with universities and other state agencies. The Montana Department of Agriculture (DOA) is charged with developing and enforcing agricultural chemical groundwater management plans aimed at preventing groundwater contamination from agricultural chemicals. Both DEQ and DOA have rules to implement their respective responsibilities under this act.

VII. Administration

A. Institutional and Legal Framework for Water Use in Montana

PRIOR APPROPRIATION DOCTRINE

In order to legally put water to a beneficial use in Montana, a person must have a water right. The elements of a Montana based water right - the right to the beneficial use of water – are dictated by the prior appropriation doctrine. In its simplest form, the prior appropriation doctrine provides that a person's right to use a specific quantity of water depends upon when that use began – the first in time, is the first in right. A water right consists of a priority date, a purpose of use, point of diversion, a source, place of use, period of use, and a quantity reflected in a flow rate, volume or both. There are no preferences among beneficial uses other than priority date. A water right does not create ownership in the water itself. Rather, it creates a property interest in the right to beneficially use a quantity of water for a specific purpose. Accordingly, actual historical beneficial use constitutes the basis, measure, and the limit of a water right.

Prior to July 1, 1973, Montana's prior appropriation system provided two primary methods for acquiring a water right: 1) a water user could simply construct a diversion and put the water to beneficial use (known as a use right); or 2) a water user could comply with the statutory notice of appropriation requirements (known as a statutory right). No prior authorization was required and the state had no control over use of this state-owned natural resource. As demands and conflicts over water increased, it became increasingly difficult to administer water rights because the rights were not recorded in a central location.

The 1972 Montana Constitutional Convention sought to remedy Montana's antiquated system while at the same time preserving the fundamental prior appropriation principles of first in time, first in right and beneficial use as the basis, measure and limit of a water right. To accomplish this goal the Article IX Section 3(1) of the Montana Constitution recognized and confirmed "existing rights" to the "use of any waters for useful or beneficial purpose." The Constitution also confirmed, in Article IX Section 3(3), that all waters within Montana are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law. Finally, in order to provide the necessary tools to better manage use of Montana's water resources, Article IX Section 3(4) of the Constitution charged the legislature with providing for the administration, control, and regulation of water rights and establishing a system of centralized records.

The Legislature responded to these constitutional charges by passing the Montana Water Use Act (Act), effective July 1, 1973. In order to fulfill the constitutional mandates of Article IX, the Act established an adjudication system to adjudicate pre-July 1, 1973 water rights, a permit system to control and regulate post-July 1, 1973 water appropriations, changes in use of existing water rights, and a centralized system of recording water rights.

The Act confirmed the fundamental principles of Montana's prior appropriation doctrine, including the following:

1. Montana's water belongs to the state for the beneficial use of its people. Therefore, water right holders do not own the water; they possess the right to use the water.
3. Doctrine of Prior Appropriation (first in time, first in right).
4. "Use it or lose it." A water right holder must use the water or risk losing the right to it.
5. The water diverted must be for a beneficial use, and all beneficial uses are equal under the law.
6. A water right is a property right and can be separated from the land.

7. One must have a water right to beneficially use water, and after July 1, 1973, new water rights can be obtained only from the DNRC, generally through the permitting process.
8. Any change in the purpose, place of use, place of storage, or point of diversion of a water right may not adversely affect other water rights and must first be approved by the DNRC

Over time the Act has refined elements of the permitting and change process to reflect increased understanding of water use and resources in the state. The Act has also evolved to provide for state-based water reservations, temporary changes and leases including for instream flows, and permits and change authorizations for marketing and mitigation. However, these refinements continue to be subject to the fundamental principles of the prior appropriation doctrine.

New Beneficial Water Use Permits, Change in Use Authorizations, and the DNRC

Under the Act, the DNRC has jurisdiction over all changes in use and new appropriations occurring after July 1, 1973. The DNRC has the authority to enforce against illegal water use, and performs a number of other responsibilities related to post July 1, 1973 water use, planning and management in Montana.

In exercising its jurisdiction over new appropriations, the DNRC evaluates the proposed use pursuant to the §85-2-311, MCA, permit criteria. These criteria require the applicant prove that water for a proposed appropriation is both physically and legally available, that existing appropriators will not be adversely affected, that the proposed use is a recognized beneficial use of water, that the proposed diversion is adequate, and that the applicant has a possessory interest in the place of use.

Similarly, DNRC exercises its jurisdiction over changes in use for existing water rights pursuant to the Act's change criteria found at §85-2-402, MCA. A water user can change the place of use, purpose of use, point of diversion, and place of storage for a water right. While these elements of a water right are subject to being changed, a water user may not expand the extent of the underlying water right. Therefore, evaluation of the change criteria focuses on the historic beneficial use of the underlying water right, alteration of return flows, and a determination of whether the change in use will adversely affect other water users (senior and junior) on the source. The change provisions of the Act are discussed in more detail under Section IX of this plan.

The permit and change provisions of the Act reflect a fundamental shift from pre-July 1, 1973, water appropriation in that they require prior approval from the DNRC before water is appropriated or a change in use occurs. The Act provides the DNRC with the authority to condition, revoke, or modify permits and change authorizations as necessary to ensure compliance with the Act through administrative proceedings. §85-2-311, 312, and 314, MCA.

Over the past 40 years, DNRC has developed and refined the permit and change procedures in an effort to maintain the balance between authorizing new water uses and changes while at the same time protecting water users from adverse effects. The DNRC has developed specialized expertise and adopted rules on various aspects of water availability and water use throughout the state. See Title 36, Chapter 12, Mont. Rules Admin. For example, DNRC's rules include information regarding accepted methods for measuring water availability in gauged and un-gauged sources, estimating historic consumptive use, and modeling groundwater aquifer characteristics and properties.

<u>Criteria for Issuance of a Permit</u>
Section 85-2-311(1), MCA
The applicant for a water use permit to appropriate less than 4,000 acre-feet a year and 5.5 cfs has the initial burden to prove by a preponderance of the evidence that the criteria for issuance of a permit are met. The criteria include:

1. Water is physically available at the proposed point of diversion in the amount that the applicant seeks to appropriate.
2. Water can reasonably be considered legally available during the period in which the applicant seeks to appropriate, in the amount requested.
3. The water rights of a prior appropriator under an existing water right, a certificate, a permit, or a state WATER RESERVATION will not be adversely affected. Adverse effect is based on a consideration of the applicant's plan to exercise the water right so that prior water rights will be satisfied.
4. The proposed means of diversion, construction, and operation of the appropriation works are adequate.
5. The proposed use of water is a beneficial use.
6. The applicant has a possessory interest, or the written consent of the person with the possessory interest, in the property where the water is to be put to beneficial use.

A water right owner must obtain a change authorization by meeting criteria under 85-2-402, MCA before work begins on a project that will result in a change to the point of diversion, place of use, purpose of use, or place of storage. An applicant submitting a change in purpose or place of use of an appropriation to divert 4,000 or more acre-feet of water a year and 5.5 or more cubic feet a second will be required to prove the criteria set out in section 85-2-402(4), MCA. If a proposed change in purpose or place of use for a diversion results in 4,000 or more acre-feet and 5.5 or more cubic feet a second of water being consumed, the applicant must prove the criteria in section 85-2-402(5), MCA. If the change involves the transport of water out of state, the applicant must prove the criteria listed in section 85-2-402(6), MCA, and obtain legislative approval.

<u>Criteria for Issuance of a Change Authorization</u>
Section 85-2-402, MCA
The applicant for a change in an appropriation water right has the burden to prove by a preponderance of the evidence that the criteria for issuance of an authorization are met. The criteria include:

1. The proposed use will not adversely affect the use of other water rights or other planned developments for which a permit or certificate has been issued or water has been reserved.
2. The proposed means of diversion, construction, and operation of the appropriation works are adequate.
3. The proposed use of the water is a beneficial use.
4. The applicant owns or has permission from the person who owns the property where the water is to be used.

An applicant may change up to the historic amount of water diverted and the historic consumptive use. In a change proceeding, it must be emphasized that other appropriators have a vested right to have the stream conditions maintained substantially as they existed at the time of their appropriations. It must also be emphasized that a water right in a change proceeding is defined by actual beneficial use, not the amount claimed or even decreed.

WATER RIGHTS ADJUDICATION AND THE WATER COURT

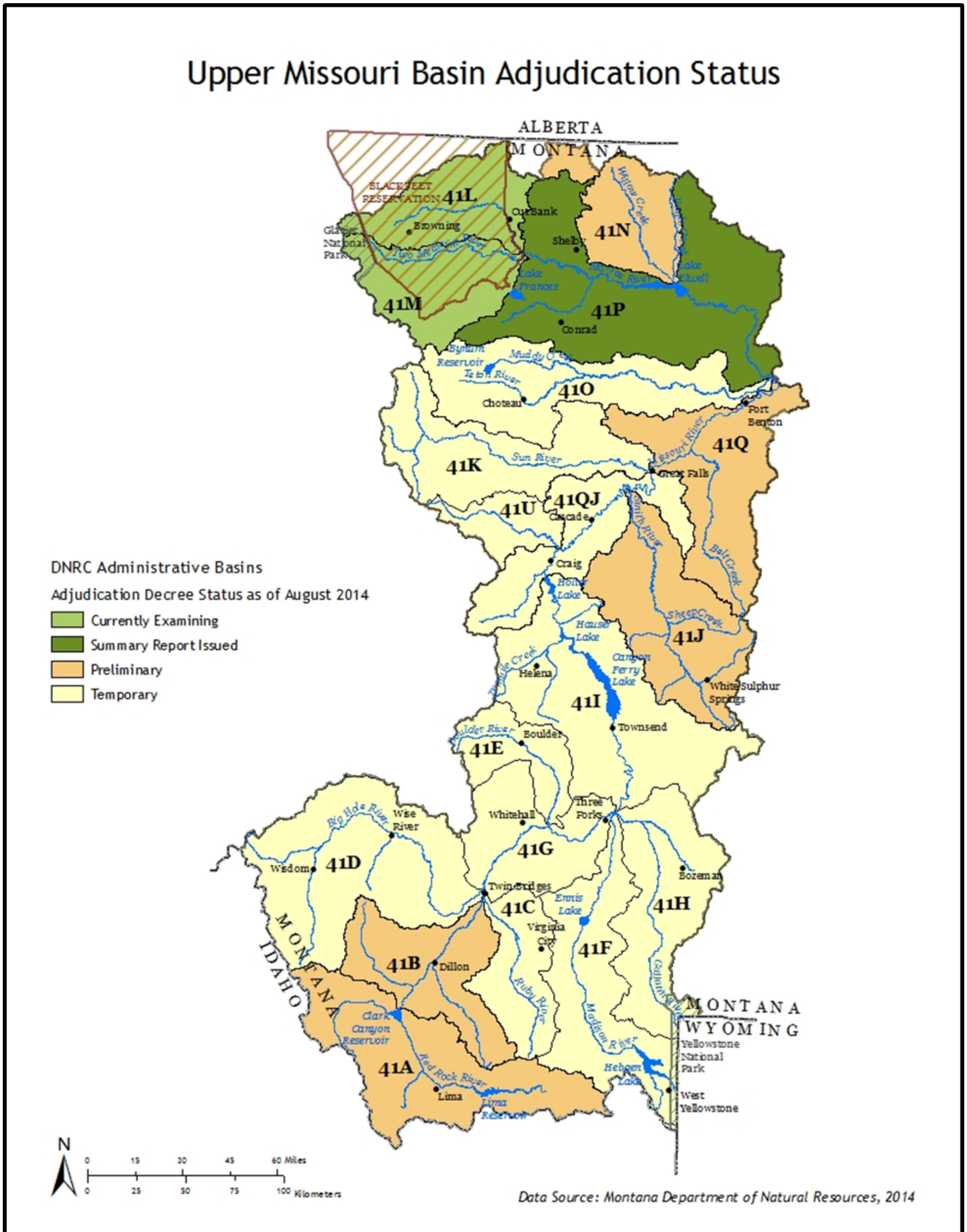
The Montana Water Use Act set forth the framework for Montana to embark upon a state-wide general stream adjudication of pre-July 1, 1973, existing water rights. The adjudication serves to recognize and confirm existing water rights as required by the Constitution. The adjudication involves examining, litigating and decreeing claims to water with priority dates prior to July 1, 1973 through the Water Court (§85-2-2 MCA).

The first phase of the adjudication process involved the examination of each water right claim for factual and legal issues in accordance with Montana Supreme Court Claim Examination Rules. Over 220,000 claims for pre-1973 water use were received. This phase of examination was performed by the DNRC and completed in 2014. Additionally, the Water Court issued an order for DNRC to re-examine certain elements of claims in 45 basins that were not examined according to the current and more rigorous Montana Supreme Court Claim Examination Rules. The second phase of the adjudication involves issuance of temporary and/or preliminary decree, public notice, litigation of objections, and resolution of issue remarks. Following the resolution of objections and issue remarks, the Water Court will issue final decrees for each of Montana's 85 river basins which will define pre-July 1, 1973 water rights by owner, purpose, priority date, source, place of use and other elements of the water right. The current target date for the Water Court to issue final decrees is 2028. Map 7.4 depicts the state of the adjudication in the Upper Missouri River Basin.

Montana's water rights adjudication process will not be complete until all Federal and Tribal reserved water right compacts have been decreed by the Water Court. Prior to review by the Water Court, all compacts must be ratified by the Montana Legislature, approved by appropriate federal authorities, and in the case of Tribal compacts approved by Tribes. Where federal authorization or federal appropriations are needed to implement provisions of the settlement, congressional approval is required.

To date seventeen compacts have been negotiated and approved by the Montana Legislature. A negotiated compact with the Confederated Salish and Kootenai Tribes (CSKT) is awaiting approval by the Montana Legislature. If the legislature does approve not the proposed CSKT compact, the Tribes must file their claims with the Water Court prior to July 1, 2015.

Map 7.1 Upper Missouri Basin Adjudication



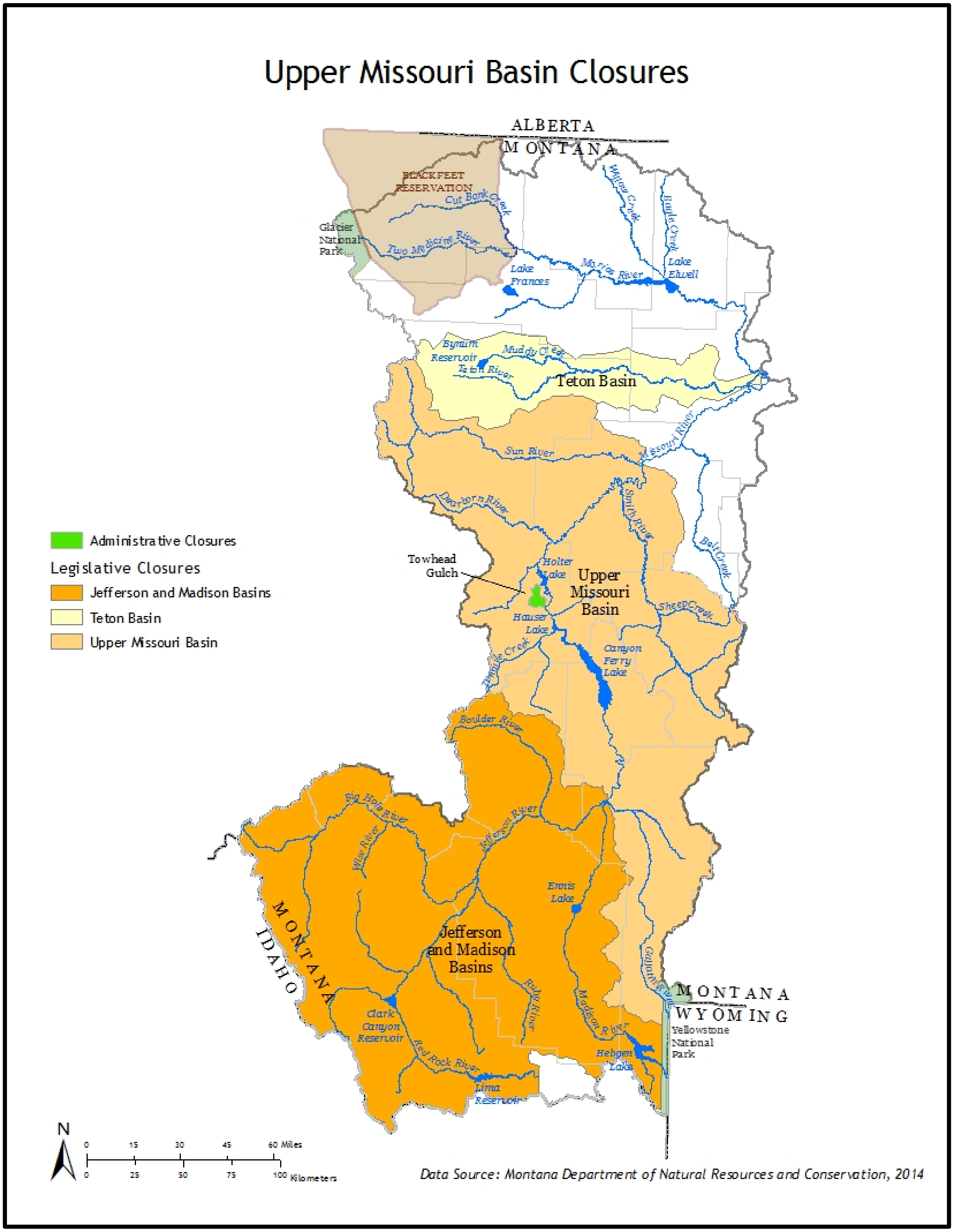
BASIN CLOSURES IN THE UPPER MISSOURI BASIN

Montana has closed some of its river basins to certain types of new water appropriations because of water availability problems, over-appropriation, and a concern for protecting existing water rights Map 7.2. Section 85-2-319, MCA, legislatively authorizes the closure of basins to certain new appropriations through the adoption of administrative rules and negotiation of reserved water rights compacts. The law also provides for the closure of highly appropriated basins through the adoption of administrative rules.

A person wanting to appropriate groundwater in a closed basin must complete a hydrogeologic assessment and must meet requirements of 85-2-360, 85-2-361, and 85-2-362, MCA. If the hydrogeologic assessment predicts that the appropriation would have no net depletion of surface water, the application moves through the permitting process. If the assessment predicts net depletion of surface water, it must be determined if net depletion would have an adverse effect on prior appropriators. If not, the application moves through the permitting process. If there would be an adverse effect, the applicant must submit a plan for mitigation or aquifer recharge.

Closed basins in the Upper Missouri Basin include the Upper Missouri, Jefferson, Madison, Towhead Gulch, and Teton River (Map 7.2). The Upper Missouri River basin closure includes the Missouri River and its tributaries above Morony Dam near Great Falls. The Jefferson-Madison closure includes the respective rivers and their tributaries above their confluence. The Teton River and its tributaries are closed above the confluence between the Teton and the Marias Rivers. Exceptions to each of these closures include permits for groundwater, non-consumptive use, domestic, municipal or stock use, storage of high spring flows, and emergency appropriations. The Towhead Gulch closure at Upper Holter Lake is closed to new appropriations of surface water for consumptive use and only allows appropriations for non-consumptive use, subject to conditions to protect the source of supply and prior appropriators. Applicants for groundwater greater than 35 gpm up to 10 acre-feet annually in any basin closure area must prove criteria for issuance of a permit under §§85-2-311, MCA, and are subject to the requirements of HB-831 found in §§85-2-360, 85-2-361, and 85-2-362, MCA.

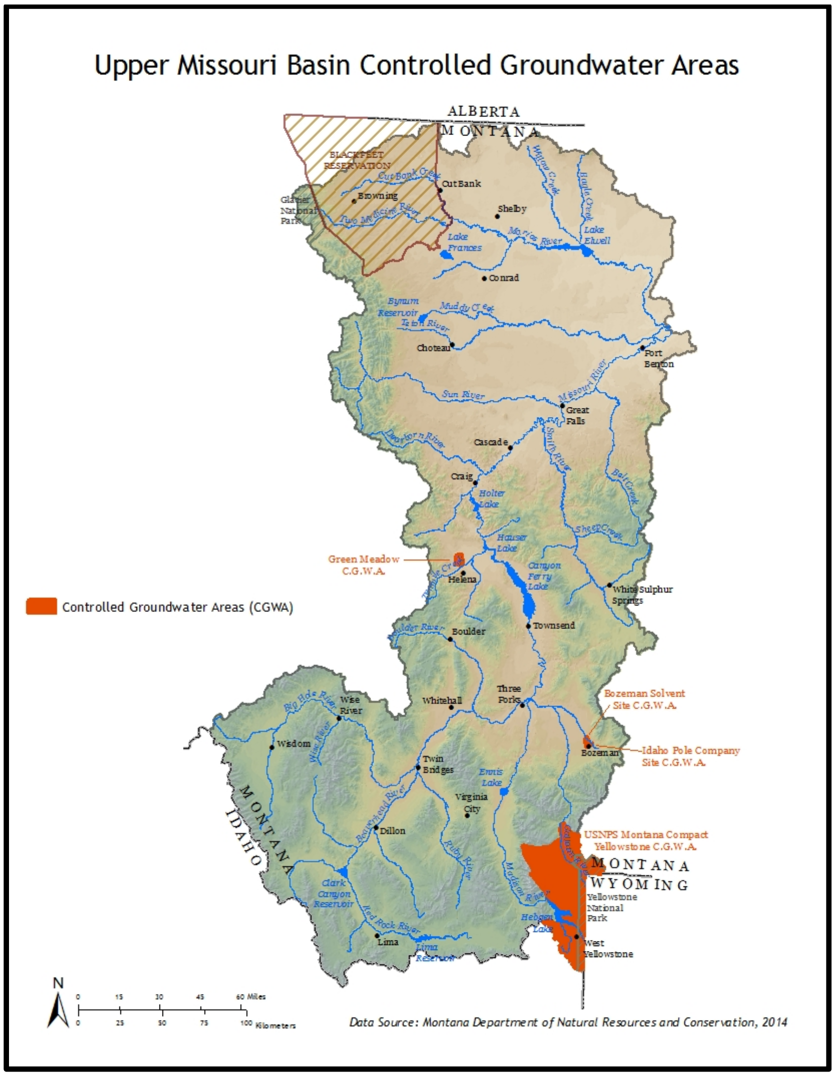
Map 7.2 Upper Missouri Basin Closures



CONTROLLED GROUNDWATER AREAS IN THE UPPER MISSOURI BASIN

In addition to basin closures for surface water, controlled groundwater areas may be designated to protect water quality or quantity (section 85-2-506, MCA). An area for designation may be proposed by DNRC on its own motion, by petition of a state or local public health agency, municipality, county, conservation district, or local water quality district. An area also may be proposed upon petition of at least one-third of the water rights holders in the proposed controlled groundwater area. See further discussion regarding the Yellowstone Controlled Groundwater area in the Reserved Water Rights Compact (section VII- 7). Map 7.3 depicts controlled groundwater areas in the Upper Missouri River Basin.

Map 7.3 Upper Missouri Basin Controlled Groundwater Areas (Note: Green Meadow Controlled Groundwater Area was temporary, and expired in April 2014)



STATE BASED WATER RESERVATIONS

When the Montana Water Use Act was passed in 1973, the option to reserve water became a major component of the law. Policy makers recognized the need to create a mechanism for preserving the potential for future diversionary uses and for maintaining instream flows to protect aquatic life, recreation, and water quality. The law established a process for the reservation of waters by public entities for beneficial uses that serve the public interest. The reservation process is unique since it allows the claimant to appropriate water for future use. The reservation establishes a current priority date even if the water is not actually used until a later time. Three classes of water reservations emerged from the 1973 legislation: municipal reservations to serve domestic and industrial needs, conservation district reservations to serve irrigation and stockwater demands, and instream flow reservations to protect fish and aquatic wildlife habitat, recreation, and water quality. The Montana Department of Fish, Wildlife & Parks (DFWP), Conservation Districts, and municipalities are among the entities that currently hold state water reservations on the Yellowstone, Missouri, and other river systems in Montana.

In 1985, the Montana Legislature directed DNRC to initiate a water reservation proceeding for the Missouri River Basin. The legislature felt that implementation of water reservations would encourage more coordinated development of the basin's water resources and help form a stronger and more unified basis for protecting Montana's share of the Missouri River from downstream states. Due to the size of the basin, DNRC split the Missouri reservation process into upper and lower basins. The upper basin encompassed the area above Fort Peck Dam, and the lower basin encompassed the area below Fort Peck Dam, which included the Milk River and Little Missouri sub-basins. The reservation process in the Upper Missouri Basin was completed in June, 1992. Water reservations were identified for US Bureau of Land Management (BLM, B-1), MT Department of Environmental Quality (DEQ, C-1), conservation districts (D-1) and municipalities (E-1). Appendices B-1, C-1, D-1 and E-1 contain detailed information about the specific reservations.

B. Agencies with a Role in Managing Montana's Water Resources

FEDERAL AGENCIES WITH A ROLE IN MANAGING MONTANA'S WATER RESOURCES

Department of Agriculture

Farm Service Agency – administers cost share programs for farmers that improve water quality, soil stabilization, and irrigation systems. www.fsa.gov

Natural Resources Conservation Service – assists private landowners with watershed protection, flood prevention, soil and water conservation, snow surveys and soil inventories; conducts land-use inventories, cropland studies, and wetland assessments. www.nrcs.gov

Forest Service – conducts watershed management within ten national forests in Montana, and manages three wild and scenic river reaches within its forest boundaries. www.usfs.gov

Department of the Army

Corps of Engineers – authorizes permits for private projects affecting navigable waters; administers large multipurpose reservoirs for navigation, flood control, hydroelectric generation, and flood damage reduction. www.usace .army .mil

Department of Commerce

Economic Development Administration – provides public works grants for community water development. www.eda.gov

National Oceanic and Atmospheric Administration – issues information on weather, river, and climactic conditions; maintains a flood warning system. The National Weather Service at NOAA forecasts weather and issues weather warning and watches. www.noaa.gov

Department of Energy
Bonneville Power Administration – markets electric power for the 31 hydroelectric projects of the federal Columbia River Power System, including the Libby and Hungry Horse dams in Montana, and mitigates loss of fish and wildlife caused by this system; operates transmission systems. www.bpa.gov

Western Area Power Administration – distributes and markets hydro power from federal facilities outside of the Columbia River basin in a 15 state region, including Montana; operates transmission lines. www.wapa.gov

Department of Homeland Security
Federal Emergency Management Agency – delineates flood plains, publishes maps, and administers the National Flood Insurance Program, a Federal program enabling property owners in participating communities to purchase insurance protection against losses from flooding. www.fema.gov

Department of Housing and Human Development – Provides financial aid for local water resource projects such as water and wastewater improvements through Community Development Block Grants for "entitlement communities" with populations of over 50,000. www.hud.gov

Department of Interior
Bureau of Indian Affairs – protects water rights of Indian tribes and promotes productive water use. www.bia.gov

Bureau of Land Management – administers federally-owned lands and use of natural resources, including water, on these lands. www.blm.gov

Bureau of Reclamation – designs, constructs, and operates water projects; conducts river basin water management studies; coordinates water conservation efforts. www.bor.gov

National Park Service – protects water resources (reserved water rights) and conducts water resource studies in Montana's national monuments, battlefields, and national parks. www.nps.gov

U.S. Fish and Wildlife Service – reviews comprehensive water plans and projects for impacts on fish and wildlife habitat and populations; works to recover endangered fish and wildlife species; manages hatcheries; studies fish disease. www.fws.gov

U.S. Geological Survey – researches the source, quantity, distribution, movement, and availability of surface and ground water for national water data network and technical reports. www.usgs.gov

Environmental Protection Agency

- Works with states to establish and enforce standards for water quality and drinking water; provides grants for drinking water and water pollution control facilities. www.epa.gov

  Federal Energy Regulatory Commission – Issues licenses for hydroelectric projects and transmission lines. www.ferc.gov

STATE AGENCIES WITH A ROLE IN MANAGING MONTANA'S WATER RESOURCES

Montana Department of Natural Resources and Conservation

- Administers the portions of the Act that relate to water uses after June 30, 1973 such as Permits and Change Authorizations;

- Provides training for court appointed water commissioners;
- Provides technical information and assistance to the Water Court on water rights claims (pre-July 1, 1973) including examining those claims;
- Maintains a central water rights record system;
- Investigates complaints of illegal water use; and
- Other duties related to Water Operations, Water Management, and State Water Projects.

Montana Water Court

- Adjudicates water rights as they were protected under the laws pre- July 1, 1973;
- Decides any legal issues referred from the District Court on pre- July 1, 1973 water rights; and
- Assists District Courts with enforcement.

District Courts

- Can issue injunctive relief while it certifies water rights issues to the Water Court;
- Appoints Water Commissioners for enforcement; and
- Manages the enforcement of water rights and handles complaints by dissatisfied water users.

Reserved Water Rights Compact Commission (Commission)

9. Negotiates settlements with federal agencies and Indian tribes claiming federal reserved water rights within the State of Montana; and
10. Negotiates on behalf of the Governor's Office and represents the interests of the State water users.

Attorney General

- The Water Court may join the Attorney General to intervene, on behalf of the state, in the adjudication of water right claims that are being decreed by the Water Court.

Legislature – Provides policy direction and laws for the administration of waters. When the Legislature is not in Session, two interim committees have oversight of water related issues:

- *Water Policy Interim Committee (WPIC)* – permanent, joint bipartisan committee that studies water issues in order to develop a clear policy direction and necessary legislation to guide Montana's water policy.
- *Environmental Quality Council* – contributes policy oversight to the administration of state water rights by advising and updating the legislature and overseeing institutions dealing with water, and communicates with the public on matters of water policy

LOCAL GOVERNMENT AND NON-GOVERNMENTAL ORGANIZATIONS WITH A ROLE IN MANAGING MONTANA'S WATER RESOURCES

Montana's geography and communities are diverse. No uniform approach to water management dictated from above would be appropriate across the state. Consequently a large number of decisions that directly or indirectly affect water resources have devolved to local government. Some are legal requirements; for example, conservation district boards review proposals for activities that would affect streams, and issue "310 permits" under state law. Other local actions are more discretionary. In adopting their growth policies, for example, county commissions can choose to incorporate various kinds of measures to protect water resources in the development process. Water management is an important responsibility for local governments. The information below is a synopsis of local government or local group responsibilities over water.

City & County Commissions and Boards direct local water management through shaping and administering county growth policies, subdivision regulations, and other land-use and protection measures.

Conservation Districts (CDs) are located in each of the 56 Montana counties to address local land and water resource needs. Guided by elected supervisors and supported by local tax mill levies, conservation districts address special water problems, regulate stream management through the Montana Natural Streambed Preservation Act (310 law) and educate citizens about water and land-use practices. The Montana Association of Conservation Districts (MACD) serves as a statewide organization for the 58 county based conservation districts across Montana that work on Natural stream and land protection. (http://www.macdnet.org).

Local Water Quality Districts (LWQDs) serve to protect, preserve, and improve the quality of surface and groundwater within the district. LWQDs operate with a board of directors and funding from county fees. LWQD's research local water quality, answer citizen inquiries, and conduct public outreach programs. Under some circumstances, they can take on regulatory authority.

County Water and Sewer Districts have taxing authority, operate under the authority of county government, and are established for the purpose of developing and operating public water or sewer systems, or both.

Water Commissioners ensure that daily water allocations in the basin occur in accordance with the water users' rights. Local water users can petition for a water commissioner after the water rights in a basin have been decreed by the Montana Water Court. The local district court appoints the commissioner, and oversees his work.

Irrigation Districts are subdivisions of government that supply water to irrigators within a specified region. Citizens may establish one by petitioning the court. Members of the district elect a board of directors to make policy, hire, and manage based on legal regulations and self-adopted bylaws. All district members pay taxes to construct and maintain the water project, usually a storage reservoir or canal system, supplying their district. Most federal irrigation projects are managed by irrigation districts.

Water User Associations are non-profit corporations that manage mostly state or local irrigation projects. If they manage state-owned projects, they are bound to terms of water-use contracts prepared by DNRC. The State of Montana holds the water rights of these projects. If not associated with state-owned projects, water user associations (sometimes called ditch or canal companies) develop their own operating rules.

Ditch or Canal Companies are private companies set up by local irrigators to share the cost and maintenance of the ditch system servicing their collective lands. Ditch companies vary greatly in membership and acreage, and often address the water needs of many individual water rights holders.

Watershed Groups: These community based citizen groups are as diverse as the communities they serve, often convening local stakeholders to participate directly in watershed-level decision-making and problem solving, as well as initiating local cleanups, conservation and watershed education, data gathering and on the ground restorations projects.

- Montana Watershed Coordination Council serves to build and unite watershed communities by bringing people and information together. The statewide council is comprised of private organizations and staff from many local, state, and federal natural resource agencies
- http://www.mtwatersheds.org
- The Montana Wetland Council's mission is to conserve and restore Montana's wetlands and riparian ecosystems through the cooperation of public and private interests http://www.deq.mt.gov/wqinfo/wetlands/wetlandscouncil.mcpx

- Special Interest Groups: Agriculture, recreation, industry, and fisheries have a stake in how water is managed. Reflecting this diversity, a variety of special interest groups develop creative solutions related to issues that affect Montana's water.

Table 7.1 Conservation Districts/Municipalities/Water Quality Districts Contact Information

Conservation District	Mailing Address	Phone
Beaverhead CD	420 Barrett St, Dillon, MT, 59725	406-683-3840
Broadwater CD	415 South Front St., Townsend, MT 59644	406-266-3146
Cascade CD	12 Third St. Northwest, Great Falls, MT 59404	406-727-3603
Chouteau Co. CD	PO Box 309, Fort Benton, MT 59442	406-622-5627
Gallatin CD	PO Box 569, Manhattan, MT 59741	406-282-4350
Glacier County CD	#1 Third Street NE, cut bank, MT 59427	406-873-5752
Hill County CD	206 25th Ave. West, Havre, MT 59501	406-265-6792
Jefferson Valley CD	PO Box 890, Whitehall, MT 59759	406-287-7875
Lewis & Clark CD	790 Colleen St, Helena, MT 59601	406-449-5000
Liberty Co. CD	PO Box 669, Chester, MT 59522	406-759-5778
Madison CD	PO Box 606, Ennis, MT	406-682-7289
Meagher Co. CD	PO Box 589, White Sulphur Springs, MT 59645	406-547-3633
Mile High CD	PO Box 890, Whitehall, MT 59759	406-287-7875
Missouri River CD Council	1101 11th Ave. Helena, MT 59601	406-454-0056
Pondera Co. CD	406 N. Main, Conrad, MT 59425	406-278-7611
Ruby Valley CD	PO Box 295, Sheridan, MT 59749	406-842-5741
Teton CD	1102 Main Avenue N., Choteau, MT 59422	406-466-5722
Toole Co. CD	1125 Oilfield Dr., Shelby, MT 59474	406-434-5234
Municipalities	**Mailing Address**	**Phone**
Belgrade	91 E. Central Avenue, Belgrade, MT 59714	406-388-3760
Belt	P. O. Box 453, Belt, MT 59412	406-277-3621
Boulder	P. O. Box 68, Boulder, MT 59632	406-225-3381
Bozeman	P. O. Box 1230, Bozeman, MT 59771	406-582-2300
Browning	P. O. Box 1624, Browning, MT 59417	406-338-2344
Cascade	P. O. Box 314, Cascade, MT 59421	406-468-2808
Choteau	P. O. Box 619, Choteau, MT 59422	406-466-2510
Conrad	413 S. Main Street, Conrad, MT 59425	406-271-3623
Cut Bank	221 W. Main Street, Cut Bank, MT 59427	406-873-5526
Dillon	125 N. Idaho Street, Dillon, MT 59725	406-683-4245
Dutton	P.O. Box 156, Dutton, MT 59433	406-476-3311
East Helena	P.O. Box 1170, East Helena, MT 59635	406-227-5321
Ennis	P.O. Box 147, Ennis, MT 59729	406-682-4287
Fairfield	P.O. Box 8, Fairfield, MT 59436	406-467-2510
Fort Benton	P.O. Box 8, Fort Benton, MT 59442	406-622-5494
Great Falls	P.O. Box 5021, Great Falls, MT 59403	406-771-1180
Helena	316 N. Park Avenue, Helena, MT 59623	406-447-8410
Lima	P.O. Box 184, Lima, MT 59739	406-276-3521
Manhattan	P.O. Box 96, Manhattan, MT 59741	406-284-3235

Municipalities	Mailing Address	Phone
Neihart	P.O. Box 61, Neihart, MT 59465	406-236-5301
Shelby	112 1st Street South, Shelby, MT 59474	406-434-5222
Sheridan	P.O. Box 78, Sheridan, MT 59749	406-842-5431
Sunburst	P.O. Box 245, Sunburst, MT 59482	406-937-2141
Three Forks	P.O. Box 187, Three Forks, MT 59752	406-285-3431
Townsend	110 Broadway, Townsend, MT 59644	406-266-3911
Twin Bridges	P.O. Box 307, Twin Bridges, MT 59754	406-684-5243
Valier	P.O. Box 512, Valier, MT 59486	406-279-3721
Virginia City	P.O. Box 35, Virginia City, MT 59755	406-843-5321
West Yellowstone	P.O. Box 1570, West Yellowstone, MT 59758	406-646-7795
Whitehall	P.O. Box 529, Whitehall, MT 59759	406-287-3972
Local Water Quality Districts		
Gallatin Co. LWQD	215 West Mendenhall, Suite 300 Bozeman, MT 59715	406-582-3168
Lewis and Clark Co. WQPD	316 North Park Ave., Helena, MT 59623	406-447-8304

Map 7.4 Upper Missouri Conservation Districts

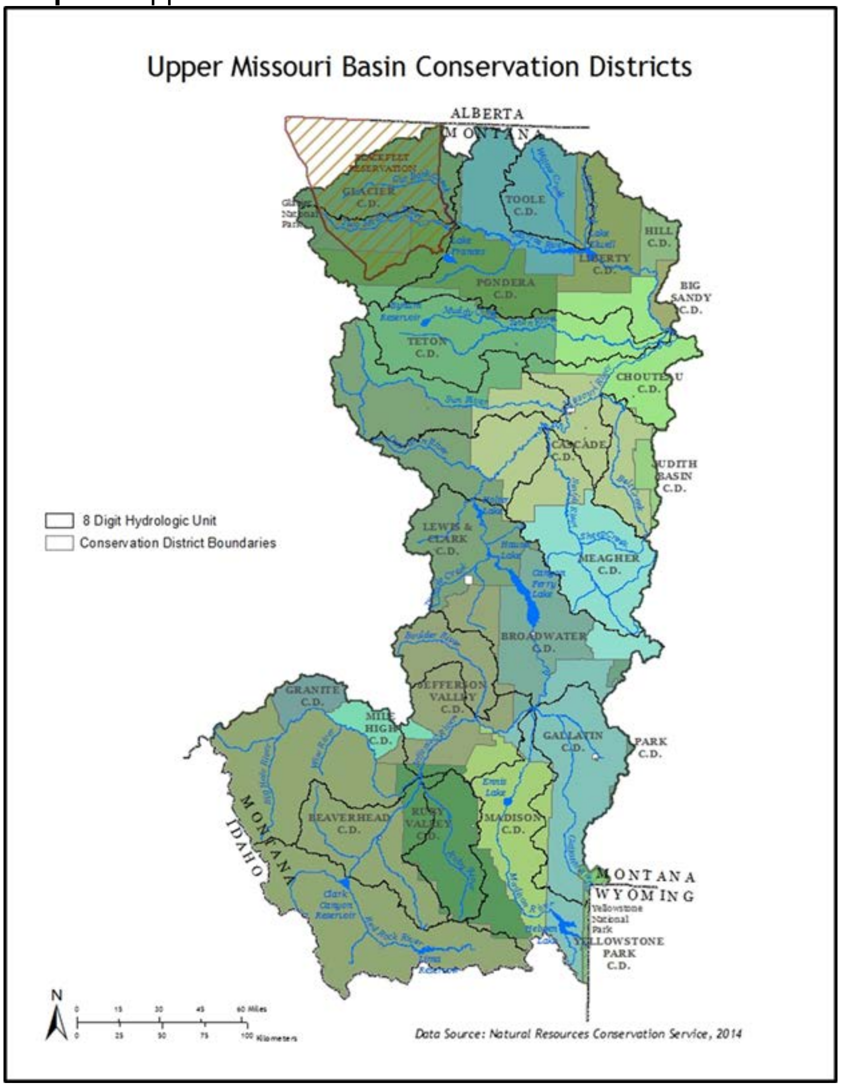


Table 7.2 Irrigation Districts and Reservoir and Canal Companies in the Upper Missouri River Basin

Irrigation and Canal Companies by County	
Canyon Irrigation Company	Beaverhead
Clark Canyon Water Supply Company	Beaverhead
Dillon Canal Company	Beaverhead
East Bench Irrigation District	Beaverhead
Lima Reservoir Water Users Irrigation Company	Beaverhead
Ruby Water Company	Beaverhead
West Side Canal Company	Beaverhead
Montana Ditch Company	Broadwater
Toston Irrigation District Crow Creek Pumping Unit	Broadwater
Rocky Reef Ditch Company	Cascade

Irrigation and Canal Companies by County	
Sun River Park Water Association	Cascade
Sun River Valley Ditch Company	Cascade
Sunnydale Water Association	Cascade
Baker Ditch Company	Gallatin
Beck and Border Ditch LLC	Gallatin
Bozeman Creek and Reservoir Company	Gallatin
Buffalo Land Company Water Users Association	Gallatin
Burrell Ditch Company	Gallatin
Dry Creek Irrigation Company	Gallatin
Farmers Canal Company	Gallatin
High Line Canal Company	Gallatin
Hoy Ditch Company	Gallatin
Kughen Ditch Company Inc.	Gallatin
Lewis Ditch Company	Gallatin
Low Line Canal Company	Gallatin
Lower Jefferson Canal Company	Gallatin
Lower Middle Creek Supply Ditch Company	Gallatin
Mammoth Ditch Company	Gallatin
Middle Creek Ditch Company	Gallatin
Middle Creek Water Users Association Inc.	Gallatin
Old Hale Ditch Company	Gallatin
Perks Canal Corporation	Gallatin
Spain Ferris Ditch Company	Gallatin
Valley Ditch Company	Gallatin
Warm Springs Canal Company	Gallatin
West Gallatin Canal Company	Gallatin
Blackfeet Irrigation Project	Glacier
Piegan Water Supply Company	Glacier
Fish Creek Ditch Company	Jefferson
Jefferson Canal Company	Jefferson
Pipestone Ditch Company	Jefferson
Pleasant Valley Ditch Company	Jefferson
Whitetail Water Users Association	Jefferson
Dearborn Canal Company	Lewis and Clark
Fort Shaw Irrigation District	Lewis and Clark
Green Meadow Seven Mile Water Association	Lewis and Clark
Helena Valley Irrigation District	Lewis and Clark
Nilan Water Users Association	Lewis and Clark
Meagher County Newlan Creek Water District	Meagher
North Fork of the Smith River Water Users Association	Meagher
South Side Canal Users Association	Meagher
Big Hole Co-op	Madison
Cameron Ditch Company	Madison
D&D Irrigating Company	Madison
Elk Hills Irrigation Company	Madison
Holly Creek Water Users	Madison
Indian Creek Ditch and Irrigation Company	Madison

Irrigation and Canal Companies by County	
Madison Irrigation Company	Madison
Norwegian Creek Reservoir Inc.	Madison
O'Dell Ditch Company	Madison
Pageville Canal Company	Madison
Parrot Ditch Company	Madison
Ruby River Water Users Association	Madison
Sunrise Reservoir Association	Madison
Swan Water and Ditch Company	Madison
Three Creeks Water Company	Madison
Troutdale Association	Madison
Vigilante Canal Users Association	Madison
Water Users Irrigation Company	Madison
West Bench Canal Users Association	Madison
West Madison Canal Company	Madison
Willow Creek Water Users Association	Madison
Pondera County Canal and Reservoir Company	Pondera
Brady Irrigation Company	Teton
Bynum Irrigation District	Teton
Eldorado Co-Op Canal Company	Teton
Farmers Co-Op Canal Company	Teton
Greenfields Irrigation District	Teton
Teton Co-Op Canal Company	Teton
Teton Co-Op Reservoir Company	Teton

Table 7.3 Non-Governmental Organizations

WATERSHED GROUPS	ADDRESS	PHONE
Beaverhead River Watershed Committee	420 Barrett St. Dillon, MT 59725	406-988-0191
Big Hole River Foundation	PO Box 3894, Butte, MT 59702	406-925-2276
Big Hole Watershed Committee	PO Box 21,Divide, MT 59727-0021	406-960-4855
Blue Water Task Force	PO Box 160513,Big Sky, MT 59716	406-993-2519
Centennial Valley Association	215 E. Helen St, Dillon, MT 59725	406-660-0310
Elkhorn Restoration Committee	Helena, MT	406-439-0197
Greater Gallatin Watershed Council	PO Box 751,Bozeman, MT 59771-0751	406-551-0804
Jefferson River Watershed Council	PO Box 585, Pony, MT 59747	406- 579-3762
Lake Helena Watershed Group	316 North Park Ave, Helena, MT 59623	406-457-8584
Lower Jefferson Watershed Council	Boulder, MT	406-287-5117
Madison River Foundation	PO Box 1527 / Ennis, MT 59729	406-682-3148
Madison Valley Ranchlands Group	PO Box 330, Ennis, MT 59729-9012	406-682-7364
Madison Watershed Partnership	PO Box 1178, Ennis, MT 59729	406-682-3181
Marias River Watershed Group	PO Box 669 / Chester, MT 59522	406-434-5234
Missouri Headwaters Partnership	PO Box 201601, Helena, MT 59620	406-444-1806
Missouri River Conservation District Council	1101 11th Ave Helena, MT 59601	406-454-0056
Ruby Watershed Council	PO Box 295 Sheridan, MT 59749	406-842-5741
Sage Creek Watershed Group	PO Box 669 Chester, MT	406-759-5778
Sun River Watershed Group	816 Grizzly Drive, Great Falls, MT 59404	406-727-4437

WATERSHED EDUCATION PARTNERS	ADDRESS	PHONE
Clark Fork Watershed Education Program	Health Sciences Bld. Rm 003 1300 W Park St. Butte, MT 59701	406-490-5191
Montana Environmental Education Association	PO Box 1015, Missoula, MT 59806	
Montana Outdoor Science School	P.O. Box 502 · Bozeman, MT 59771	406-582-0526
Montana Water Center	23 Faculty Court MSU, Bozeman, MT 59717	406-994-6690
Montana Watercourse	PO Box 170570 Bozeman, MT 59717	406-994-1910
MT State University Extension Water Quality	P.O. Box 173120 Bozeman, MT 59717-3120	406-994-7381
STATEWIDE, REGIONAL, NATIONAL ORGANIZATIONS	ADDRESS	PHONE
Montana Association of Conservation Districts	1101 11th Avenue, Helena, MT 59601	406-443-5711
Montana Watershed Coordination Council	1101 11th Avenue, Helena, MT 59601	406-475-1420
Montana Wetland Council	PO Box 200901, Helena, MT 59620	406-444-6652

C. Federal and Tribal Reserved Water

INTRODUCTION

The doctrine of reserved water rights evolved to ensure that Indian reservations and public lands set aside by the federal government would have sufficient water to fulfill the purposes for which they were established. Whereas most western water rights (state-based appropriative rights) have a priority date based on when water was first put to beneficial use, federal reserved water rights have a priority date that goes back at least as far as the date on which the lands were set aside.

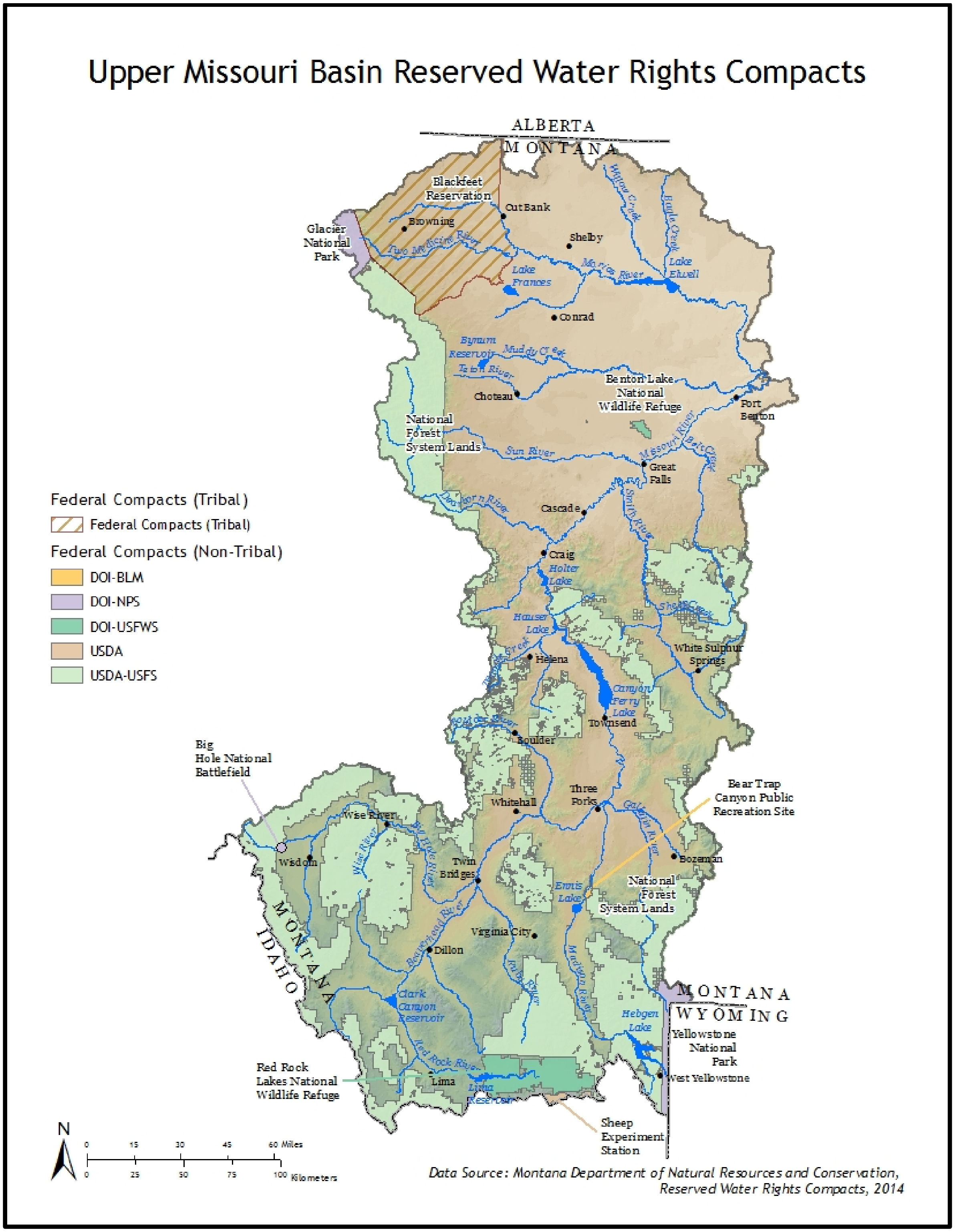
The reserved water rights doctrine is rooted in a number of judicial decisions, beginning with a 1908 U.S. Supreme Court decision now known as the Winters Doctrine. The case of Winters vs United States involved a dispute between Native Americans of the Ft. Belknap Reservation and homesteaders over the use of the Milk River. When the water used by the settlers upstream from the reservation diminished water supplies for agriculture on the reservations, the dispute eventually made it to the U.S. Supreme Court. The Court sided with the Tribes, holding that the 1855 treat establishing the Reservation had implicitly reserved an amount of water necessary to fulfill the purposes for which the Reservation was established. Therefore, although the homesteaders had perfected their water rights under Montana state law, the water right of the Indians of the fort Belknap Reservation was prior, or senior in use.

The rationale used in the Winters decision on behalf of Native Americans also applies to public lands held by the federal government for national parks, wildlife refuges, national forests, military bases, wilderness areas, or other Public purposes. It holds that when Congress authorized the establishment of federal land, it implicitly intended to reserve enough water to fulfill congressional purposes. This idea of “implied rights” serves as the basis and foundation for tribal and federal claims to state waters embodied in the many compacts negotiated by the state of Montana and its many tribal and federal partners.

The Reserved Water Rights Compact Commission (RWRCC) was created by the Montana Legislature in 1979 to act on behalf of the state to negotiate settlement of federal reserved water right claims as part of the statewide water adjudication. A federal reserved water right is created when an act of Congress or a presidential executive order or proclamation sets aside federal land from the public domain for a specified purpose. This includes national forests, national parks, national wildlife refuges, some BLM lands, Indian reservations, and others. The water right has the priority date of the reservation of the land, even though the water right might not be used at that time. The water right includes the amount of water necessary to accomplish the specified purpose for which the land was reserved.

By state law, a negotiated settlement must be enacted by the Montana Legislature, be approved by federal officials, and go through an objection process in the Montana Water Court. After objections to all claims (including objections to the compact) are resolved, the Water Court issues a final decree for all water rights in each basin, including the reserved rights in the negotiated settlement.

Map 7.5 Upper Missouri Reserved Water Rights Compacts



Blackfeet Indian Reservation

TRIBAL COMPACTS

BLACKFEET TRIBAL COMPACT

The Blackfeet Indian reservation is located east of Glacier National Park and borders the Canadian province of Alberta. Cut Bank Creek and Birch creek make up part of its eastern and southern borders. The reservation contains 3,000 square miles, half again the size of the national park and larger than the state of Delaware. It is located in parts of Glacier and Pondera Counties. Elevations in the reservation range from a low of 3,400 feet to a high of 9,066 feet at Chief Mountain. The eastern part of the reservation is mostly open hills of grassland, while a narrow strip along the western edge is covered by forests of fir, spruce and aspen. Free-ranging cattle are present in areas throughout the reservation. Several waterways drain the area, with the largest being the St. Mary River, Two Medicine River, Milk River, Birch Creek and Cut Bank Creek. There are approximately 175 miles of streams and eight major lakes on the reservation.

After 20 years of negotiations, a compact settlement between the Blackfeet Tribe, the United States, and the Montana Reserve Compact Commission passed the Montana legislature in 2009. The 2013 Montana legislature completed the State's financial commitment to the settlement with an appropriation of $14 million, bringing the total cash contribution to $54 million. The compact will provide water and economic development for the Blackfeet while protecting the rights of water users locally and downstream. The compact was first introduced in Congress in 2010. More recently, former Montana Senator Max Baucus introduced SB 434 to the Senate Committee on Indian Affairs on March 4, 2013. On May 8, 2013 a hearing was held to consider the bill, but no action has occurred since that time. The parties continue to work on details of the Federal settlement bill.

Summary of agreements

- Provides water for the existing and future needs of the Blackfeet Tribe.
- Protects all current non-irrigation water rights, such as domestic and stock water uses, from the tribe's future exercise of its water right.
- Provides protection for all current irrigation and non-irrigation uses in Birch Creek, Badger Creek, and the Two Medicine River basins and a grace period before tribal development in Cut Bank Creek and Milk River drainages.
- Provides a process for the tribe to lease a portion of its water right to off-reservation water users.
- Settles tribal claims in the St. Mary River basin by providing the tribe with an allocation of 50,000 acre-feet of water, with protections for the Milk River Project downstream.
- Closes on-reservation portions of streams to new water appropriations under state law.
- Provides for tribal administration of the Tribal Water Right, and state administration of water rights arising under state law.
- Creates a Compact Board with an administrative process for the resolution of any future disputes between tribal and non-tribal water users.
- Provides for an allocation of water stored in Tiber Reservoir (in an amount to be determined by Congress) for the tribe to use or market.
- Mitigates the impacts of the tribe's water rights on Birch Creek water users through a separate Birch Creek Agreement that commits the state to pay the tribe $14.5 million in exchange for the tribe deferring new development of its Birch Creek water rights for 15 years and providing 15,000 acre-feet of water per year to Birch Creek water users from on-reservation storage for at least 10 more years, the total deferral and provision of water not to exceed 25 years from effective date.

Water rights by Tributary:
BIRCH CREEK

- 100 cfs from the natural flow of Birch Creek for irrigation use in the Upper Birch Creek drainage.
- Instream flow of 25 cfs from April 1 to September 1 and 15 cfs from October 1 to March 31.
- Any additional water remaining after satisfaction of existing rights arising under state law
- A management plan exists as an appendix to the compact, which provides for coordinated management of Birch Creek tribal and non-tribal water use.

BADGER CREEK/TWO MEDICINE RIVER

- The tribe has a water right to all currently unappropriated surface water and groundwater. Current non-tribal water uses are not subject to a call from new tribal development.
- Instream flow of 20 cfs in both Badger Creek and Two Medicine River.
- The Blackfeet Irrigation Project will be supplied water from the tribal water right and will be administered by the Bureau of Indian Affairs (or as otherwise provided by Congress).

CUT BANK CREEK and Milk River

- The tribe has a water right to all currently unappropriated surface water and groundwater. Current non-tribal non-irrigation water uses are not subject to a call from any new tribal development.

- Irrigation uses on Cut Bank Creek and the Milk River are subject to a call from tribal water uses. The tribe will not develop new irrigation uses on Cut Bank Creek or the Milk River, except projects using exclusively stored or imported water, for 10 years from the effective date of the compact.
- Instream flow of 2 cfs in the on-reservation portions of both Cut Bank Creek and the Milk River.

FEDERAL COMPACTS

A federal reserved water right is created when an Act of Congress or a Presidential Executive Order or Proclamation sets aside federal land from the public domain and reserved for a specified purpose. The water right then carries the priority date of the reservation of the land, even though the water right might not be put to use at that time. The amount of water is that necessary to accomplish the specified purpose for which the land was reserved. In the Upper Missouri Basin, compacts have been negotiated for several federal agencies including; the National Park Service, US Forest Service, US Fish and Wildlife Service and the Bureau of Land Management (BLM).

NATIONAL PARK SERVICE COMPACTS

A water rights compact with the National Park Service for Yellowstone and Glacier Parks, and the Big Hole Battlefield was finalized by the Montana Legislature in 1993. The Montana Water Court issued a final decree for this compact in April 2005.

Big Hole National Battlefield

Big Hole National Battlefield was created by Executive Order No. 1216 on June 23, 1910 as a memorial to members of the Nez Perce Bands and the soldiers of the 7th U.S. Infantry who fought in the Big Hole Battle.21 The 655-acre Battlefield marks the spot of the turning point in the Nez Perce War which began on June 15, 1877. Approximately 55,000 visitors tour the site each year. Land was added to the Big Hole Battlefield by Presidential Proclamation on June 29, 1939, and by Congress in 1963. The Battlefield carries a reserved water right for purposes defined in the 1910 and 1939 reservations. The 1910 Executive Order set aside the acreage, stating that embracing the Big Hole Battlefield Monument in Beaverhead County, be, and the same is hereby, reserved for military purposes for use in protecting said monument. The 1939 Presidential Proclamation added contiguous land to the Battlefield site and gave more detail regarding the purpose of the Battlefield as an historic landmark. Although the Battlefield was originally reserved in 1910, the Executive Order did not set out specific purposes for the reservation. Commission and the Park Service agreed that based on the 1939 Proclamation a primary purpose for reserving the Battlefield is historic interpretation. Thus they agreed to a priority date of June 9, 1939.

The Big Hole Battle took place on August 9-10, 1877, when less than 200 members of the 7th Infantry of the U.S. Army attacked a group of about 800 Nez Perce Indians who were fleeing to Canada to escape being placed on a small reservation in the United States. The Nez Perce were surprised early on the morning of August 9, 1877 while they were sleeping in their camp along the east bank of the Big Hole River. Historical sources show that the Nez Perce camp was located on a grassy plain adjacent to the confluence of Ruby and Trail creeks which come together at the site to form the North Fork of the Big Hole River. The battle took place in and around the river, and both Nez Perce and 7th Infantry soldiers fought and died while Nez Perce women and children tried to hide in the water and under the river banks. Thus the parties agreed that the presence of the river is a necessary part of the historic interpretation for the Battlefield.

Summary of Agreements

Consumptive Use

The Park Service and the Commission agreed that Park Service consumptive uses would include water for the visitor center, administrative offices, picnic area, maintenance area, residences, and irrigation within the Battlefield. The total amount agreed to is 7.14 acre feet per year. This amount is based on past water use, as well as expected visitation increases.

In addition, the agreement recognizes that the use of water for emergency fire suppression benefits the public, and that the Park Service may divert water for fire suppression at the Battlefield. Such use will not be counted as Park Service consumptive use, or be considered a violation of the instream flow right.

Instream Flow Rights - North Fork of the Big Hole River

Because a purpose of the Monument is to preserve the historic condition of the Battlefield site, the Park Service and the Commission agreed that a federal reserved water right exists for instream flow necessary to maintain the channel characteristics and riparian habitat of the North Fork of the Big Hole River. As noted above, the river and surrounding riparian vegetation was where soldiers and Nez Perce took cover during the fighting.

Quantification

The Commission and the Park Service agreed that a Park Service water right for 10 cubic feet per second (cfs) of instream flow on the North Fork of the Big Hole River from November through March would be subordinated to state water rights with a priority date prior to effective date of the Compact. The North Fork is formed by Ruby Creek and Trail Creek, therefore, the parties agreed that the instream flows granted to the Montana Fish, Wildlife and Parks for those two streams would be added together (4 cfs for Ruby Creek and 6 cfs for Trail Creek).

From April through October the Park Service will have a water right for instream flow in the amount left in the river after all existing consumptive uses with a priority date prior to the effective date of the Compact are satisfied. The existing consumptive uses are mostly upstream irrigation during the summer months. The purpose of the instream flow is to keep water in the stream during the summer to maintain vegetation and channel characteristics.

Groundwater

As part of the instream flow right on the North Fork of the Big Hole River, there are clauses in the Compact relating to groundwater appropriations. These provisions do not recognize a reserved water right for groundwater that is separate and distinct from that for instream flow. Instead, they are included in the Compact in recognition of the fact that appropriation of groundwater may impact streamflow. These agreements take into consideration the effect on existing users as well as on Park Service instream flow rights.

The Park Service agreed to subordinate its water right to future non-consumptive uses of water even if developed after the limit on consumptive use is reached, if they do not cause a reduction in the source of supply, do not delay the return of the diverted water to the source of supply, or adversely affect the quality of the water as it enters Big Hole National Battlefield.

Glacier National Park

One million acres in size, Glacier National Park is visited by over 2 million people each year. Due to the spectacular mountainous scenery in the area, the park was reserved by an Act of Congress on May 11, 1910, "as a public park or pleasure ground for the benefit and enjoyment of the people of the United States." Glacier National Park was reserved out of land in the Lewis and Clark Forest Reserve created by President Cleveland on

22 February, 1897, as superseded by a 1903 Presidential Proclamation, and includes land east of the continental divide ceded by the Blackfeet Tribe in 1896.

The legislative history indicates many references to Glacier's unique location on the triple divide between the headwaters of the Missouri, Columbia, and Hudson rivers, and the need to protect the park's fish and game. The priority date for Glacier National Park is May 11, 1910.

Summary of Agreements

Consumptive Use

The Park Service and the Commission agreed on Park Service consumptive uses which include water for park administrative and domestic uses, park concessions, maintenance sites, ranger stations, campgrounds, lodges, and other places of use within Glacier National Park. The total amount agreed to is 567.8 acre-feet per year. The amount is based on current water use, and additional water to allow for future management flexibility and response to increased visitation. The Park Service may divert water for fire suppression as necessary. See Table 5 of the Compact.

Instream Flow Rights

Stream Categories-In order to more easily address the issues involving reserved water rights for Glacier National Park, the negotiators broke the watersheds into categories based on the types of streams involved. The same categories would be used for the other Park Service units as necessary.

Category 1 includes all streams that begin in the park and flow directly out. These streams are dedicated to instream flow, minus any Park Service consumptive use claims. No private claims exist on these streams.

Prior to the 1910 reservation of Glacier National Park, certain land within the area that was to become the Park had been patented by private parties. To protect the pre-existing rights of these landowners, category 1a includes all streams that begin in the park and flow out through non-federal land within the Park. The water in these streams is dedicated to instream flow after existing private water rights within the Park are satisfied.

Categories 2 and 3 were established for Yellowstone National Park to include all streams that headwater in the State of Montana outside of the Park and flow into the Park. There are no category 2 or 3 streams associated with Glacier National Park.

Category 4 streams are special case streams requiring individual treatment for quantification. They include the North Fork and Middle Fork of the Flathead River, which form the south and west boundaries to the Park; Rubideau Creek, which is fed by a spring diverted for use outside the Park by the Community of West Glacier; and Divide, Jule, and Wild Creeks, reaches of which are shared by the Park and the Blackfeet Reservation.

Due to the impacts of impoundments on a natural flow regime, the negotiators agreed that no new impoundments will be permitted after the date of the Compact on the mainstem of Category 4 streams where they border or lie upstream of the Park. However, existing impoundments may be repaired or rehabilitated providing the repairs do not cause the impoundment to exceed its original capacity. This prohibition would not apply to impoundments approved through settlement of a Tribal reserved water right.

As with the Big Hole Battlefield, the Park Service agreed to subordinate its water right to future non-consumptive water uses, even those developed after the limit on consumptive use is reached, if they do not cause a reduction in the source of supply, do not delay the return of the diverted water to the source of supply or adversely affect the quality of the water as it enters Glacier National Park.

Yellowstone National Park

Yellowstone National Park was created as the world's first national park by an Act of Congress on March 1, 1872. The park contains more than 3,300 square miles of land, most of which is in Wyoming. In September of 1869, a group from Montana explored part of the region and made it known that some of the most intense geyser activity in the world was located in the area. Other expeditions led to increased public interest in the area. The park contains approximately 10,000 hydrothermal features, including 3,000 geysers and hot springs, and abundant wildlife including bison, elk, deer, moose and bear roam the area. Each year, approximately 2.9 million people visit Yellowstone National Park.

Summary of Agreements

Consumptive Use

The Park Service and the Commission agreed on Park Service consumptive uses, which include water for park administrative and domestic uses, concessions, maintenance sites, visitor centers, lodges, entrance stations, back country patrol cabins, day use areas, and other places of use within the Montana portion of Yellowstone National Park. The total amount agreed to is 174.9 acre feet per year. This amount is based on past water use, with a margin of future use to allow for management flexibility and increased visitation. The Park Service may divert water for fire suppression. See Table 8 in Compact (MCA 85-20-401).

Instream Flow Rights

The preservation purposes of Yellowstone National Park, including "all timber, mineral deposits, natural curiosities, or wonders within said park, "mean that a federal reserved water right exists for instream flow. This instream flow right keeps water in the streams to protect park resources as required by the founding Act.

Groundwater and Impoundments

As part of the instream flow rights, there are clauses in the Compact relating to groundwater appropriations and impoundments. As explained in the sections on Big Hole Battlefield and Glacier National Park, these provisions do not recognize a reserved water right for groundwater that is separate and distinct from that for instream flow. Instead, they are included in the Compact in recognition of the fact that appropriation of groundwater may impact streamflow. These agreements take into consideration the effect on existing users and on Park Service instream flow rights.

The Commission and the Park Service agreed that new wells in basins upstream from a reserved portion of a stream (and appropriated after January 1, 1993) will not be included in the limits on consumptive use unless they are hydrologically connected to surface flows tributary to streams which flow into, or border the park. An applicant for a well in excess of 35 gpm will be required to submit a report prepared by a qualified professional showing that the well is not hydrologically connected to surface flow.

Groundwater appropriations by well or a developed spring of 35 gpm or less that do not exceed 10 acre-feet per year, i.e., those wells currently exempt from permit requirements under state law, must register but will not be included in the calculation of total consumptive use unless the United States shows that the proposed appropriation is hydrologically connected to surface flow. Because such uses would normally be exempt from permit requirements under state law, the Commission and the Park Service agreed to an expedited process for small wells in which only the United States may appear as an objector. There are no requirements for wells with a priority date before January 1, 1993.

Due to the impact of impoundments on a natural flow regime, the Commission and the Park Service agreed that new impoundments will not be permitted after the date of the Compact on the mainstems of category 3 and 4 streams. Impoundments in place as of December 31, 1992 are protected but may be called on Soda Butte Creek

in dry years by the United States' critical flow right. Existing impoundments may be repaired or rehabilitated providing the repairs do not cause the impoundment to exceed its original capacity.

The Park Service agreed to subordinate its water right to future non-consumptive uses of water even after the limits on consumptive use are reached if they do not cause a reduction in the source of supply, do not delay the return of the diverted water to the source of supply or adversely affect the quality of the water as it enters Yellowstone National Park.

Yellowstone Controlled Groundwater Area
The most difficult aspect of negotiations was brought on by the Park Service's assertion of a reserved water right in the amount necessary to protect the hydrothermal features of Yellowstone National Park. The parties had no difficulty in agreeing to the existence of a reserved water right to protect the hydrothermal system at the Park. Although courts in other states and the Commission have refused to recognize a federal reserved water right to groundwater when asserted merely as an incident of reservation of the overlying land, the U.S. Supreme Court has held that withdrawal of water from a well may be enjoined when it impacts water reserved for the specific purpose of the reservation.

The legislative history of the establishment of Yellowstone National Park indicates that one of the primary purposes in the reservation of the Park was to preserve the numerous geysers, hot springs, and other thermal features within the boundaries of the Park. These features are surface manifestations of the hydrothermal system, or systems. In addition to heat, experts agreed that groundwater is an essential component of that system.

Despite the United States' claim to a reserved water right for the hydrothermal features, it was apparent that quantification would be impossible. Earlier settlements of the reserved water rights for Yellowstone National Park, with Idaho and Wyoming, did not deny the right of the U.S. to seek an injunction, but declined to quantify this reserved right.

The difficulty in quantification also became apparent in testimony before Congress concerning the impact of potential geothermal development on the Park, when, in 1988, Congress amended the Geothermal Steam Act. The amendment authorized a study to determine the potential effects of geothermal development within the Corwin Springs Known Geothermal Resource Area (KGRA), adjacent to the northern boundary of the Park in Montana, on the thermal features within Yellowstone National Park. The amendment also placed a moratorium on production of geothermal resources in the KGRA until 180 days after receipt of the study by Congress, which was to be transmitted to Congress by December 1, 1990.

The USGS report concluded that substantial development of hydrothermal waters outside of the park could result in decreased discharge of thermal springs in Yellowstone, specifically in the Mammoth Hot Springs area.[54] The report provided a recommendation for limits on hydrothermal development in the Gardiner/Corwin Springs area.

Initial Restrictions on Groundwater Development within the Yellowstone CGA
Until the initial boundaries or restrictions are modified, the following initial restrictions apply to groundwater appropriations with a priority date on or after January 1, 1993. The restrictions will not apply to appropriations prior to January 1, 1993. However, the pre-1993 appropriations will be subject to inventory and sampling of current use in order to assess current levels of groundwater development, to record the cumulative effect of current and future development, and to provide baseline data on the characteristics of the groundwater and hydrothermal systems.

The 1993 Compact went into effect on January 31, 1994, and the 1995 Compact went into effect May 30, 1995, after they were respectively ratified by the Montana Legislature and approved by the U.S. Department of Interior and the U.S. Department of Justice.

US FOREST SERVICE COMPACT

The USDA Forest Service Compact recognizes a reserved water right to divert water for the Forest Service for administrative uses (such as for ranger stations, pack stock, road watering) and for emergency fire suppression. The priority date is date of the creation of the National Forest or as specified. This compact settles all federal reserved water rights of the Forest Service. The Forest Service has other water use claims based on state law that are in the adjudication process and are not part of this agreement (for example, campgrounds are not "specific purposes" for which Forest Service land was originally reserved). The USFS Compact was ratified by the Montana legislature and signed by Governor Bullock April, 2014.

Summary of Agreements

Discrete Administrative Uses - These reserved water rights to divert or withdraw water are to serve administrative sites on the National Forest System Lands. These rights typically are for water used at ranger stations, guard stations, and work centers, water for permanent tree nurseries and seed orchards, and water for riding and pack stock used for administrative purposes. These uses are in discrete (site specific) places and the priority date is creation of the national forest[1]. Each Discrete Administrative Use that is currently in place has an Abstract of Water Right. 88% of the 264 current discrete administrative uses have a volume of 1.5 acre-feet per year or less. This compact settles all federal reserved water rights of the Forest Service.

Dispersed Administrative Uses – These reserved water rights to divert or withdraw water are for administrative uses that are not site specific nor permanent but are occasional uses in varying places within the national forests, such as, road watering, prescribed fire management, and temporary tree nurseries. The priority date is the creation of the national forest.

Emergency Fire Suppression: The Compact recognizes a reserved water right with a priority date of the creation of the national forest to divert or withdraw water for emergency fire suppression.

Instream Flows

The compact creates instream flow water rights under state law for 77 streams and one in-place water right for a fen (wetland), all located on National Forest System lands throughout Montana. All of these water rights have a priority date of 2007.

Established a process that the Forest Service may use in the future to apply for additional instream flows under state law on other streams throughout the National Forest System lands in Montana. The priority date will be the date of application.

In exchange for water rights created and the means of acquiring instream flows under state law, the Forest Service will withdraw forever all of its existing or possible claims for reserved water rights for instream flows in the ongoing water adjudication.

US FISH AND WILDLIFE SERVICE COMPACTS

Benton Lake National Wildlife Refuge

Benton Lake National Wildlife Refuge was set aside by a Presidential Executive Order on November 21, 1929. The Executive Order stated that the public lands were reserved and "set apart for the use of the Department of Agriculture, as a refuge and breeding ground for birds." Therefore, Benton Lake National Wildlife Refuge carries a reserved water right for the maintenance of bird habitat with a priority date of November 21, 1929. That means that the U.S. Fish and Wildlife Service has the right to use an unquantified amount of water it needs for this purpose before owners of state water rights with priority after 1929 can use water. This compact was approved by the Montana legislature in 1997.

Summary of agreements

- The U.S. Fish and Wildlife Service has the right to the remaining natural flow in the Lake Creek watershed after the following rights are satisfied:
- all valid water rights (as finally decreed by the Water Court or permitted by DNRC with a priority date before the date of the Compact) are satisfied; and
- new post-Compact wells of less than 35 gallons per minute that use 10 acre-feet per year, and
- new post-Compact stock impoundments with a surface acreage of 15 acre-feet capacity or less that appropriate a maximum of 30 acre-feet per year
- Following the satisfaction of the criteria above, there would be:
- Basin closure in the Lake Creek watershed to new water permits other than the 35 gpm or less wells, and stock water up to 15 acre-feet capacity or less that appropriates a maximum of 30 acre-feet per year.
- 2 acre-feet of groundwater for headquarters site well

Red Rocks Lakes National Wildlife Refuge

A water rights compact for Red Rocks Lakes NWR was ratified by the Montana Legislature and signed by the Governor in 1999.

Summary of agreements

Consumptive use:

Represent existing conditions with minor increases for possible future increases in visitation and irrigation

Priority date is subordinate to all upstream state-based water rights with a priority date before final approval of the Compact, and all subsequent upstream state-based water rights that are exempt from the basin closure listed below.

Instream flow:

The remaining flow after satisfaction of all upstream state-based water rights with a priority date before final approval of the Compact, and all subsequent upstream state-based water rights that are exempt from the basin closure listed below.

Water right for natural flow must remain in the stream and may not be diverted, transferred or changed to any other use.

The natural flow water right has no impact on existing and future water rights downstream from the Refuge.

Minimum flows:

In addition to the natural flow, a minimum flow is established on three creeks at the point they enter the refuge:

- Red Rock Creek: 15.0 cfs
- Tom Creek: 1.4 cfs
- Odell Creek: 11.0 cfs

- The water right for minimum flow is subordinate to all upstream state-based water rights for domestic and instream stockwatering purposes (including stock tanks installed to replace instream stockwatering).
- The water rights for minimum flow is not subordinated to any other state-based water rights, thus the FWS may assert priority over junior upstream water rights to satisfy the minimum flow.
- Stream flow on the three creeks rarely drops to the minimum. These low flows are most likely to occur in late summer of very dry years.
- Most water users upstream from the Refuge on the three creeks have agreed to enter cooperative agreements with the FWS that will allow their needs to be met during periods where streamflow is below the minimum.

Basin Closure:
The basin upstream from the refuge will be closed to new permits for water use with the following exceptions:

- Groundwater wells of developed springs of 35 gallons per minute or less with a maximum appropriation of 10 acre-feet per year.
- Larger groundwater wells that appropriate water that is not connected to surface water.
- Stock impoundments of less than 15 acre-foot capacity with an appropriation of less than 30 acre-feet per year.
- Nonconsumptive uses.
- Temporary emergency appropriations.

U.S. BUREAU OF LAND MANAGEMENT COMPACTS

A water rights compact with the Bureau of Land Management for both the Upper Missouri Wild and Scenic River and Bear Trap Canyon Public Recreation Site on the Madison River was ratified by the Montana Legislature and was signed by the Governor in 1997... In May 2011 the Montana Water Court issued a final decree for the BLM-Montana Compact.

Bear Trap Canyon Public Recreation Site
Set aside by the Secretary of the Interior on June 9, 1971, pursuant to authority granted by Presidential Executive Order. The public recreation site is located in the Madison River corridor directly below Ennis Lake.

Summary of agreements

- The reserved water right is for 1,100 cfs year round for instream flow with a June 9, 1971 priority date.
- Montana Power Company's successor PPL Montana operates Madison Dam at Ennis Lake and is required by licensing agreement to make a minimum release of 1,100 cfs.

Upper Missouri River Breaks National Monument
The Compact for the Monument was agreed to by the Parties following four negotiation sessions and three public meetings. The Compact was approved unanimously by the Commission in December of 2012. It was ratified by the 2013 Montana Legislature as SB 88. The draft abstracts have been prepared by Commission technical staff.

Summary of agreements

- Protection of all existing water rights arising under state law with a priority date earlier than June 1, 2012. All of these existing rights are senior in priority to any rights granted to the BLM under this compact.

- No reduction in the amount of water available for future development in the Judith Basin as a result of this compact.
- Continued exception to permitting for domestic wells, stock ponds, and other uses that meet the requirements for exception to permitting as listed in 85-2-306 MCA. These uses will not be subject to call by the BLM under the specifications of this compact.
- <u>Judith River:</u> The Judith River water right is in the amount of 160 cfs measured at the USGS gaging station near the confluence of the Judith River with the Missouri River. The period of use is January 1 through December 31 of each year. This right shall run concurrently and junior in priority to a Montana Fish, Wildlife & Parks right for the same source, flow rate, and period of use.
- <u>Arrow Creek:</u> The Arrow Creek water right is in the amount of 5 cfs measured where the national monument boundary intersects Arrow Creek. The period of use is March 1 through July 31 of each year. A proportionally lower flow rate may be determined at an alternate measurement point.
- The reserved water right will have a priority date of January 17, 2001, but this reserved right will be subordinate to state-based permits with a priority date before June 1, 2012.
- Restriction on Main stem Impoundments: New main stem impoundments under this compact not otherwise excepted from permitting requirements under Montana law will not be permitted on the following reaches of the Judith River and Arrow Creek. Off-stream impoundments will continue to be permitted under DNRC permitting procedure.
  a. <u>Judith River:</u> from the confluence of the Middle and South Forks of the Judith River downstream to its confluence with the Missouri River.
  b. <u>Arrow Creek:</u> from its confluence with Hay Creek downstream to its confluence with the Missouri River.
- Ramped Diversion Requirement**:** Flows on both the Judith River and Arrow Creek that have not already been appropriated as of the date of this compact will be available for future state-based development, subject to the reserved water right and applicable permit restrictions. New permits issued after the date on which this compact is ratified will be subject to a ramped diversion requirement for diversions greater than 20 cfs capacity. Direct from source diversions from the Judith River and Arrow Creek that have a diversion capacity greater than 20 cfs will be allowed an increase in diverted water of no more than 20 cfs per 24-hour period.

OTHER FEDERAL RESERVED WATER

USDA Sheep Experiment Station

A water rights compact for USDA Sheep Experiment Station was approved by the Montana Legislature and signed by the Governor in 2007. The Compact recognizes federal reserved rights for the Sheep Experiment Station located in Water Court Basin 41A near Lakeview, Montana and settles the stock water, domestic, irrigation, storage, dust abatement, reclamation, research, emergency fire suppression and other water rights of the small portion of the Sheep Experiment Station located in Montana. The Compact addresses and quantifies federal reserved water rights for the Sheep Experiment Station from seeps, naturally-occurring surface flows and groundwater sources arising inside the boundaries of the Sheep Experiment Station. The Montana Water Court filed a Preliminary Decree on August 21, 2014.

Summary of agreements

The Compact recognizes federal reserved water rights in three categories, existing uses, future uses, and emergency fire suppression. The priority date for these rights shall be December 19, 1922.

Existing Uses

- The U.S. Sheep Experiment Station currently uses up to 11.72 acre-feet per year from surface water for stock water use.

Future Uses

- Up to a total of an additional 15 acre-feet per year. The future uses may be for stock water or for administrative uses. (Administrative uses could include water for domestic use, to conduct research, dust abatement, reclamation or other administrative purposes from surface or groundwater to fulfill the purposes of the U.S. Sheep Experiment Station.

Emergency Fire Suppression

- Emergency Fire Suppression, as needed.

D. Water Quality Laws in the Upper Missouri Basin

MONTANA WATER QUALITY LAWS

Numerous laws and regulatory programs in Montana control activities to protect water quality. There are laws that regulate discharges to surface water, discharges to groundwater, streambed disturbance, mining operations, hazardous waste, underground storage tanks, septic systems, and almost every other activity that poses a threat to water quality. Most of these laws are administered by DEQ, with a handful administered by other state and local entities. The Montana Water Quality Act (75-5-101, MCA) is the primary water pollution control authority in Montana. The act states that it is public policy to:

Conserve water by protecting, maintaining, and improving the quality and potability of water for public water supplies, wildlife, fish and aquatic life, agriculture, industry, recreation, and other beneficial uses; [and] provide a comprehensive program for the prevention, abatement, and control of water pollution; and balance the inalienable rights to pursue life's basic necessities and possess and use property in lawful ways with the policy of preventing, abating, and controlling water pollution.

Water quality standards, adopted by the Montana Board of Environmental Review, establish the level of water quality necessary to support existing and future beneficial uses of rivers, lakes, and groundwater resources. The standards establish a basis for limiting discharges of pollutants.

The 1972 federal Clean Water Act (CWA) established a national framework for protecting and improving water quality. Sections of CWA passed in 1987 (303(d) and 305(b)), require states to monitor and assess statewide water quality conditions, identify and list water bodies that fail to meet water quality standards, and prepare Water Quality Improvement Plans (WQIPs) for restoring water quality. These WQIPs must include quantitative limits, known as Total Maximum Daily Loads (TMDLs), for each of the pollutants of concern. Most of Montana’s water quality impairments reflected on the 303(d) list are a result of nonpoint source (NPS) pollution.

Surface Water Quality Protection

Nonpoint water pollution comes from contaminants (originating from a variety of land-use activities over generally large areas) that are transported to streams, lakes, wetlands, and groundwater by precipitation, snowmelt, and stormwater runoff. Nonpoint pollution also comes from substances that erode directly into surface waters or from aerially transported substances deposited on land and water. Common nonpoint pollutants include sediment, nutrients (nitrogen and phosphorus), temperature changes, metals, pesticides, pathogens, and salt.

Nonpoint pollution is a significant problem in Montana, constituting the single largest cause of water quality impairment on a statewide basis (Figure V-24). More than 75 percent of Montana's assessed rivers and streams and 45 percent of its lakes, reservoirs, and wetlands fail to meet state water quality standards largely as a result of the effects of NPS pollution (from Table 4-1, DEQ, 2012). DEQ estimates that 37 percent of the state's perennial river and stream miles, and 72 percent of lake and reservoir acres have been assessed.

The NPS management program is a voluntary program of land, soil, and water conservation practices designed to prevent pollution from land-use activities. DEQ works with conservation districts, watershed groups, nonprofit organizations, local/state/federal agencies, and individual Montanans to provide training, monitoring support, and project funding. For those waters not meeting standards, TMDLs are developed, followed by voluntary implementation of best management practices for nonpoint sources, and potentially, point source permit waste load allocations (Figure V-25). The TMDL program establishes the maximum amount of a pollutant that a water body may receive and still be expected to achieve applicable water quality standards. TMDLs are designed to achieve and protect designated beneficial uses.

Besides nonpoint pollution, there is point source pollution. Point source pollution comes from a single point, commonly thought of as an end-of-pipe discharge. DEQ maintains a point source pollution control program, known as the Montana Pollutant Discharge Elimination System (MPDES), which is aimed at protecting water quality in water bodies receiving point source discharges from sewage, industrial, or other wastes.

Other water quality protection laws include Section 310 of the Montana Stream Protection Act, which requires conservation districts to regulate private activities that disturb the bed or banks of rivers and streams. Similarly, government activities that disturb the bed or banks of streams are regulated by FWP. Such activities include temporary disturbances, such as construction or maintenance activities for irrigation diversions. In addition, the legislature provided for creation of local water quality protection districts. Such districts have limited regulatory authority, and are primarily intended to provide funding to locally monitor and plan for the protection of water quality resources of particular concern to the people within the district.

Groundwater Quality Protection

The Montana Ground Water Pollutant Control System (MGWPCS) (Chapter 17.30, subchapter 10, ARM) is a regulatory program to control all otherwise unregulated sources of groundwater pollution. Important aspects of the MGWPCS rules are groundwater quality standards, a non-degradation requirement, and a discharge permit system. A wide variety of activities are exempt from having to obtain MGWPCS permits (see 75-5-401 MCA and 17.30.1022, ARM). Discharges from the exempted activities are typically covered under other permitting programs or regulations.

Groundwater quality is also addressed in the Agricultural Chemical Ground Water Protection Act. Under this act, DEQ is responsible for developing and enforcing groundwater quality standards for agricultural chemicals. DEQ is also charged under this act with monitoring, promoting research, and providing public education in cooperation with universities and other state agencies. The Montana Department of Agriculture (DOA) is charged with developing and enforcing agricultural chemical groundwater management plans aimed at preventing groundwater contamination from agricultural chemicals. Both DEQ and DOA have rules to implement their respective responsibilities under this act.

VIII. Potential Future Demands for Water in the Upper Missouri Basin

OVERVIEW OF PLANNING SCENARIOS

Estimates of water demand for public water systems and self-supplied domestic for the 20-year planning period ending in 2035 are based on population trends extrapolated from the 1990 and 2010 censuses and per-capita use rates. Population projections are provided at the state, county, planning basin, and sub-basin (4th-code, 8-digit HUC) levels. In those HUCs where negative growth was historically observed (54 HUCS, primarily located in the Lower Missouri and Yellowstone planning basins), zero population growth is assumed for planning purposes. The intent of these projections is not to predict or forecast precise population levels at particular points in time and locations in Montana; the purpose, rather, is to offer reasonable estimates of magnitudes of population growth that would presumably relate to the supply and demand for water in various ways over the course of the planning period. Extrapolating state-wide population growth at the average annual rate of population change for the period between 1990 and 2010 would result in 302,923 additional residents in 2035. If Montana's rate of growth were to continue at this rate, the state's population would reach 2 million in 2077.

Another set of population projections developed by the Montana Department of Commerce (MT Commerce) are available for comparison to the extrapolated census values. The MT Commerce projections are at the state and county levels developed using eREMI, a population projection product of Regional Economic Models, Inc. (REMI). Rather than extrapolate recent trends, the MT Commerce projections forecast declining rates of population increase through 2035, reflecting assumptions about Montana's age structure, natality and survival rates, and migration patterns over the period. Population increases forecast by the MT Commerce population are about half of the projections obtained by extrapolating census trends from 1990 to 2010. While the courses of population change in Montana and in particular parts of the state are highly uncertain from the perspective of the present, these projections offer two distinct scenarios for consideration when regarding prospects for future water use in Montana. They should be viewed as potentially useful tools in examining various factors affecting—and consequences affected by— the supply and demand of Montana's waters.

Scenarios of future demand for agricultural irrigation are based on trends in irrigation water use, and agricultural production statistics.

Projections of future irrigated acres, by watershed, will be developed using extrapolation of historic trends from National Agricultural Statistics Service (NASS) data, and possibly other sources

Future crop-type trends also will be assessed using trends from NASS data; water-use characteristics will vary as crop-type ratios change

Trends in irrigation system types (for instance: sprinkler versus flood) also will be used to predict future irrigation efficiencies, and resulting required per-acre diversions and per-acre water consumption rates. Irrigation system types also will affect return flow patterns and potential changes to these patterns also will be taken into consideration

Changes in the timing of irrigation demands and monthly crop irrigation requirements will be estimated for future scenarios and compared to historic conditions. Modeled temperature and precipitation projections will be used along with crop consumptive use equations to project future per-acre irrigation demands

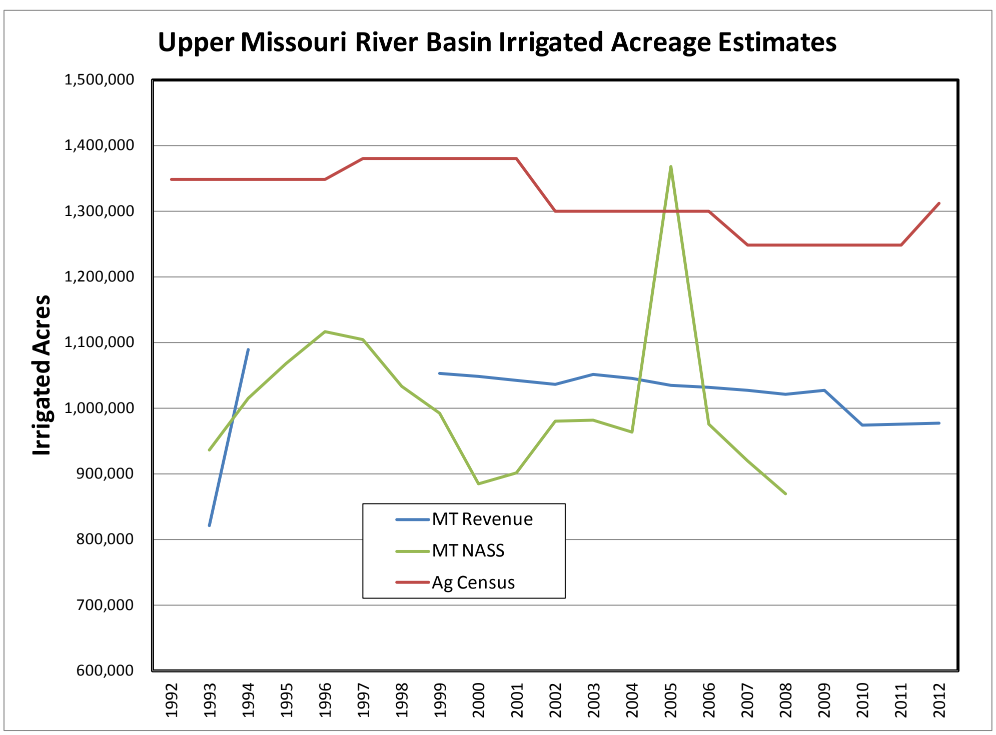
Upper Ruby Basin

AGRICULTURAL DEMAND PROJECTIONS

Trends in Irrigated Agricultural Development

Some general trends in irrigated lands in production during the last twenty years in the Upper Missouri Basin can be surmised from data in the Montana Department of Revenue Final Lands Unit (FLU) and National Agricultural Statistics Service (NASS) data, and Ag Census Data. Although the acreages estimated to be irrigated by the three sources vary, overall there does not appear to be a discernible trend of substantial increases or decreases In Upper Missouri River Basin irrigation (Figure 8.1).

Figure 8.1 Irrigation trends in the Upper Missouri River Basin.



WATER RESERVATIONS

In 1992, the Board of Natural Resources and Conservation issued an Order granting water reservations to Conservation Districts in the Upper Missouri River Basin for the development of irrigated land in the future. Although 18,675 acre feet was reserved for the future development in the Upper Missouri Basin, only about 2,000 acre-feet of this water has been developed, due to basin closures and economic factors. Two scenarios were developed to project future development of this reserved water. The first assumes that water will be developed at rates from trends to date; the second assumes that all of the reserved water will be developed by 2035. These scenarios are summarized in Table 8.1.

Table 8.1 Potential increases in Upper Missouri River irrigation due to development of water reservations

Scenario	Acres	Withdrawals (af)	Consumption (af)
Current Levels	2,299	4,311	3,449
Full Development	18,675	35,015	28,012

Each of these scenarios represents a relatively small increase in irrigated acres, and irrigation water use compared to the estimated current irrigated acreages of 902,118 acres, and withdrawals and consumption of 1,855,945 acre-feet and 969,620 acre-feet respectively. The water reservation process anticipates that most new irrigation projects will use sprinkler irrigation systems and that conveyance losses will be minimal. Consequently, the ratio of consumption to withdrawals for these projects will be much lower than the current basin-wide average of less than 30 percent.

INCREASES IN IRRIGATION CONSUMPTION DUE TO MODELED FUTURE EVAPOTRANSPIRATION RATES

With warming temperatures projected into the future, evapotranspiration (ET) by irrigated crops is expected to increase as well. Table 8.2 compares projected increases in ET and agricultural water consumption by 2035 for the following three future-climate scenario groupings: (1) lower range warming with wetter conditions, (2) middle range of warming with a small precipitation increase, and (3) higher range warming with drier conditions. The percentage increases used are based on modeled potential evapotranspiration for the Fairfield Bench agricultural area just north and west of Great Falls. More details on evapotranspiration, how it is projected to increase in the future, and the three scenario groupings can be found in the climate change section of this report. The projected increases in irrigation consumption, by subbasin, were computed based on the estimated volumes consumed under existing conditions, as presented in Table 8.2 of the Consumptive Water Use section of this report, times the projected percentage increase in ET.

Table 8.2 Upper Missouri River Basin projected increases in irrigation water consumption for three future scenarios by subbasin

Subbasin	Increase in simulated ET for 2010-2059 period compared to 1950-1999 period (acre-feet per year)		
	Scenario 1 3.3% ET Increase	Scenario 2 6.5% ET Increase	Scenario 3 8.5% ET Increase
Gallatin River	5,400	10,700	13,900
Madison River	1,600	3,100	4,100
Ruby River	800	1,600	2,100
Beaverhead-Red Rock Rivers	4,700	9,300	12,100
Big Hole River	1,400	2,800	3,600
Jefferson River	2,900	5,600	7,400
Missouri River Headwater Total (to Canyon Ferry Dam)	**16,800**	**33,100**	**43,200**
Smith River	1,300	2,600	3,400
Sun River	5,600	11,100	14,500
Missouri River main stem and smaller tributaries	2,100	4,100	5,400
Teton River	3,500	6,800	8,900
Marias River	5,600	11,100	14,500
Missouri River to Marias River Total	**34,900**	**68,800**	**89,900**

Overall, irrigation water consumption might increase from about 5 to 10 percent in the future due to increased evapotranspiration, and development of new irrigated lands through water reservations. Increases in irrigation withdrawals will likely be lower than 5 to 10 percent because, overall, irrigation systems are becoming more efficient and new acres would likely be served by pipe-to-sprinkler systems.

Potential Irrigation Development with Stored Federal Contract Water

There still are substantial volumes of stored water in Reclamation's Tiber and Canyon Ferry Reservoirs that might be available for future development through contract. Although there are no definitive plans now for large-scale irrigation development with this water, during the recent past there has been some interest expressed in developing more water from Tiber Reservoir for irrigation.

During 2005, DNRC, the Bureau of Reclamation, and their consultant assisted a local group in conducting a reconnaissance investigation on the potential of developing 20,000 to 40,000 acres of new irrigation with Bureau of Reclamation contract water from Tiber Reservoir (DNRC, 2005; Aquoneering, 2005). To date, the project has not been pursued further, due primarily to high projected water development and delivery costs.

MUNICIPAL AND DOMESTIC DEMAND PROJECTIONS

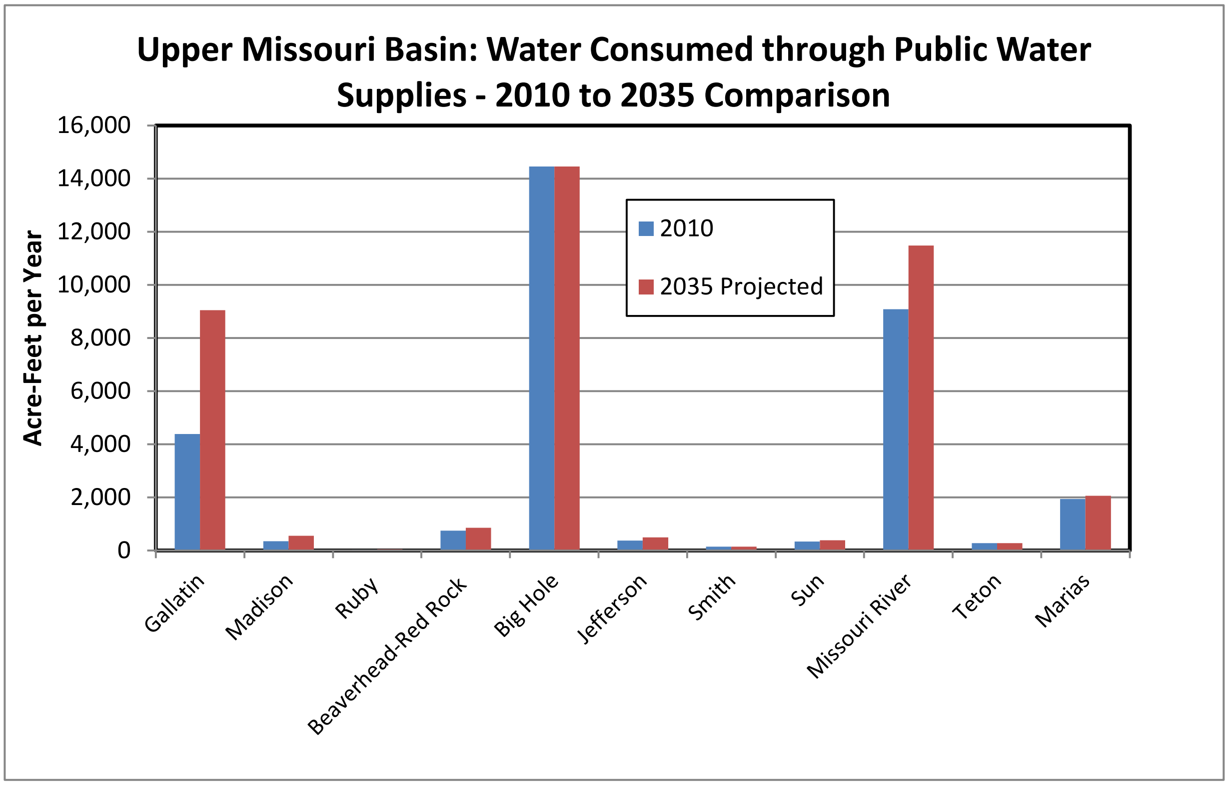
Water demands and consumption are expected to increase with population in the Upper Missouri River Basin. To keep up with this growth, public water systems might need to increase delivery capacity, and new public water supply systems might be built. Table 8.3 presents the projected 2035 population served by public water systems and projected volumes of water diverted and consumed to serve that population. Figure 8.2 compares estimates of the water delivered through public water supply systems that is consumed for 2035 versus 2010.

Table 8.3 Upper Missouri River Basin projected 2035 water use through public water supplies by sub-basin

Sub-basin	Projected 2035 Population Served	Projected 2035 Population Served Increase over 2010	Projected 2035 Volume Diverted (acre-feet)	Projected 2035 Volume Consumed (acre-feet)
Gallatin River	133,223	62,021	24,456	9,049
Madison River	14,881	3,028	1,502	556
Ruby River	1,016	182	138	51
Beaverhead-Red Rock Rivers	6,365	805	2,318	858
Big Hole River*	33,555	0	14,471	14,464
Jefferson River	3,584	871	1,347	498
Missouri River Headwater Total (to Canyon Ferry Dam)	**192,624**	66,907	**44,232**	**25,476**
Smith River	1,859	85	416	154
Sun River	4,709	687	1,067	395
Missouri River main stem and smaller tributaries	140,146	26,485	31,034	11,483
Teton River	2,327	0	760	281
Marias River	28,528	1,634	5,576	2,063
Missouri River to Marias River Total	**370,193**	95,798	**83,085**	**39,852**

* Primarily Big Hole River water diverted by the Butte-Silver Bow water system, from which waste-water does not return to the Missouri River Basin.

Figure 8.2 Water consumption through public water supply systems: 2010 – 2035 comparison



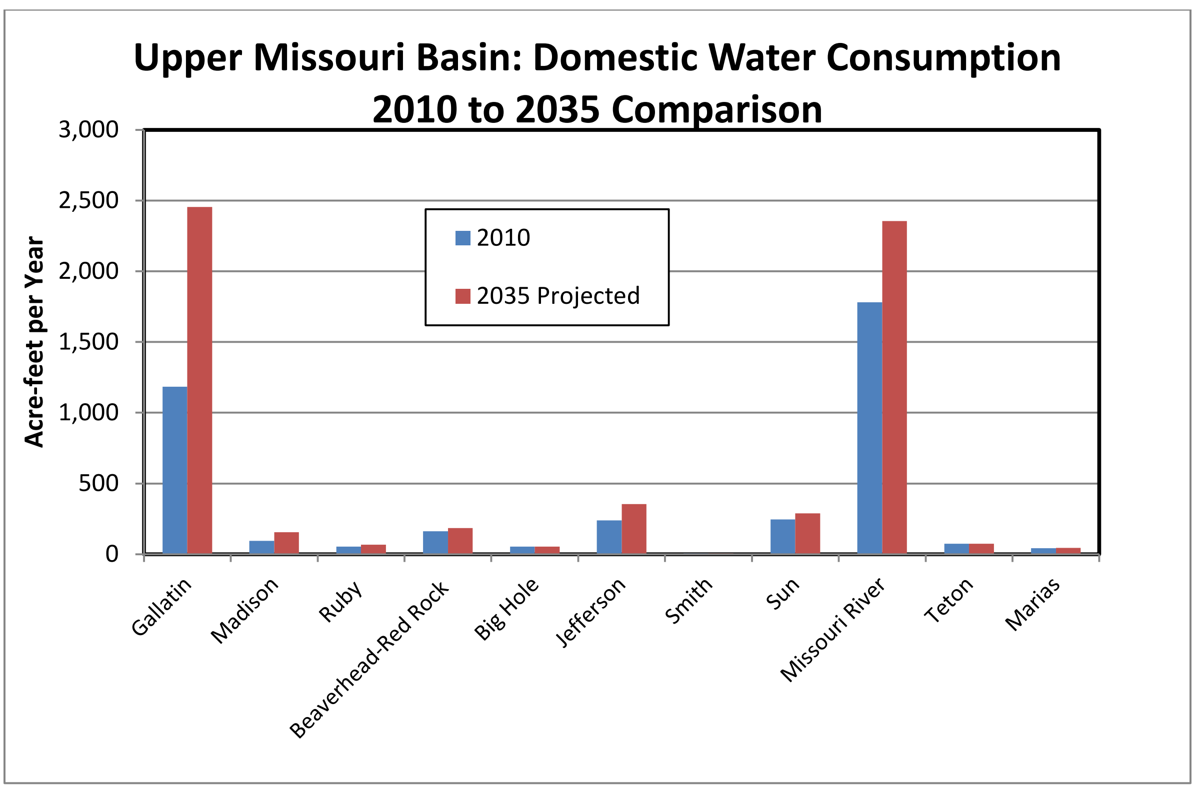
The population also is expected to increase in areas of the basin that are not served by public water supply systems. Most of this population likely will rely on individual wells for their water source. Table 8.3 presents the projected 2035 population of domestic water users not served by public water supply systems and projected volumes of water diverted and consumed by those users. Figure 8.3 compares estimates of the water consumed by domestic water users (not supplied by public water systems) for 2035 versus 2010.

Figure 8.3 Upper Missouri River Basin projected 2035 domestic water by sub-basin (non-public water supplies)

Sub-basin	Projected 2035 Population Served	Projected 2035 Population Served Increase over 2010	Projected 2035 Volume Diverted (acre-feet)	Projected 2035 Volume Consumed (acre-feet)
Gallatin River	56,043	27,037	4,910	2,455
Madison River	3,576	2,169	313	157
Ruby River	1,519	1,247	133	67
Beaverhead-Red Rock Rivers	4,223	3,729	370	185
Big Hole River*	1,235	1,235	108	54
Jefferson River	8,080	5,455	708	354

Sub-basin	Projected 2035 Population Served	Projected 2035 Population Served Increase over 2010	Projected 2035 Volume Diverted (acre-feet)	Projected 2035 Volume Consumed (acre-feet)
Missouri River Headwater Total (to Canyon Ferry Dam)	**74,676**	40,872	**6,542**	**3,272**
Smith River	147	140	13	6
Sun River	6,583	5,621	577	288
Missouri River main stem and smaller tributaries	53,745	40,634	4,709	2,354
Teton River	1,701	1,701	149	75
Marias River	1,051	953	92	46
Missouri River to Marias River Total	**137,903**	89,921	**12,082**	**6,041**

Figure 8.4 Projected 2035 domestic water consumption compared to estimated 2010 consumption



INDUSTRIAL DEMAND PROJECTIONS

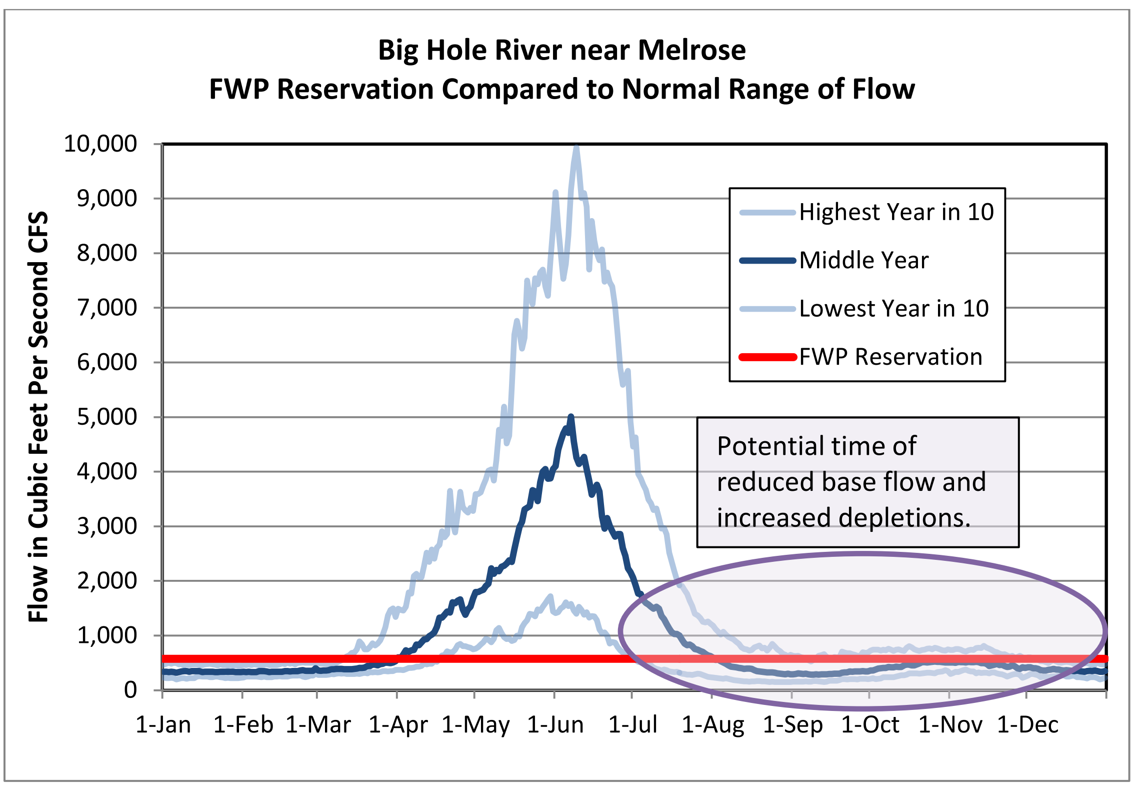
Water demand for construction and other urban industrial water uses generally are expected to grow in proportion to population and are reflected in projections of future water demands for public water supplies. Other industrial uses, such as mining and fracking for oil and gas extraction, are not served by public water supplies and do not follow predictable trends. Water needs can be as high as 10 to 25 acre-feet per well for fracking and this could add significantly to local demands in areas that have oil-bearing strata similar to the Bakken in the Williston Basin, such as central Montana and the Rocky Mountain Front.

INSTREAM FLOW DEMAND PROJECTIONS

As discussed in the non-consumptive uses section of this report, the Montana Department of Fish, Wildlife and Parks holds Murphy rights and water reservations on many streams in the Upper Missouri River Basin to maintain aquatic habitat for fish, wildlife, and recreation. These instream flow rights typically are for lower, base flows. As discussed in the climate change section of this report, runoff timing changes are projected for the future, with December-through-March flows showing an increasing trend, while late season flows (June through November) show a decreasing trend. This suggests that, in the future, instream flows will be lower during late summer and early fall. Further contributing to this seasonal trend might be increased depletions due to higher evaporation by irrigated crops, and increased water use by municipal and domestic water users (see discussions on future water demands). The earlier shift in runoff timing is more predominant for the warmer future climate scenario groupings.

Figure 8.4 shows FWP water reservation amounts for the Big Hole River, highlighting the summer and early fall low-flow period, where reduced water supplies and increased depletions are projected.

Figure 8.5 Big Hole River flow graph with times when lower minimum flows are projected highlighted



Data source http://mt.water.usgs.gov/

Demand for instream flow and recreation takes many forms including flat water and stream fisheries, aquatic habitat including wetlands, boating and wildlife. Population growth, demographic trends, trends in hunting and pattern of demand for instream flows.

EFFECTS OF NEW OR INCREASED DEPLETIONS ON THE AVAILABILITY OF FUTURE SURFACE WATER SUPPLIES

Agricultural

Agricultural water demands and depletions over the next 20 years in the Upper Missouri River Basin might increase from about 5 to 10 percent overall due to a combination of continued development of water reservations and increases in evapotranspiration. Although this rise in depletions would be modest overall, it could lead to increased competition for water and increased dewatering, especially on streams where water shortages already occur.

Municipal and Domestic

In most cases, municipal and domestic demands are projected to increase at moderate rates in the Upper Missouri River basin and are not expected to significantly increase depletion of water supplies. Where development is concentrated, localized impacts might still occur, especially to aquifers and connected surface water resources. An example would be the Gallatin Valley, where municipal and domestic water consumption might double by the year 2035, a rise of about 5,000 acre-feet per year over current consumption.

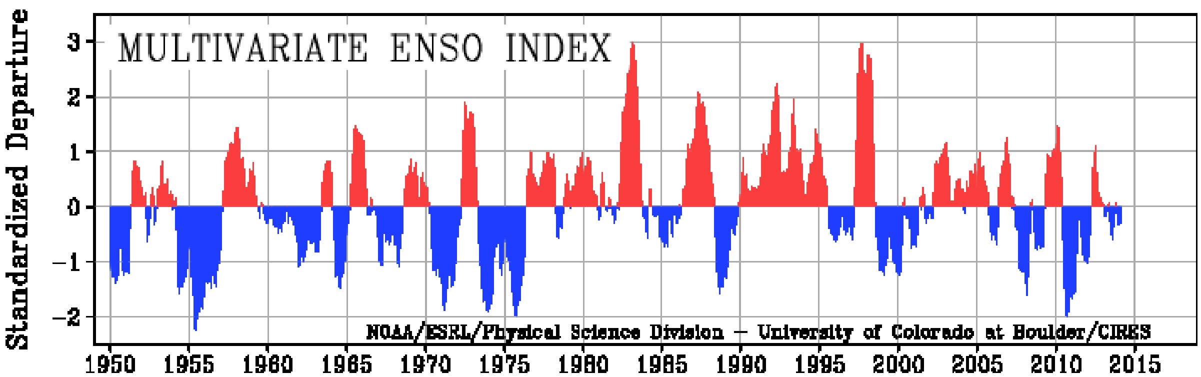
EFFECTS OF PROLONGED DROUGHT AND CLIMATE VARIABILITY ON THE AVAILABILITY OF FUTURE SURFACE WATER SUPPLIES.

Climate Variability

The climate of the Upper Missouri River Basin varies from day to day, month to month, year to year, and even between decades. For instance, thunderstorms affect the weather at a local scale and for a short duration, while the position of the jet stream can affect the weather during an entire winter at a continental scale. At the global scale, factors that include climate fluctuations connected to the temperatures of the Pacific Ocean, such the El Niño Southern Oscillation (ENSO), can affect temperature and precipitation for a series of years. Other dynamics, such as Pacific Decadal Oscillation (PDO) can have effects that persist for decades. All of these factors lead to variability in water supplies and demands, including the drought cycles familiar to residents in the Upper Missouri Basin.

ENSO can affect the timing of the basin's wet and dry cycles and is attributed to changes in the near-surface temperature of Pacific Ocean off the coast of South America, which can be characterized by warm, cool, and neutral phases. The general effects of these oscillations between ENSO phases for the Upper Missouri Basin is as follows: (1) El Niño or warm phases are characterized by below average precipitation, (2) La Nina or cool phases are characterized by above average precipitation, and (3) ENSO neutral conditions have about an equal chance of above or below average precipitation. The Multivariate ENSO Index (NOAA) presented in Figure 8.5 below uses several oceanic parameters to create an index of El Niño, La Niña or natural conditions. In general, red positive numbers represent warm (El Niño) conditions and blue negative numbers represent cold (La Niña conditions). The strength of the El Niño or La Niña is indicated by a greater positive or negative number. Neutral conditions are indicated by values near zero.

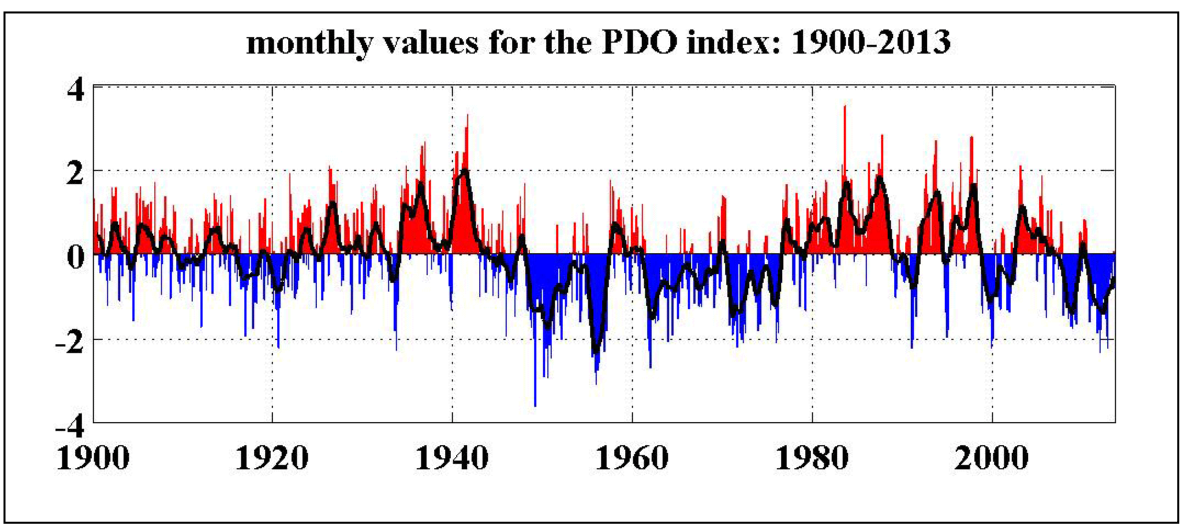
Figure 8.6 NOAA Multivariate ENSO Index



The Pacific Decadal Oscillation (PDO) is described as changes to the temperature of water in the North Pacific Ocean. The warm and cool phases of the PDO occur on an inter-decadal time scale, typically lasting 20 to 30 years. The PDO index is presented in Figure 8.6 (JISAO) with the strength of the warm or cool phase indicated by the magnitude of the positive or negative index.

For the Upper Missouri Basin, the warm phase (positive) of the PDO generally results in drier conditions and the cool (negative) phase typically results in wetter conditions. The data indicates that the PDO recently changed to the cool negative phase.

Figure 8.7 PDO index from 1900 to 2013

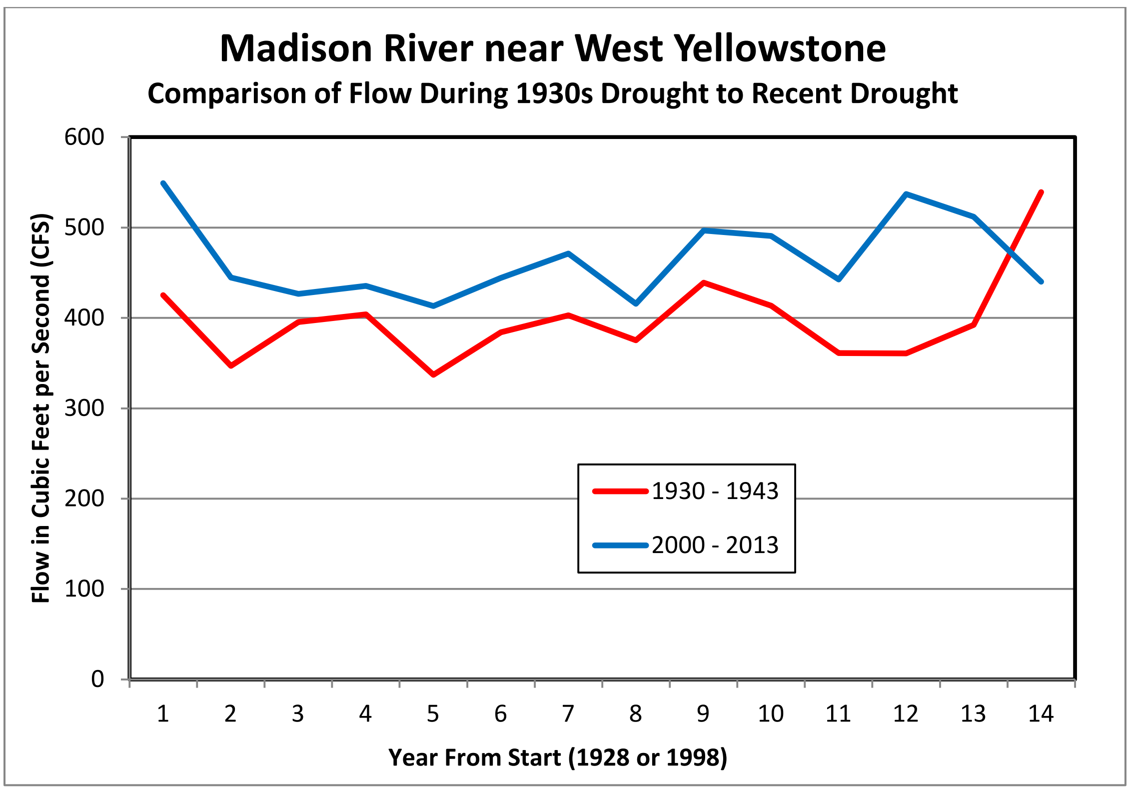


Drought

Drought by definition is an extended period when a region is deficient in water supply. Drought in the Upper Missouri River Basin varies in time and space. It is not uncommon for portions of Montana or even the Upper Missouri Basin to be in drought conditions while other areas will have excess water supply. The most momentous drought in modern history occurred during the 1930s, but most of today's population did not live through it. A more recent series of drought years occurred in the early 2000s. Because this recent drought is the point of reference for most people for how dry it can get, a comparison of water supply conditions in the Upper Missouri River Basin during the most recent drought was made to that for the 1930s drought. This might provide some context on how severe drought conditions can get in the Upper Missouri River Basin, and how our current infrastructure might perform under similar conditions in the future.

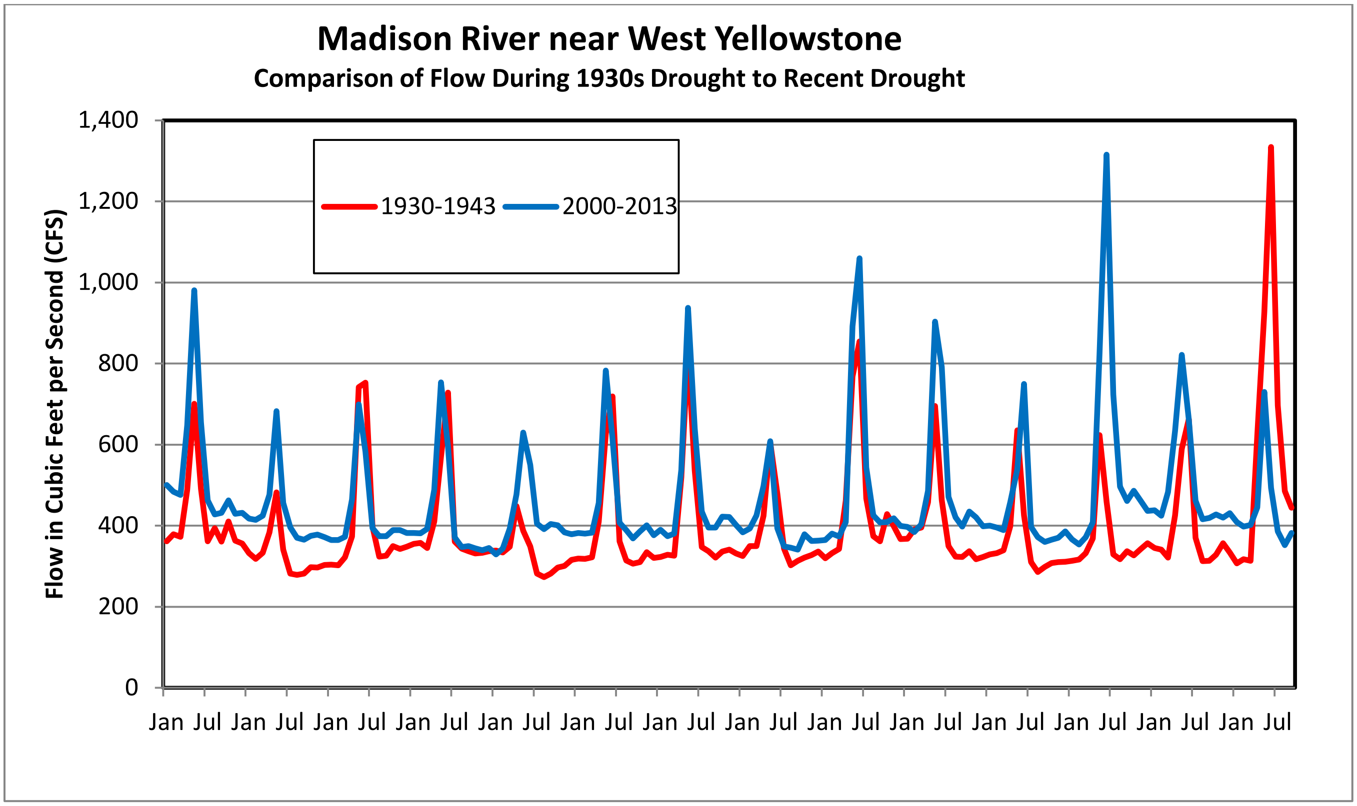
The 1930s drought was more severe than the most recent drought in the headwaters area. Figure 8.7 and 8.8 compare annual and monthly average flows for the Madison River near West Yellowstone, Montana, for the 1930s and 2000s drought periods. Overall, the river produced about 15 percent less water during the 1930s than it did during the more recent drought. Base flows appear to have been even lower. The Madison River near West Yellowstone gaging station was chosen as an indicator because the basin upstream is in a natural condition and not significantly influenced by human activities that could have changed over time.

Figure 8.8 Average annual flow comparison for the Madison River near West Yellowstone: 1930s versus 2000s drought.



Data source http://mt.water.usgs.gov/

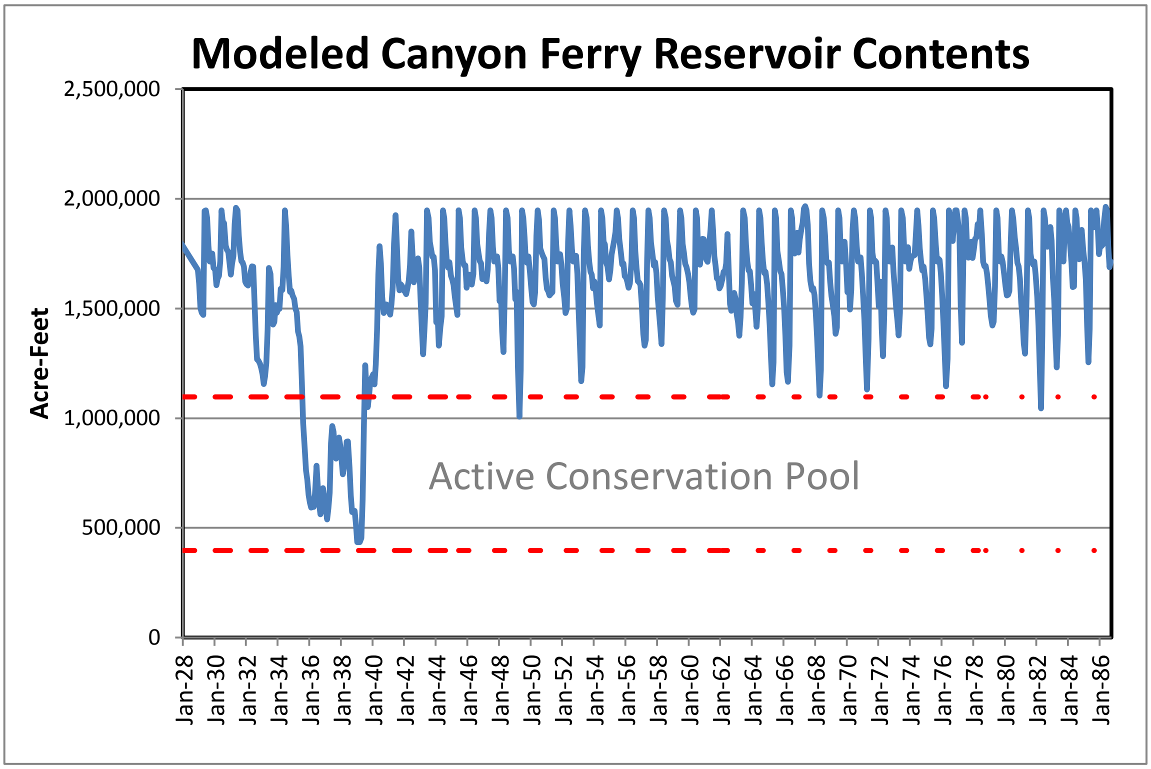
Figure 8.9 Monthly flow comparison for the Madison River near West Yellowstone: 1930s versus 2000s drought.



Data source http://mt.water.usgs.gov/

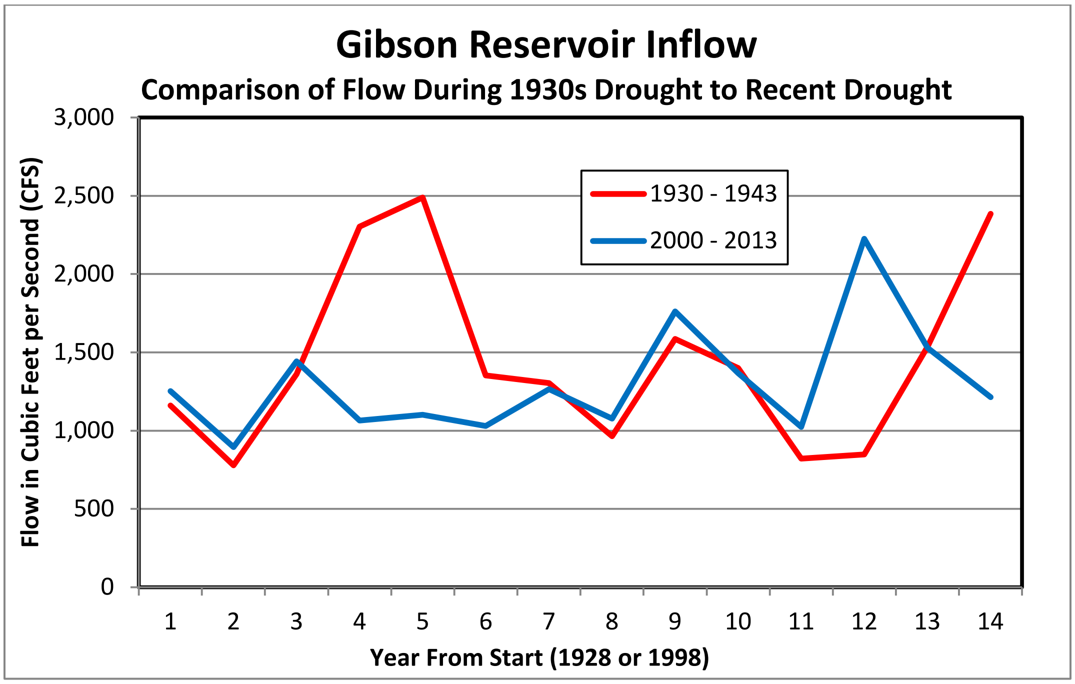
Canyon Ferry Reservoir, with a storage capacity of almost 2 million acre-feet, is by far the largest reservoir in the Missouri headwaters area. Although Canyon Ferry Reservoir was not completed until 1954, it is possible through modeling to simulate how the reservoir might have performed had it been in place during the 1930s drought. Figure 8.9 is a graph of simulated Canyon Ferry Reservoir contents for the 1928-1985 period based on the DNRC Missouri Basin Model (Dolan and Deluca, 1993). The simulation shows reservoir contents dropping to near the bottom of the active reservoir conservation pool during the drought. Under this simulation, the reservoir was modeled to attempt to maintain current levels of downstream hydropower production. It is possible, or perhaps even probable, that USBR would modify its operations of the reservoir under these extreme circumstances to avoid such a low reservoir drawdown. Still, the simulation demonstrates that a prolonged drought of this magnitude would stretch the limits of the carry-over storage of even the largest reservoir in the basin. The ability of the smaller reservoirs to meet demands likely would be even more constrained.

Figure 8.10 Modeled Canyon Ferry Reservoir Contents



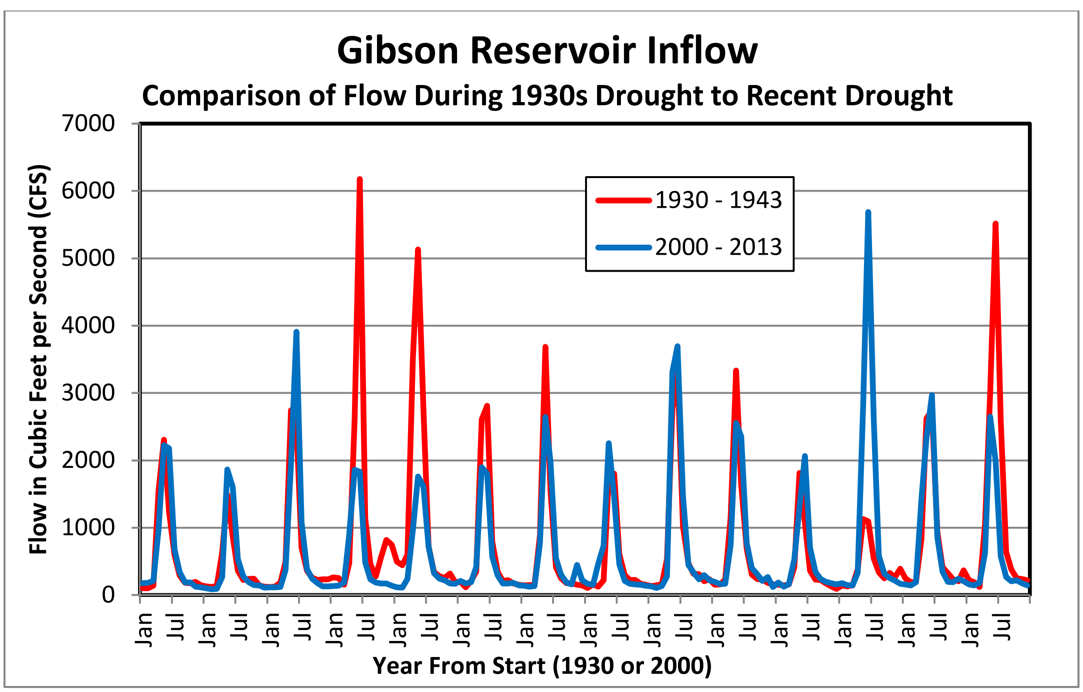
In the middle and lower portions of the Upper Missouri River Basin, the most recent drought might have been of a similar magnitude to that of the 1930s. Gibson Reservoir on the Rocky Mountain Front at the confluence of the North and South Forks of the Sun River was completed in 1929. Figures 8.10 and 8.11 compare annual and monthly average Gibson Reservoir inflow for the 1930s and 2000s drought periods. Overall, it appears that the two periods were similar, with the more recent drought having lower runoff peaks overall. In this case, local water users have had the recent experience of managing the resource during a historic drought of near record magnitude.

Figure 8.11 Average annual comparison for Gibson Reservoir inflow: 1930s versus 2000s drought



Data Source: U.S. Bureau of Reclamation Hydromet system; http://www.usbr.gov/gp/hydromet/

Figure 8.12 Monthly comparison for Gibson Reservoir inflow: 1930s versus 2000s drought



Data Source: U.S. Bureau of Reclamation Hydromet system; http://www.usbr.gov/gp/hydromet/

EFFECTS OF DROUGHT ON GROUNDWATER SUPPLIES AND THE ROLE OF GROUNDWATER IN SUSTAINING BASE FLOW DURING DROUGHTS

In general, groundwater is an important storage reservoir that supports base flow during dry years and in the early years of extended droughts. Prolonged drought slows aquifer recharge, so less groundwater storage is available to support base flow and water levels decline.

Groundwater sensitivity to drought varies throughout the Upper Missouri River Basin and is correlated to the groundwater system's ability to transmit and store water, location to surface water (recharge), and depth below the ground surface. The GWIC statewide monitoring network provides long-term water level records that show change in groundwater storage or pressure. Upward trends (increasing elevation and decreasing distance to water) show increased groundwater storage or pressure. Most hydrograph traces portray concurrent high- and low-frequency signals that illustrate the local balance between the numerous signal sources. The high-frequency signals are related to seasonal/annual trends, while the low-frequency, slowly varying signals are characteristic of climate sensitive wells (Patton, 2013).

Groundwater levels in the Madison Group near Great Falls (Figure 8.12) respond to multi-year trends in climate variability (GWIC # 2526). For example, water levels fell approximately 10 feet during the early 2000s drought period. Beginning in 2006, water levels rose to the current levels, which were last seen in 1995-1996.

Monitoring wells (GWIC # 130177) on the East Bench near Dillon (Figure 8.13) show water levels prior to the East Bench irrigation project, increased water levels from irrigation leakage, and water level declines as irrigation practices change. Evident in the graph is a 'climate' response in 2005-2006 that occurred because Clark Canyon Reservoir was not able to supply water to the East Bench irrigation district (Patton, 2013). The hydrograph shows the impact of annual water level fluctuations superimposed on a large-amplitude, low-frequency cycle that is likely climate related.

The water levels in the Eagle Formation well (GWIC # 85046) near Valier (Figure 8.14) show water level responses to climate variability, during periods of dry and wet cycles. The hydrograph shows annual changes in signal related to seasonal recharge and trends in precipitation and runoff near Valier.

Figure 8.13 Long-term record of groundwater levels in the Madison Limestone near Great Falls showing the effects of drought in the 2000s and recovery during wetter periods (***GWIC # 2526***).

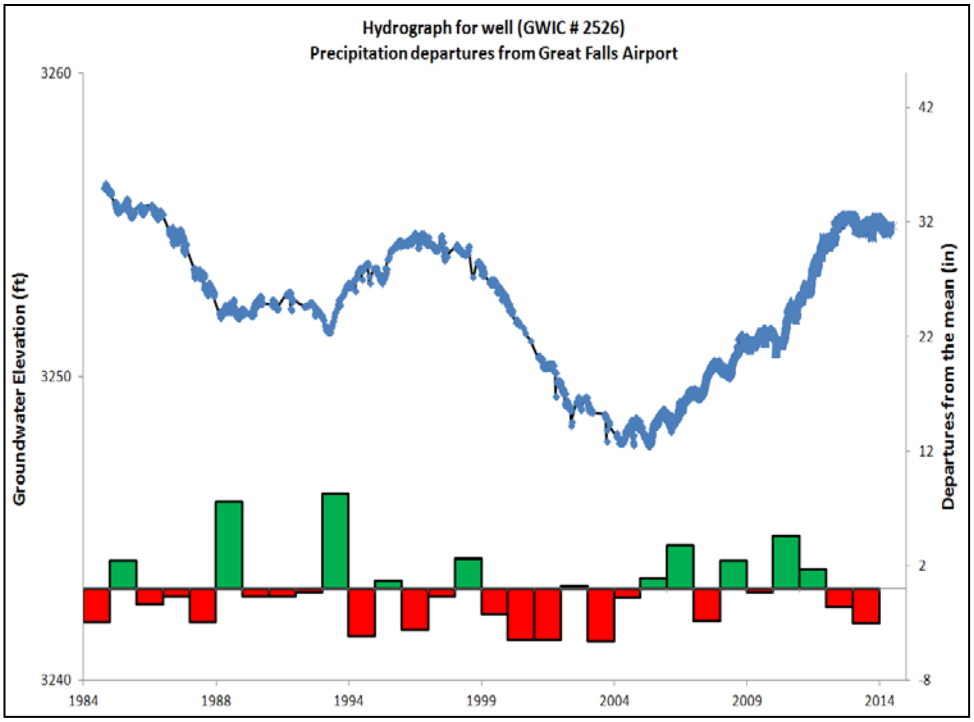


Figure 8.14 Long-term record of Tertiary sediment groundwater levels on the East Bench Irrigation district showing pre-irrigation in 1960s, pressuring up in the 1970s, and long-term cyclic decline (GWIC # 130177).

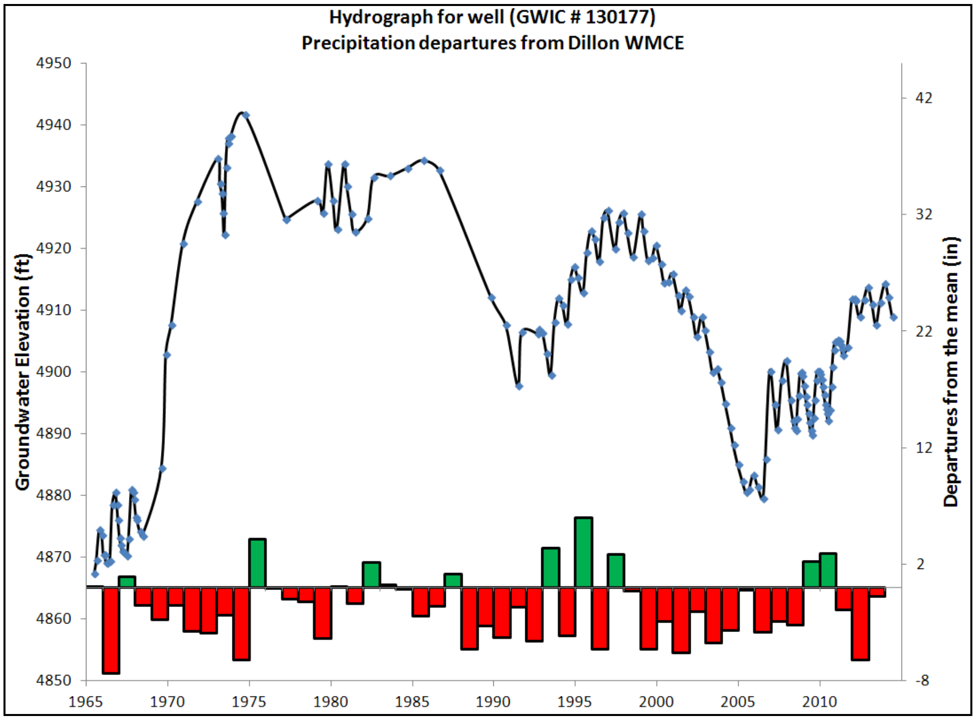
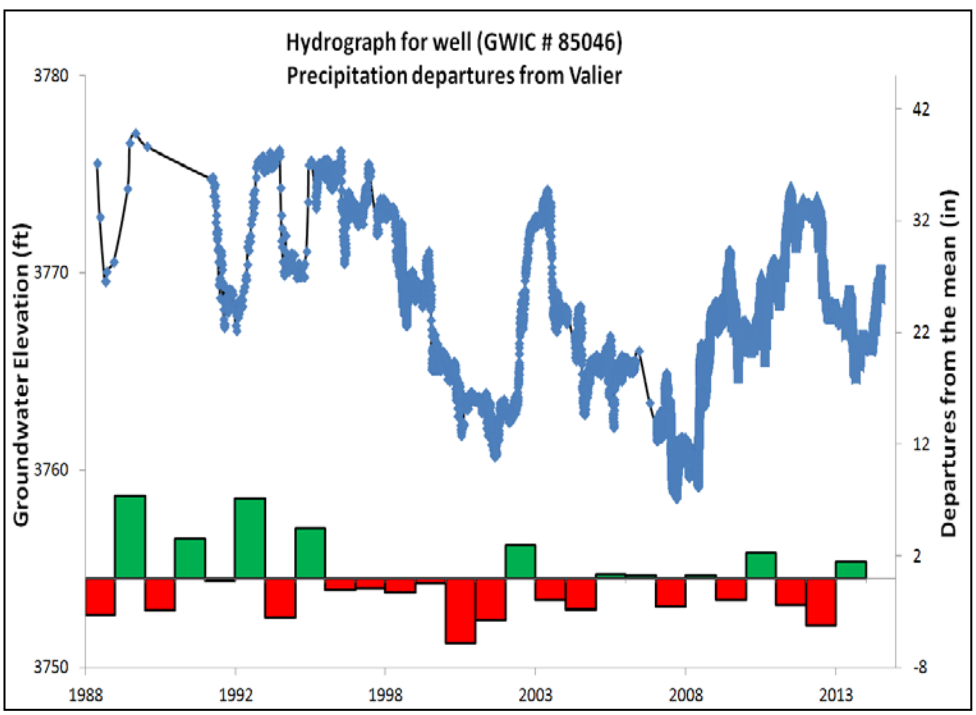


Figure 8.15 Groundwater levels in the Eagle Formation near Valier showing the effects of dry periods and recovery during wetter periods (*GWIC # 85046*).



POTENTIAL EFFECTS OF CLIMATE CHANGE ON FUTURE WATER SUPPLIES AND DEMANDS

Introduction

Traditionally, water planning assessments have assumed that future water supply conditions will be similar to what they have been in the past while recognizing that the exact sequencing of past flow patterns will not be repeated. Recent information suggests that future streamflow variability may differ from historical trends. Much of the United States has warmed during the 20th century and this is likely to continue in the 21st century. This warming, in turn, will affect the amount and distribution of precipitation, and whether that precipitation occurs as rain or snow. It also will affect the rates of evaporation and evapotranspiration by natural vegetation and irrigated crops. An important water-resources implication is that streamflow is likely to change in amount, timing, and distribution. This section discusses climate change in the Upper Missouri River Basin, with a focus on how these projected changes in climate might affect water supply and demand. This information can be used to evaluate the ability to meet future water demands within the basin and to identify adaptation strategies.

Methods

The general procedures used in this section are similar to those described in the USBR (2011) West-Wide Climate Risk Assessments. Future temperature and precipitation projections were obtained from the Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections archive site maintained by USBR at: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/. The root climate data sources for this archive are the World Climate Research Program Coupled Model Intercomparison Project3 (WCRP CMIP3) phase 3 multi-model climate projections (Meehl et al., 2007). The CMIP3 dataset consists of results from coupled atmosphere and ocean general circulation models, which simulate global climate responses to future greenhouse gas (primarily carbon dioxide) emissions. A range of modeled scenarios were available, based on how potential greenhouse gas emission rates and atmospheric concentrations might vary with global technological and economic developments during the 21st century. In total, 112 climate projections, based on projections by 16 different CMIP3 models, were downloaded and used for this analysis. The CMIP3 and CMIP5 Climate and Hydrology Projections archive site contains statistically down-scaled global-scale climate projections to a 12-kilometer (km) square grid (1/8° latitude by 1/8° longitude), which were used because raw CMIP3 dataset and climate models projections are too coarse for basin-scale water resources planning.

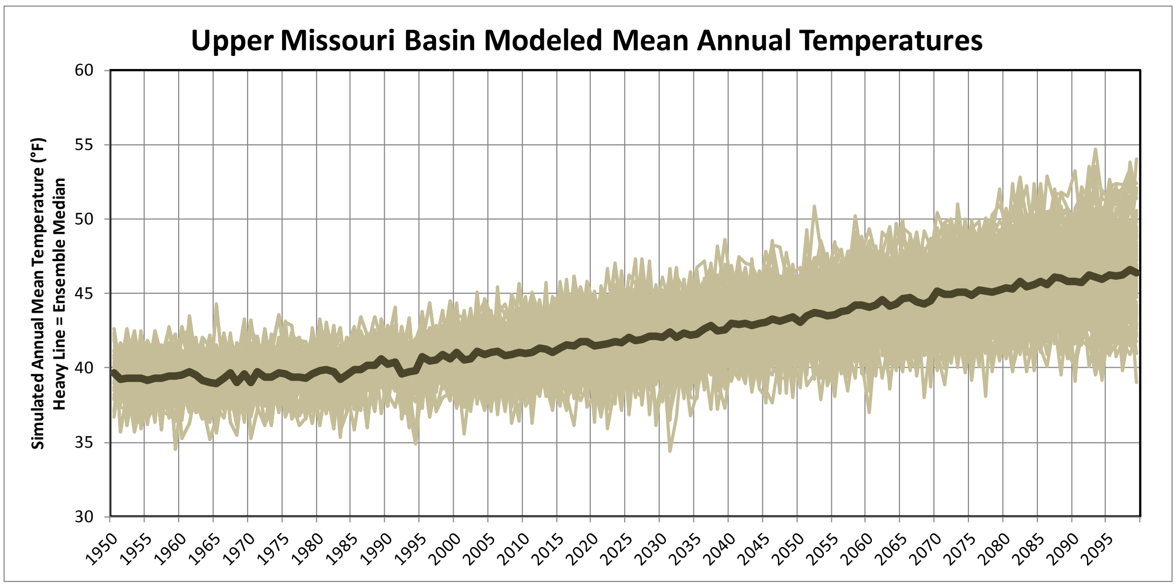
Hydrology projections also were downloaded from the same Reclamation Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections archive website, for the same 112 CMIP3 projections. The projections were developed using the University of Washington Variable Infiltration Capacity (VIC) hydrology model (Liang et al., 1994; Liang et al., 1996; Nijssen et al., 1997) to translate climate data to streamflow runoff, and the VIC model also produces evapotranspiration and snow water equivalent output data. Input data to the VIC model is spatially downscaled precipitation, temperature, and wind speed data. Output includes runoff (both surface and subsurface runoff), evapotranspiration, and snow water equivalents over a grid corresponding to the watershed selected. The model solves the water balance for each grid cell, and then the gridded runoffs are linked and hydraulically routed to a watershed outflow point.

The 112 downscaled CMIP3 temperature, precipitation, and hydrologic projections were obtained from the USBR website for the 1950-2099 period. Because the period for this state water plan cycle is 20 years, discussions here will focus on comparing model results that are representative of the recent past (1950-1999) to those for a look-ahead period centered on the year 2035 (years 2010-2059).

Temperature

Figure 8.15 graphs simulated Upper Missouri Basin mean annual temperatures. The solid line represents the median change, while the shaded band represents the variability for the 112 climate projections. All of these projections indicate that temperatures in the Upper Missouri Basin will continue a warming trend into the future, although the rate of warming projected varies among the models and scenarios. Average annual temperature increases for the 2010-2059 period over those for 1950-1999 period ranged from 1.1° to 4.8° Fahrenheit, with the median increase being 2.8°.

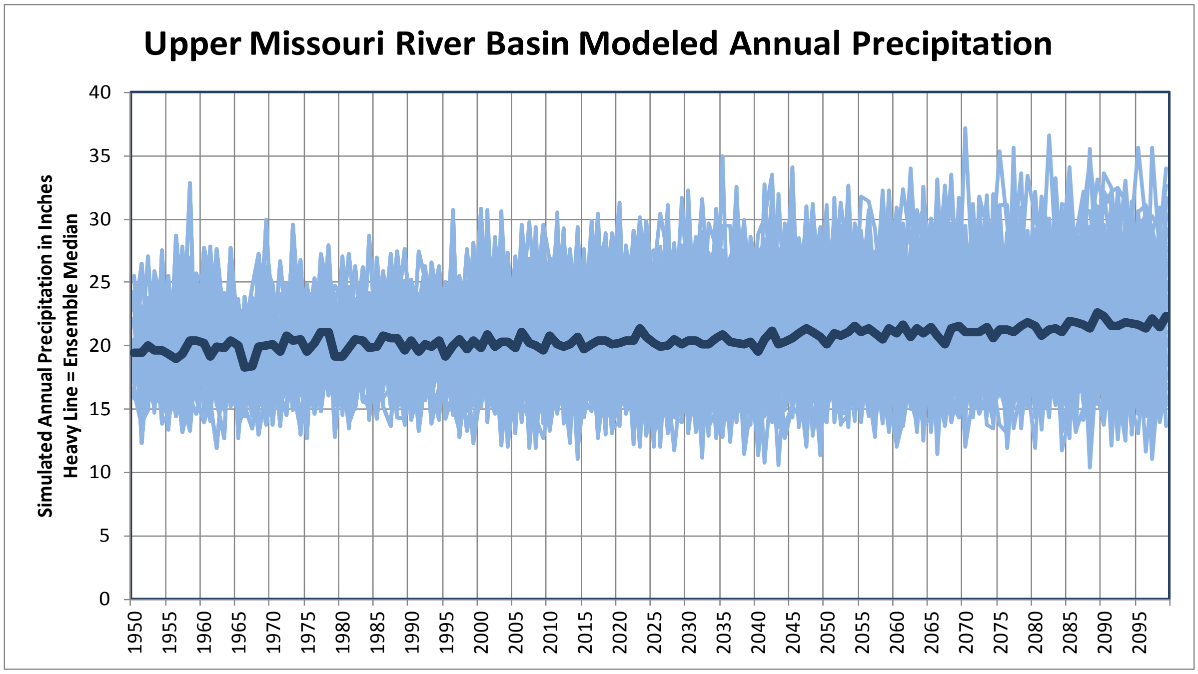
Figure 8.16 Mean annual temperature simulations based on downscaled projections from 112 GCM models



Precipitation

The projections for precipitation are more mixed with scenario trends varying from somewhat wetter to somewhat drier, with most depicting a nominal wetting trend but perhaps increased variability over time (Figure 8.16). For the Upper Missouri Basin, the maximum projected increase for the 2010-3059 period relative to the 1950-1999 period was 4.6 inches (22.8%) and the minimum was for a decrease of 1.1 inches (5.5%), with a median projected increase of 0.5 inches (2.4%).

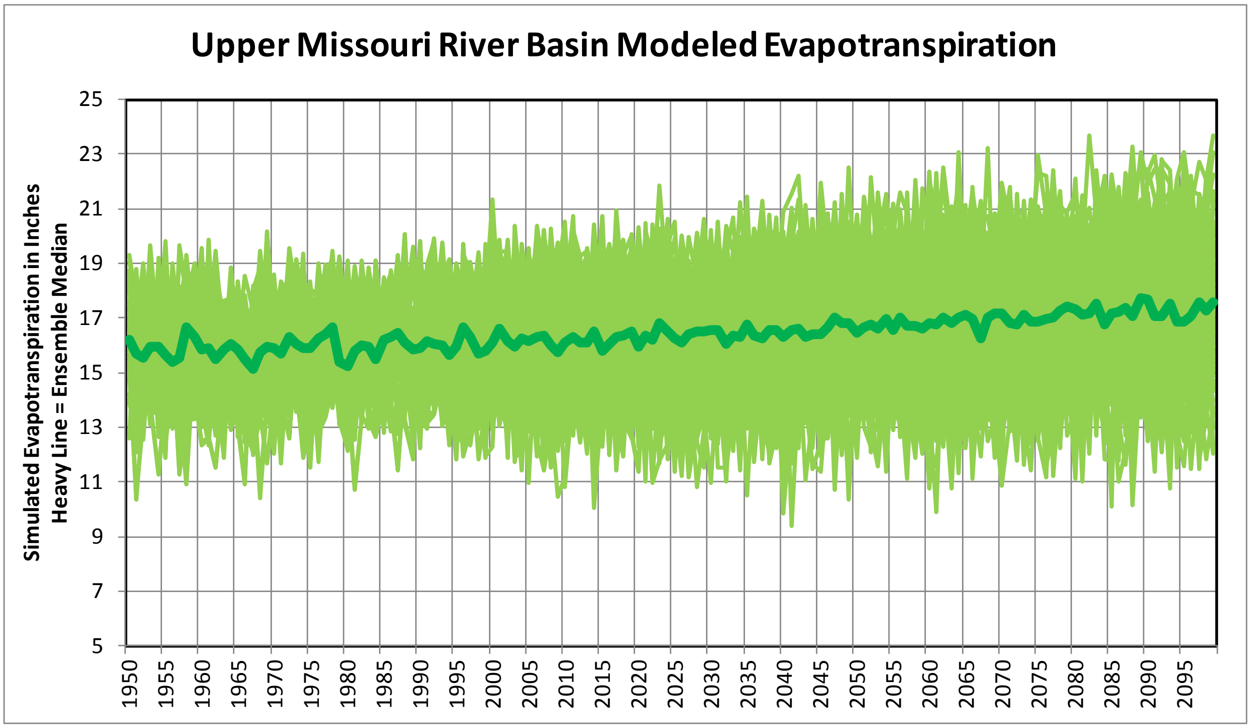
Figure 8.17 Annual precipitation simulations for the Upper Missouri Basin based on downscaled projections from 112 GCM models



Evapotranspiration (ET)

As described in the Streamflow section of this report, only about 18 percent (about 3.5 inches) of the precipitation that falls on the Upper Missouri Basin ultimately leaves the basin as streamflow. Most precipitation will infiltrate into the soil profile and most of this will be consumed by plants or evaporated from the surface of the soil through the process of evapotranspiration. Evapotranspiration is projected to increase under most scenarios as temperatures warm and the growing season increases, although some of the modeled scenarios showing an ET decrease due to projected drier conditions. Figure 8.17 depicts modeled ET by natural vegetation in the Upper Missouri Basin for the 1950-2099 period. ET is projected to increase under most modeled scenarios for the 2010-1959 period compared to the 1950-1999 period. The maximum modeled increase was 2.6 inches (16%), the maximum decrease 0.8 inches (5%), and the median increase was .5 inches (3.1%).

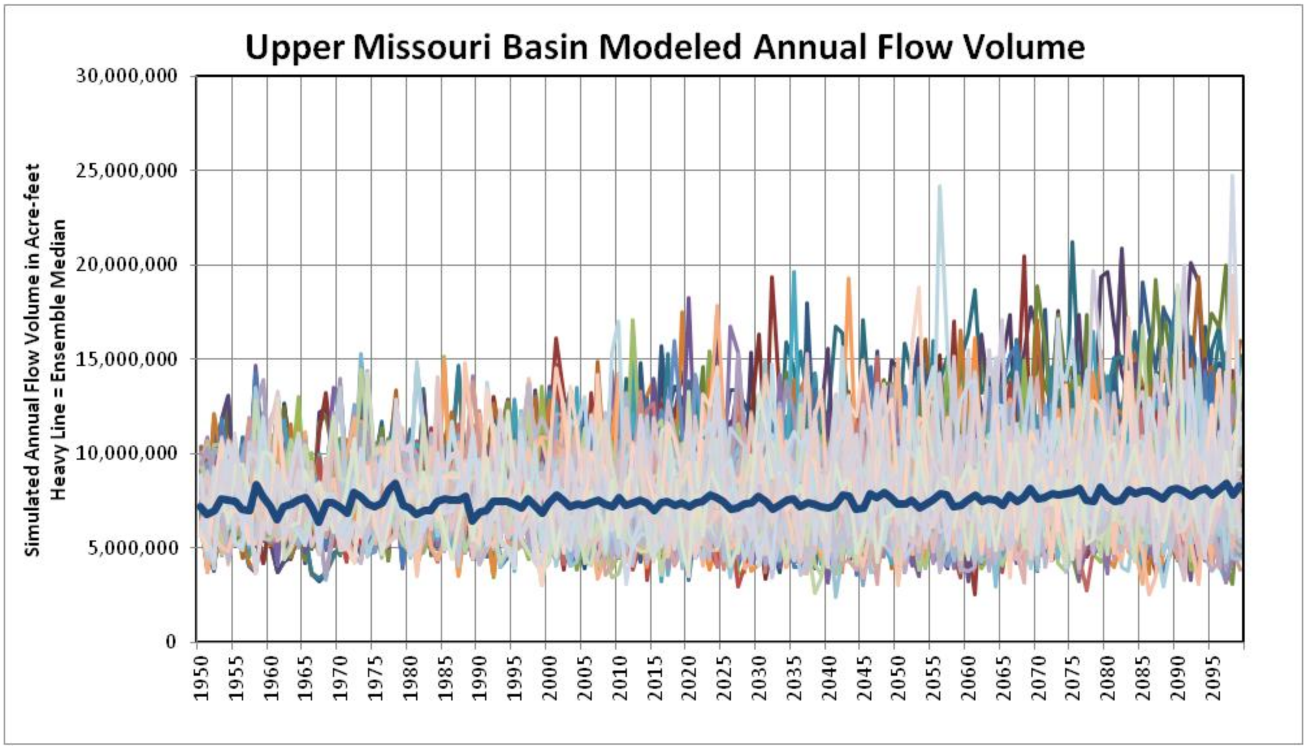
Figure 8.18 Annual evapotranspiration by natural vegetation simulations for the Upper Missouri Basin based on VIC model results and downscaled projections from 112 GCM models



Runoff (Annual Volume)

The total amount of flow produced in the Upper Missouri River Basin depends on the amount of precipitation that is received, and how much of that precipitation is not consumed by evapotranspiration and evaporation and can be realized as runoff. Figure 8.18 depicts the modeled annual runoff volumes for the Upper Missouri River Basin at the basin outflow point, at the Missouri River near Virgelle. For this graph, unique colors have been assigned to each of the 112 model simulation trace lines, with the dark line depicting the ensemble median. Although most scenarios project modest increases in precipitation for the Upper Missouri River Basin, the projected evapotranspiration increases seem to offset these. Annual runoff volume is projected to be similar under most modeled scenarios for the 2010-1959 period compared to the 1950-1999 period, with a few scenarios projecting substantial increases and a few others projecting substantial decreases. The maximum modeled increase was 2,630,000 acre-feet inches (37 percent), the maximum decrease was -1,450,000 acre-feet (-19 percent), and the median was for a small increase of 4,000 acre-feet (0.06 percent). These runoff volumes are for “natural” flow, before depletions due to irrigation and other uses, and reservoir operations and evaporation. The median gaged annual flow volumes at Virgelle are about 1,000,000 acre-feet lower than the modeled volumes for the historic period, due to these depletions associated with human uses.

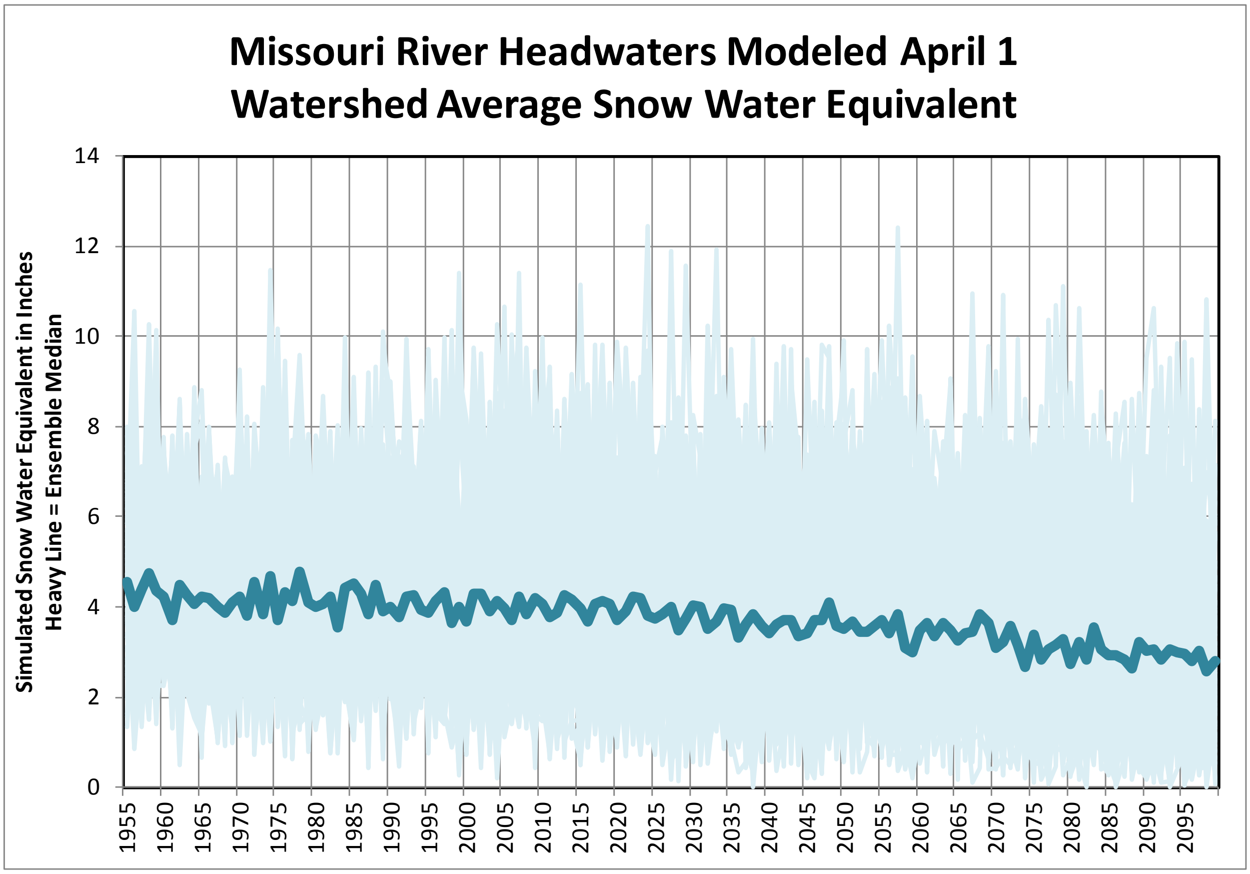
Figure 8.19 Simulated annual natural flow volumes for the Upper Missouri Basin based on VIC model results and downscaled projections from 112 GCM models



Snow

Warmer temperatures would affect the accumulation of snow in the mountains during the cooler months and the availability of melting snow to sustain runoff during spring and summer. The hydrology of much of the Upper Missouri Basin is snow-melt dominated and warming temperatures likely would lead to proportionally more rain and less snow. Snow water equivalent (SWE) on April 1 is a measure for assessing snowpack and subsequent spring–summer runoff conditions in the snowmelt dominated basins. SWE is a variable computed and used by the VIC hydrology model for each grid cell. Figure 8.19 depicts modeled April 1 snowmelt conditions for the Missouri River headwaters area (upstream of Canyon Ferry Dam) for the 112 simulations. This gridded SWE on April 1st was averaged over all the grid cells in the headwaters area to calculate the basin-wide April 1st SWE in each of the simulation years from 1950–2099. April 1st SWE shows a decreasing trend, although about 20 percent of the modeled scenarios show a trend of increasing April 1 SWE for the years 2010-2059 relative to the 1950-1999 base. The highest decrease for the 2010-2059 period relative to the 1950-1999 base was 1.4 inches SWE (32.4 percent decrease) while the largest increase was 1.0 inches (24.4 percent) and the median SWE decrease was 0.4 inches (8.9 percent). Under most modeled scenarios increased precipitation overall, mostly in the form of rain, might somewhat offset the snow decreases.

Figure 8.20 Modeled April 1 snow water equivalents for the Missouri River headwaters area based on VIC model results and downscaled projections from 112 GCM models

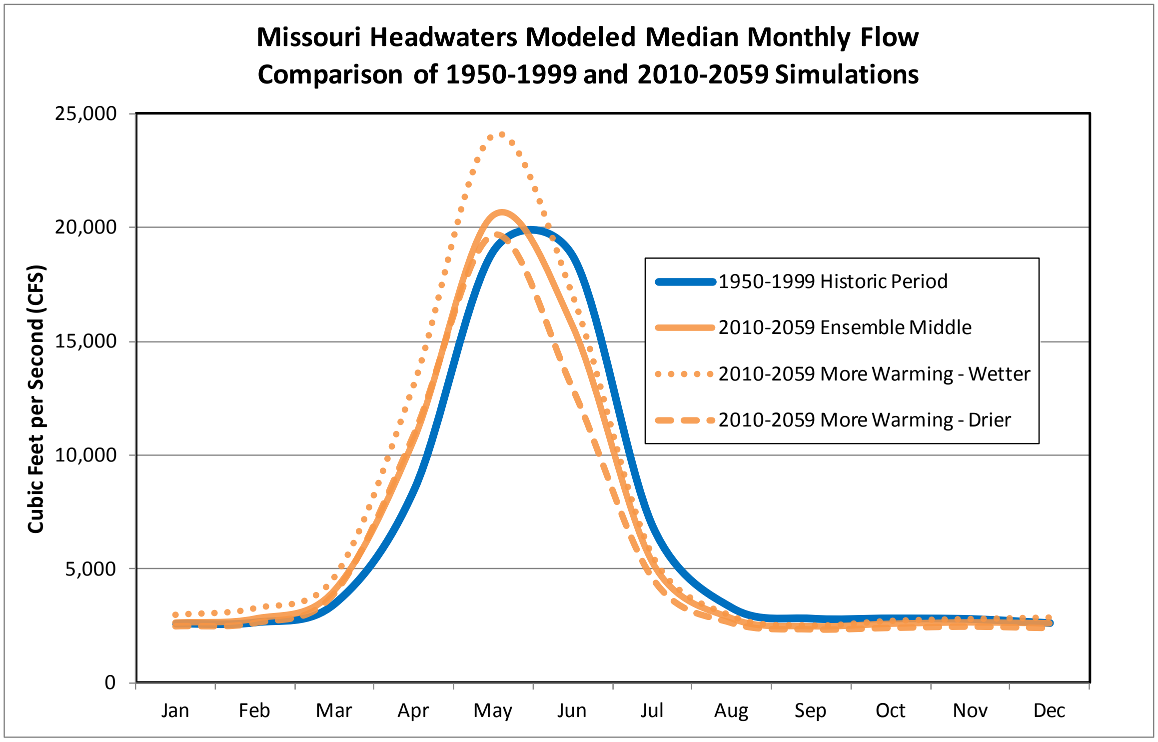


Streamflow

Figure 8.20 and 8.21 compare simulated median Missouri River streamflow for the future 2010-2059 period to the historic 1950-1999 period for the headwaters area (Missouri River near Toston) and the entire Upper Missouri River basin (Missouri River near Virgelle). The results depicted are for groupings (ensembles) of VIC modeled runoff using the 112 CMIP3 climate scenarios using methods similar to those described by USBR (2010). The groupings partitioned the 112 scenarios into four quadrants that bracketed the climate-change scenario range based on relative changes in mean annual temperature and precipitation, with a fifth “central tendency” grouping. For simplicity, we only graphed the results for the quadrant scenario groupings that produce the highest, lowest, and median runoff values. Also note that these graphs are for the modeled “natural” flow produced by the basins: they do not include the effects of water development such as reservoirs and irrigation.

In the future, the flow produced in the Upper Missouri Basin might be of similar volume to what has been produced in the past, with shifts in streamflow timing and wetter scenarios showing increased overall runoff. The timing shifts would be due to an earlier snowmelt and an increase in the rain fraction of the precipitation during the later winter and early spring. Earlier runoff is projected, with December through March showing an increasing trend, while late season runoff (June through November) shows a decreasing trend. The earlier shift in runoff timing is more predominant for the warmer scenario groupings.

Figure 8.21
Modeled median monthly flow for the Missouri River Headwaters under historic conditions and future climate scenarios



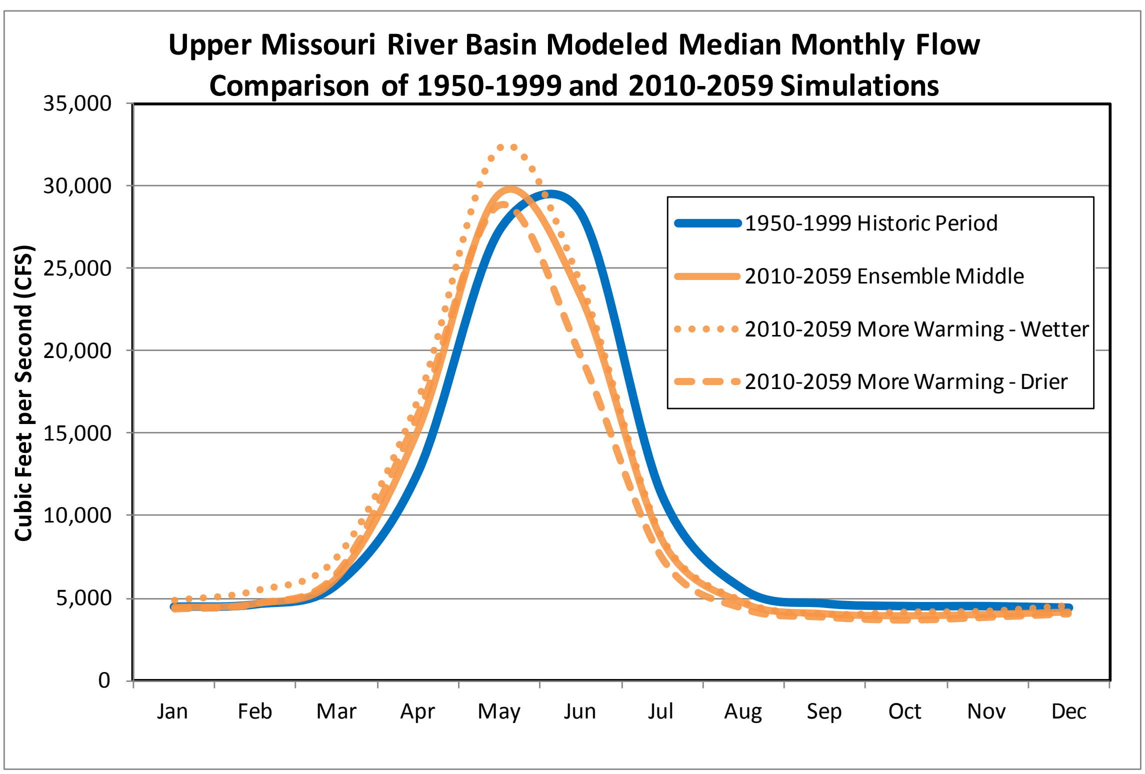


Figure 8.22
Modeled median monthly flow for the Upper Missouri River Basin under historic conditions and future climate scenarios

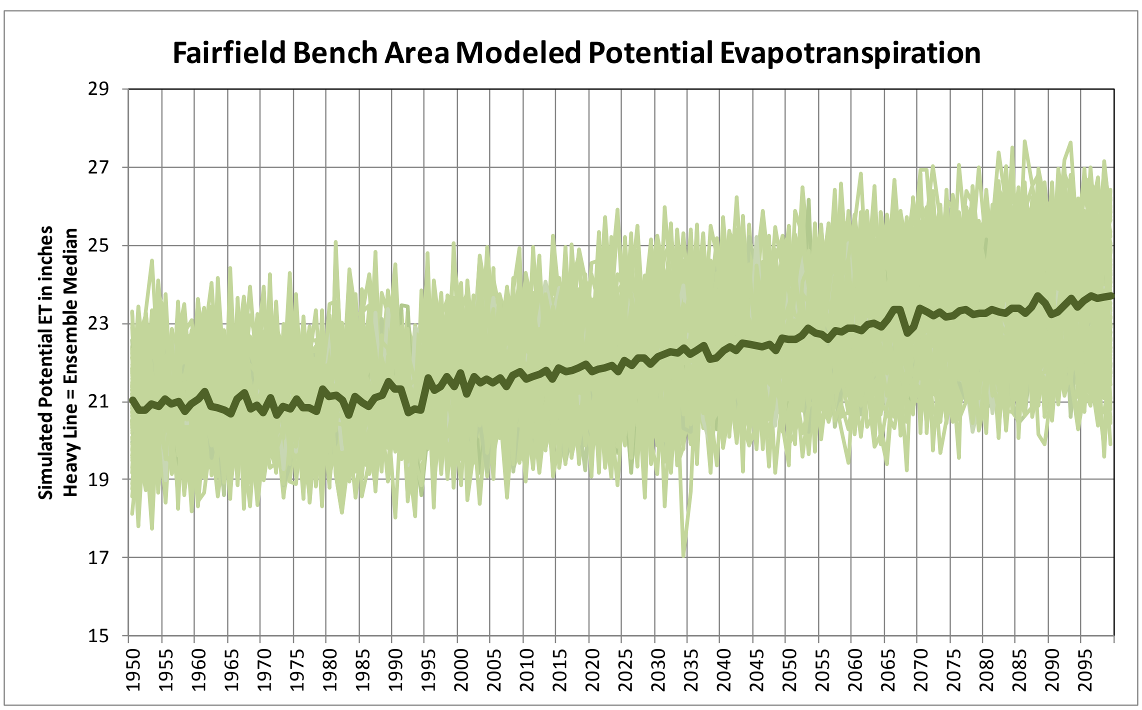
Future Water Demands

All of the 112 simulations project increased temperature in the Upper Missouri Basin, and most show modest precipitation increases. The increase in temperature could result in increased water demands, especially for irrigation. Figure 8.22 depicts modeled potential evapotranspiration for natural vegetation for the Greenfields Bench agricultural area north of Great Falls. Potential evapotranspiration is the maximum amount of water that could be evaporated and transpired from the landscape at a given temperature, if there were a sufficient supply of water. Although this graph depicts potential evapotranspiration for natural vegetation, it could be used to infer how water requirements might change for irrigated crops. The VIC model uses a Penman-Montieth formulation to compute potential evapotranspiration (Liang and others, 1994), which also can be used to predict evapotranspiration for agricultural crops.

Potential evapotranspiration is projected to increase during the 2010-2059 period when compared to the 1950-1999 historic period under all but one of the 112 scenarios modeled. The maximum projected increase was 2.2 inches (10.7 percent), the minimum was the scenario with 0 inches increase, and the median modeled increase was 1.2 inches (5.5 percent). Increased evapotranspiration would result in increased consumption and increased diversion requirements for irrigated crops. The projected increasing evapotranspiration irrigation requirements might suggests that there could be an increase in crop production, if the increased water demand could be satisfied. This might be the case during wetter years when sufficient irrigation water is available to supply crop demands.

Although evaporation from open water surfaces, such as reservoirs and stream channels, was not modeled, it also is expected to increase some with warming temperatures. The wetter conditions projected for some climate change scenarios would at least partially offset the effects of more warming on evaporation rates.

Figure 8.23 Simulated Annual potential evapotranspiration for natural vegetation simulations for the Fairfield Bench Area based on VIC model results and downscaled projections from 112 GCM models



Uncertainties

The current scientific understanding of physical processes that affect climate and how to model such processes is not complete. Atmospheric circulation, clouds, ocean circulation, deep ocean heat uptake, ice sheet dynamics, sea level, land cover effects from water cycle, vegetative, and other biological changes are some important factors in climate modeling that are not fully understood. There are uncertainties relevant to the statistically down-scaling of global-scale climate models to the finer scale used in basin planning. For this investigation, global-scale model results were downscaled using temperature and precipitation patterns from historic weather-station data. Future projections assume that these historic local climate patterns at the finer-scale and their relationships to the climate at the larger scale will still hold in the future, although that may not be the case.

Note on potential effects of climate change section: DNRC acknowledges the modeling groups, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) and the WCRP's Working Group on Coupled Modeling (WGCM) for their roles in making available the WCRP CMIP3 multi-model dataset. Support of this dataset is provided by the Office of Science, U.S. Department of Energy.

IX. Options for Meeting New Water Demands

A. Opportunities, Strategies and Tools

BASINS WITH UNALLOCATED WATER

Montana has the authority to restrict or close river basins and groundwater aquifers to future withdrawals, based on concerns to protect existing uses, water quality issues, and additional water shortages. Montana is a "prior appropriation" state, and must first protect existing senior water uses before allowing additional demands on water resources. Legal water availability, if any, is based on surplus water above and beyond existing, valid water uses. Applicants for water use must prove that their proposed future use of water does not impact existing users surface or groundwater uses. Applicants for a new groundwater appropriation that depletes surface water may need to implement a mitigation or aquifer recharge plan in order to obtain a new permit.

The purpose of mitigation and aquifer recharge plans is to offset net depletion to surface water from a groundwater appropriation in order to provide water for legal demands by senior water users and to prevent adverse effects. Mitigation plans involve a change of an existing surface water or groundwater right, whereas aquifer recharge plans involve infiltration of surface water to groundwater in addition to a water use change. Mitigation by changing a surface water right is accomplished by stopping the existing use (for example, drying up irrigated acreage) and leaving water instream that was previously diverted and possibly protecting it through a depleted stream reach. This type of mitigation is appropriate where net depletion and adverse effects are predicted to occur within the period of historic use of the existing water right, such as may occur where a well is located very close to a stream or where water shortages are limited to the irrigation season.

In contrast, changing an existing groundwater right by stopping use of another well and eliminating its associated purpose may mitigate adverse effects outside the historic period of use of the existing right. This occurs because wells that are not very close to a stream typically have year-round depletion effects; therefore, eliminating an existing well is essence provides year-round mitigation effects. The feasibility of a mitigation plan involving a change of a ground water right depends on consumption amounts of the historic and new uses and on whether the adverse effects of the new use are similar to the historic effects of the retired use.

An aquifer recharge plan or project accomplishes essentially the same thing as retiring use of a well by diverting surface water and allowing it to infiltrate ground water through a well or other means. Again, the viability of a plan depends on a comparison of the historic and new consumptive uses, and an evaluation that indicates whether mounding from aquifer recharge offsets drawdown from the new use. The existing water right may be relatively junior if recharge is conducted in early summer.

Simple mitigation with surface water generally requires a water right with an early priority. A summary of the general legal availability of surface water available for appropriation in the Upper Missouri River Basin is summarized in Table 9.1. The summary is based on past permitting records and the working knowledge of DNRC Regional Office staff. New appropriations from aquifers hydraulically connected to these streams and rivers also may be subject to limitations.

Table 9.1 General summary of legal water availability for streams in the Upper Missouri Basin by DNRC Region

Lewistown Region			
Water Source	**Legally Available**	**Not Legally Available**	**Comments**
Belt Creek	May and June (potentially, July)	Water not legally available remainder of year	1951-1982 Monarch stream gage data shows median flows in excess of 90 CFS FWP instream reservation only from April through July. April is 95.1 CFS, so not enough water legally available for new permits. Potential appropriations in July, based on median flows for period of record being 197.1 CFS with ~130 CFS for legal demands.
Smith River	Not Likely	Basin Closure	Upper Missouri River Closure Area.
Middle Missouri (downstream of Morony Dam)	Potentially		The most recent permit application indicates water is legally available in the Missouri River near the Judith River confluence. With that said, water is likely available in the Missouri River between Morony Dam and Fort Peck Reservoir. The impact of the Army Corps water right(s) for Fort Peck is unknown until the adjudication is complete. New permits would likely be conditioned with trigger flow points.
Upper Missouri (upstream of Morony Dam)	Not Likely	Basin Closure	Upper Missouri River Closure Area
Havre Region			
Water Source	**Legally Available**	**Not Legally Available**	**Comments**
Upper Marias River	Early season	Late season?	Pretty good opportunity for new water uses though early season better than later.
Lower Marias River		In-stream flow and irrigation.	Flows pretty much regulated by Tiber releases which are primarily FWP in-stream plus existing rights.
Sun River		Basin Closure	Part of the Upper Missouri River Basin legislatively closed on April 16, 1993. Exceptions to this closure which impacts the Sun River drainage specifically are new appropriations which help in dewatering or controlling erosion problems found in the Muddy Creek drainage. Other exceptions to this closure include small groundwater developments, small impoundments for stock watering purposes or larger groundwater appropriations that either do not cause depletions of surface water.

Havre Region cont.

Water Source	Legally Available	Not Legally Available	Comments
Teton River Basin		Basin Closure	Legislatively closed on April 21, 1993. Exceptions to this closure are small groundwater developments, small impoundments for stock watering purposes or larger groundwater appropriations that do not cause depletions of surface water.

Helena Region

Water Source	Legally Available	Not Legally Available	Comments
Beaverhead River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed.
Big Hole River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed.
Boulder River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed.
Jefferson River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed.

Helena Region cont.

Water Source	Legally Available	Not Legally Available	Comments
Missouri River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed. Canyon Ferry Reservoir may be available to provide mitigation for certain new uses via contracts with the Bureau of Reclamation.
Red Rock River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed.
Upper Missouri River		Basin Closure	Surface water permits for domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Applications for storage of high spring flows are allowed, however a storage application may be difficult. New water right permits for non-consumptive uses are also allowed.

Bozeman Region

Water Source	Legally Available	Not Legally Available	Comments
East Gallatin River		Basin Closure	Surface water permits for exceptions such as domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Non-consumptive exceptions, such as hydropower, have a high potential for success. Applications for storage of high spring flows are allowed, however a storage application may be difficult.

Bozeman Region cont.			
Water Source	**Legally Available**	**Not Legally Available**	**Comments**
Gallatin River		Basin Closure	Surface water permits for exceptions such as domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Non-consumptive exceptions, such as hydropower, have a high potential for success. Applications for storage of high spring flows would be very difficult, as any water right with a priority date of or after 1890 is essentially a high/flood water right...
Jefferson River		Basin Closure	Surface water permits for exceptions such as domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Non-consumptive exceptions, such as hydropower, have a high potential for success. Applications for storage of high spring flows are allowed, however a storage application may be difficult.
Madison River		Basin Closure	Surface water permits for exceptions such as domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Non-consumptive exceptions, such as hydropower, have a high potential for success. Applications for storage of high spring flows are allowed, and with the moderation of flows by existing dams and the potential for Canyon Ferry mitigation, these have a higher chance of success than in other closed basins in this region.
Ruby River		Basin Closure	Surface water permits for exceptions such as domestic, municipal, or stock use and groundwater permits can be processed, but they will only be successful with the retirement of an existing water right that is changed to mitigation or aquifer recharge. Non-consumptive exceptions, such as hydropower, have a high potential for success. Applications for storage of high spring flows are allowed, however a storage application may be difficult.

CHANGES

Under a change authorization a water user may permanently reallocate water to a new purpose while preserving the priority date for the underlying water right. Because a change is doing something new on a source and other water rights exist on the source, a change in use is limited to the historic period of diversion, historic diverted volume, and historic consumptive use (collectively referred to as historic use). These limitations are important ensure that a proposed change will not adversely affect other water users on the source. Increases in amount of consumption or changes in the pattern of use from the historic use of the right can affect other water right holders who depended on that historic pattern of use and amount in making their own use of water. One person's return flows are another's supply. Therefore, the historic use analysis also looks at the timing and location of return flows.

Over the past 40 years, the DNRC has developed an extensive set of data and rules to assist water users in identifying relevant evidence to establish the parameters of historic use. However, potential adverse effect to other water users is often a limiting factor in the ability to change a water right.

A traditional change is an effective means of permanently reallocating water to a new use.

Permanent changes also provide a means for mitigating new groundwater uses that deplete surface water and potentially cause adverse effect on over appropriated surface water sources and in closed basins. Changes for mitigation require identification of the specific water right for which mitigation is being provided. The applicant is typically required to demonstrate that the water right being changed will provide sufficient water in timing, location and amount to mitigate potential adverse effect either by leaving the water instream or through use of aquifer recharge.

MARKETING FOR MITIGATION (HB24)

In 2011, the Montana Legislature adopted an innovative approach to facilitate the reallocation of existing water rights for the purpose of mitigation or aquifer recharge to allow new uses of water in water short areas. Water for mitigation or aquifer recharge is used to offset depletions to surface water sources from new groundwater wells. Unlike the traditional change process discussed above, the new approach enables a water user to prospectively change all or a portion of a water right to mitigation and have that mitigation water available for lease or sale to applicants seeking new water rights from the DNRC. This process is similar to a water bank for mitigation uses. This new statutory tool provides greater predictability for new water users who need to mitigate depletions from a proposed use and

Ruby Dam and Reservoir

provides existing water users with the opportunity to market water while preserving their existing use.

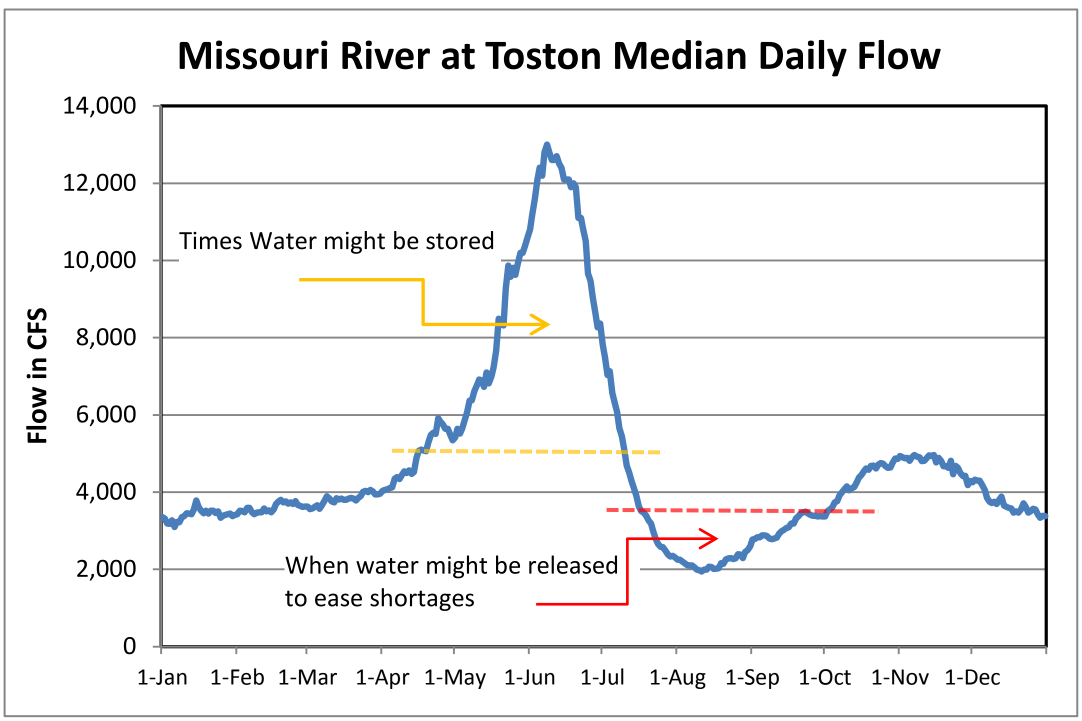
RESERVOIR STORAGE AND NEW STORAGE POTENTIAL

By storing flow when there is a surplus and releasing that stored water later, during times of shortage, reservoirs can be used to more effectively match water needs with water availability. This section discusses potentially storable flows in the Upper Missouri Basin with consideration given to possible impacts on prior uses, including those for existing reservoirs. Although this section does not identify specifically where water might be stored, it provides some observations concerning where hydrologic conditions might offer the potential for new future water storage.

Suitability of Upper Missouri Basin Hydrology for Water Storage

Because much of the annual flow volume in the Upper Missouri Basin is produced during the relatively short spring-runoff period, the hydrology of many of the streams might be considered suitable for storage. As a descriptive example, Figure 9.1 depicts median daily flows for the Missouri River near Toston, including simplified delineations of when water might be stored and again released to ease shortages. Although this is a large stream that produces a lot of flow, the general shape of the graph is representative of many of the streams in the Upper Missouri River Basin that originate in mountainous, headwaters areas. It is important to remember that flow is variable from year to year, with some years having much higher flows and with dry years producing substantially less flow than the median. Also note from this example that it might not be necessary to store all of the high spring flow to offset the shortage in late summer and early fall; just a portion might be enough.

Figure 9.1 Example flow graph for the Upper Missouri Basin depicting times of potentially storable flow and when releases might be used to offset shortages.



Data source http://mt.water.usgs.gov/

Canyon Ferry Reservoir, just downstream of Toston, regulates the flow of the Missouri River. Although actual operations are much more complex, it at least partially captures, stores, and releases water in a similar way to that described in Figure 9.1. By capturing much of the upstream flow, Canyon Ferry Reservoir and its water rights also might restrict, but not necessarily preclude storage development upstream (discussed later in this section). For any potential storage reservoir, it is not a simple matter of depicting whether water is physically available to store at the site. There are likely to be existing downstream users with water rights to use some of these higher flows, including other downstream reservoirs that would need to be considered.

Existing Level of Storage Development by Sub-basin

There is potential for storage reservoirs to compete for limited flow and, in some basins, the existing level of storage development might be sufficient with no need for additional storage. For the major sub-basins in the Upper Missouri River Basin, Table 9.2 summarizes the storage capacity of existing reservoirs and compares this capacity to the total estimated natural flow produced during wet, median, and drier years. The purpose of the table is to provide some insight concerning the extent of existing storage development, where water might be available for new storage, and to investigate were potential new storage might conflict with or be duplicative with existing storage.

Table 9.2 Storage capacity by subbasin compared to estimated annual runoff

		Estimated Natural Annual Runoff (acre-feet)		
Sub-basin	Total Active* Storage (acre-feet)	High Year 90th Percentile	Median Year 50th Percentile	Low Year 10th Percentile
Beaverhead-Red Rock	249,600	1,030,000	724,000	429,000****
Ruby	36,600	377,000	236,000	162,000
Big Hole	No storage > 1,000	1,560,000	843,000	442,000
Jefferson**	311,900	2,820,000	1,870,000	985,000
Madison	352,200	1,950,000	1,330,000	907,000
Gallatin	10,200	1,490,000	977,000	640,000
Headwaters total including Canyon Ferry Reservoir	2,666,300	6,660,000	4,530,000	2,910,000
Smith	23,600	572,000	253,000	143,000
Sun	171,300	1,120,000	582,000	380,000
Teton	101,200	328,000	182,000	110,000
Marias	1,681,300	1,440,000	705,000	519,000
Upper Missouri Basin Total***	4,992,500	11,100,000	7,360,000	5,288,940

* Dead storage, the amount of storage below the dam outlet which cannot be withdrawn, was not included when that information was available for a reservoir.

**For Jefferson watershed, includes flow and storage values for Beaverhead-Red Rock, Ruby, and Big Hole sub-basins

***Also includes Missouri River reservoirs downstream of Canyon Ferry Dam

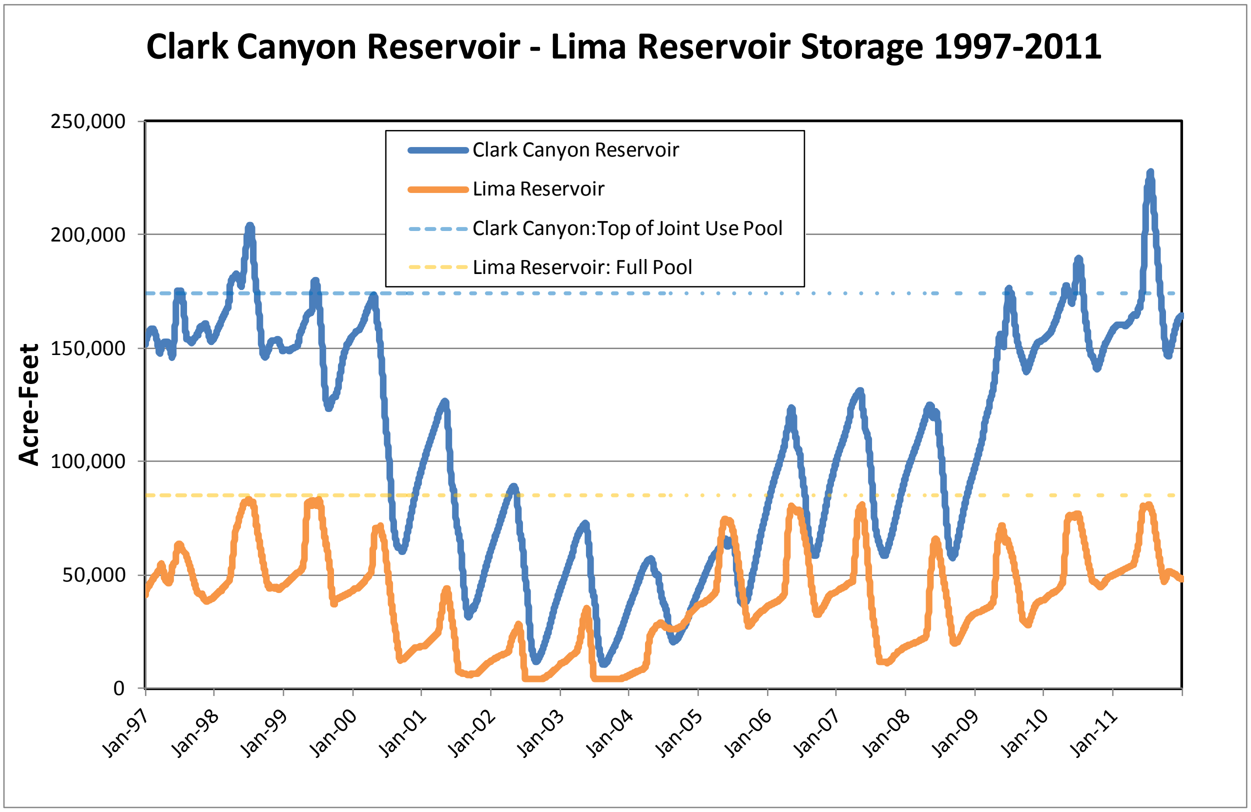
****Assumes three-fourths of consumptive demand would be supplied during a low run-off year, with the rest coming from carry-over storage or not used because there was a shortage.

The table indicates that existing reservoirs in the Marias, Teton, Sun, and Beaverhead basins store a relatively large volume of water when compared to the amount of water annually produced in these watersheds. In comparison, the existing storage capacity is small compared to the total flow produced in the Gallatin and Big Hole watersheds. The other sub-basins have developed storage capacities that fall somewhere in between. It might be that storage is more necessary and has been built in sub-basins where the natural flow regime is less productive and reliable.

Some examples of basins where the storage potential might be more fully developed
Taking the Marias River watershed as an example, the total storage capacity in the basin exceeds the estimated runoff produced in almost all years, primarily due to Tiber Reservoir, which has an active storage of about 1.5 million acre-feet. Having all this capacity though doesn't mean that all flow will be stored. It is likely, however, that, during drier years, there is a high potential that water which might be stored in a hypothetical new reservoir in the Marias River upstream would reduce that which could be captured and stored in Tiber. This might not necessarily be a problem if USBR (the owner of the reservoir) did not see a potential conflict between the new storage and its operational goals at Tiber.

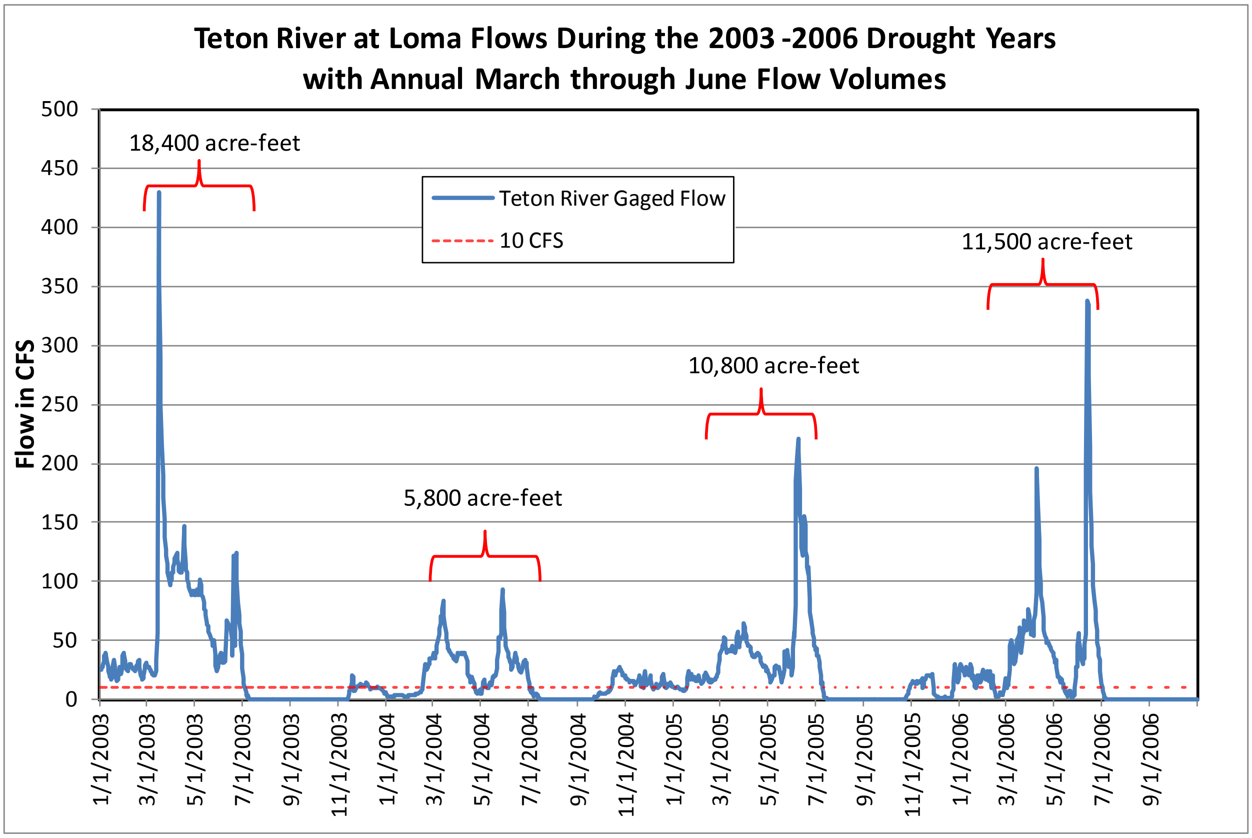
Although water might be available to store in a basin during higher years or even moderately wet years, a new reservoir might not be viable if it were not able to store water during a sequence of dry years. This concept can be explained by the example of the upper portions of the Beaverhead-Red Rock watershed. Figure 9.2 shows that the natural flow produced in the Beaverhead-Red Rock sub-basin exceeds the reservoir storage capacity during wet, median, and dry years. Yet storage in the upper portion of the basin above Dillon probably is, from a practical standpoint, fully developed. During a sequence of dry years from 2000 to 2010, carry-over storage at Lima Reservoir on the Red Rock River and Clark Canyon Reservoir downstream on the Beaverhead River was depleted and both reservoirs were drawn to dead storage levels (Figure 9.2). In this circumstance, a hypothetical junior new storage reservoir upstream wouldn't be able to store water for about a 10-year period, until both existing reservoirs finally got back to full pool.

Figure 9.2 Storage at Clark Canyon and Lima Reservoir during a drought compared to full-pool levels



Another example, in the lower portion of the basin, where the potential for new storage might be quite limited is the Teton River drainage. Here there is a little more than 100,000 acre-feet of existing storage capacity, and intense demand for limited natural flow for irrigation water. During dry years, little water leaves the Teton River basin. During the late summer and fall it is common for the lower portion of the stream to go dry. Figure 9.3 depicts the flow leaving the Teton River basin near Loma during an extended dry period from 2003 through 2006. The figure also lists the total volume of “higher” spring flows (March through June flows above 10 cfs) for each year during that drought. There would be limited opportunities in this watershed to store any more water without affecting prior water users during drier years. During a sequence of dry years, a new junior storage reservoir might not be able to store appreciable water for several years in a row.

Figure 9.3 Flows in the lower Teton River and water volumes leaving the basin during spring runoff during a series of drought years.



Data source http://mt.water.usgs.gov/

Canyon Ferry Reservoir and Possible Implications for New Storage both Upstream and Downstream

Both the Missouri River Basin above the Great Falls and the Teton River basin are closed to most new permits to appropriate water, with an exception made for applications to store water during "high spring flows." In the headwaters area, there are streams where high spring flow could be considered available, in the context of the physical amount of flow on-site and local water rights. Storing this water though might have the potential to affect downstream water users, including those for Missouri River hydropower dams and Canyon Ferry Reservoir.

Canyon Ferry Reservoir captures and regulates the flow of the Missouri River headwaters. It does this in a way that not only maintains hydropower production at the downstream hydropower dams, but enhances it overall. Because Canyon Ferry Reservoir efficiently captures and regulates most of the flow of the Missouri River, a case could be made that new upstream storage development could encroach on USBR's senior storage rights. Reclamation though has indicated that it might be able to accommodate some new upstream development, including storage, through contractual arrangements for Canyon Ferry exchange water. For new storage development in the basin below Canyon Ferry Reservoir and upstream of the Great Falls hydropower dams, USBR contracts for stored water releases from Canyon Ferry Reservoir might be a way to potentially offset any negative impacts to downstream hydropower rights.

Non-reservoir Storage

Flood irrigation system in an alluvial valley

Alluvial valleys and floodplains with healthy vegetations and riparian areas act to slow runoff and promote groundwater recharge; effectively storing water and allowing it to flow slowly back to the surface water system. In this way, these natural systems fill a role similar to traditional reservoirs. Disturbances that can limit infiltration, connectivity and access of flood waters to floodplains include impervious surfaces, degraded vegetation, stream incision, stream channelization, and subsurface drains. The natural storage and retention benefits of these systems can be maintained and potentially enhanced by limiting the encroachment of urban development and associated impervious surfaces, controlling storm water discharge, protecting vegetation from overgrazing, minimizing stream incision and channelization, and preventing erosion through good forest and range management practices. Artificial recharge of alluvial aquifers and floodplains may provide additional opportunities to store water when the physical supply exceeds legal demands.

The groundwater flow systems in nearly all of the watersheds of the Upper Missouri River basin have been substantially changed by recharge from irrigation canals and the irrigation itself, especially flood irrigation. Significant volumes of water lost during irrigation conveyance and application are temporarily stored in alluvial aquifers and then naturally released to support late season streamflow. For example, the East Bench Irrigation Canal in the lower Beaverhead River may lose as much as 398 acre-feet per season; with a length of about 17 miles between Dillon and Beaverhead Rock, the seasonal ditch loss would be about 6,800 acre-feet. Many water users have grown dependent on return flow from irrigation diversions. While existing aquifer recharge is incidental to the primary beneficial use of the water, which is irrigation, the irrigation infrastructure provides a potential means for augmenting the recharge of shallow groundwater systems.

In some areas it may be feasible to use these linked irrigation-aquifer systems outside of the normal irrigation season for the purpose of recharging shallow groundwater aquifers. This might be a way to offset depletion by new groundwater uses, but these types of activities would require a change authorization from DNRC to ensure other water users are not adversely affected. There may also be opportunities to take advantage of the natural storage potential of shallow aquifers, through design, by diverting unallocated flows into constructed wetlands or retention basins and then allowing the water to infiltrate into aquifers. The feasibility of an artificial aquifer recharge project will depend on a number of factors including, but not limited to, site specific geologic conditions, and the physical and legal availability of surface water to divert and store.

VOLUNTARY WATER MANAGEMENT

Locally initiated drought management plans are also an effective tool for stretching Montana's water supplies during times of shortages. All of these efforts are highlighted by some common elements: voluntary cooperation from a wide range of stakeholders, local solutions to fit local needs, joint sacrifices and sharing of shortages. The tension that develops between irrigated agricultural interests and advocates for instream flow during times of shortages are typically the genesis for the development of these plans. Although the parties may have competing water use interests, they are united in their desire to improve management of resource for the benefit of their local communities and businesses. The success of these drought management plans is dependent on strong local leadership, access to timely and relevant information to support decision making, and a willingness on the part of all parties to support the plan. Technical support from state and federal natural resource agencies is also a critical component of successful local planning efforts. Examples of the successful locally developed drought management plans can be found in the Jefferson, Big Hole, and Blackfoot river basins.

X. Major Findings and Key Recommendations

The following information is taken from the recommendations report that was developed by the Upper Missouri Basin Advisory Council during the MWSI process.

The Upper Missouri Basin Advisory Council decided to present its water plan recommendations in the context of 12 issue areas listed below, but was quick to recognize that all 12 issues are highly interrelated. Because the issues are all connected, you will see some cross-referencing in these recommendations to other issues. Still, there are important water-related themes in the Upper Missouri Basin that the Council identified with special interest. These include: 1) the need to better define the use of exempt wells in dense developments; 2) recognition of the importance of the statewide adjudication and dependence by many on its completion; and 3) a need to protect natural streamflows in light of the desire to also identify opportunities for built and natural storage in a closed basin.

In its closing deliberations, the Upper Missouri Basin Council thoughtfully stressed three core conditions essential to representing the people, livelihoods, and resources of the Upper Missouri River Basin. The first is that all 62 of the Council's recommendations recognize and support the Prior Appropriation Doctrine and its protection of multiple uses and existing water rights. None of these recommendations should infringe on the Prior Appropriation Doctrine and valid existing water rights. The second is that, like the issues themselves, all recommendations presented are highly interrelated and difficult to consider in isolation. For example, many recommendations deal with improving water-use and management efficiencies that, if carried out, could have both positive and negative impacts. In many cases, systems are already in place, but the recommendations call for additional tools to improve systems management. Finally, it is the ardent hope of the Council that this report does not reside on a shelf, but that it is revisited often as a living document to be updated regularly, especially in a way that keeps local efforts highly engaged. In this regard, the Council hopes to continue to participate and contribute on a regular basis.

RECOMMENDATIONS BY ISSUE

Each of the issues identified by the Council is presented in this format:

11. Issue Title
12. Overall Goal
13. Issue Statement
14. Objectives, which are statements of desired future conditions
15. Recommendations, numbered in order of presentation across issues to easily identify for discussion
16. Implementation Tasks, where the Council wished to enter this level of detail

The issues are presented in the following order, the first four of which the Council considers as priority topics, although all issues are highly interrelated and critical:

A. Conjunctive Surface Water/Groundwater Management
B. Adjudication
C. Storage
D. Instream Flow
E. Local Cooperative Efforts
F. Water Use Efficiency and Conservation
G. Integrated Water Quality and Quantity
H. Water's Role in the Economy
I. Water Information Systems
J. Available Water Supply and Climate Change
K. Water Transfers and Marketing
L. Large Scale Factors

CONJUNCTIVE SURFACE WATER/GROUNDWATER MANAGEMENT

Goal: Improve Management of Surface Water and Groundwater as a Conjunctive Resource

THE ISSUE

Surface water and groundwater are usually connected, and withdrawal from or reduced recharge to one can significantly affect availability of the other. Common examples in the Upper Missouri Basin include the potential for well pumping to reduce surface water flow, and where shifts from flood to sprinkler irrigation can decrease aquifer recharge. Aquifer characteristics in the basin vary from limestone, shales and alluvial fill, and these differences can affect water availability. With variability among and even within aquifer systems, the hydrologic connections between surface water and groundwater are difficult to measure and monitor. To help understand trends, several state, federal and local agencies routinely collect data on groundwater quality and quantity. Although the agencies work together, at times they make management or permitting decisions internally without integration of all data, or without optimal data. For example, irrigation return flows and seepage from the more than 3,300 miles of canals in the basin offer potential opportunities to augment groundwater recharge, and this should be factored into decision-making.

Exempt wells were discussed in detail and are a topic of great importance. In particular there is broad agreement that exempt wells should not impact senior water rights. The Council believes that resolution of the exempt well issue is imperative. Since much of the basin is legislatively closed to most new water right appropriations, many new developments have relied on exempt wells to meet the needs of individual lot owners. By statute, these wells are granted a water right by filing a simple “Notice of Completion” after development, and are exempt from permit review criteria required for larger wells or surface water appropriations. Withdrawals from the roughly 53,000 individual groundwater wells throughout the basin, 11,700 of which were drilled between 1990 and 2000, can cumulatively impact surface water availability and quality especially where they are densely located. Impacts vary on the basis of local groundwater availability and extent, and should be addressed accordingly.

Objectives

1. Groundwater and surface water resources are conjunctively managed by DNRC and the Montana Department of Environmental Quality (DEQ)

   RECOMMENDATION 1*:* Support cooperative efforts to integrate, share, and analyze the data needed to conjunctively manage surface water and groundwater resources.

   Implementation Task: Enhance a multi-agency water data collection and analysis system managed by NRIS. Assure that this system: 1) houses enough data to accurately describe cumulative impacts of all groundwater withdrawals on recharge and local water supplies; 2) can be used to investigate mitigation strategies, such as enhanced aquifer recharge; 3) is a ready tool to access when surface water and groundwater interactions play into management decisions, especially in areas where streams are already dewatered or where there is the potential for flow reductions; and 4) is adequately funded.

- Exempt wells are allowed and managed within the original intent of the legislation.

  RECOMMENDATION 2: Implement interpretation of the exempt well statute, which identifies exempt wells as small-scale, widely dispersed groundwater wells with little potential to impact other water rights.

  Implementation Task: Adopt an administrative rule (DNRC) and/or legislation (Montana Legislature) that recognizes the cumulative impacts of densely developed wells on local groundwater supplies and senior water rights. This rule or legislation should take into account the following principles:

  a. Most wells use less than 2 acre-feet of water, but an exempt well may tap up to 10 acre-feet, which can impact other users.
  b. The intent of original legislation was to allow for smaller, widely dispersed uses.
  c. High density of exempt wells is a critical issue and needs immediate attention.
  d. The density of exempt wells indicates a direct relationship to water quality.
  e. Use of exempt wells for stock water is supported.
  f. Continued monitoring/study of exempt wells in high-density areas is essential.

- **Recommendation:** Implement water conservation incentives within three years that are adaptable to the needs of individual watersheds. These incentives should focus on encouraging programs such as irrigation efficiency, water banking, drought management plans, etc.

  Recommendation: Ensure that water regulations clarify that water users participating in water conservation measures will Public Comment

All respondents supported Recommendations 1 and 2. Comments reflected on aquifer subsidence, the impacts of hydraulic fracturing, priority dates for exempt wells, and the impact of dewatering on water quality. The BAC concluded that addressing the recommendations as stated will also address these concerns.

ADJUDICATION

Goal: Complete an Accurate and Enforceable Water Rights Adjudication

THE ISSUE

The Statewide Adjudication Process is critical to all water users in the Upper Missouri River Basin, and the Council recognizes that it is already occurring at an accelerated pace. When completed, it will produce enforceable Final Decrees of all historic water rights. Water users in the basin are anxious to complete decrees and resolve issues of enforcement, which are important not only to water users and managers in the basin, but also for protecting Montana's interests against illegal uses of water and downstream claims. Currently, no Final Decrees have been issued in the basin, and sub-basins with Temporary Preliminary Decrees may need further examination to bring them to modern adjudication standards. In sub-basins where water users choose to petition for water distribution and enforcement of water rights according to a decree, a decree must be in place and objections and issue remarks resolved. Final Decree, which is the end goal, is important to water rights holders because it is a declaration that the historical water right can no longer be debated and modified within the current adjudication process. Water right holders acknowledge that adjudication will sometimes only generally characterize water use, but they also recognize that it is a very important tool for moving forward. To that end, additional resources are necessary to achieve enforceable decrees in a timely manner.

Objectives

1. Decrees are accurate and enforceable in the Upper Missouri Basin.

   RECOMMENDATION 3: Continue funding of both the Water Court and DNRC to complete the current adjudication process at the desired level of staffing and to meet benchmarks for accountability.

- Management roles of the Water Court, District Court and DNRC are well defined.

  RECOMMENDATION 4*:* Create a plan for transitioning to post-adjudication roles. Maintain the current role of the District Court; keep the Water Court focused on adjudication and DNRC focused on new permits, change applications and assisting in the adjudication process.

  RECOMMENDATION 5: Adequately resource and authorize the Water Rights Enforcement Section of DNRC to reduce illegal use of water.

- The public recognizes the value and outcomes of the d process, and is engaged through informative public education.

  RECOMMENDATION 6: Continue public education and outreach efforts that inform on progress and outcomes of the adjudication.

- The Confederated Salish and Kootenai Tribe water compact is successfully endorsed and passed during the 2015 Legislative session (**See issue L).**

PUBLIC COMMENT

All respondents supported all recommendations for this issue. Their written comments focused on enforcement of water rights, the roles of the Water Court and the District Court, and public education on the significance of the adjudication. The BAC concluded that addressing the recommendations as stated will also address these concerns. It did add recognition of illegal water use to the issue statement.

STORAGE

Goal: Increase Water Availability through Storage and Retention

THE ISSUE

With much of the Upper Missouri River Basin closed to new appropriations, many stakeholder groups hope to find options for additional water storage using a variety of methods. This is especially of interest in the Big Hole River watershed. Stakeholders point to a desire to capture high flows earlier and retain them in the basin longer for additional flexibility in the late season and to accommodate expanded demand. Assessment of multi-use on-stream and off-stream storage is of interest, along with exploring storage tools such as natural storage (in beaver ponds, wetlands and floodplains), retrofitting existing reservoirs, snow banking, and the potential for augmenting groundwater recharge through irrigation canals to recharge basins during high runoff. An increase in natural storage capacity is desirable because of its cost effectiveness. Constructed (built) water storage facilities in the basin are working well and capture water during high flows for use during periods of shortage, but some of these facilities might be retrofitted for efficiency and expanded use.

Objectives

1. There is public understanding of the costs and benefits of built and natural storage to increase the flow of water in the basin when it is most needed.

   RECOMMENDATION 7*:* Develop a comprehensive basin-wide study of natural and built storage potential, including consideration of costs, benefits, watershed characteristics and geologic factors; share findings.

   RECOMMENDATION 8: Identify and develop pilot projects to demonstrate and quantify the capacity of natural storage options in smaller watersheds.

   RECOMMENDATION 9: Increase natural storage capacity (wetland, riparian areas, floodplains) on public and private lands in the basin.

- There is recognition of the public costs and benefits of both built and natural storage options in decision-making and state funding allocations.

  RECOMMENDATION 10: Review guidelines and criteria for state funding programs (Renewable Resource Grant and Loan Program [RRGL] and Reclamation and Development Grants [RDG]) and agency resource management decisions to include both built and natural storage opportunities.

  RECOMMENDATION 11: Create a position for a State Water Storage Coordinator to work with stakeholders to investigate ideal locations for off-stream storage, natural storage, retrofitting existing facilities for increased storage, and integrating built and natural storage planning.

- Existing storage facilities (built) are retrofitted, where feasible, to increase storage capacity and uses.

  RECOMMENDATION 12: Identify potential for existing facilities to provide additional municipal supply, streamflow supplementation, hydropower generation and other benefits. Allocate hydropower revenues from these facilities to the reservoir management account for future water storage rehabilitation or construction projects (e.g.; Ruby Dam). For federal storage projects, there is Congressional approval to this effect.

  RECOMMENDATION 13*:* View hydropower retrofits as both an investment in renewable energy and as a source of rehabilitation and construction funding for existing and future projects. Encourage the federal government to relax the Federal Energy Regulatory Commission requirements on smaller, in place storage facilities retrofitted for hydropower generation to make them more economical.

RECOMMENDATION 14: Consider multiple benefits, including ecological health, in all new basin water storage and management decisions (e.g., reservoir re-operation). (Example: reservoir re-operation to increase storage for offstream use AND increase releases during critical low-flow periods.)

RECOMMENDATION: (See Issue D)

PUBLIC COMMENT

All respondents supported all recommendations for this issue, except for those who question the implications of some recommendations to expand built storage, and one who was opposed to Recommendation 11 unless it was clear that the new coordinator will focus on helping improve municipal and agricultural efficiencies. The BAC recognizes that addition built storage is an option that would take immense planning to accomplish, and only in places where the benefits outweigh the costs. The exploration of natural storage and increased efficiencies is also well-addressed recommendations; therefore, no changes were made in this section.

INSTREAM FLOW

Goal: Maintain and Enhance Instream Flow

THE ISSUE

Instream flow pertains to streamflow in rivers and streams used non-consumptively for fish and wildlife, channel maintenance, habitat conservation, recreation, and hydropower. Maintenance of instream flows is a significant issue in the Upper Missouri, especially on tributaries where fish spawn and rear, and on mainstems where native cottonwood forests fail to reproduce. Despite the legal tools available for protecting and restoring streamflows, there are still situations in the Upper Missouri where streamflows are insufficient at critical times. There is a broad recognition that streams and rivers in the Upper Missouri Basin are already heavily utilized for many purposes, yet future water management should strive, when possible, for streamflow conditions that maintain or restore the desired ecological functions and processes, typically but not always, similar to those exhibited in their natural state.

Objective

1. More tools are available to protect or enhance instream flows within the prior appropriation framework.

RECOMMENDATION 15: Expand statutory authority for the instream flow fishery change use process to include permanent and temporary exchanges and beneficial uses for other species and ecological benefits.

RECOMMENDATION 16: Create sub-watershed plans that identify where, when, and to what degree flows are insufficient to support healthy ecosystems, and include plans for restoring and protecting streamflows to more efficiently meet the needs of all water users.

RECOMMENDATION 17: Consider earmarked user fees to recreational users to generate revenue to support instream flows leases, water conservation, stream restoration and watershed health by FWP in critical stream reaches, and then seek Legislative approval of new Montana Fish, Wildlife and Parks (FWP) license fees and a process for setting them.

RECOMMENDATION 18: Assure that public funding for water development and infrastructure (e.g., RRGL) prioritizes projects that enhance instream flows where needed.

- Instream flows preserve ecological functions and natural processes.

RECOMMENDATION 19: Determine the frequency, magnitude, timing, and duration of high (flushing) flows needed to maintain healthy rivers and streams across the basin. Use this information to prioritize water transactions and ensure that new storage (including groundwater) schemes protect these values. Likewise, determine the location, timing, and quantity of instream flow needed to respond to drought conditions.

RECOMMENDATION: (see Issue C)

PUBLIC COMMENT

Respondents supported these recommendations except for one who opposed Recommendations 15, 18, and 19 with no reasons presented. The BAC made no changes to this section except for the addition of the word "flushing" in Recommendation 19.

LOCAL COOPERATIVE EFFORTS

Goal: Expand General Support for Conservation Districts, Local Watershed Groups and Water Quality Districts

THE ISSUE

Community-based, local watershed groups, water quality and conservation districts, and other informal cooperative efforts are vital connections between water resource agencies and knowledgeable stakeholders. These groups bring diverse water users together to identify, design and implement water management solutions that address local and statewide goals. The Upper Missouri basin has many community-based watershed groups, Conservation Districts and local Water Quality Districts poised to solve local issues, monitor resources and educate the public. There has been significant reliance on these groups to coordinate grants to implement water quantity and quality projects. Budgets have been reduced and general funding for these groups has been extremely difficult to sustain. State and federal funding is often directly tied to projects rather than to operational expenses to retain staff, coordinate projects and maintain community involvement. Local groups rely on a variety of funding sources (grants, donations, project dollars and local mil levies), but overall financial support is limited and often not sustainable. Long-term solutions can best be developed collaboratively through strong partnerships between the local watershed communities that offer on-the-ground feedback and assessment, and the responsible statewide agencies that can offer technical and financial assistance to do so.

Objective

1. There is recognition of on-the-ground water-issue expertise and awareness that local water and land management groups offer; agencies support and make use of this local expertise.

RECOMMENDATION 20*:* Create a dedicated and sustainable source of funds for both the operational and technical (e.g.; data collection) support of local watershed groups and districts to respond to issues with local expertise.

RECOMMENDATION 21: Develop an information exchange for sharing data and ideas among local management groups. Also, assure regular communication between local groups and agencies to help identify watershed improvement priorities.

PUBLIC COMMENT

All respondents supported all recommendations in this section. The BAC made two changes to this section to clarify meaning, adding the word "diverse" in the issue statement, and clarifying language in Recommendation 21.

WATER USE EFFICIENCY AND CONSERVATION

Goal: Improve Water Use Efficiency and Conservation

THE ISSUE

With limited supplies, water use efficiency is playing a bigger role in the Upper Missouri Basin, especially in ranching and municipal operations. Many irrigators are converting their fields from flood to sprinkler irrigation systems to decrease labor costs and to improve crop yields. People recognize that these changes in irrigation practices can affect the hydrologic regime and return flow rates. From a flow management perspective, it might make sense to continue flood irrigation practices in some areas, such as headwaters, and convert to sprinkler irrigation in others. Where a particular irrigation system type is most beneficial to the producer will vary depending on local geology and soil type, economics, infiltration return rates, source (groundwater versus surface water), competing uses and time of year. In the end, economic considerations probably will compel most producers to continue to change flood irrigation systems to sprinkler systems. Although improving water efficiency and conservation is important and probably necessary for many ranches to stay economically viable, it also leads to questions about the cumulative impacts of these irrigation system changes on the timing of return flows, depletions, and the legal uses of any associated “saved” water. In municipalities with limited water rights for expanding populations, efficiency measures and storage potentials are the subject of intensive analyses.

Objectives

1. Water use efficiency improvements are in place. There is recognition that certain irrigation methods can have return flow benefits, and that irrigation methods have trade-offs among all water users.

   RECOMMENDATION 22: Support irrigation improvements at the local level (flood to sprinkler, conveyance system upgrades) where it makes economic and hydrologic sense; Identify opportunities to offset or mitigate impacts of sprinkler conversion systems on return flow, and create and fund mechanisms for capturing water (aquifer recharge, constructed wetlands) to offset the impacts of sprinkler conversions.

   RECOMMENDATION 23: Develop a local groundwater assessment for each sub-basin that characterizes geology, infiltration rates and groundwater availability; to compliment these studies, create a basin-wide Council or group that can recommend when efficiency projects are best to implement with public funding (e.g., locations where pivots or canal lining make sense and others where groundwater storage from flood irrigation is desirable).

   RECOMMENDATION 24: Assess banking, leasing and mitigation opportunities to offset water saved through efficiencies for recharge and other uses, without expanding the consumptive or historic use portion of a water right.

- Municipal water systems promote and employ water conservation measures wherever feasible.

  RECOMMENDATION 25: Implement incentivized conservation programs in high-density municipal areas.

  RECOMMENDATION 26: Assess the legal aspects of wastewater reuse

- There is public awareness of the effects of water use efficiencies and mitigation measures on local basin hydrology.

  RECOMMENDATION 27: Create a public awareness program, delivered by Conservation Districts, Water Quality Districts, municipalities and watershed groups that describes the benefits and consequences of sprinkler and flood irrigation systems, municipal water conservation measures, and other water efficiency-related topics[2].

PUBLIC COMMENT

All respondents supported all recommendations in this section, except for one who felt that Recommendation #23 would be a staff and time sink. The BAC responds that this kind of effort is critical for setting priorities for improving efficiencies. No changes were made to this section.

INTEGRATED WATER QUALITY AND QUANTITY

Goal: Advance Integrated Water Quantity and Quality Management

THE ISSUE

The direct relationship between water quality and quantity in a basin with little available water underscores the importance of their integrated management. Any improvement in water quality requires deliberate attention to nonpoint source pollution, including naturally occurring, which is the cause of the majority of water quality problems in the Upper Missouri Basin. Low streamflows can be a major trigger of water quality concerns as problems intensify when pollutants like nutrients, metals, pathogens, and salinity concentrations are present at low flows. Warm water temperature is also a major water quality and fisheries concern associated with low flows. The biggest challenge to controlling non-point source pollution is the fact that much of its mitigation lies in voluntary, informed action by individuals who contribute to collective results.

Objective

1. Systems are in place to integrally manage water quality and water quantify

   RECOMMENDATION 28: To assist in local, voluntary efforts and improved understanding of instream flow needs, define "low flow alteration" in the DEQ's and FWP's assessment methodologies.

   RECOMMENDATION 29: Expand on current efforts to develop a multi-stakeholder campaign that increases public awareness of non-point source mitigation activities and opportunities.

   RECOMMENDATION 30: Support a program that allows entities needing to meet discharge requirements to purchase a credit from upstream users who deliver clean water downstream.

   RECOMMENDATION 31: Recognize impacts of dense septic system development on water quality, and create incentives and programs for improved performance. (Also see Recommendation 1)

   RECOMMENDATION 32: Recognize the role of healthy municipal watersheds in the reduction of potable water supply treatment costs.

   RECOMMENDATION 33: Create a Strategic Nutrient Reduction Plan for the Upper Missouri basin that assists local governments, Conservation Districts, watershed groups, and local Water Quality Districts to take a deeper role in nutrient-related issues in their watersheds, including septic management in high-density areas.

   RECOMMENDATION 34: For each sub-basin in the Upper Missouri, create a baseline groundwater study that also recognizes the water quality/quantity interface.

   RECOMMENDATION 35: Develop a legal analysis of water re-use from a water rights perspective; identify how municipalities might approach water re-use or discharge choices, given recent changes in water quality standards.

[2] Note Colorado SB 14-023 Water Efficiency Savings Bill as one example

PUBLIC COMMENT

All respondents supported all recommendations of this section except for one who strongly opposed Recommendation 30, which recommended a nutrient trading program. The BAC agreed with parts of this comment and modified the recommendation to embrace the concept, but temper the recommendation. The BAC also tightened the language in Recommendations 28, 31, and 33.

WATER'S ROLE IN THE ECONOMY

Goal: Recognize the Role of Water in Montana's Growing Economy

THE ISSUE

Even though most of the Upper Missouri Basin is sparsely populated, its urban and industrial centers generate a robust economy and compliment Montana's rich agricultural and outdoor recreation traditions. The Upper Missouri Basin has 31% of Montana's population, nearly 23 % of Montana's land area, almost half of Montana's irrigated agricultural lands (more than 1,000,000 acres), and accounts for 46% of all fishing in the state. Current estimates put the population in the basin at about 313,000, and somewhere between 365,000 and 415,400 by 2035, creating new pressures on housing, water infrastructure and fire control. Water availability, water conveyance, water conservation, and the value of water during rapid development have received immediate attention in response. Many miles of water conveyance infrastructure so important to agriculture have a shared value in providing habitat and a healthy watershed. Besides the value associated with water diverted for agricultural and other uses, maintaining streamflows to protect habitat, offer recreational opportunities, support robust tourism, and generate energy is as important. Given that population growth is inevitable in the basin, careful attention is needed to assure sustainable economic development while protecting senior users and instream resources. Accelerated changes in land and water use, and the need to better manage those changes, are drivers of this issue.

Objectives

1. The Prior Appropriation Doctrine and current water uses and conveyances are protected and recognized as supporting the economy.

  RECOMMENDATION: (see Issue B)

- There are incentives and protections to efficiently use and conserve water, and to allow for transfer to other uses while protecting senior users.

  RECOMMENDATION: (see Issue F)

- Municipal water supplies and infrastructure are managed to accommodate economic development and population growth.

  RECOMMENDATION 36*:* Survey municipal water supply infrastructure and secure funding to repair and update inefficient systems to support additional growth.

- Water is available for economic development through well-managed systems that offer opportunities to: a) Market, transfer and lease water including stored water **(see Issue K)***;* and b) utilize water reservations **(see Issue L)**

- There is a broad recognition that clean water and healthy watersheds support a healthy economy and expanded tourism.

  RECOMMENDATION 37: Provide comprehensive tools to support water conservation, while maintaining and enhancing resources for current and future use, job creation and sustainable economic development. This includes providing water for uses such as irrigation and industrial applications, as well as recreation and tourism. In a region that has a diverse economy, the ability to provide and maintain clean, usable water is critical to all.

PUBLIC COMMENT

All respondents supported all recommendations in this section. One respondent recommended adding the maintenance of water conveyance systems as a key need, and the BAC agreed. This is reflected in the issue statement and the first objective statement.

WATER INFORMATION SYSTEMS

Goal: Increase Scope of and Access to Centralized Water Data

THE ISSUE

Rapid response to water problems—flood, drought, dewatering, nutrient overload, pollutant spikes—is impossible without reliable and accessible data. Currently, response to water problems relies on an incomplete data system. Water data collection in the Upper Missouri Basin is the responsibility of several federal, state and local agencies that monitor streamflow, snowpack, well levels, temperature trends, habitat composition and water quality. This is all good, but there are two prominent issues. First, water data collection is varied and highly dispersed among several groups, making access to data complex, time consuming and decentralized. In addition, and probably a bigger issue, is the difficulty of accurately describing local water availability where there are not enough real-time data or monitoring sites.

Objectives

1. Surface water, groundwater and snow data collected by all state, federal, local and private entities are accessible from one portal managed by the State Library Natural Resource Information System (NRIS) Water Data System.

   RECOMMENDATION 38: Assure consistent funding for long-term, full-time NRIS Water Data System staffing needed to centralize, populate, create and maintain a user-friendly navigation tool for the water data access system.

   RECOMMENDATION 39*:* Assure that the Water Data System benefits from data generated and contributed by many state and federal agencies and local groups; collaborate with the Western States Water Council to build a data access system that is compatible with the Water Data Exchange for western states.

   RECOMMENDATION 40: Create a geo-referenced database of the adjudicated places of use and points of diversion that is available through the statewide Water Data System; the geo-referenced database can be used to estimate water uses and to obtain information on water rights during change, transfer or decree administration processes.

   RECOMMENDATION 41: Update an online training tool to help local watershed groups, districts, and the public access information cataloged by NRIS.

- New stream gages, monitoring wells and snow monitoring sites are installed and managed, and hydrologic monitoring techniques are employed, to characterize hydrologic conditions in areas of special interest and collaboration in the Upper Missouri Basin.

***RECOMMENDATION 42**:* Create agency and local partnerships to prioritize study sites, finance data collection, and make information readily available for problem solving.

RECOMMENDATION 43: Train and fund local volunteer water-monitoring teams, and improve access to data collected.

RECOMMENDATION 44: Maintain the state's contribution to the vital U. S. Geological Survey (USGS) gauging program and establish a state real-time streamflow monitoring network, to complement the vital USGS system, to include additional sites and locations on smaller streams.

RECOMMENDATION 45: Use more cost-effective hydrologic modeling techniques to estimate streamflow data for ungauged sites.

PUBLIC COMMENT

All respondents supported all recommendations in this section. One comment asked for recognition of the groundwater collection that is already undertaken by the GWIC database. To address this, the BAC clarified in Objective 1 that groundwater, surface water and snow data collected by many agencies should be referenced in the portal.

AVAILABLE WATER SUPPLY AND CLIMATE CHANGE

Goal: Protect Available Water Supply and Develop Strategies in Response to Climate Changes

THE ISSUE

Climate change and shifting weather patterns affect the amount and distribution of precipitation, and whether that precipitation occurs as rain or snow. As a result, streamflow is likely to change in the Upper Missouri basin in amount, timing and distribution. Climate changes also affect the rate of evaporation and plant water use by both natural vegetation and irrigated crops. Shifts in seasonal flow and water availability are resulting in earlier spring runoff and lower late season flow. In response, water users are learning to adapt to changes in streamflow, growing season and irrigation demand. Although fire on the land often benefits native fish, and therefore the economy, prolonged drought and increased incidence and intensity of forest fires are other changes affecting water users. Ultimately, management agencies and stakeholders will need to adapt to these shifts in their land- and water-use practices and in their decisions to protect water supplies.

Objectives

- Adaptive management strategies are in place that respond to shifts in growing seasons and streamflow.

  RECOMMENDATION 46: Investigate adaptive management strategies for existing reservoirs and water distribution infrastructures.

  RECOMMENDATION 47: Review period of use specified on water rights and how we manage those during drought.

- Forests and rangelands are managed to protect cost-effective natural storage potential and watershed health (optimal forest density, wetlands integrity, reduced soil erosion, etc.); these measure have a direct impact on water quality.

  RECOMMENDATION 48: Implement forest thinning and prescribed burns in areas where high forest stand density has resulted in high risk of wildfire. Work to develop and implement prioritized restoration, soils protection and/or runoff management plans in degraded forestlands and sub-watersheds in the urban/forest interface. In addition to prescribed burn, use mechanical forest thinning to create conditions for allowing the reintroduction of fire.

PUBLIC COMMENT

All respondents supported all recommendations in this section. The BAC made no changes.

WATER TRANSFERS AND MARKETING

Goal: Analyze the Scope of Water as a Transferable Property by Exploring Additional Opportunities for Water Marketing, Mitigations and Banking

THE ISSUE

Most western water allocation regimes evolved during periods of relative abundance and are not well suited to the management of water scarcity. Montana can lead the world in its innovative approaches to address scarcity. Right now, there are both unique opportunities for and concerns about water transfers and the need to plan for more water transactions. Water marketing, mitigation and water banking each offer distinct functions and opportunities, and understanding their nuances is the first step for water users in the Upper Missouri Basin. The potential for water marketing (the sale of water or the water right by the owner) is high in the Upper Missouri, especially in a closed basin where the value of water increases with new water demands. Mitigation requires reallocation of surface water or groundwater through a change in appropriation right. It is designed to offset adverse effects resulting from net depletion of surface water that is not legally available. A new "marketing for mitigation" process opens the door in Montana for water banking. It allows for facilitated marketing and a way to determine the amount of water available for mitigation within a water right. The process is in its infancy and only two applications have been made in Montana to date. There are questions about the scope of water banking–the facilitated sale of developed water for another use–and its role in the brokering of conserved water. These issues and opportunities for water marketing, mitigation and banking deserve intensive research and application in the next decade.

Objective

1. Water marketing tools are effectively used as an option to assure fair and effective basin-wide water use.

RECOMMENDATION 49: Create well-managed systems that offer opportunities to market, transfer and lease water including stored water; explore changes to existing water laws.

RECOMMENDATION 50: Build public awareness and understanding of water marketing opportunities.

RECOMMENDATION 51: Create an easily navigable webpage managed by DNRC listing known available water in the market and opportunities for marketing for mitigation

RECOMMENDATION 52: Explore use of water banks to mitigate for exempt wells.

RECOMMENDATION 53: Encourage DNRC (lessee) to work with the Bureau of Reclamation (lessor) to assign blocks of stored contract water to the state from Canyon Ferry and Tiber Reservoirs, which can be marketed incrementally through a user-friendly system; advertise this opportunity to water users.

RECOMMENDATION 54: Continue to develop tools or tables to quickly estimate return flows (or conversely, consumptive water use) under different crop, soil, climate, and irrigation conditions. This will reduce the time needed to assess each water transaction.

RECOMMENDATION 55: Encourage water leasing with arrangements that incentivize and reward water savings and protect the full extent of the lessor's water right.

RECOMMENDATION 56: Create or support a Water Bank to facilitate temporary and permanent water transfers for both diversionary and instream uses.

PUBLIC COMMENT

All respondents supported all recommendations in this section except for one respondent who opposed Recommendations 49, 50 51 and 56 with an assessment that marketing would over-value water such that other used would be forgotten/dropped. The BAC responded that systems are already in place to test water marketing and that those systems protect existing uses. No changes were made to this section except in Recommendation 50 to build an understanding of water marketing options.

LARGE SCALE FACTORS

Goal: Assess Selected Large-Scale Factors

THE ISSUE

Certain large-scale factors like quantification of the Confederated Salish and Kootenai Tribal (CSKT) reserved water rights through the proposed water rights compact with the state, perfection of state water reservations, implications of the Endangered Species Act, and downstream demands of the federal managed mainstem dams, could impact future water availability in the Upper Missouri Basin. The CSKT Compact is the one remaining compact to be negotiated by the Reserved Water Rights Compact Commission before it sunsets in 2015. With claims to 1855 and “time immemorial” priority dates stemming from the Treaty of Hellgate, the Tribes possess strong claims to water throughout much of Montana. Under the proposed compact, the Tribes have agreed to relinquish all claims to water in the Upper Missouri River basin and elsewhere east of the continental divide. In addition, state water reservations for current and future municipal, agricultural, instream and water quality uses are located throughout the basin. Some are being used, and some are available to be put to use in the future. Uncertainty surrounds still others, such as many Conservation District reservations, regarding whether they will ever be able to be developed. These reservations secure water for both consumptive and non-consumptive purposes. Many water users and others are unaware of the legal status of the reservations but they are certainly a consideration for water management in the Upper Missouri basin.

Objective

1. Large federal, state and tribal water rights are quantified and interpreted such that their impacts to water users are clearly recorded and recognized.

RECOMMENDATION 57: Endorse resolution and successful passage of the proposed CSKT compact during the 2015 Legislative session to assure prompt continuation of the basin adjudication and protection of Upper Missouri Basin water users from Tribal instream flow claims.

RECOMMENDATION 58: Promote local proactive involvement in Endangered Species Act listed species protection and recovery programs, and build an understanding on how these programs affect water availability. Promote collaborative and proactive efforts, such as the Big Hole Candidate Conservation Agreement with Assurances (CCAA) habitat conservation plan, that improve streamflows while protecting participants’ water rights.

RECOMMENDATION 59: Determine how changes in downstream needs for navigation and flood control, as outlined in the U.S. Army Corps of Engineers' Master Manual for Fort Peck, affect water management in the Upper Missouri Basin.

RECOMMENDATION 60: Provide information to owners of water reservations and to water managers/users regarding the legal status of reservations.

RECOMMENDATION 61: Continue support for the DNRC/U.S. Department of Agriculture Forest Service Compact designed to protect streamflows (Note: The Compact does not have an adverse effect on senior water rights, but does help to protect senior users from future exploitation).

- Effective aquatic invasive species prevention and education in place.

  RECOMMENDATION 62: Support agency coordination efforts to implement aquatic invasive species programs.

PUBLIC COMMENT

All respondents supported all recommendations in this section. The BAC made no changes to this section.

XI. References

Aquoneering 2005. West Chester Irrigation Project Reconnaissance Study. Prepared for DNRC and USBR, July 2005. Available from DNRC, Helena.

DNRC 2005. Chester Irrigation Project Preliminary Feasibility Assessment. DNRC, Helena, September 2005.

DNRC 1980. Montana Water Use in 1980. Montana DNRC, Helena.

DNRC 1975. Water Use in Montana, Inventory Series Report No. 13. DNRC, Helena.

Dolan, L.S. and D.K. Deluca, 1993. Use of a hydrologic model in a basin-wide water allocation proceeding. Water Resources Bulletin, Vol. 29, No. 1.

Fields, R.W., Rasmussen, D.L., Tabrum, A.R., and Nichols, Ralph, 1985, Cenozoic rocks of the intermontane basins of western Montana and eastern Idaho a summary, *in* Flores, R.M., and Kaplan, S.S., eds., Cenozoic paleogeography of west-central United States: Denver, Colo., Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, p. 9-36.

Great Falls Tribune 2004. Hydroelectric plant at Tiber goes online. Article by Karen Ogden, June 17, 2004.

Hackett, O.M., F.N. Visher, R.G. McMurtrey, and W.L. Steinhilber, 1960. Geology and ground-water resources of the Gallatin Valley Gallatin County Montana, United States Geological Survey Water-Supply Paper 1482, 282 pp.

Huntoon, P.W., 1993. The influence of Laramide foreland structures on modern groundwater circulation in Wyoming artesian basins, Geology of Wyoming: Geological Survey Memoir NO. 5, p. 756-789.

Kendy, E. and R.E. Tresch, 1996. Geographic, geologic, and hydrologic summaries of intermontane basins of the northern Rocky Mountains, Montana. U.S. Geological Survey Water Resources Investigations Report 96-4025, 233 p., http://pubs.usgs.gov/wri/1996/4025/report.pdf.

Liang, X., D.P. Lettenmaier, E.F. Wood, and S.J. Burges. 1994. —A simple hydrologically based model of land surface water and energy fluxes for general circulation models, *Journal of Geophysical Research*, 99(D7), 14415–14428.

Liang X., E.F. Wood, and D.P. Lettenmaier. 1996. —Surface soil moisture parameterization of the VIC-2L model: Evaluation and modifications, *Glob Planet Chang* 13: 195–206.

Lohman, S.W., 1972. Definitions of selected ground-water terms: Revisions and conceptual refinements, U.S. Geological Survey Water Supply Paper, 1988, 21 p. http://pubs.usgs.gov/wsp/wsp_1988/pdf/wsp_1988.pdf.

Madison, J.P., 2004. Hydrogeology of the Burton Bench aquifer, north-central Montana: Montana Bureau of Mines and Geology Open-File Report 512, 20 p.

Meehl, G.A., C. Covey, T. Delworth, M. Latif, B. Mcavaney, J.F.B. Mitchell, R.J. Stouffer, and K.E. Taylor. 2007. —THE WCRP CMIP3 MULTIMODEL DATASET – A New Era in Climate Change Research, *Bulletin of the American Meteorological Society*, 88(9), 1383–1394.

Miller, K.J., Rise, D.S., and McDonald, C., 2002. Ground-water and surface-water quality, herbicide transport, and irrigation practices: Greenfields Bench aquifer, Teton County, Montana: Montana Bureau of Mines and Geology Open-File Report 463, 177 p.

Montana Department of Environmental Quality. 2012. Montana 2012 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality. Report WQPBIMTSTR-004F.

Montana Department of Fish, Wildlife and Parks. 1989. Application for reservations of water in the Missouri River basin above Fort Peck Dam. Submitted to DNRC, Helena.

National Agricultural Statistics Service (NASS) 2010. Agricultural statistics data for 2010: http://www.nass.usda.gov/.

Nijssen, B., D.P. Lettenmaier, X. Liang, S.W. Wetzel, and E F. Wood. 1997. ―Streamflow simulation for continental-scale river basins, *Water Resour. Res*, 33, 711–724.

Osborne, T.J., Noble, R.A., Zaluski, M., and Schmidt, F.A., 1983. Evaluation of the ground-water contribution to Muddy Creek from the Greenfield irrigation district, Cascade and Teton counties, Montana: Montana Bureau of Mines and Geology Open-File Report 113, 232 p.

Patton, T., 2013. Climate 2013: Groundwater level response in wells, Presentation to Governors drought and water supply committee, http://drought.mt.gov/Committee/Presentations/2013/mbmg_july.pdf.

Perry, E.S., 1933, Possibilities of ground-water supply for certain towns and cities of Montana, Montana Bureau of Mines and Geology: Miscellaneous Contribution 2, 49 p.

SCS 1978. Water Conservation and Salvage Report for Montana. United States Department of Agriculture, Soil Conservation Service.

Smith, L.N., LaFave, J.I., Patton, T.W., Rose, J.C., McKenna, D.P., 1999, Ground-water resources of the Lower Yellowstone River Area: Dawson, Fallon, Prairie, Richland, and Wibaux Counties, Montana. Part A- Descriptive overview and basic data, Montana Bureau of Mines and Geology: Ground-Water Assessment Atlas 1A, 43 p., http://www.mbmg.mtech.edu/pdf/groundwateratlas1.pdf.

Theis, C.V., 1941. The effect of a well on the flow of a nearby stream. *American Geophysical Union Transactions*, 22(3), 734-738.

USGS, 2005. Preliminary integrated geologic map databases for the United States: Central states: Montana, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Iowa, Missouri, Arkansas, and Louisiana, Open-File Report 2005-1351 http://pubs.usgs.gov/of/2005/1351/

USGS, 2004. Estimated Water Use in Montana in 2000. Scientific Investigations Report 2004-5223.

U.S. Bureau of Reclamation. 2010. *Climate Change and Hydrology Scenarios for Oklahoma Yield Studies*, prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver Colorado. April 2010. 71 pp.

U.S. Bureau Reclamation, 2011. 'West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections', Technical Memorandum No. 86-68210-2011-01, prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado. 138pp.

Wilke, K.R., 1983, Appraisal of water in bedrock aquifers, northern Cascade County, Montana, Montana Bureau of Mines and Geology: Memoir 54, 22 p., 2 sheet(s).

Wolock, David, 2003. Flow characteristics at U.S. Geological Survey stream gages in the conterminous United States. USGS Open-File Report: 2003-146, http://pubs.er.usgs.gov/publication/ofr03146.

Wolock, David M., 2003. Base-Flow Index Grid for the Conterminous United States. USGS Open-File Report: 2003-263, http://pubs.er.usgs.gov/publication/ofr03263.

Wolock, David M., 2003. Estimated Mean Annual Natural Ground-Water Recharge in the Conterminous United States. USGS Open-File Report: 2003-311, http://pubs.er.usgs.gov/publication/ofr03311.

Zimmerman, E.A., 1967, Water resources of the Cut Bank area, Glacier and Toole counties, Montana, Montana Bureau of Mines and Geology: Bulletin 60, 37 p.

XII. List of Figures, Maps and Tables

List of Figures


MONTANA WATER SUPPLY INITIATIVE
UPPER MISSOURI RIVER BASIN WATER PLAN

List of Maps

List of Tables

XIII. Glossary of Terms

Abandonment – The intentional, prolonged, non-use of a perfected water right. [1]

Acre-feet – A unit of volume, mostly used in the United States, to describe large-scale water volumes. It is the volume of one acre of surface area to the depth of one foot which is equal to 43,560 cubic feet.

Adjudication of Water Rights – In the context of Montana water law this refers to the statewide judicial proceeding to determine the type and extent of all water rights claimed to exist before July 1, 1973.[2]

Adverse Effect – Interference with a water right owner's ability to reasonably exercise their water right. In the context of new water use permits and change applications, the applicant must prove lack of adverse effect prior to appropriating water for a beneficial use pursuant to §85-2-311, MCA, or changing a water right pursuant to §85-2-402, MCA. [3]

Appropriate – To divert, impound, or withdraw, including by stock for stock water, a quantity of water for a beneficial use.[1]

Appropriation Right/Water Right – Any right to the beneficial use of water which would be protected under the law as it existed prior to July 1, 1973, and any right to the beneficial use of water obtained in compliance with the provisions and requirements the Title 85, Chapter 2.[1]

Aquatic Ecology – The relationships among aquatic living organisms and between those organisms and their water environment.

Aquatic Invasive Species – Non-native plants, animals or pathogens that cause environmental or economic harm.

Beneficial Use – Use of water for the benefit of the appropriator, other persons, or the public, including but not limited to agricultural (including stock water), domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, and recreational uses; use of water to maintain and enhance streamflows to benefit fisheries pursuant to conversion or lease of a consumptive use right. [1]

Call – The request by an appropriator for water which the person is entitled to under his/her water right; such a call will force those users with junior water rights to cease or diminish their diversions and pass the requested amount of water to the downstream senior water right holder making the call.

Claim/Statement of Claim – The assertion that a water right exists under the laws of Montana or that a reserved water right exists under the laws of the United States in Montana's general adjudication. [2]

Climate – The average weather over a period of time, typically taken as a 30-year period from a human perspective. Geologists and paleoclimatologists refer to the earth's climate over thousands to millions of years.

Climate Variability – The fluctuation of temperature, precipitation, wind, and other climate descriptors, over a period of time. This variation may be due to natural processes or human-induced factors.

Compact – a negotiated agreement for the equitable division and apportionment of waters between the State and its people and: 1) the several Indian Tribes claiming reserved water rights within the state (MCA 85-2-701); or, 2) between the State and its people and the federal government claiming non-Indian reserved waters within the state.

Conjunctive Management – Management of ground and surface water as a single resource.

Conjunctive Use – The deliberate combined use of groundwater and surface water.

Conservation District – A political subdivision of state government, possessing both public and private attributes, that primarily distributes irrigation water in a given region and that may also administer electric power generation, water supply, drainage, or flood control.

Consumptive Use – Use of water that reduces supply, such as irrigation or household use.[1]

Decree – Is a final product of adjudication and is a legal document issued by a district court or the Montana Water Court defining the priority, amount, use, and location of a water right or set of water rights. The Montana Water Court adjudicates and prepares decrees for entire basins as part of the adjudication process.[2]

Dewatering of Streams, Chronic and Periodic – Dewatering is a reduction in stream flow below the point where stream habitat is adequate to support healthy fish populations. Chronic dewatering is a significant problem in all years while periodic dewatering is a significant problem only in drought years.

Means of Diversion/Diversion – Structures, facilities, or methods used to appropriate, impound, or collect water including but not limited to a dike, dam, ditch, headgate, infiltration gallery, pipeline, pump, pit or well. [1]

Evapotranspiration (ET) – means the loss of water from the soil both by evaporation and by transpiration from living plants. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. [1]

Exempt Wells – Under Montana water law, wells that divert 35 gallons per minute or less, and do not exceed 10 acre-feet per year in the total volume of water diverted are considered exempt from the permitting process. Appropriators of water under these conditions are, however, required to file a notice of completion with DNRC.[4]

Existing Water Right – “Existing right” or “existing water right” means a right to the use of water that would be protected under the law as it existed prior to July 1, 1973. The term includes federal non-Indian and Indian reserved water rights created under federal law and water rights created under state law. [1]

Federal or Tribal Reserved Water Rights – Established by an act of Congress, a treaty, or an executive order. Gives a right to use water; the amount of water reserved depends on the purpose for which the land was reserved.

Flowing Well – An oil or water well from which the product flows without pumping due to natural or artificially supplied subterranean pressure.

Flow Rate – A measurement of the rate at which water flows or is diverted, impounded, or withdrawn from the source of supply for beneficial use, and commonly measured in cubic feet per second (cfs) or gallons per minute (gpm). [1]

Geographic Information System (GIS) – A computer system designed to capture, store, manipulate, analyze, manage, and present geographical data.

Ground Water – Any water beneath the land surface.[1]

Ground Water Recharge or Aquifer Recharge – Can refer both to the natural process of ground water recharge (achieved by infiltration of precipitation or discharge from surface water), OR can refer to human efforts to enhance more groundwater storage. Artificial aquifer recharge (AR) is the enhancement of natural ground water supplies using man-made conveyances such as infiltration basins or injection wells. Aquifer storage and recovery (ASR) is a specific type of AR practiced with the purpose of both augmenting ground water resources and recovering the water in the future for various uses.[1]

Hydrologic Regime – The relationship between precipitation inputs and streamflow outputs in a basin or watershed. The amount and timing of water moving through a watershed often characterized by the average annual hydrograph.

Hydrograph – A chart showing the relationship between flow rate and time at given point (gage) in a watershed flow network. Time is usually on the horizontal axis and flow rate is usually on the vertical access.

Instream Flow – Water left in a stream for non-consumptive uses such as aquatic habitat, recreation, navigation, or hydropower.

Interstate Compact – A legal agreement between two states that divides (or apportions) water crossing the states' boundaries.

Junior Appropriator/Junior Water Right – A general term referring to a water right or the owner of a water right with a priority date that is later in time than another water right.

Channel Migration – Natural movement of river channels through the processes of erosion and deposition.

Legal Water Availability – Typically determined based upon comparison of physical water availability to the legal demands on a source or reach of a source by subtracting the legal demands from physical water availability.

METRIC (Mapping Evapotranspiration at high Resolution and with Internalized Calibration) – An image-processing tool for computing evapotranspiration (ET) using Landsat Thematic Mapper data.

Montana Code Annotated (MCA) – Laws of Montana classified by subject. Title 85 contains laws pertaining to water use.

Murphy Rights – Instream flow rights on 12 Blue Ribbon trout streams for the preservation of fish and wildlife. Named for the legislative author, Jim Murphy of Kalispell. Murphy Rights exist for specific reaches of the following rivers: Big Spring Creek, Blackfoot River, Flathead River, Middle Fork Flathead River, South Fork Flathead River, Gallatin River, West Gallatin River, Madison River, Missouri River, Rock Creek, Smith River, and Yellowstone River. The priority dates are 1970 and 1971 and only protect flows when senior water rights have been satisfied.

Natural Storage of Water – See storage of water, natural.

Non-Consumptive Use – Use of water that does not consume water.

Overstated Water Rights – Water rights in excess of what was perfected through beneficial use.

Permit – An authorization to use water, issued by DNRC, specifying conditions such as type, quantity, time, and location of use. [3]

Physical Water Availability – the amount of water physically available at a specific point on a source typically measured in flow rate and volume. [3]

Priority Date – The clock time, day, month, and year assigned to a water right application or notice upon DNRC acceptance of the application or notice. The priority date determines the ranking among water rights. [1]

Federal Reserved Water Right – A special water right accompanying federal lands or Indian reservations, holding a priority date originating with the creation of the land.

Resource Indemnity Trust – Article IX of the Montana Constitution provides for the protection and improvement of the Montana environment and requires the existence of a resource indemnity trust (RIT) fund for that purpose, to be funded by taxes on the extraction of natural resources.

Return flow – Part of a diverted flow that is applied to irrigated land or other beneficial use and is not consumed and returns underground to its original source or another source of water. Other water users may be entitled to this water as part of their water right. [1]

Riparian – Riparian means related to or situated on the banks of a river. A riparian zone or riparian area is the interface between land and a river or stream.

Riverine Processes – The processes of erosion, transport and deposition of sediment that shape a river's channel(s) and floodplain.

Senior Appropriator/Senior Water Right – A general term referring to a water right or the owner of a water right with a priority date that is earlier in time than another water right.[1]

Storage of Water, Artificial or Constructed – Storing water in reservoirs or other human made impoundments.

Storage of Water, Natural – Storage of water in natural landscape features such as groundwater aquifers, ponds (including beaver ponds, floodplain ponds), wetlands and swales.

Stream Depletion Zone – An area where hydrogeologic modeling concludes that as a result of a ground water withdrawal, the surface water would be depleted by a rate equal to a rate of at least 30% of the ground water withdrawn within 30 days after the first day a well or developed spring is pumped at a rate of 35 gallons a minute. [1]

Stream Gage – A stream gage measures the flow of water at a point along a stream. The U.S. Geological Survey defines a stream gage as, "an active, continuously functioning measuring device in the field for which a mean daily streamflow is computed or estimated and quality assured for at least 355 days of a water year or a complete set of unit values are computed or estimated and quality assured for at least 355 days of a water year".

Sub-basin – A structural topographic feature where a basin forms within a larger basin. For example, the Bitterroot River basin is sometimes referred to as a sub-basin of the Clark Fork River basin. 64

Surface water – All water of the state at the surface of the ground, including but not limited to any river, stream, creek, ravine, coulee, undeveloped spring, lake, and other natural surface source of water regardless of its character or manner of occurrence.[1]

Telemetered (real-time) Stream Gage – A telemetered gage has the capability to transmit water elevation and streamflow data to a central location where it may be viewed (for example, via the Internet) as the data is collected.

Waste – Unreasonable loss of water through the design or negligent operation of an appropriation or water distribution facility or the application of water to anything but a beneficial use. [1]

Water Bank – An institutional mechanism used to facilitate the legal transfer and market exchange of various types of surface water, groundwater, and storage entitlements. Water banks use the market to make water available for new uses.

Waterway and Water Body – Usually refers to surface water features like rivers, streams, lakes, or ponds.

Waterway Health – Waterways are considered to be healthy when surface & groundwater flows & levels are of a timing and duration that provides habitat capable of supporting self-sustaining populations of native fish species and water dependent wildlife. In addition, waterway health refers to flows that help meet water quality standards, support beneficial uses, and support stream renewal functions.

Water Commissioner – Local water users can petition for a water commissioner after the water rights in a basin have been verified by the Montana Water Court. The commissioner ensures that daily water allocations in the basin occur in accordance with the users' rights. The local district court appoints the commissioner, and oversees his or her work. [5]

Water Court – Located in Bozeman, the Montana Water Court's primary function is to carry out the state-wide adjudication. Disputes between water right holders are still handled in local district court, and the local district courts oversee water commissioners in their area.

Water Lease – An agreement with a water user to allow a person or organization, for a fee, to lease water from the user. Water leases are often used in Montana to maintain instream flow.[6]

Water Quality – Chemical, physical, and biological characteristics of water that determine its suitability for a particular use.

Water Right Change – A change in the place of diversion, the place of use, the purpose of use, or the place of storage of a water right. These changes need the approval of DNRC to assure that the change will cause no adverse effect to other water users. [3]

Watershed – All the land that drains to a river or lake, with boundaries defined by topography (and includes wetlands, floodplains, riparian areas and uplands). For the purpose of this planning document, the term "watershed" is referring to a subunit of a sub-basin (smaller area).

Watershed Health – A watershed is considered healthy if it can continue to perform without depletion or degradation of watershed services such as: water collection, storage & delivery, flood and drought moderation; water purification, wildlife habitat and support of waterway health (see Waterway Health).

Water Reservation – A water right created under state law after July 1, 1973, that reserves water for existing or future beneficial uses or that maintains a minimum flow, level, or quality of water throughout the year or at periods or for defined lengths of time. [7]

[1] *See §85-2-102, Mont. Code Ann., and Rule 36.12.101, Admin. Rules Mont.*

[2] *See Title 85, Chapter 2, Part 2, Mont. Code Ann.*

[3] *See §85-2-311, and 402, Mont. Code Ann., and Title 36, Chapter 12, Subchapters 17 through 19. Admin. Rules Mont.*

[4] *See §85-2-306, Mont. Code Ann.*

[5] *See Title 85, Chapter 5, Mont. Code Ann.*

[6] *See Title 85, Chapter 2, Part 4, Mont. Code Ann.*

[7] *See §85-2-316, Mont. Code Ann.*